Cambridge Entrance Exam

Chemistry ESAT

Engineering and Science Admission Test

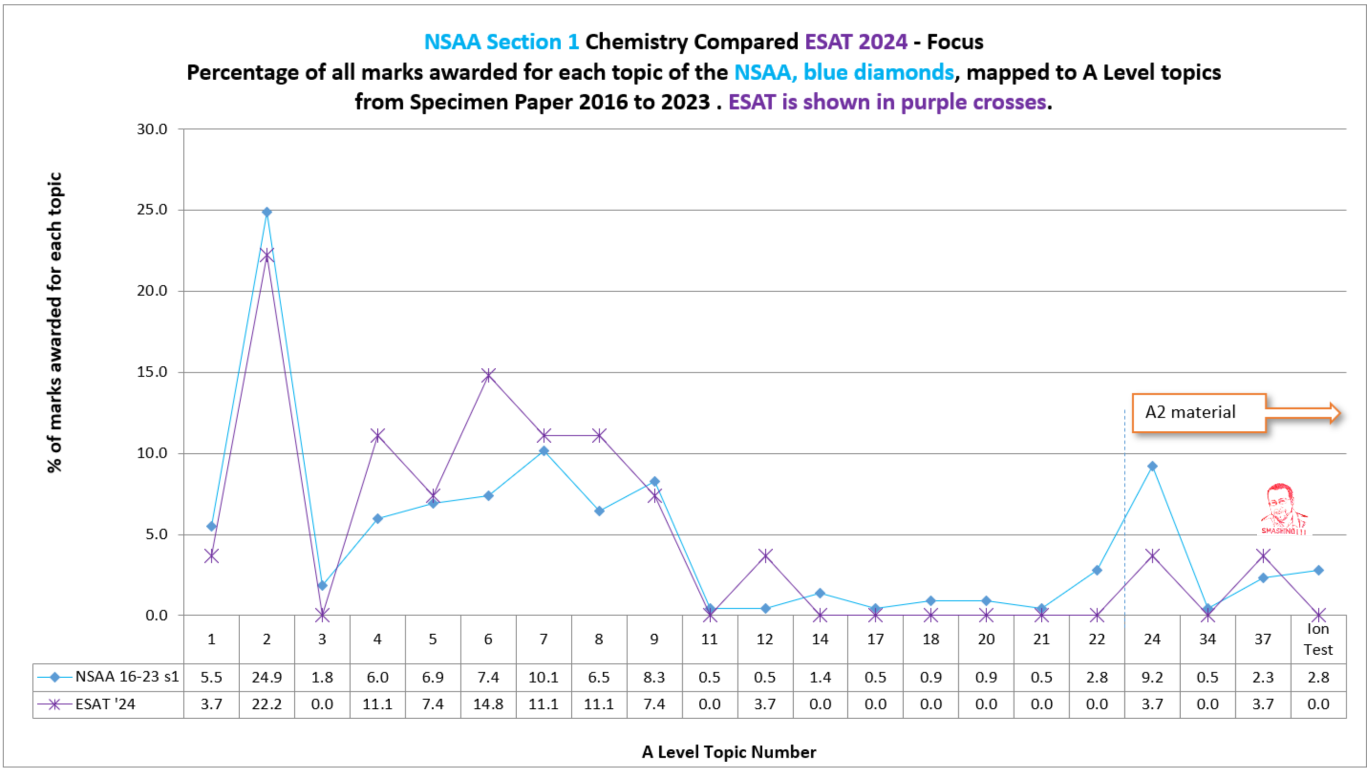
Past Exam Questions

Organised by A Level Topic

Specimen 2016 (NSAA) to 2024 (ESAT)

Name: ______________________________

Class: _______________



	1	2	3	4	5	6	7	8	9	11	12	14	17	18	20	21	22	24	34	37	Ion Test
NSAA 16-23 s1	5.5	24.9	1.8	6.0	6.9	7.4	10.1	6.5	8.3	0.5	0.5	1.4	0.5	0.9	0.9	0.5	2.8	9.2	0.5	2.3	2.8
ESAT '24	3.7	22.2	0.0	11.1	7.4	14.8	11.1	11.1	7.4	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0	3.7	0.0

For digital version of this book

www.SmashingScience.org

Patrick Brannac

As well as a wide variety of other free AS and A2 Chemistry resources, and some Biology resources, visit the website (www.SmashingScience.org) or scan this code:

A note on the CHEMISTRY version of this revision book

For students who are interested in Oxford university, check if your course requires an entrance exam, most don't, if it does, it appears to be the BMSAT or possibly the PAT exams. [1] If you are really good at exams, than a route to Oxbridge through an entrance exam might be a better bet, but there are many other factors, most of which are discussed in this book: find out which path is best for you! Currently, as of June 2024 no specimen questions are presented on the Oxford website, but when they do become available later in 2024 something might appear on SmashingScience.

For any student interested in making a great top 20 university application than a lot that is in here EXCAPT the exam questions that can provide context and further background information about making your best UCAS application. If you have looked at the grade statistics in here and realise that you fit the grade profile than making an Oxbridge application is most likely worth doing. You should try to understand that success should be measured in the new skills you have learnt, and the things you are now better at. If you approach it as an opportunity for growth than you have nothing to lose in making an ambitious but less likely application (as well as 3 or 4 applications that are more likely to deliver you offers) a jolly good go will deliver powerful advantages, now and throughout a well lived life. If you don't quite have the grades but have been successful academically but have also overcome other challenges, for instance, you have spent time in local authority care, or are currently eligible for Free School Meals, or have been eligible in the last six years[2], then you definitely should think about applying.

For teachers there is a lot you can do with especially the easier past exam questions here, for instance introducing them as a starter and then teaching enough content in the lesson so that most students in the class leave the lesson able to answer a Cambridge entrance exam question That makes a great observed lesson. There is also a lot of information in here that may help you advise students through their UCAS process.

For parents and guardians there are a great many voices in this space. The official websites from the universities, colleges and departments are more reliable sources, but the general internet also has a great deal of information. The traditional approach is through careful selection of the school; for most students who would perform well at Oxbridge, complete choice of school is not usually possible. The UCAS process is about making the finish line as fair as possible: student A, at the end of the race is ahead of student B. But where and when the students start, and how much, and importantly, how effective, the help they get along the way varies wildly. A student who goes to a top 20 university may have achieved more than another student who gets an offer from Oxbridge, and that student from a less famous university could easily go on to have a more interesting, meaningful and successful life. Finding the time to find out what your child is doing, when they are doing it, and taking the opportunity to feel pride in the work that they are doing, and communicating those positive feelings to them, can address some of the more challenging feelings that working within any important but difficult process delivers. And it would also encourage and promote stronger achievement.

[1] https://www.ox.ac.uk/admissions/undergraduate/applying-to-oxford/guide/admissions-tests
[2] https://www.undergraduate.study.cam.ac.uk/apply/after/contextual-data

To do checklist for making your greatest Oxbridge application

Tick ✓ each box when you've finished the task.

Learning about making a great UCAS application and this book	Silver - read it	Winner–thought about it (why is it included?)	Legend –revisited the idea a month later and talked about it with a teacher/parent/adult
Read this statement.	✓		
Understand that a great Oxbridge application involves a thorough understanding of alternate university degree courses that you can be happy and proud of completing, and with hard work, can deliver the same kind of life opportunities.			
Read about the deadlines and read the calendars at the back.			
Finished your first draft of your personal statement and talked to someone about it, ideally a teacher with experience with UCAS applications.			
Look at www.SmashingScience.org for other free resources, especially about Paper 1 MCQ.			
Understand why NSAA Section 1 is like the ESAT.			
Understand which topics are most important.			
Understand why most of your extended learning should be done becoming an expert at a topic before you try an NSAA question.			
Use the calendar to plan out the rest of the year until your last Oxbridge Interview.			
Spend 3 minutes each week thinking about which of your working time slots are productive, and which are not. Think about why they may have been different (e.g. first/last week after/before holiday, feeling unwell, Monday etc), and update your working schedule if these changes in your patterns are likely to be important next week.			
Used the graphs and tables to compare how the AS topics compare with the ESAT, and how the ESAT compares with the NSAA.			
Read each of the sections highlighted in "*Contents mapped to Cambridge's assessment of applicants list*" and using a calendar planned through how and when you are going to act to improve your chances and application across all these different assessment points.			
Thought about how you are going to get the best possible reference, and what you can do to help make that happen, including, perhaps, by completing the questionnaire at the back: "*Appendix: How to get the best reference*".			
Thought about how the test being online now will affect your working on the exam questions. You are likely to have to write on lined paper to do your working and will enter your answers with a keyboard. This is very different compared to A levels and IB Diploma qualifications which all use paper exams, so you preparation should change to deal with this.			
Thought about what makes these questions harder than normal AS questions: more steps for each, more answer choices, tighter time allowance. Generally, these require a stronger approach to eliminating errors in your process, through a more systematic approach to showing yourself your thinking in your working.			
Thought about this whole UCAS process as a magnificent way to build invaluable skills in dreaming about, planning and then working towards the world's biggest goals that you will be able to use for the rest of your life at the most critical times, regardless of the outcome of your Oxbridge application.			

Contents

Week Starting	Wk #	Events	Topic Focus
3-Jun	1	Tue 4th PM Paper 1(ADMINISTRATIVE Zone 5) When you have finished all of your exams, start planning out the rest of the year to know what you have to do and when: https://www.undergraduate.study.cam.ac.uk/apply https://www.ox.ac.uk/admissions/undergraduate/applying-to-oxford/guide	
10-Jun	2	Finish an early draft of Personal Statement and talk to someone, ideally a teacher or university counselor. Tell someone, probably several people, at your school you intend to apply to Oxford or Cambridge (ideally, they should know much earlier than this). Find out about the interview process and begin preparing (ideally earlier) by talking to others about science, ideally a teacher who knows about UCAS and Oxbridge applications.	
17-Jun	3		
24-Jun	4	Last chance usually to get feedback before the summer on your latest version of your personal statement	
1-Jul	5		
8-Jul	6		
15-Jul	7		
22-Jul	8		
29-Jul	9	**Thursday 1st August – Start of ESAT registration period**	
5-Aug	10		
12-Aug	11		
19-Aug	12		
26-Aug	13	Get your most up-to date version of your personal statement seen by someone at your school for feedback if possible; it should be largely finished now (for most students there will not be time to do anything extra to add to it now before the deadline)	
2-Sep	14		
9-Sep	15	Your personal statement should be ready to fit into the 4000-character 47-line limit; you should not be adding to it now, rather cutting out and condensing now	

Week Starting	Wk #	Events	Topic Focus
16-Sep	16	**Monday 16th September – Deadline to register for the ESAT Cambridge Entrance Exam**	
23-Sep	17		
30-Sep	18	Tue 1st Morning Chemistry Paper 3.5 (ADMINISTRATIVE Zone 5) Last good opportunity to get feedback on your **personal statement** and then act on it	
7-Oct	19		
14-Oct	20	**TUESDAY 15TH OCTOBER UCAS DEADLINE for OXBRIDGE APPLICATIONS** Tuesday 15th ESAT Wednesday 16th ESAT Fri 18th Morning Chemistry Paper 2.3 & Paper 5.3 (ADMINISTRATIVE Zone 5)	
21-Oct	21		
28-Oct	22	Tue 29th Morning Chemistry Paper 3.6 (ADMINISTRATIVE Zone 5)	
4-Nov	23	Interview invitations for Cambridge sent out this month starting about now Mon 4th Morning Chemistry Paper 4.3 (ADMINISTRATIVE Zone 5)	
11-Nov	24	Thu 14th Morning Chemistry Paper 1.3 (ADMINISTRATIVE Zone 5)	
18-Nov	25		
25-Nov	26		
2-Dec	27	Oxford interviews are carried out this week and next	
9-Dec	28		
16-Dec	29		
23-Dec	30		
30-Dec	31		
6-Jan	32		
13-Jan	33	Normally last Oxbridge interviews for Winter Pool applicants	

For calendars and revision timetables see "*Appendix – Calendars and stage-management*" at the back of this book

Throughout this book direct quotes from indicated websites are used, with largely original formatting, except passages highlighted yellow.

"You need to take the Engineering and Science Admissions Test (ESAT) if you are applying for:

- Chemical Engineering and Biotechnology
- Engineering
- Natural Sciences
- Veterinary Medicine

You will take the test on 15 or 16 October 2024. You must take the test in this first sitting.

You should make sure to register for the ESAT by **16 September 2024**.

Test format

The ESAT is a computer-based assessment. It is made up of individual multiple-choice assessments lasting 40 minutes each. You will sit these back-to-back on the day of the test.

Mathematics 1 is compulsory for all candidates.

The remaining assessments will depend on the Cambridge course you are applying to. If you're applying for Chemical Engineering and Biotechnology, Natural Sciences or Veterinary Medicine, you will complete Mathematics 1 and two additional multiple-choice assessments from the following list, making the test 120 minutes in total:

- Biology
- Chemistry
- Physics
- Mathematics 2

If you're applying for Engineering, alongside Mathematics 1, you'll also complete:

- Physics
- Mathematics 2

There is no pass or fail for ESAT. You should aim to do the best you can.

Your final scores are based on the number of correct answers you give. You do not lose marks for wrong answers, so it's worth attempting all questions.

How to register for the ESAT

You must be registered in advance to sit the ESAT.

You can register for the ESAT from 1 August 2024. The registration deadline is 16 September 2024."[3]

[3] https://www.undergraduate.study.cam.ac.uk/apply/how/science-engineering-admission-test (accessed on 27th May 2024):

ESAT preparation recommendations

By far the most effective revision will be completing the past exam questions FOR THE FIRST TIME, starting from a position of strength, under timed conditions.

1. **Start early**, but not seriously until AFTER AS Paper 2 and 3 exams; could start this process before Paper 1 (usually end of May). **If you are finding AS or IB level difficult, DO NOT work on any of this until after ALL your May exams!**
2. Identify an ESAT/NSAA topic you are strong in and find the corresponding AS or IB topic at the back of this book. **NSAA questions are extremely rare** and should be done AFTER you are already extremely good at AS or IB questions NOT before!
3. Revise that topic using A level exam questions (and IB past exam questions, especially HL Paper 1 MCQ questions on relevant topics).
4. **Start with questions with explained answers** to them, which is indicated in the question ID that precedes each question.
5. When you are really confident in your understanding of that topic try **2 NSAA questions under timed conditions** (90 seconds per mark, 3 minutes).
6. **Mark** those 2 questions.
7. If you found them easy, and got them correct with time to spare, try another 2 questions of the same topic.
8. **If you found any question hard**, or couldn't finish in the time you had, **stop this process** and **use A Level** and IB exam questions to get stronger in this topic before you come back.
9. Some of the **last questions** you should try are **Section 2 MCQ** on ESAT syllabus topics (180 seconds per mark). These are available towards the back of this book. Start with the questions with explained answers to them.
10. The very last thing you could do, after you have gained full confidence in all aspects of the MCQ process, is the Section 2 short answer questions which are included at the very back, as well as the section 2 MCQ covering material that is not on the ESAT syllabus (essentially A2 or IB HL material). **More practice talking about chemistry** in preparation for the **interview** will be by far better use of time for nearly all students than solving these questions, however.
11. For students less familiar with AS or IB chemistry most of the work will be done using AS and IB exam questions to get to a suitable standard.
12. **If you arrive at this book later in the application process** (September for exams on the 15th October):

    ignore AS or IB questions and just get as much of the MCQs in this book done as time allows.

13. **If you arrive at this book early** (September or October, the **YEAR BEFORE** you will sit the exam):

    you can **try a small number** of these questions as you are studying AS chemistry after you have revised completely a given topic for a test or an exam but stop using this book if you are unable to get them correct within the time limit. For many students it would be better to do them after your AS exams, when their chemistry is stronger, rather than work unsuccessfully on them throughout the year. **You want to have had as much experience in delivering this skill of solving them for the first time, correctly, and as quickly as possible**. Being able to solve these kinds of question within the time limit, but only after several attempts is a skill that will not help much in the real exam.

Things to avoid:

- **Do NOT start after the summer holidays**.
- Do NOT only work over the summer holidays. Some time should be spent taking a real break that is able to recharge you so you can hit your September, October and November months with your full force. A break is doing something that you thoroughly enjoy doing, so if an activity could be put in a UCAS personal statement, it's highly unlikely to be properly regarded as a break.
- Spoiling the impact of a brand new and fresh NSAA past question, by for instance, looking over an NSAA question just to see what it looks like.
- Attempting any question in a given topic you are not sure you are really strong in (because of extensive work you have already done with AS or IB questions).

How the NSAA (1st exam 2016) became the ESAT (1st exam 2024)

No past exam papers exist for the ESAT, but the ESAT Preparation Materials[4] suggested are all of the NSAA Section 1 exam papers.

The sample tests given on the official ESAT website[5] all seem to be in line with Section 1:

- Same format: both MCQ with 5 to 8 possible answers
- Similar time: 90sec/mark for Section 1 and 89 sec/mark for the ESAT
- Identical syllabus, but Advanced Mathematics from Section 2 has been renamed and added to create Mathematics 2

NSAA changes: description

From 2016 to 2023 the Natural Science Admission Assessment, (NSAA)[6] was a test[7] all students sat when applying for any science subject at University of Cambridge. In its final form it was all Multiple-Choice Questions (MCQ), and had 2 exam papers, called Section 1 and Section 2.

Section 1 (always MCQ) has these parts:

- Part A Mathematics (compulsory)
- Part B Physics
- Part C Chemistry
- Part D Biology
- Part E Advanced Mathematics and Advanced Physics (until 2019, Part E was removed in 2020 and later)

Section 2 as a short answer exam (from 2016 to 2019) with these parts which are all optional, choose any 2:

- Physics P1 and P2 (contains Advanced Mathematics syllabi)
- Chemistry C1 and C2
- Biology B1 and B2

Section 2 as a MCQ short answer exam (from 2020 to 2023):

- Part X Physics
- Part Y Chemistry
- Part Z Biology

The **ESAT** has these parts:

- ESAT Mathematics 1 (syllabi almost identical to NSAA Mathematics in 2023) - Compulsory
- ESAT Biology (syllabi identical to NSAA Biology in 2023)
- ESAT Chemistry (syllabi identical to NSAA Chemistry in 2023)
- ESAT Physics (syllabi identical to NSAA Physics in 2023)
- ESAT Mathematics 2 (syllabi identical to NSAA Advanced Mathematics in 2023)

NSAA changes: analysis

The ESAT is essentially the NSAA Section 1 exam which also has Mathematics 1 (based on AS material) compulsory but these changes:

- 7 more MCQ questions (27 total) per Part
- 2 of the 4 optional Parts must be completed
- Mathematics 2 assesses material previously in NSAA Part X Physics from Section 2

[4] https://esat-tmua.ac.uk/esat-preparation-materials/
[5] https://home.pearsonvue.com/uatuk

[6] https://web.archive.org/web/20231207155418/https://www.undergraduate.study.cam.ac.uk/apply/how/natural-sciences-admission-test
[7] For past exam questions 20106 to 2022 including marking schemes, example answers and both Section 1 and Section 2 from Cambridge university: https://www.undergraduate.study.cam.ac.uk/publications/natural-sciences-admissions-assessment-papers

How the structure of the NSAA (Section 1 and 2) has changed through time:

Paper ID	Date	Day	Section	MCQ?	Total parts	Parts to do	Marks/ part	Total time	Total marks	Part A (Maths)	sec/ mark	Notes	Dictionaries or calculator allowed?
2016sp	Specimen	N/A	1	Yes	5	3	18	80	54	Essential	88.9		No
2016	2nd Nov '16	Wed	1	Yes	5	3	18	80	54	Essential	88.9		No
2017	2nd Nov '17	Thu	1	Yes	5	3	18	80	54	Essential	88.9		No
2018	31st Oct '18	Wed	1	Yes	5	3	18	80	54	Essential	88.9		No
2019	30th Oct '19	Wed	1	Yes	5	3	18	80	54	Essential	88.9		No
2020sp	Specimen	N/A			4	2	20	60	40	Essential	90	New format, advanced maths is gone	No
2020	November	N/A	1	Yes	4	2	20	60	40	Essential	90	No day	No
2021	November	N/A	1	Yes	4	2	20	60	40	Essential	90	No day	No
2022sp	Specimen											Section 1 not part of this, only Section 2	
2022	"2022"	N/A	1	Yes	4	2	20	60	40	Essential	90		No
2023	"2023"	N/A	1	Yes	4	2	20	60	40	Essential	90		No
2024	15/16 Oct '24	Tu/We	1	Yes	5	3	27	120	81	Essential	88.9	Section 1 (?) is now ESAT	No
2016sp	Specimen	N/A	2	No	6	2	25	40	50	N/A	48	6 multipart questions (range: 1 to 12 marks)	Name calculator model
2016	2nd Nov '16	Wed	2	No	6	2	25	40	50	N/A	48	6 multipart questions (range: 1 to 12 marks)	Name calculator model
2017	2nd Nov '17	Thu	2	No	6	2	20	40	40	N/A	60	6 multipart questions (range: 1 to 10 marks)	Name calculator model
2018	31st Oct '18	Wed	2	No	6	2	20	40	40	N/A	60	6 multipart questions (range: 1 to 10 marks)	Name calculator model
2019	30th Oct '19	Wed	2	No	6	2	20	40	40	N/A	60	6 multipart questions (range: 1 to 10 marks)	Name calculator model
2020sp	Specimen	N/A		Yes	3	1	10	30	10	N/A	180	"New format", half as many Qs as normal. All MCQ exam.	No calculator
2020	November	N/A	2	Yes	3	1	20	60	20	N/A	180		No calculator
2021	November	N/A	2	Yes	3	1	20	60	20	N/A	180		No calculator
2022sp	Specimen	N/A	2	Yes	3	1	10	30	10	N/A	180	"Updated for 2022", half as many Qs as normal. Cannot see what was updated, but explained answers were given	No calculator
2022	"2022"	N/A	2	Yes	3	1	20	60	20	N/A	180	Last one easily available	No calculator
2023	"2023"	N/A	2	?	?	?	?	?	?	N/A	180	Not published, but likely same format at 2022 and before	No calculator
2024												NSAA section 2 does not exist in 2024	

NSAT and ESAT syllabi comparisons

By looking with the aid of a plagiarism detector[8], everything on the ESAT (on the left) is also on the NSAA 2023 syllabi (red highlight indicates exact match; **non-highlighted text is essentially what is not in the ESAT but was in the NSAA**). The difference is NSAA Section 2 material, which has been removed from the ESAT. Mathematics 2 in the ESAT is a renamed version of the NSAA Advanced Mathematics.

< Back

Your File

Source: Batch Result

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May 29, 2024, 00:37:05 | Mike Housden

Plagiarism Detection 98.1%

Content

Questions will draw upon the topics listed for each part in Appendix 1. All parts will assume knowledge of the content of Mathematics 1. The knowledge assumed for each part is summarised:

Part	*Knowledge assumed*
Mathematics 1	topics labelled 'M' in Appendix 1
Biology	topics labelled 'B', and topics labelled 'M', in Appendix 1
Chemistry	topics labelled 'C', and topics labelled 'M', in Appendix 1
Physics	topics labelled 'P', and topics labelled 'M', in Appendix 1
Mathematics 2	topics labelled 'M', and topics labelled 'MM', in Appendix 1

Candidates are expected to apply conceptual knowledge to solve problems. Some questions involve the straightforward application of this knowledge, but others require more creative thinking and the application of principles in less familiar contexts.

Scoring

In all parts, each correct answer will score 1 mark. No marks are deducted for incorrect answers. Results for each part will be reported separately.

Content

Section 1

Questions in Section 1 will draw upon the topics listed for each part in Appendix 1. All parts will assume knowledge of the mathematical content of Part A (Mathematics). The knowledge assumed for each part in Section 1 is summarised:

Part A (Mathematics)	Mathematics	(topics labelled 'M', Appendix 1)
Part B (Physics)	Physics Mathematics	(topics labelled 'P', Appendix 1) (topics labelled 'M', Appendix 1)
Part C (Chemistry)	Chemistry Mathematics	(topics labelled 'C', Appendix 1) (topics labelled 'M', Appendix 1)
Part D (Biology)	Biology Mathematics	(topics labelled 'B', Appendix 1) (topics labelled 'M', Appendix 1)

Section 2

Questions in Section 2 will draw upon the relevant subject-specific topics as in the following table:

Part X (Physics)	Advanced Physics Advanced Mathematics Physics Mathematics	(topics labelled 'AP', Appendix 2) (topics labelled 'AM', Appendix 2) (topics labelled 'P', Appendix 1) (topics labelled 'M', Appendix 1)
Part Y (Chemistry)	Advanced Chemistry Chemistry Mathematics	(topics labelled 'AC', Appendix 2) (topics labelled 'C', Appendix 1) (topics labelled 'M', Appendix 1)
Part Z (Biology)	Advanced Biology Biology Mathematics	(topics labelled 'AB', Appendix 2) (topics labelled 'B', Appendix 1) (topics labelled 'M', Appendix 1)

All parts in this section assume knowledge of the mathematical content of Section 1 Part A (Mathematics). Parts X (Physics), Part Y (Chemistry) and Part Z (Biology) assume knowledge of the specified additional 'Advanced' content listed in Appendix 2.

Candidates are expected to apply conceptual knowledge to deconstruct and solve problems. Some questions involve the straightforward application of this knowledge, but others require more creative thinking, problem solving, and the application of principles in less familiar contexts.

Scoring

In both Section 1 and Section 2, each correct answer will score 1 mark. No marks are deducted for incorrect answers. Results for each part will be reported separately.

APPENDIX 2: ADDITIONAL ASSUMED KNOWLEDGE IN SECTION 2

The material that follows outlines the additional scientific and mathematical knowledge assessed in Section 2 of the Natural Sciences Admissions Assessment.

Section 2 consists of three parts. **Candidates will be required to answer one part only.** The three parts are:

Part X Physics

Part Y Chemistry

Part Z Biology

There are 20 multiple-choice questions in each part.

The time allowed to complete Section 2 is 60 minutes.

Calculators may NOT be used in Section 2.

Questions in Section 2 will draw upon the relevant subject-specific topics as in the following table:

Part X (Physics)	Advanced Physics Advanced Mathematics Physics Mathematics	(topics labelled 'AP', Appendix 2) (topics labelled 'AM', Appendix 2) (topics labelled 'P', Appendix 1) (topics labelled 'M', Appendix 1)
Part Y (Chemistry)	Advanced Chemistry Chemistry Mathematics	(topics labelled 'AC', Appendix 2) (topics labelled 'C', Appendix 1) (topics labelled 'M', Appendix 1)
Part Z (Biology)	Advanced Biology Biology Mathematics	(topics labelled 'AB', Appendix 2) (topics labelled 'B', Appendix 1) (topics labelled 'M', Appendix 1)

All parts assume knowledge of the mathematical content of Section 1 Part A (Mathematics).

Parts X (Physics), Part Y (Chemistry) and Part Z (Biology) assume knowledge of the specified additional 'Advanced' content listed in Appendix 2.

ADVANCED CHEMISTRY

AC1. Atomic structure

AC1.1 Deduce the electron configuration of atoms (up to Z = 36) and corresponding ions (given ionic charge) in terms of main energy levels and s, p and d orbitals.

AC1.2 Define first ionisation energy, and write equations for first and successive ionisation energies.

AC1.3 Understand how first and successive ionisation energies in Period 3 and Group 2 relate to electron shells and sub-shells.

AC1.4 Understand how a simple time-of-flight (ToF) mass spectrometer works, including expressions for kinetic energy ($\frac{1}{2}mv^2$) and speed ($\frac{d}{t}$).

AC2. Bonding and structure

AC2.1 Describe permanent and induced dipole–dipole interactions between molecules, including hydrogen bonding.

AC2.2 Describe the term *electronegativity*, and use it to explain the existence of polar bonds.

AC2.3 Know why some molecules with polar bonds do not have a permanent dipole.

AC2.4 Understand and be able to predict the shapes of simple molecules and ions with up to six outer shell pairs of electrons (any combination of bonding pairs and lone pairs, excluding those involving a total of 5 pairs with at least one lone pair) in terms of electron pair repulsion theory (valence shell electron pair repulsion model, 'VSEPR').

ADVANCED BIOLOGY

AB1. Cell structure

AB1.1 Know and understand the principles and limitations of light microscopes, transmission electron microscopes and scanning electron microscopes, including reference to magnification and resolution.

AB1.2 Recall and apply the equation:

$$\text{magnification} = \frac{\text{image size}}{\text{actual object size}}$$

AB1.3 Know and understand the structure and function of the main organelles and cellular components found in eukaryotic cells including:

a. nucleolus
b. nucleus (including nuclear envelope)
c. rough endoplasmic reticulum (RER)
d. smooth endoplasmic reticulum (SER)
e. ribosome
f. Golgi apparatus
g. lysosome
h. tonoplast
i. cilia/flagella
j. centrioles

ADVANCED PHYSICS

AP1. Forces and equilibrium

AP1.1 Understand the nature of scalars and vectors:

a. Examples include velocity, speed, mass, momentum, force, weight, acceleration, displacement and distance.
b. Know and be able to interpret vector notation.

AP1.2 Components and resultants of vectors:

a. Be able to resolve a vector into two components at right angles to each other by drawing and by calculation.
b. Find the resultant of two coplanar vectors at any angle to each other by drawing.
c. Find the resultant of two coplanar vectors at right angles to each other by calculation.

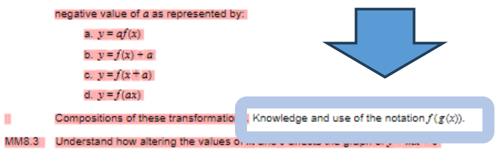
AP1.3 Moments:

a. Understand moment defined as force × perpendicular distance from the point to the line of action of the force.
b. Be able to calculate the moment of a force about a point (2 dimensions only).
c. Know and be able to apply the principle of moments.

8 https://app.copyleaks.com/text-compare

Examples of similarity for the different sciences :

Perhaps the only addition to the ESAT is here at AM8.2 (which would definitely be worth learning about):


negative value of a as represented by:

a. $y = af(x)$

b. $y = f(x) + a$

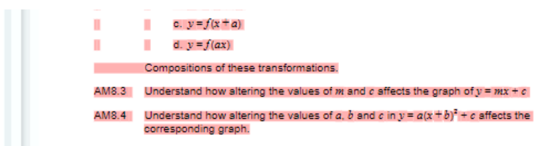
c. $y = f(x + a)$

d. $y = f(ax)$

Compositions of these transformatio

Knowledge and use of the notation $f(g(x))$.

MM8.3 Understand how altering the values o


c. $y = f(x + a)$

d. $y = f(ax)$

Compositions of these transformations.

AM8.3 Understand how altering the values of m and c affects the graph of $y = mx + c$

AM8.4 Understand how altering the values of a, b and c in $y = a(x + b)^2 + c$ affects the corresponding graph.

Additional information

There is a strong focus on mental arithmetic. IB Chemistry Higher Level Topic 1 (Stoichiometric Relationships) might help provide additional practice for these kinds of questions which can be found in the IB page of this website: www.SmashingScience.org

There is a note about when marking would happen for the 2016 exam for Biology, at 11th November, the exam was on the 2nd November, which implies that the marking of them happens as one might expect, and before the interviews.

A note on how marks were assigned topics

Sometimes topic boundaries are blurred, for instance reactivity from periodicity and electrochemistry.

For section 1 most of the material mapped to AS except electrolysis which is instead found in A2 Topic 24.

Also, a couple of questions, labelled with 2x, examined a range of topics in a sequential way that made it hard to satisfactorily slice the questions into disparate topics, though the marks were assigned correctly. This is for the older short answer section 2 before it became all multiple choice, so a lot less relevant moving ahead.

For more practice on the all important topic 2 (stoichiometry) you can look at IB Higher Level (IB Topic number 1) questions, which can be found here:

https://www.smashingscience.org/ib-chemistry-hl-sl

Remember, these questions need to be done without a calculator, and if there are about 3 steps to an IB HL question, there are 5 to 7 steps for a calculation question in the NSAA. So being quick o these kind of questions is key.

Explained Exam Mark Schemes for MCQs

The Specimen Paper for 2020 has explained answers for section 1 questions.

The Specimen Paper for 2022 has explained answers for section 2 questions.

Comments on marking and unusual questions

Sometimes 2 marks was assigned for a single point, or 4 marks were assigned for a single correct number, but the method marks were not clearly described. This implies a style and a creative flair in the marking process that would be hard to find in CAIE or IB mark schemes for such a small sample space. This is for the older short answer section 2 before it became all multiple choice, so a lot less relevant moving ahead, but it can be helpful to think that these kinds of questions do not follow all of the same principles and processes as, for instance CAIE A Level or IB Diploma Level. Other parts of other assessment points, like the interview, might also be different.

UCAS entry requirements for some degrees that need Chemistry A Level (as of Nov. 2023)

Uni	Biochemistry Degree			Biology Degree			Pharmacy Degree			Medicine			GCSE requirements		
	BSc or MSci	A Level	IB	A Level	IB	Bio Notes	A Level	IB	Notes	A Level	IB	Notes	Math	English	Other
Aberystwyth	BSc	BBC/BBB	28/30	BCC/BBB	28/30	Biology							N/A	4/C	C in Biology
Aston	BSc	BBB		BBB	31	Biological sciences	BBB/ABB	31/32		A*AA	39	UCAT and Interview needed	4/C	4/C	
Bath	MBiochem	AAB	36	AAB	36	Biology	AAB	36	[9]				4/C	4/C	
Bath	BSc	AAB	36	AAB	36	Biology			[10]				4/C	4/C	
Birmingham	BSc	AAB	32	AAB	32	Biological sciences				A*AA	32		N/A	N/A	5xC
Birmingham	MSci	AAA	32 (HL 665)	AAA	32	Biological sciences	AAB	32							
Birmingham	BSc[11]	AAB	32												
Bristol	MSci	ABB/AAA	32-36	ABB/AAA	32-36	Biology				BBC	29	[12]			
Bristol	BSc	ABB/AAA	32-36	ABB/AAA	32-36	Biology				ABB/AAA	32/36	Standard entry, UCAT			
Cambridge				A*A*A	40/42					A*A*A	40/42	BMAT			
Durham	BSc	AAA	37	N/A		Biological sciences							N/A	N/A	
East Anglia	BSc	ABB	32	ABB	32	Biological sciences							4/C	4/C	
East Anglia	MSci	AAB		AAB	33	Biological sciences	AAB	33		AAA	36	UCAT and Interview needed			
Edinburgh	BSc	ABB/AAA	32/37	ABB/AAA	32/37	Biological sciences				A*AA	40				
Glasgow	BSc	BBB/AAB	32/36												
Grenwich	BSc			32 points from Bio	HL5	Biology									

[9] MPharm & Always interviewed

[10] https://www.pharmacyschoolscouncil.ac.uk/study/international-applicants/

[11] Medical Biochem

[12] Gateway to medicine, UCAT. This course is open to applicants from specific schools and colleges in the UK only and/or to those who have spent 3 months or more in care. Further information and lists of the eligible schools and colleges is available at contextual offers: http://www.bristol.ac.uk/study/undergraduate/entry-requirements-qualifications/contextual-offers/

Uni	Biochemistry Degree BSc or MSci	A Level	IB	Biology Degree A Level	IB	Bio Notes	Pharmacy Degree A Level	IB	Notes	Medicine A Level	IB	Notes	GCSE requirements Math	English	Other
Huddersfield	BSc	BCC/BBC	112-104 points[13]	BCC/BBC	112-104 points	Biological sciences	BBB/ABB	136 UCAS points[14]							
Imperial	BSc	AAA	38	AAA	38	Biological sciences				AAA	38	BMAT			
Imperial	MSci	AAA	38												
King's, KCL	BSc	AAA	35	N/A			AAB	35		A*AA	35				
Kingston	BSc	BBC/ABB	27	BBC/ABB	27	Biological sciences	BBB/AAB	32							
Liverpool	BSc	ABB	33	ABB	33	Biological sciences				AAA/A*AB		[15].	4/C		
Manchester	BSc	AAB/AAA	35/36	AAB/AAA	35/36	Biology	AAB	35		AAA	36	UCAT and Interview needed	4/C	4/C	
Nottingham	BSc	AAB	34	AAB	34	Biology	AAB	34					6/B	4/C	
Nottingham		AAB	34										6/B	4/C	
Oxford	MBio	A*AA	39	A*AA	39	Biology									
Queen Mary	BSc	ABB	34	ABB	34	Biology				A*AA	38	UCAT and Interview needed	4/C	4/C	
Queen's University Belfast	BSc	BBB/ABB	32/33	BBB/ABB	32/33	Biological sciences	AAB	34		A*AA	Not given	UCAT and Interview needed	C	C	CC in Double science
Royal Holloway, Uni London	BSc	BBC/BBB	32	N/A											5x A* to C
UCL	BSc	AAA	38	AAA	38	Biological sciences	AAB	36					6/B	6/B	
Warwick	BSc	ABB/AAB	32-34	ABB/AAB	32-34	Biological sciences									
York	BSc	AAB	35	AAB	35	Biology									

[13] UCAS tariff points from International Baccalaureate qualifications which should include modules in relevant Science subjects.

[14] including Higher Level Chemistry at grade 6 and Higher Level Mathematics and Biology at grade 6 and 5 (in any order).

[15] A levels taken in one sitting after a 2 year period of study, AAA, to include Chemistry together with either Biology, Physics or Mathematics and a third academic subject. The Advanced Welsh Baccalaureate Skills Challenge Certificate is accepted in lieu of a third academic subject. Alternatively, A*AB also accepted but the A* A grades must include Chemistry together with either Biology, Physics or Maths; and a B grade required in the third academic subject. Applicants with a minimum of 12 points at GCSE may be considered if, at the time of application, they have achieved AAA or A*AB (as defined above). GCSEs in nine subjects attained by the end of Year 11 which must include: English Language, Mathematics, Biology, Chemistry, and Physics. Core & Additional Science is an acceptable alternative to the three individual sciences. Minimum of grade B (score 6) required in core subjects

Selected Chemistry degrees and entrance requirements

University	Chemistry Degree		Material Science Degree		Chemical Engineering		Deadline
	A Levels	IB points	A Levels	IB points	A Levels	IB points	
Aberystwyth							31-Jan
Aston	BCC/BBC				BCC/BBB	31	31-Jan
Bath	AAB/AAA	36					31-Jan
Bath					A*AA	36	31-Jan
Birmingham	AAB/AAA	32	AAB	32	AAA	32 (HL 666)	31-Jan
Birmingham	AAA/AAA*				A*AA/AAAA[16]	32	31-Jan
Birmingham							31-Jan
Bristol					N/A		31-Jan
Bristol	ABB/AAA	32-36			N/A		31-Jan
Cambridge	A*A*A	40/42			A*A*A	40/42	16-Oct
Durham	A*AA	38					31-Jan
East Anglia	BBB	31					31-Jan
East Anglia	AAB	33					31-Jan
Edinburgh	ABB/AAA	32/37			ABB/AAA	32/37	31-Jan
Glasgow							
Greenwich	32 points from Chemistry	HL5			[17]	HL5 Maths and Phx	31-Jan
Huddersfield	BCC/BBC	112-104 points			BBC/BBB[18]	Not given	31-Jan
Imperial	AAA	38	AAA	38	A*A*A	40	31-Jan
Imperial							31-Jan
King's, KCL	AAA	35					31-Jan
Kingston	BBC/ABB	28					31-Jan
Liverpool	ABB	33					31-Jan
Manchester	AAA[19]	36	AAB	35	AAA[20]	36	31-Jan
Nottingham	ABB/AAB[21]	32-34			AAA	36	31-Jan
Nottingham							31-Jan
Oxford[22]	A*A*A	40	A*AA	40	A*A*A	40	16-Oct
Queen Mary	ABB	34	ABB	32	AAB	34	31-Jan
Queen's University Belfast	BBB[23]	32			BBB	32	31-Jan
Royal Holloway, Uni London	N/A						31-Jan
UCL	AAA	38			AAA	38	31-Jan
Warwick	AAB	34					31-Jan
York	AAB/A*AA	35/37					31-Jan

[16] Only course to ask for 4 Alevels!
[17] 32 points from Chemi32 Points from Mathematics and 32 points from a physical science or a numerate subject.
[18] https://www.hud.ac.uk/undergraduate/how-to-apply/entry-requirements/
[19] English is easier 6.5 overall with no less than 6.0 in any component
[20] AAA including Mathematics and either Chemistry or Physics.
[21] Need a C in maths GCSE, easier
[22] MChem only available, no BSc offered
[23] Only need C in GCSE maths

Factors that affect acceptance rates for Cambridge

What does success in the ESAT look like?

Key information supplied by the University of Cambridge regarding the ESAT and especially the NSAA over the last few years:

"Please note that your performance in the pre-interview assessment will not be considered in isolation, but will be taken into account alongside the other elements of your application.

Specimen and past papers

A specimen paper has been produced to allow you to sample the written assessment format and practice under timed conditions. It is not expected that you will answer every question correctly; the written assessment is designed to be challenging. Even some strong candidates may not complete the paper in the time allowed; it is designed to distinguish across our field of high-calibre applicants.

Experience with similar assessments and from trials indicates that, on average, typical applicants to the most highly selective undergraduate courses (who are by definition academically very able) **will gain approximately half of the available marks**. The best applicants will score more highly, but only **relatively few are expected to gain more than 80 per cent** of the available marks.

Written assessments help admissions tutors to assess whether candidates have the skills, aptitudes and any required subject knowledge and understanding required to study the relevant course at Cambridge. They are only one of the elements used in the admissions process. Others include:[24]

1. a candidate's academic record and forecast grades in school-leaving examinations;
2. UCAS application form;
3. examples of recent written work submitted to the College to which they are applying;
4. and performance at interview, if invited to attend.(2020)"[25]

"You don't need to get every question right

We don't expect that you will answer every question correctly. The assessments are designed to challenge you.

Some strong applicants may not even complete the paper in the time given. Almost no one gets full marks.(2024)"[26]

For more details on changes to this website see "*Appendix – Changes to the Natural Sciences Entrance Requirements webpage through time*" at the back of this book.

In addition to the websites, Cambridge also delivers information through feedback on individual applicants:

"Our assessment includes, in **no particular order**:

1. Recent academic achievement, as evidenced by transcripts, GCSEs (or equivalent), AS-levels (where relevant), A-levels, or other school-leaving qualifications;
2. Contents of references and quality of predicted grades, where relevant;
3. Quality of the personal statement, and evidence of interest in the subject to be studied and of engagement with that subject outside the classroom;
4. **Performance in admissions assessments, where relevant;**
5. Quality of submitted work, where relevant;
6. Performance at interview;
7. Performance in standardised tests of English language proficiency such as IELTS, where relevant;
8. Individual contextual factors, as signalled in the UCAS application, My Cambridge Application, and where applicable the Additional Applicant Information Form and/or Extenuating Circumstances Form;
9. Geo-demographic and school-level indicators such as those supplied by the Index of Multiple Deprivation and other UK databases (see here: https://www.undergraduate.study.cam.ac.uk/apply/after/contextual-data)."[27]

In this list they have also included references. Ands while they have explicitly stated that these are not in order, it does seem that there is in fact a particular order, or hierarchy, to their assessment process, and that some things are more important than others, which can be seen later where we see some students who have top NSAA scores can also be rejected.

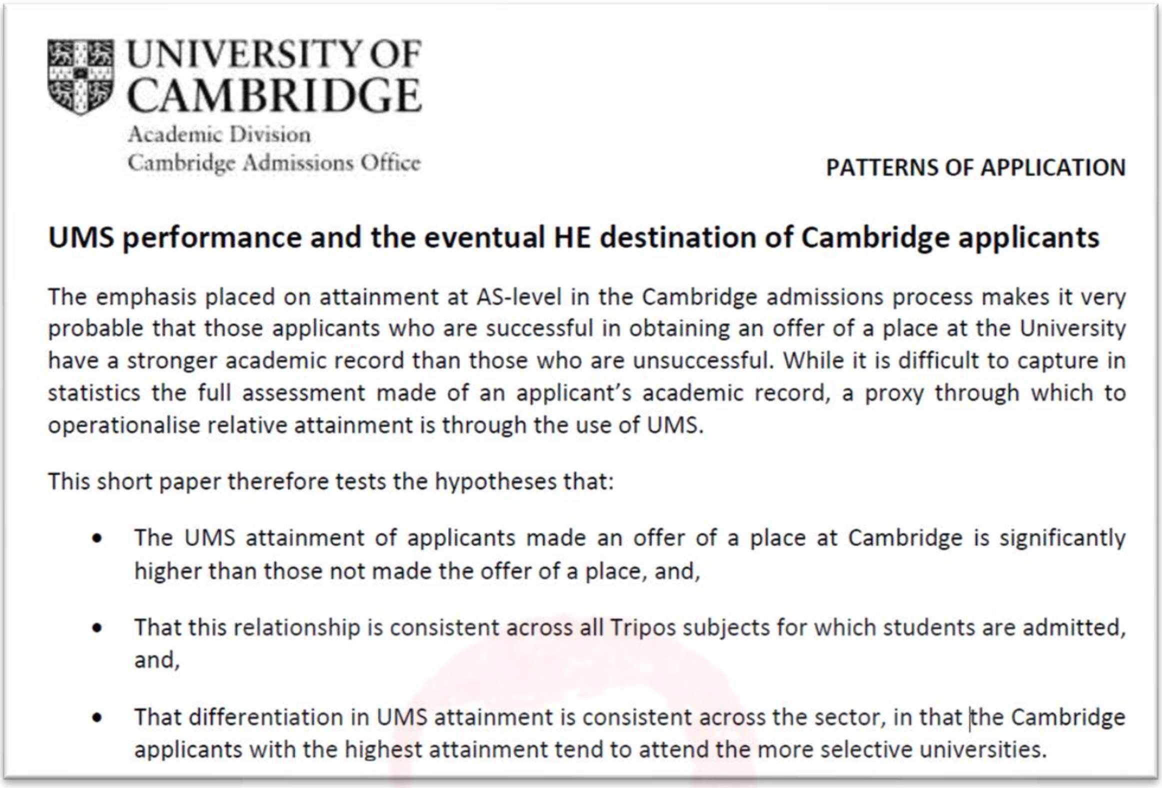
[24] The original paragraph has been reformatted here to convert this sentence into a numbered list

[25] From: https://www.undergraduate.study.cam.ac.uk/courses/natural-sciences#entry-requirements (accessed September 2020)

[26] https://www.undergraduate.study.cam.ac.uk/apply/how/admission-tests, accessed 27th May 2024

[27] Generic statement that follows an individual student's feedback that they can (and always should) request after the application process has finished. [The original bullet points were changed to the numbered list]

UMS(/PUM) performance and the eventual HE destination of Cambridge applicants[28]



UNIVERSITY OF CAMBRIDGE
Academic Division
Cambridge Admissions Office

PATTERNS OF APPLICATION

UMS performance and the eventual HE destination of Cambridge applicants

The emphasis placed on attainment at AS-level in the Cambridge admissions process makes it very probable that those applicants who are successful in obtaining an offer of a place at the University have a stronger academic record than those who are unsuccessful. While it is difficult to capture in statistics the full assessment made of an applicant's academic record, a proxy through which to operationalise relative attainment is through the use of UMS.

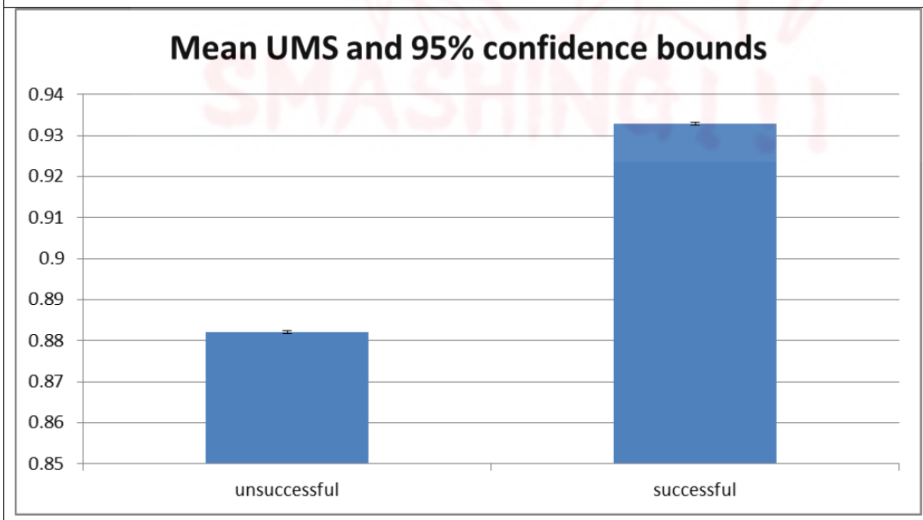
This short paper therefore tests the hypotheses that:

- The UMS attainment of applicants made an offer of a place at Cambridge is significantly higher than those not made the offer of a place, and,
- That this relationship is consistent across all Tripos subjects for which students are admitted, and,
- That differentiation in UMS attainment is consistent across the sector, in that the Cambridge applicants with the highest attainment tend to attend the more selective universities.

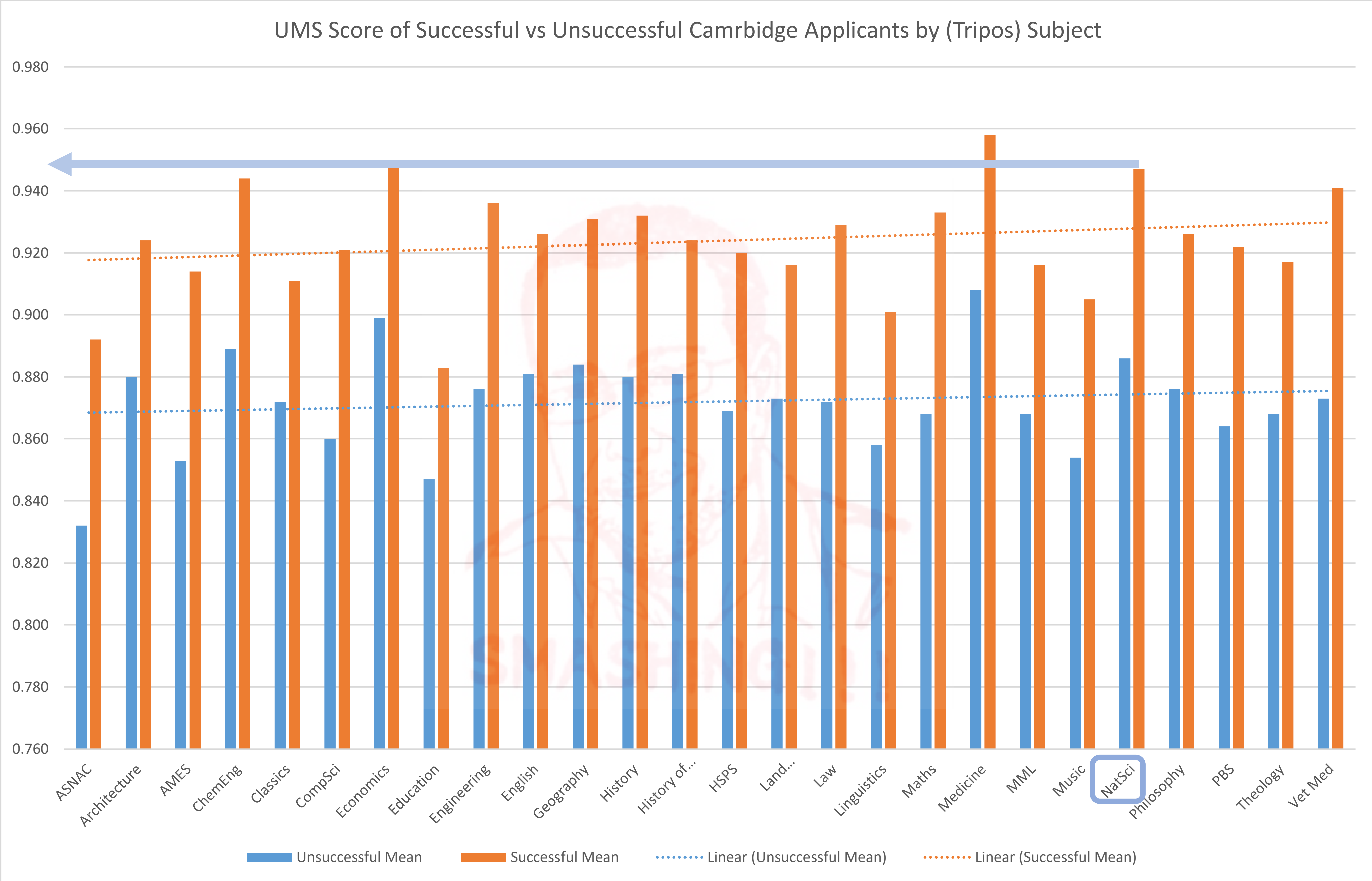
This is a report by into students UMS (Uniform Mark Scale, the UK version of PUM, Percentage Uniform Mark score, which is used in international exams like the ones used by CAIE) from their AS levels, which were achieved before they applied to university. The main finding was that the students accepted into the university had on average a UMS score of 93 across all of their subjects, while those rejected had a UMS score of 88. The fact that this study of 40 000 applicants was carried out, and especially because it was published and is still hosted by the university means that this is something they would like the world, and probably also prospective applicants, to know about. They are the only university that asks every student specifically for their UMS/PUM scores.

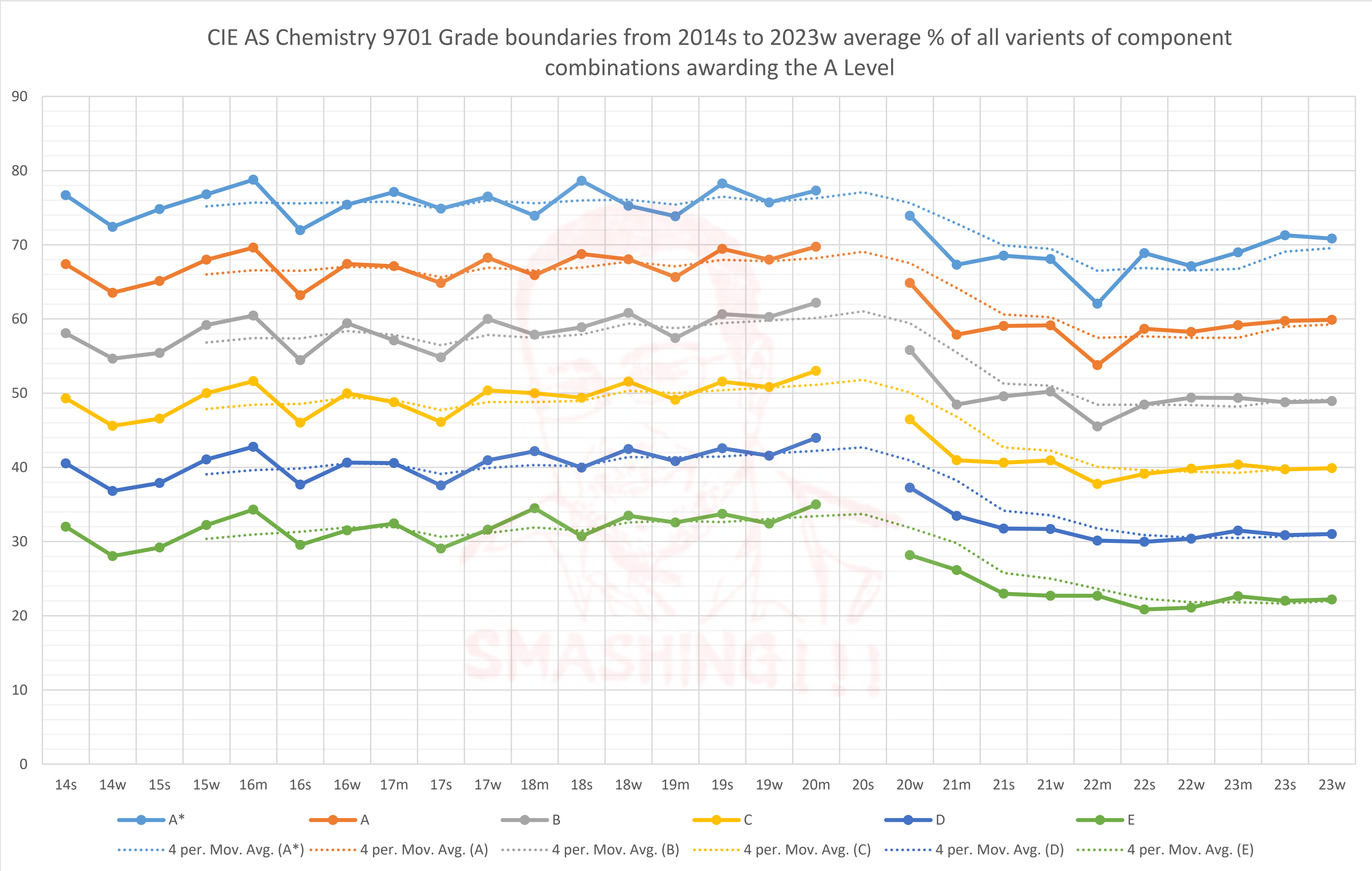
Another way to think about this is that if you have a lower UMS/PUM score, you probably might rethink Cambridge, and maybe lean more towards Oxford instead.

Figure 1. Observed difference in mean UMS, for all subjects



[28] https://www.cao.cam.ac.uk/ums-performance-and-eventual-he-destination-cambridge-applicants


UMS Score of Successful vs Unsuccessful Camrbidge Applicants by (Tripos) Subject
0.980
0.960
0.940
0.920
0.900
0.880
0.860
0.840
0.820
0.800
0.780
0.760
ASNAC
Architecture
AMES
ChemEng
Classics
CompSci
Economics
Education
Engineering
English
Geography
History
History of...
HSPS
Land...
Law
Linguistics
Maths
Medicine
MML
Music
NatSci
Philosophy
PBS
Theology
Vet Med
Unsuccessful Mean
Successful Mean
Linear (Unsuccessful Mean)
Linear (Successful Mean)



CIE AS Chemistry 9701 Grade boundaries from 2014s to 2023w average % of all varients of component combinations awarding the A Level
90
80
70
60
50
40
30
20
10
0
14s
14w
15s
15w
16m
16s
16w
17m
17s
17w
18m
18s
18w
19m
19s
19w
20m
20s
20w
21m
21s
21w
22m
22s
22w
23m
23s
23w
A*
A
B
C
D
E
4 per. Mov. Avg. (A*)
4 per. Mov. Avg. (A)
4 per. Mov. Avg. (B)
4 per. Mov. Avg. (C)
4 per. Mov. Avg. (D)
4 per. Mov. Avg. (E)
SMASHING!!!

How does Cambridge process grades and UMS scores?[29]

This table was created from a Freedom of Information (FOI) request. Cambridge is unusual in that they always ask for UMS scores for all applicants. But it also seems that exceptional AS results are stored in a different way to all other results (results in green, 781 total results for 317 total unique ApplyID candidates almost all not shown here).

A total of 1054 candidates had A Level results in this data set. It is not explained why there is such a mismatch between the number of AS results held and the A Level results. The random anonymising ApplyID for the two tables from the original pdf do not seem to match. A total of 84 unique ApplyID numbers were made offers from this AS results cohort, against a total of 271 of students with A Level Results who were made offers from the same Apply Year with the same FOI document. Most offers were made then to students who did not have AS results.

At least 2 students who had flawless UMS scores (shown in yellow below) in at least some of the AS levels were not offered a place.

The CAIE international exam board is contained within the Title of the subject, as shown at 300007 (highlighted blue), indicating that some differentiation is made with regards to the same subject from different exam boards. In this case, and everywhere else, just because information has been stored does not mean it was all reported here, and just because it was does not mean it was used, or even that those making decisions had access to it.

Course	Apply Year	ApplyID	Offer Holder	Qualification	Title	Result	Additional Info
Natural Sciences (Physical)	2020	300172	Yes	GCE Advanced Subsidiary	Chemistry	a 92	92
Natural Sciences (Physical)	2020	300172	Yes	GCE Advanced Subsidiary	Physics	a 95	95
Natural Sciences (Physical)	2020	300082	Yes	GCE Advanced Subsidiary	Chemistry	A- 200/200	200/200
Natural Sciences (Physical)	2020	300082	Yes	GCE Advanced Subsidiary	Physics	A- 200/200	200/200
Natural Sciences (Physical)	2020	300082	Yes	GCE Advanced Subsidiary	Mathematics	A- 240/240	240/240
Natural Sciences (Physical)	2020	300083		GCE Advanced Subsidiary	Physics	A (111/160)	(111/160)
Natural Sciences (Physical)	2020	300083		GCE Advanced Subsidiary	Chemistry	A (127/160)	(127/160)
Natural Sciences (Physical)	2020	300083		GCE Advanced Subsidiary	Further Mathematics	A (130/160)	(130/160)
Natural Sciences (Physical)	2020	300083		GCE Advanced Subsidiary	Mathematics	A (153/160)	(153/160)
Natural Sciences (Physical)	2020	300233		GCE Advanced Subsidiary	Physics	A- 196/200	196/200
Natural Sciences (Physical)	2020	300233		GCE Advanced Subsidiary	Chemistry	A- 200/200	200/200
Natural Sciences (Physical)	2020	300233		GCE Advanced Subsidiary	Mathematics	A- 239/240	239/240
Natural Sciences (Physical)	2020	300212		GCE Advanced Subsidiary	Chemistry	A-200/200	200/200
Natural Sciences (Physical)	2020	300212		GCE Advanced Subsidiary	Physics	A-200/200	200/200
Natural Sciences (Physical)	2020	300212		GCE Advanced Subsidiary	Mathematics A	A-240/240	240/240
Natural Sciences (Physical)	2020	300006	Yes	GCE Advanced Subsidiary	Chemistry	A	
Natural Sciences (Physical)	2020	300006	Yes	GCE Advanced Subsidiary	Physics	A	
Natural Sciences (Physical)	2020	300007		GCE Advanced Subsidiary	Biology 9700	A	
Natural Sciences (Physical)	2020	300007		GCE Advanced Subsidiary	Mathematics 9709	A	
Natural Sciences (Physical)	2020	300007		GCE Advanced Subsidiary	Physics 9702	A	
Natural Sciences (Physical)	2020	300007		GCE Advanced Subsidiary	Chemistry 9701	B	
Natural Sciences (Physical)	2020	300008		GCE Advanced Subsidiary	Chemistry	A	
Natural Sciences (Physical)	2020	300008		GCE Advanced Subsidiary	Mathematics	A	
Natural Sciences (Physical)	2020	300008		GCE Advanced Subsidiary	Physics	A	
Natural Sciences (Physical)	2020	300009		GCE Advanced Subsidiary	Chemistry	A	
Natural Sciences (Physical)	2020	300009		GCE Advanced Subsidiary	Mathematics	A	
Natural Sciences (Physical)	2020	300009		GCE Advanced Subsidiary	Physics	A	

In the same document [30] we can see here some of the overall A Level results after 2 years of study 1054 unique ApplyIDs in total, most of this data is not shown here.

Course	Apply Year	A Level Applicant	ApplyID	Offer Holder	A Level Results
Natural Sciences (Physical)	2020	Yes	401013		Mathematics: A, Further Mathematics: B, Physics: B
Natural Sciences (Physical)	2020	Yes	401014	Yes	Mathematics: A, Further Mathematics: C, Physics B (Advancing Physics): D
Natural Sciences (Physical)	2020	Yes	401015		Mathematics: A, Music: A, Physics (Astrophysics): A
Natural Sciences (Physical)	2020	Yes	401016		Mathematics: A, Physics (Astrophysics): A, Chemistry: B

They evidently have and store all A Level results of all applicants, including students who are not made an offer, which might help them measure a school's effectiveness at making reliable predictions at A2 level.

[29] https://www.whatdotheyknow.com/request/statistics_for_applicants_for_ph
[30] https://www.whatdotheyknow.com/request/statistics_for_applicants_for_ph

Top 15 performing UCAS Apply Centres in 2022 for Cambridge[31]

#	UCAS Apply Centre	School Name	School Sector	Apps	Offers	Accept.	Offer rate %	2 Years?	Notes	Reference
1	15326	Brampton Manor Academy	Maintained	205	65	72	32	?	No info on syllabus on website or prospectus	https://www.bramptonmanor.org/Information/Prospectus/
2	48056	Raffles Junior College, Singapore	Other and Overseas	129	49	39	38	?	Uses a H1, H2 and H3 SEAB Singapore Examinations Board	https://www.ri.edu.sg/
3	12060	Westminster School	Independent	86	35	34	41	2 Years	Now study CAIE A Level Chemistry; might do combined instead of individual exams, in 2023 study PreU Chemistry	https://www.westminster.org.uk/academic-life/exam-results-he/
4	45199	Hwa Chong Institution, Singapore	Other and Overseas	92	34	27	37	?	Doesn't study A level. "The Hwa Chong Integrated Programme (IP) is designed by our own teachers who have years of experience teaching high ability students"	https://www.hci.edu.sg/high-school/academic-prog/
5	13040	Brighton Hove and Sussex Sixth Form College	Maintained	133	31	20	23	2 Years	"all culminate in final exams at the end of two years."	https://www.bhasvic.ac.uk/courses/sixth-form-study
6	11078	Queen Elizabeth's School, Barnet	Maintained	69	29	28	42	?	AQA AS and A Level syllabi followed, but not easy to see if all exams are at the end of A2 year.	https://www.qebarnet.co.uk/academic-programme/our-curriculum/
7	10172	Hills Road Sixth Form College	Maintained	101	27	26	27	?	OCR Chemistry; cannot see if it has AS exams, or all at the end	https://www.hillsroad.ac.uk/study-with-us/a-level-subjects/chemistry
8	10642	King Edward VI Grammar School, Chelmsford	Maintained	58	24	22	41	2 Years	OCR Chemistry. "Total of 6 hours of exams (2 x 2 hours 15 minutes and 1 x 1 hour 30 minutes) taken at the end of the course."	https://www.kegs.org.uk/filedownload/5795FCB9-CFF7-2D4D-2F9C8875F60539AF.pdf/kegs-sixth-form-options-booklet-for-september-2024.pdf
9	11055	Peter Symonds College	Maintained	82	23	20	28	2 Years	"Methods & Patterns of Assessment. A Level: End of Year 2. Three exams of approx. 2 hours each."	https://psc.ac.uk/study/course/chemistry
10	45346	Shenzhen College of International Education	Other and Overseas	92	23	18	25	?	CAIE A Levels, but cannot see from website if they have all exams at the end, but likely have AS exams.	https://www.scie.com.cn/subject-chemistry/
11	11815	St Paul's School, London	Independent	69	22	21	32	?	"Nearly half the year group studies chemistry at A Level, following the OCR A syllabus."	https://www.stpaulsschool.org.uk/academic/academic-13-16/subjects/chemistry/
12	12092	King's College School	Independent	65	21	20	32	?	Cannot see curriculum details	https://www.kcs.org.uk/senior-school
13	12528	Magdalen College School, Oxford	Independent	72	21	20	29	2 Years	"Assessed through public exams in the summer of the Upper Sixth [A2]"	https://www.mcsoxford.org/senior-school/academic/subjects/chemistry/
14	11947	Henrietta Barnett School	Maintained	45	21	20	47	2 Years	"There are no External exams in Year 12"	https://www.hbschool.org.uk/academic-programme/departments/sciences/
15	12041	Wilson's School	Maintained	55	21	22	38	1 Year	Year 12 students currently sit the AS examination at the end of Year 12.	https://www.wilsons.school/curriculum/dept/chemistry/

[31] https://www.undergraduate.study.cam.ac.uk/sites/www.undergraduate.study.cam.ac.uk/files/publications/undergraduate_admissions_by_apply_centre_2022_cycle.pdf

Key takeaways:

Only one school of the top 15 obviously takes the AS exams at the end of the first (AS) 6th form year. Of the schools that do provide information about the structure of their exams at A levels on their websites, 6 schools have used a 2 year program with all exams at the end. One explanation for why so few AS results were in the FOI dataset used previously[32] is because most students applying to Cambridge do not take the AS exams.

Schools that have a stronger reputation with Cambridge, for instance because their A level predictions are more reliable (or other reasons), might opt for the 2-year approach which might have advantages with a variety of university applications. For instance, it avoids the substantial levels of difficulties in gaining 95% UMS in the AS year Cambridge have reported on. Students from newer schools, and others, which have a less well-established reputation might benefit instead from the AS UMS exam scores.

[32] https://www.whatdotheyknow.com/request/statistics_for_applicants_for_ph

A Level grade profiles for 2022

Table 4.1 Home applications, offers and acceptances to Cambridge by A Level profile and gender 2022[33]

A Level Grades	Applications						Offers						Acceptances					
	Male	**%**	**Female**	**%**	**Total**	**%**	**Male**	**%**	**Female**	**%**	**Total**	**%**	**Male**	**%**	**Female**	**%**	**Total**	**%**
Arts, Humanities and Social Sciences																		
A*A*A*	826	12.9	1,043	16.0	1,869	14.5	279	19.7	435	28.2	714	**24.1**	281	23.1	441	32.5	722	28.1
A*A*A	485	7.6	831	12.7	1,316	10.2	104	7.3	253	16.4	357	12.1	109	9.0	260	19.2	369	14.3
A*A*B	52	0.8	80	1.2	132	1.0	14	1.0	16	1.0	30	1.0	9	0.7	15	1.1	24	0.9
A*A*C	3	0.0	8	0.1	11	0.1	0	0.0	1	0.1	1	0.0	0	0.0	0	0.0	0	0.0
A*AA	357	5.6	573	8.8	930	7.2	74	5.2	126	8.2	200	6.8	66	5.4	124	9.1	190	7.4
A*AB	127	2.0	245	3.8	372	2.9	19	1.3	37	2.4	56	1.9	8	0.7	17	1.3	25	1.0
AAA	126	2.0	231	3.5	357	2.8	14	1.0	25	1.6	39	1.3	7	0.6	11	0.8	18	0.7
<AAA	382	6.0	799	12.2	1,181	9.1	33	2.3	63	4.1	96	3.2	2	0.2	2	0.1	4	0.2
Subtotals	**2,358**	**36.8**	**3,810**	**58.3**	**6,168**	**47.7**	**537**	**38.0**	**956**	**61.9**	**1,493**	**50.5**	**482**	**39.7**	**870**	**64.1**	**1,352**	**52.6**
Sciences																		
A*A*A*	2,066	32.3	1,106	16.9	3,172	24.5	739	52.2	469	30.4	1,208	**40.8**	659	54.2	423	31.2	1,082	42.1
% of science cohort		**30.5**		**16.4**		**46.9**		**50.4**		**32.0**		**82.4**		**54.0**		**34.7**		**88.7**
A*A*A	663	10.4	417	6.4	1,080	8.4	90	6.4	59	3.8	149	5.0	64	5.3	45	3.3	109	4.2
A*A*B	22	0.3	27	0.4	49	0.4	3	0.2	4	0.3	7	0.2	0	0.0	1	0.1	1	0.0
A*A*C	0	0.0	1	0.0	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
A*AA	511	8.0	381	5.8	892	6.9	31	2.2	31	2.0	62	2.1	10	0.8	12	0.9	22	0.9
A*AB	149	2.3	103	1.6	252	1.9	3	0.2	6	0.4	9	0.3	0	0.0	0	0.0	0	0.0
AAA	198	3.1	176	2.7	374	2.9	4	0.3	10	0.6	14	0.5	0	0.0	5	0.4	5	0.2
<AAA	432	6.8	512	7.8	944	7.3	8	0.6	9	0.6	17	0.6	0	0.0	1	0.1	1	0.0
Subtotals	**4,041**	**63.2**	**2,723**	**41.7**	**6,764**	**52.3**	**878**	**62.0**	**588**	**38.1**	**1,466**	**49.5**	**733**	**60.3**	**487**	**35.9**	**1,220**	**47.4**
Totals	**6,399**	**100.0**	**6,533**	**100.0**	**12,932**	**100.0**	**1,415**	**100.0**	**1,544**	**100.0**	**2,959**	**100.0**	**1,215**	**100.0**	**1,357**	**100.0**	**2,572**	**100.0**

Key takeaways:

- Science students academically perform better than other students; almost all of them have 3 A*. Almost no students are admitted to science with less than A*A*A.
- There is a strong gender split in the number of applications, but this is closed slightly at the “Offers” and “Acceptances” stages.

[33] https://www.undergraduate.study.cam.ac.uk/sites/www.undergraduate.study.cam.ac.uk/files/publications/undergraduate_admissions_by_apply_centre_2022_cycle.pdf

Looking at the entrance exam and the interview score together

The NSAA is just one part of the process, but looking at averages for it and accepted students, doing better in it will likely ensure you get an interview (no students with an unusually high score in it were denied an interview, but students with lower scores get accepted, and higher scores get rejected.

St John's College has published analysis for 2020 application year (these students would have sat the entrance exam in 2019, which involved the older Section 2 paper that had short answer questions, not MCQ).[34]:

		Min	Min %	Mean	Mean %	Max	Max %
Made offers	**Section 1**	9	25.0(a)	18.05	50.1(b)	27	75.0(c)
Winter Pool	**Section 1**	6.8	18.9	14.86	41.3(d)	25.6	71.1
Invited for interview (e)	**Section 1**	6.8	18.9	17.02	47.3	27	75.0
Rejected	**Section 1**	3.1	8.6	11.51	32.0(f)	25.8	71.7
Not invited for interview	**Section 1**	3.1	8.6	11.95	33.2	22.3	61.9(g)
Made offers	**Section 2**	11	27.5	28.27	70.7	40	100.0
Winter Pool	**Section 2**	6	15.0	22.91	57.3	38	95.0
Invited for interview	**Section 2**	6	15.0	26.32	65.8	40	100.0
Rejected	**Section 2**	3	7.5	19.79	49.5	36.5	91.3
Not invited for interview	**Section 2**	3	7.5	20.49	51.2	37	92.5(h)
Interview score	**Accepted**	7	70(i)	7.89	78.9	9.3	93
Interview score	**Rejected**	4.3	43	6.43	64.3	8.5	85

Logically relevant statements possible with this data working left to right, top to down):

a) Some students who are made offers perform really poorly in the entrance exam.

b) About half of students who were made an offer scored 50% or less on the MCQ part of the exam.

c) All students missed at least 1 in 4 marks, including the best accepted students.

d) Students who were placed in winter pool, so considered really good applicants by Cambridge standards, but whose applications were for an unusually (for Cambridge) competitive group, were on average lower performing than their average applicant that went for interview. This could indicate that St John's college is unusually competitive in larger proportion of places than the average college. AND/OR winter pool represents students who did unusually well in an interview. Which could be an indication that good interviews have a stronger impact.

e) More than half, perhaps as many as 80% of applicants are invited for interview, so only a small amount of selection has happened to get to this point, but likely the poorest performing quintile are likely removed by that process.

f) Students rejected do substantially less well than those who were made offers showing a clear correlation: doing better on the NSAA is linked in some way to a higher rate of acceptance.

g) Students who were not invited to interview included some who scored higher than about half of those accepted, indicating that success in the NSAA does not overcome whatever other challenges those students had that caused them to be rejected. Possibly these students had lower AS UMS/PUM scores, for instance.

h) One student got nearly a perfect sore (37) for section 2 but was not invited to interview, they could have had a problem with their GCSE or AS grades, or also possible, a problem with their personal statement (e.g. plagiarised) or their reference

i) All students who were made offers received a good interview score. It is not easy to know what information the interviewer has about the applicant before the interview. The social sciences might have made some inroads on delivering effective, reproducible interview style inquiries, but it is unclear what protocols are followed or why for the Cambridge (or Oxford) interview process.

Key take away:

Higher test scores do track with acceptance, but they are obviously not the only or most important part to the selection process. Interestingly, there is a scoring process for the interview.

To find out about Winter Pool go here:
https://www.undergraduate.study.cam.ac.uk/sites/www.undergraduate.study.cam.ac.uk/files/publications/guide_to_the_winter_pool_0.pdf

[34] https://www.whatdotheyknow.com/request/natural_sciences_applications_20_21

Impact of GCSEs on acceptance rate

From Natural Sciences A level admissions data for 2020 (excludes IB and other qualifications)[35]

Percentile	Total A* Acpt.	A* Rej.	Not A* Acpt.	Not A* Rej.	Total GCSE Acpt.	Total GCSE Rej.	% A* to all Acpt.	% A* to all Rej.	% (A*+A) to all Acpt.	% (A*+A) to all Rej.
0.01 LEAST	3	0	0	0	4	1	38	0	60	33
0.05	4	2	0	0	6	4	50	20	71	50
0.10	5	3	0	0	7	5	60	36	80	64
0.20	7	5	0	1	9	7	73	50	90	76
0.40	9	6	1	2	10	9	86	64	100	90
0.50	9	7	1	3	10	9	90	73	100	91
0.60	10	8	1	3	10	10	91	80	100	100
0.80	10	9	3	5	11	10	100	90	100	100
0.90	11	10	4	6	11	11	100	100	100	100
0.95	11	11	5	7	12	12	100	100	100	100
1.00 MOST	13	13	8	11	14	13	100	100	100	100

	GCSE A* Count	GCSE A Count	GCSE Other Count	Total	Non A* Total	% A* to all	% (A*+A) to all
Average Accepted	8.6	1.0	0.5	10.1	1.5	85.2	95.0
Averages Rejected	6.9	1.8	1.2	9.9	3.0	68.7	86.8

	A Level Applicants	Offer Holder	No offer
Totals	983	251	732

Key takeaway:

Most students who get offers have about 9A*, and almost all of them, about 80% have 7. A large number of student with a majority of A* get rejected. Almost half of all rejected students (and therefore a larger number of students than the number made offers) only have A* and A GCSEs.

Most students made offers have only A* or A grades, but students with one, and sometimes two B grades or lower are also accepted, but only about 1%, or 10 students a year, are admitted with a substantial proportion of grades lower than A.

The number of A* is less important than the ratio of A* to non A* (which is also stated on their website).

[35] https://www.whatdotheyknow.com/request/statistics_for_applicants_for_ph

Entrance statistics for NSAA percent score for each part in each section entry year 2020 [36]

	Totals	Maths	Physics	Biology	Chemistry	Advanced Maths	Section 2 B1	Section 2 B2	Section 2 C1	Section 2 C2	Section 2 P1	Section 2 P2
Offer Made NSAA Averages %		**75.8**	**66.0**	**66.3**	**61.8**	**55.2**	**N/A**	**65.0**	**69.2**	**69.0**	**64.4**	**55.3**
Rejected NSAA Averages %		**57.5**	**43.5**	**43.8**	**42.6**	**30.7**	**33.7**	**53.1**	**47.4**	**50.7**	**42.6**	**40.1**
Offer made total candidates	270	269	256	43	154	84	0	3	137	131	104	165
Rejected total candidates	775	775	714	79	447	292	17	26	368	303	364	470
Total applicants attempting NSAA part	1045	1044	970	122	601	376	17	29	505	434	468	635
Success rate %	**26**	**26**	**26**	**35**	**26**	**22**	**0**	**10**	**27**	**30**	**22**	**26**

NSAA Section 1 Results by percentile group from 2020 entry year[37]

Larger percentile represents a thresholds above which increasingly smaller numbers of more highly performing students were placed. Where higher scores are found at lower percentiles it indicates that higher scores were more common out of all exams taken.

Percentile	Maths S1 Accepted	Maths S1 Rejected	Physics S1 Accepted	Physics S1 Rejected	Biology S1 Accepted	Biology S1 Rejected	Chemistry S1 Accepted	Chemistry S1 Rejected	Advanced Maths Accepted	Advanced Maths Rejected
Average%	**75.8**	**57.5**	**66.0**	**43.5**	**66.3**	**43.8**	**61.8**	**42.6**	**55.2**	**30.7**
0.01	39	17	20	6	11	10	28	6	5	0
0.05	50	28	33	17	24	17	37	17	28	6
0.10	56	33	39	22	46	21	44	22	33	11
0.20	61	44	50	28	50	33	50	28	39	17
0.40	72	56	61	39	67	39	61	39	44	28
0.50	78	56	67	39	72	44	61	44	56	28
0.60	83	61	72	44	73	50	67	44	61	33
0.80	89	72	83	61	81	58	74	56	74	44
0.90	94	83	89	67	83	61	78	61	83	50
0.95	100	89	94	78	88	67	83	67	94	61
1.00	100	100	100	100	89	83	94	94	100	89

Even at the highest level, for most sciences students who were rejected had lower scores than around 30-40% of those candidates accepted. The mean average tends to be around 40-50% better for all subjects for those made an offer compared to those who completed the same part but were rejected.

The students who were in the highest decile (0.90 to 1.00) tended to get scores that were at often as good as more than half of the students who were accepted. And the highest scores of the best of those rejected often were as good as those who were accepted. So exceptionally achieving students were sometimes rejected. Possibly as a result of their score in other parts of the exam, which was not considered here.

But the lowest scores of students accepted in the lowest decile (0.01 to 0.10) tend to be roughly in line with the mean of those rejected, implying about half the rejected cohort got a score as good or better. So a lower score can still result in an offer.

Biology in section 1 was the lowest scoring at the highest levels of those accepted, which was reflected in having the highest success rate for those who attempted it (35% success for biology against an overall average success rate of 26%)

[36] https://www.whatdotheyknow.com/request/statistics_for_applicants_for_ph
[37] https://www.whatdotheyknow.com/request/statistics_for_applicants_for_ph

NSAA and Veterinary Medicine[38]

It is not clear if these average scores are of those made offers, accepted or successful, or just the overall average of all applicants.

Also, the score may be out of 18 (raw total) or 10, which would be calculated, like the UMS/PUM from the raw score. It seems likely that this Section 1 scores are out of 9 (like for GCSEs), which would put them roughly in line with the averages seen from more clearly explained data[39].

More information about averages (this time for the Veterinary Science course) can be found here:

Course	Accepted	Apply Year	NSAA Section	Section	Average score	Average %
Veterinary Medicine (D100)	NSAA	2018	Advanced Maths	1	5.4	
Veterinary Medicine (D100)	NSAA	2018	Biology	1	4.3	
Veterinary Medicine (D100)	NSAA	2019	Biology	1	4.6	
Veterinary Medicine (D100)	NSAA	2020	Biology	1	4.4	
Veterinary Medicine (D100)	NSAA	2021	Biology	1	5.0	
Veterinary Medicine (D100)	NSAA	2018	Chemistry	1	4.1	
Veterinary Medicine (D100)	NSAA	2019	Chemistry	1	4.6	
Veterinary Medicine (D100)	NSAA	2020	Chemistry	1	4.8	
Veterinary Medicine (D100)	NSAA	2021	Chemistry	1	2.6	
Veterinary Medicine (D100)	NSAA	2018	Maths	1	3.7	
Veterinary Medicine (D100)	NSAA	2019	Maths	1	3.5	
Veterinary Medicine (D100)	NSAA	2020	Maths	1	3.4	
Veterinary Medicine (D100)	NSAA	2021	Maths	1	3.7	
Veterinary Medicine (D100)	NSAA	2018	Physics	1	3.8	
Veterinary Medicine (D100)	NSAA	2019	Physics	1	3.3	
Veterinary Medicine (D100)	NSAA	2020	Physics	1	5.0	
Veterinary Medicine (D100)	NSAA	2021	S2 Biology	2	4.4	
Veterinary Medicine (D100)	NSAA	2021	S2 Chemistry	2	3.6	
Veterinary Medicine (D100)	NSAA	2018	Section 2 B1	2	11.8	59
Veterinary Medicine (D100)	NSAA	2019	Section 2 B1	2	11.4	57
Veterinary Medicine (D100)	NSAA	2020	Section 2 B1	2	8.3	42
Veterinary Medicine (D100)	NSAA	2018	Section 2 B2	2	12.2	61
Veterinary Medicine (D100)	NSAA	2019	Section 2 B2	2	12.4	62
Veterinary Medicine (D100)	NSAA	2020	Section 2 B2	2	11.6	58
Veterinary Medicine (D100)	NSAA	2018	Section 2 C1	2	12.7	64
Veterinary Medicine (D100)	NSAA	2019	Section 2 C1	2	15.2	76
Veterinary Medicine (D100)	NSAA	2020	Section 2 C1	2	10.7	54
Veterinary Medicine (D100)	NSAA	2018	Section 2 C2	2	14.7	74
Veterinary Medicine (D100)	NSAA	2019	Section 2 C2	2	11.4	57
Veterinary Medicine (D100)	NSAA	2020	Section 2 C2	2	11.2	56
Veterinary Medicine (D100)	NSAA	2018	Section 2 P1	2	7.5	38
Veterinary Medicine (D100)	NSAA	2018	Section 2 P2	2	9.0	45

A good explanation for this wide variability in scores is the emphasis this course places on other things, most likely a strong personal statement and portfolio of experiences related to the subject.

38 https://www.whatdotheyknow.com/request/admission_statistics_for_undergr_23#incoming-1995334

39 https://www.whatdotheyknow.com/request/statistics_for_applicants_for_ph

Analysis of MCQ answer frequencies

Averages

All subjects

All subjects		s1 & s2%	s1	s2	2020+
A		12.9	12.9	13	12.8
B		14.2	14.3	14	13.8
C		17.2	17.9	16	15.5
D		16.5	18.2	13	14.4
E		17.9	16.2	21	19.1
F		9.8	10.2	9	11.1
G		7.2	6.3	9	9.0
H		4.3	4.0	5	4.4
Totals	1119	100.0			100.0

All subjects	s1 2016SP	%	s1 2016	%	s1 2017	%	s1 2018	%	s1 2019	%	s1 2020sp	%	s1 2020	%	s1 2021	%	s1 2022	%	s1 2023	%	ESAT	%
A	14	16	10	11	11	12	14	16	8	9	12	15	10	13	11	14	9	11	10	13	6	21
B	14	16	11	12	16	18	11	12	12	13	14	18	9	11	12	15	11	14	14	18	2	7
C	18	20	20	22	16	18	20	22	17	19	13	16	12	15	11	14	12	15	10	13	7	24
D	22	24	16	18	17	19	9	10	17	19	20	25	12	15	12	15	15	19	12	15	6	21
E	13	14	12	13	14	16	20	22	16	18	12	15	10	13	14	18	14	18	19	24	6	21
F	6	7	9	10	8	9	8	9	9	10	3	4	17	21	11	14	7	9	8	10	2	7
G	1	1	7	8	4	4	4	4	5	6	4	5	7	9	5	6	11	14	4	5	0	0
H	2	2	5	6	4	4	4	4	6	7	2	3	3	4	4	5	1	1	3	4	0	0
Totals	90		90		90		90		90		80		80		80		80		80		29	

All subjects	s2 2020sp	%	s2 2020	%	s2 2021	%	s2 2022sp	%	s2 2022	%
A	6	20	5	8	4	7	6	20	6	10
B	3	10	10	17	8	13	5	17	8	13
C	5	17	10	17	11	18	5	17	7	12
D	1	3	14	23	11	18	1	3	11	18
E	9	30	8	13	10	17	8	27	11	18
F	1	3	6	10	7	12	2	7	8	13
G	2	7	5	8	6	10	2	7	7	12
H	3	10	2	3	3	5	1	3	2	3
Totals	30		60		60		30		60	

Chemistry

Chemistry		s1 & s2%	s1	s2	2020+ %
A		13.7	8.0	6.6	12.5
B		13.2	6.1	9.4	15.6
C		17.5	11.0	9.1	15.0
D		18.7	12.2	7.6	15.0
E		20.7	11.7	11.7	21.3
F		9.2	5.6	3.1	11.3
G		4.7	1.2	4.6	7.5
H		2.3	1.2	1.3	1.9
Totals	297	100.0			100.0

Chemistry	s1 2016SP	%	s1 2016	%	s1 2017	%	s1 2018	%	s1 2019	%	s1 2020sp	%	s1 2020	%	s1 2021	%	s1 2022	%	s1 2023	%	ESAT	%
A	4	22	2	11	2	11	4	22	1	6	4	20	1	5	3	15	3	15	2	10	5	19
B	1	6	0	0	2	11	3	17	3	17	2	10	2	10	3	15	2	10	2	10	2	7
C	4	22	7	39	2	11	5	28	1	6	4	20	2	10	4	20	3	15	4	20	7	26
D	3	17	5	28	7	39	2	11	4	22	5	25	4	20	2	10	3	15	3	15	6	22
E	6	33	1	6	3	17	3	17	4	22	5	25	4	20	5	25	4	20	6	30	5	19
F	0	0	3	17	1	6	1	6	2	11	0	0	5	25	3	15	2	10	1	5	2	7
G	0	0	0	0	0	0	0	0	1	6	0	0	2	10	0	0	2	10	1	5	0	0
H	0	0	0	0	1	6	0	0	2	11	0	0	0	0	0	0	1	5	1	5	0	0
Totals	18		18		18		18		18		20		20		20		20		20		27	

Chemistry	s2 2020sp	%	s2 2020	%	s2 2021	%	s2 2022sp	%	s2 2022	%
A	2	20	1	5	1	5	2	20	3	15
B	1	10	5	25	3	15	2	20	4	20
C	2	20	4	20	4	20	1	10	1	5
D	1	10	3	15	4	20	1	10	4	20
E	3	30	3	15	3	15	3	30	3	15
F	0	0	1	5	3	15	0	0	4	20
G	1	10	2	10	1	5	1	10	1	5
H	0	0	1	5	1	5	0	0	0	0
Totals	10		20		20		10		20	

Numbers of MCQs in Chemistry that have a certain number of answers:

2020+ %	S1 Only	Possible answer #	s1 & s2	
1	1	4	0	# of D
25	34	5	28	# of E
28	33	6	32	# of F
9	5	7	8	# of G
37	27	8	32	# of H
100	100 Totals		100	

	s1 2016SP	%	s1 2016	%	s1 2017	%	s1 2018	%	s1 2019	%	s1 2020sp	%	s1 2020	%	s1 2021	%	s1 2022	%	s1 2023	%	ESAT	%
# of D		0		0		0		0		0	1	5		0		0		0		0	1	4
# of E	13	72	4	22	2	11	4	22	6	33	14	70	3	15	9	45	3	15	3	15	17	63
# of F	5	28	7	39	9	50	8	44	5	28	5	25	6	30	5	25	6	30	6	30	7	26
# of G		0	2	11		0	3	17	1	6		0	1	5	1	5	1	5	1	5	2	7
# of H		0	5	28	7	39	3	17	6	33		0	10	50	5	25	10	50	10	50		0
Totals	18	100	18	100	18	100	18	100	18	100	20	100	20	100	20	100	20	100	20	100	27	96

	s2 2020sp	%	s2 2020	%	s2 2021	%	s2 2022sp	%	s2 2022	%
# of D		0		0		0		0		0
# of E	1	10	3	15	5	25	1	10	4	20
# of F	3	30	6	30	6	30	3	30	5	25
# of G	1	10	1	5	5	25	1	10	3	15
# of H	5	50	10	50	4	20	5	50	8	40
Totals	10		20		20		10		20	

Biology

Biology		s1 & s2%	s1	s2	2020+ %
A		10.7	6.8	5.2	10.6
B		12.7	8.0	6.0	11.3
C		12.6	7.2	7.2	13.8
D		14.5	8.8	5.8	13.1
E		15.2	6.5	12.3	16.3
F		13.7	8.4	6.4	14.4
G		11.7	5.4	6.3	13.1
H		9.0	6.0	4.0	7.5
Totals	270	100.0			100.0

Biology	s1 2016SP	%	s1 2016	%	s1 2017	%	s1 2018	%	s1 2019	%	s1 2020sp	%	s1 2020	%	s1 2021	%	s1 2022	%	s1 2023	%
A	1	6	1	6	3	17	2	11	2	11	3	15	2	10	4	20	2	10	3	15
B	2	11	4	22	3	17	2	11	2	11	3	15	1	5	4	20	3	15	3	15
C	1	6	3	17	4	22	1	6	3	17	0	0	4	20	3	15	2	10	0	0
D	5	28	2	11	2	11	1	6	4	22	4	20	1	5	4	20	4	20	3	15
E	1	6	4	22	1	6	5	28	2	11	2	10	1	5	1	5	1	5	5	25
F	5	28	1	6	2	11	3	17	0	0	3	15	7	35	1	5	4	20	4	20
G	1	6	1	6	1	6	2	11	2	11	4	20	2	10	1	5	4	20	2	10
H	2	11	2	11	2	11	2	11	3	17	1	5	2	10	2	10	0	0	0	0
Totals	18		18		18		18		18		20		20		20		20		20	

Biology	s2 2020sp	%	s2 2020	%	s2 2021	%	s2 2022sp	%	s2 2022	%
A	1	10	3	15	1	5	1	10	1	5
B	0	0	3	15	4	20	1	10	1	5
C	1	10	3	15	2	10	2	20	2	10
D	0	0	5	25	3	15	0	0	4	20
E	4	40	1	5	4	20	3	30	4	20
F	1	10	2	10	2	10	2	20	1	5
G	1	10	2	10	3	15	1	10	5	25
H	2	20	1	5	1	5	0	0	2	10
Totals	10		20		20		10		20	

Mathamatics

Mathamatics		s1 & s2%	s1	s2	2020+ %
A		12.2	7.4	####	15.0
B		15.9	8.8	####	16.3
C		19.6	11.2	####	15.0
D		18.1	10.0	####	20.0
E		16.5	9.2	####	16.3
F		9.4	5.9	####	10.0
G		5.9	3.1	####	5.0
H		2.3	1.5	####	2.5
Totals	190	100.0			100.0

Mathamatics	s1 2016SP	%	s1 2016	%	s1 2017	%	s1 2018	%	s1 2019	%	s1 2020sp	%	s1 2020	%	s1 2021	%	s1 2022	%	s1 2023	%
A	4	22	2	11	0	0	2	11	1	6	4	20	4	20	3	15	1	5	2	10
B	3	17	4	22	4	22	2	11	1	6	3	15	4	20	2	10	4	20	4	20
C	5	28	4	22	3	17	5	28	4	22	5	25	2	10	1	5	4	20	4	20
D	5	28	2	11	3	17	2	11	3	17	5	25	3	15	3	15	5	25	4	20
E	1	6	3	17	3	17	4	22	4	22	2	10	3	15	4	20	4	20	4	20
F	0	0	2	11	3	17	1	6	2	11	0	0	3	15	5	25	0	0	1	5
G	0	0	1	6	2	11	1	6	2	11	0	0	1	5	1	5	2	10	0	0
H	0	0	0	0	0	0	1	6	1	6	1	5	0	0	1	5	0	0	1	5
Totals	18		18		18		18		18		20		20		20		20		20	

Major takeaways from this analysis

1. The trends are stronger in chemistry than all (green indicates bias towards that letter answer), and weaker in biology (red indicates that that letter is less common).
2. In chemistry ESAT 5 answers, a to e, is the most common question type. Previously 8 answers were more common.
3. These trends exist across all papers from 2016sp to 2022, as well as for exam papers 2020sp and onwards.
4. A correct answer could be any letter, but seems less likely if it is the first or the last option. So pure guesses at answer e would be optimal if these trends persist. If you had a fifty-fifty feeling for two answers, and one was at the end of the options, maybe go for the other answer.
5. These trends are often found in other MCQ tests, like historically AS Chemistry offered by CAIE (but that was removed in 2023).

Entrance statistics for selected non-UK applicants

Table 3.2 Applications, offers and acceptances to Cambridge by country 2022[40]

This table counts applications from outside the UK only.

Country of domicile	Applications		Offers		Acceptances and success rates		
	No.	%	No.	%	No.	%	Success rate (%)
China	2,169	28.7	294	29.5	224	30.4	10.3
Singapore	573	7.6	141	14.2	114	15.4	19.9
Hong Kong	572	7.6	91	9.1	73	9.9	12.8
United States of America	427	5.7	39	3.9	23	3.1	5.4
India	377	5.0	41	4.1	23	3.1	6.1
Malaysia	252	3.3	19	1.9	17	2.3	6.7
France	181	2.4	12	1.2	11	1.5	6.1
Canada	158	2.1	18	1.8	12	1.6	7.6
Ireland	156	2.1	17	1.7	13	1.8	8.3
Korea, Republic of	144	1.9	10	1.0	9	1.2	6.3
Spain	140	1.9	11	1.1	7	0.9	5.0
Germany	138	1.8	19	1.9	16	2.2	11.6
Pakistan	134	1.8	12	1.2	8	1.1	6.0
Australia	117	1.6	22	2.2	18	2.4	15.4
Poland	104	1.4	18	1.8	13	1.8	12.5
Italy	103	1.4	8	0.8	4	0.5	3.9
United Arab Emirates	92	1.2	11	1.1	7	0.9	7.6
Switzerland	91	1.2	14	1.4	13	1.8	14.3
Cyprus (European Union)	89	1.2	13	1.3	8	1.1	9.0
Thailand	79	1.0	9	0.9	8	1.1	10.1
Hungary	66	0.9	19	1.9	12	1.6	18.2
New Zealand	61	0.8	7	0.7	5	0.7	8.2
Romania	59	0.8	12	1.2	4	0.5	6.8
Belgium	51	0.7	6	0.6	5	0.7	9.8
Russian Federation	50	0.7	4	0.4	3	0.4	6.0
Other EU	387	5.1	52	5.2	37	5.0	9.6
Other International	775	10.3	77	7.7	51	6.9	6.6
Totals	**7,545**	**100.0**	**996**	**100.0**	**738**	**100.0**	**9.8**

[40] https://www.undergraduate.study.cam.ac.uk/apply/statistics

International, China, HK/TW/MAC and Singapore for 2019 to 2022 years of entry[41]

Notable is Singapore's success rate, which has grown in 2022 to around twice that of the international average.

		International (non-UK)				China				Hong Kong/Macao/Taiwan				Singapore			
Entry Year	**College**	**Apps.**	**Offer**	**Accept.**	**Offer rate %**	**Apps.**	**Offer**	**Accept.**	**Offer rate %**	**Apps.**	**Offer**	**Accept.**	**Offer rate %**	**Apps.**	**Offer**	**Accept.**	**Offer rate %**
2019	Totals	6843	1127	852	**18**	1156	207	142	**17**	561	91	53	**17**	467	99	65	**23**
2020	Totals	6973	1110	827	**17**	1328	266	188	**21**	591	101	75	**19**	462	105	55	**22**
2021	Totals	7962	1088	800	**15**	1999	284	217	**17**	686	100	72	**17**	533	129	84	**23**
2022	Totals	7679	1042	771	**15**	2181	294	225	**19**	617	90	56	**16**	615	145	103	**30**

The numbers here for this table come from a Freedom of Informational (FOI) request from the University, but they don't exactly line up with the universities published statistics in the previous table (Table 3.2), which will be produced to include more information, so ought to be considered more accurate to the message the University of Cambridge intends to deliver.

Proportion of total, %	**China**			**Hong Kong/Macao/Taiwan**			**Singapore**		
	Apps %	**Offer %**	**Accept %**	**Apps %**	**Offer %**	**Accept %**	**Apps %**	**Offer %**	**Accept %**
2019	16.9	18.4	**16.7**	8.2	8.1	**6.2**	6.8	8.8	**7.6**
2020	19.0	24.0	**22.7**	8.5	9.1	**9.1**	6.6	9.5	**6.7**
2021	25.1	26.1	**27.1**	8.6	9.2	**9.0**	6.7	11.9	**10.5**
2022	28.4	28.2	**29.2**	8.0	8.6	**7.3**	8.0	13.9	**13.4**

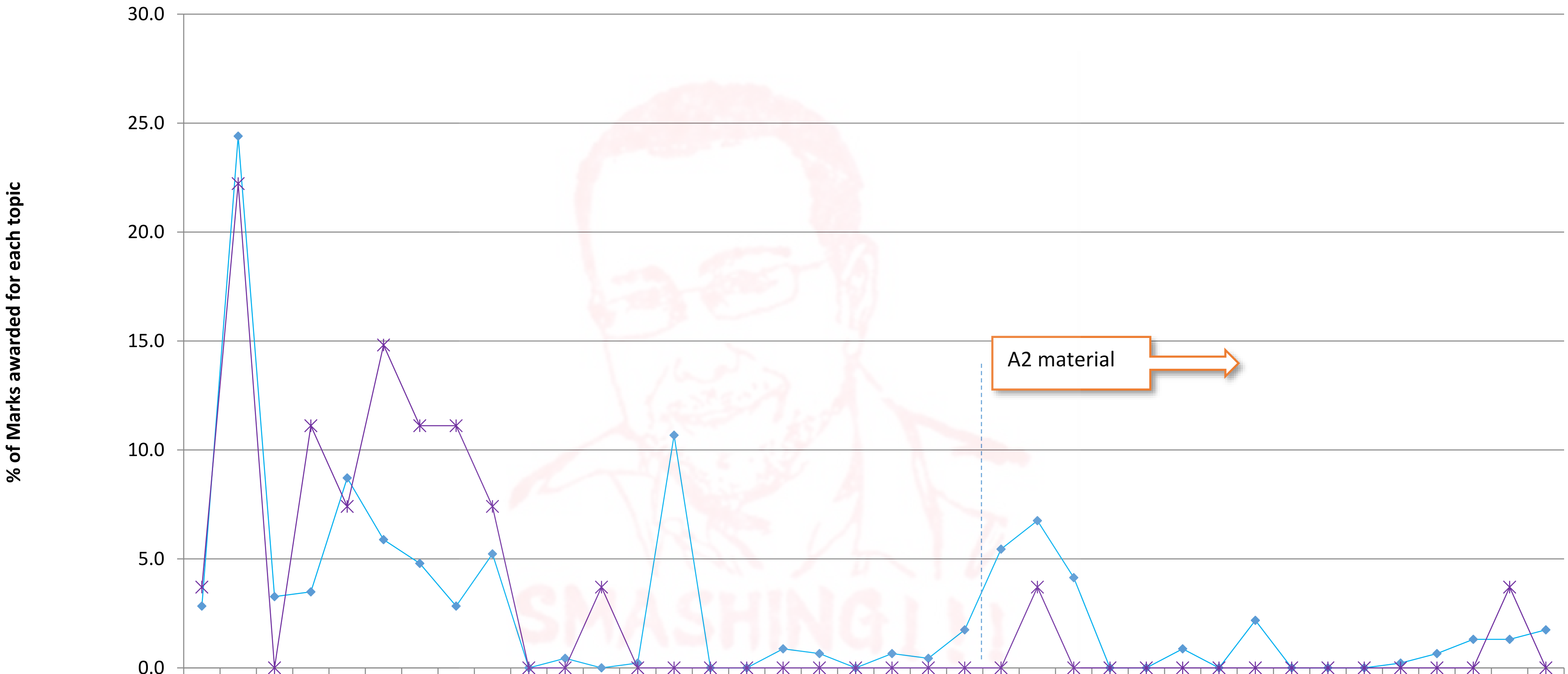
For more details about applications and colleges see at the back of this book: "*Appendix - Admissions statistics for China, Hong Kong, Singapore and all International Students for 20109 to 2022 entry*".

[41] https://www.whatdotheyknow.com/request/undergraduate_admission_statisti_90

Comparing marks allocated to each topic

NSAA Section 1 AND 2 Chemistry and the **ESAT**

Percentage of all marks awarded of the NSAA mapped to A Level topics from Specimen Paper 2016 to 2023, blue diamonds, compared with the 2024 ESAT Specimen Paper, purple crosses.



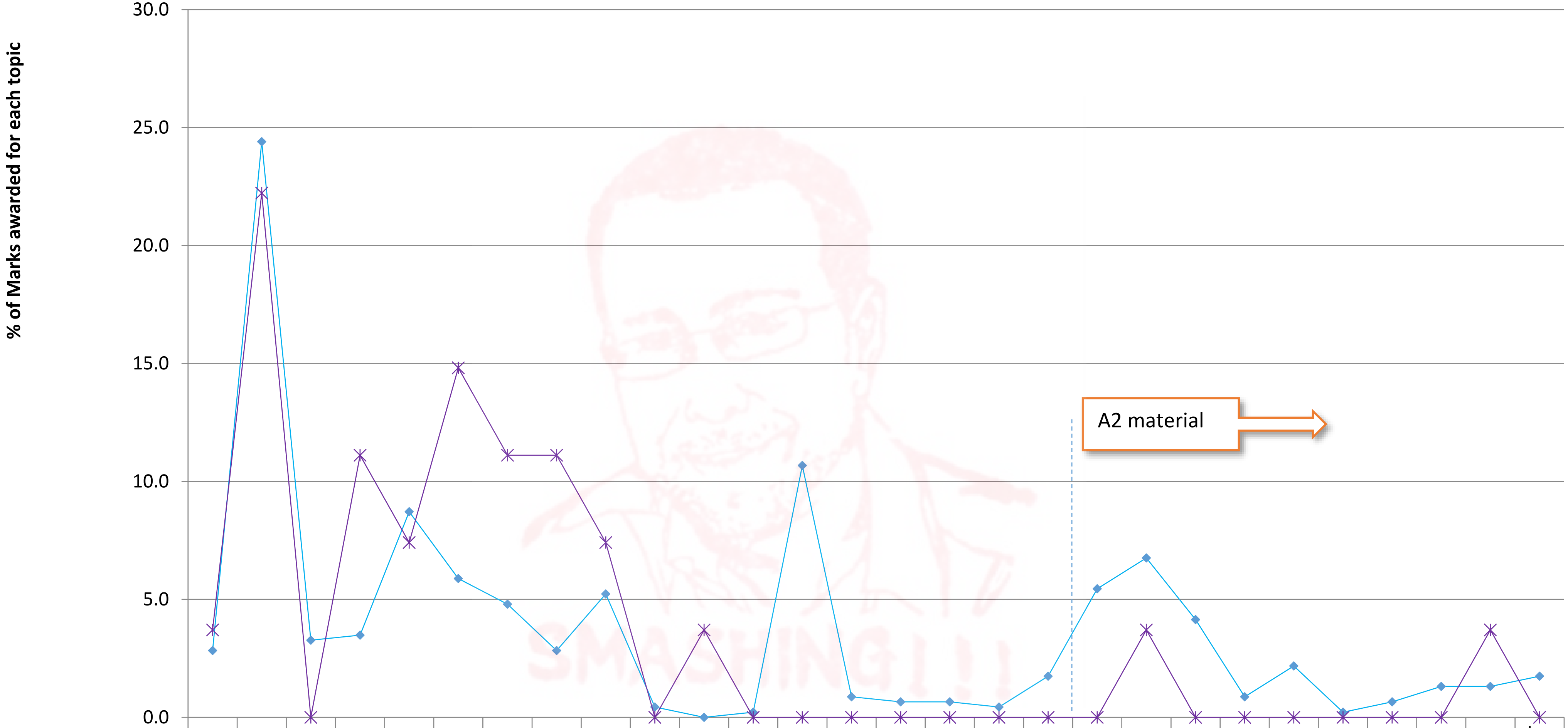
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Sctn1&2 16-23	2.8	24.	3.3	3.5	8.7	5.9	4.8	2.8	5.2	0.0	0.4	0.0	0.2	10.	0.0	0.0	0.9	0.7	0.0
ESAT '24	3.7	22.	0.0	11.	7.4	14.	11.	11.	7.4	0.0	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	Ion Test
Sctn1&2 16-23	0.7	0.4	1.7	5.4	6.8	4.1	0.0	0.0	0.9	0.0	2.2	0.0	0.0	0.0	0.2	0.7	1.3	1.3	1.7
ESAT '24	0.0	0.0	0.0	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0

A Level Chemistry CAIE Topic Number

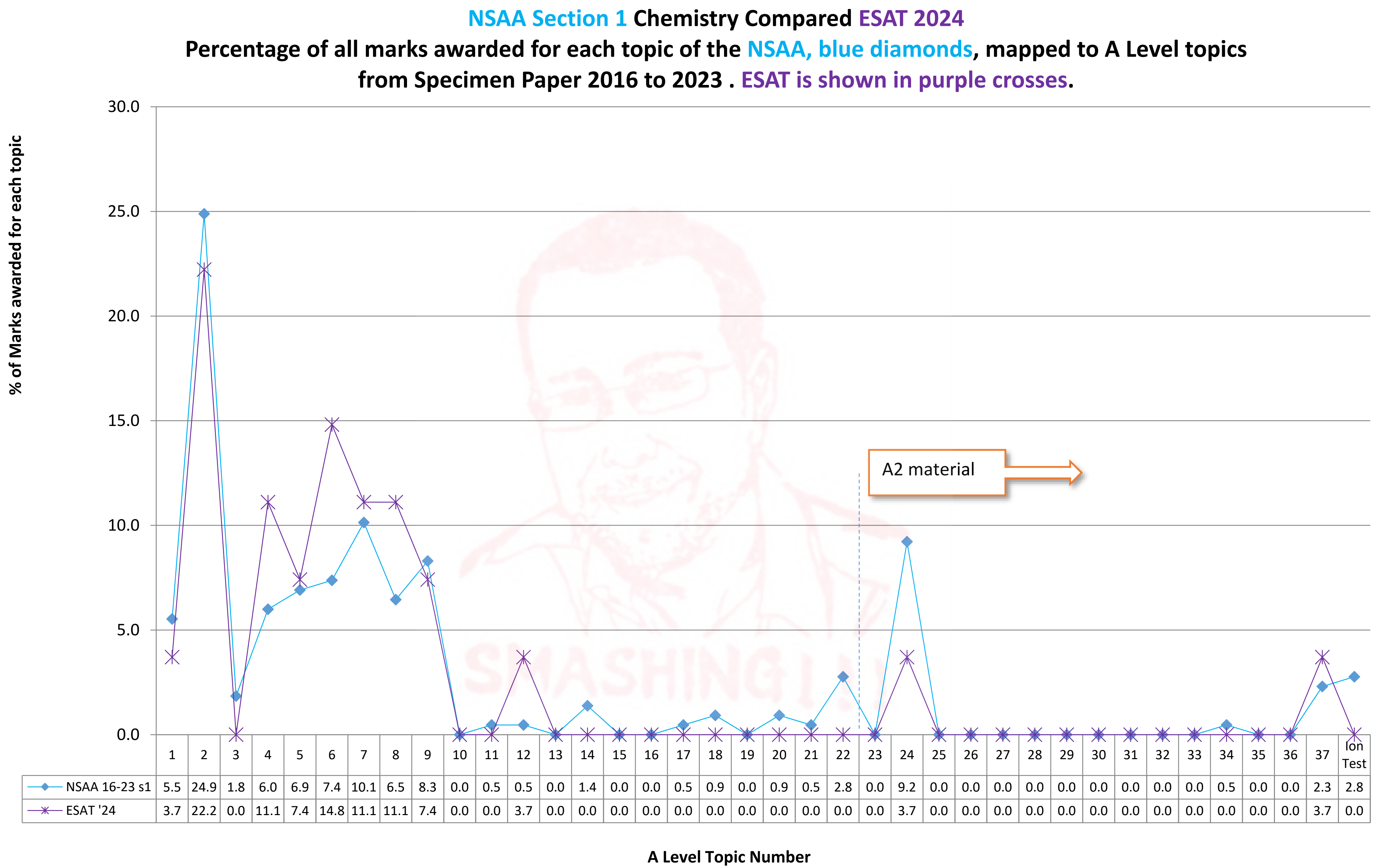
NSAA Section 1 AND 2 Chemistry and the ESAT - **Focus**

Percentage of all marks awarded of the NSAA mapped to A Level topics from Specimen Paper 2016 to 2023, blue diamonds, compared with the 2024 ESAT Specimen Paper, purple crosses.



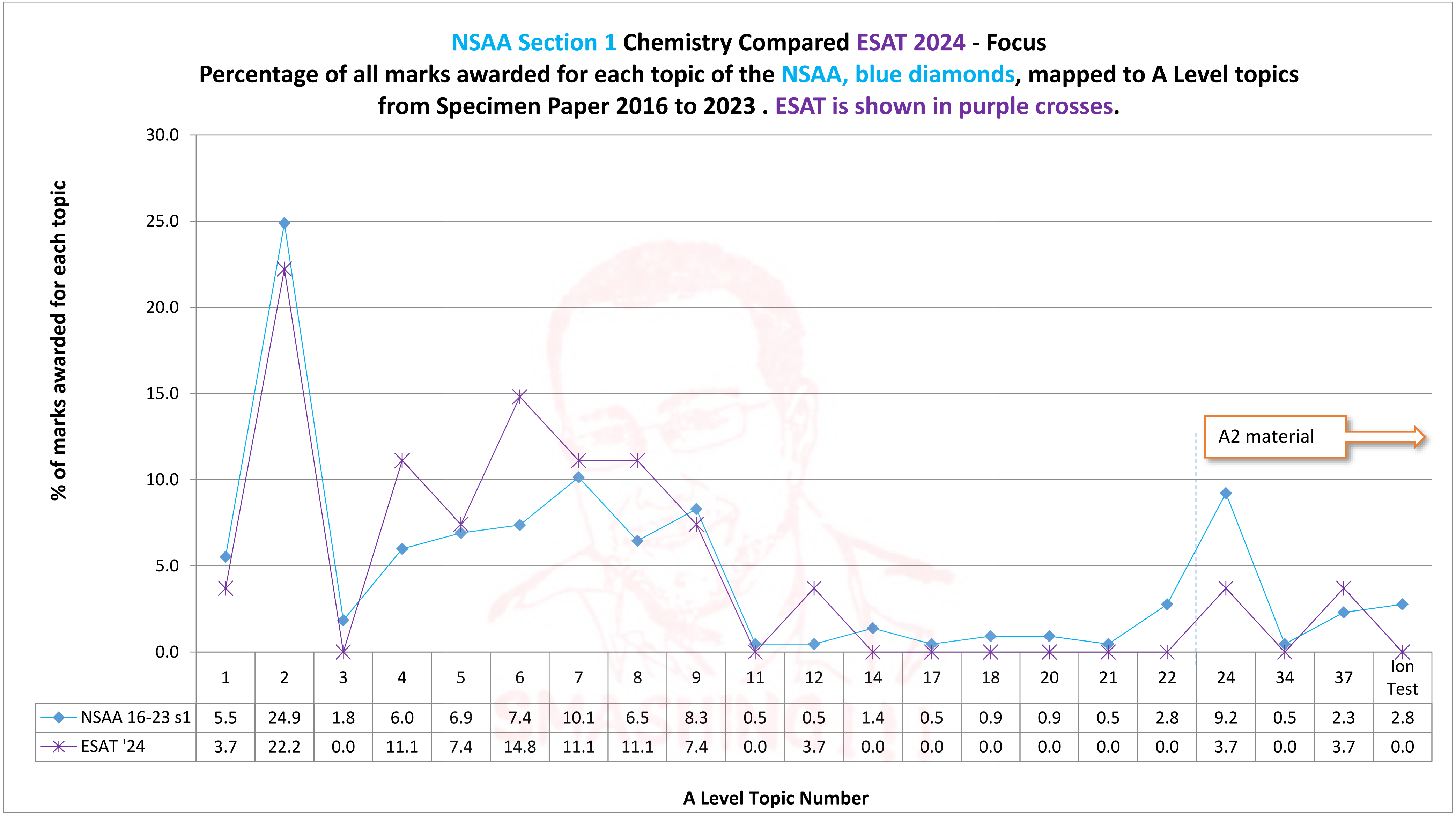
	1	2	3	4	5	6	7	8	9	11	12	13	14	17	18	20	21	22	23	24	25	28	30	34	35	36	37	Ion Test
Sctn1&2 16-23	2.8	24.4	3.3	3.5	8.7	5.9	4.8	2.8	5.2	0.4	0.0	0.2	10.7	0.9	0.7	0.7	0.4	1.7	5.4	6.8	4.1	0.9	2.2	0.2	0.7	1.3	1.3	1.7
ESAT '24	3.7	22.2	0.0	11.1	7.4	14.8	11.1	11.1	7.4	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0

A Level Chemistry CAIE Topic Number



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
NSAA 16-23 s1	5.5	24.9	1.8	6.0	6.9	7.4	10.1	6.5	8.3	0.0	0.5	0.5	0.0	1.4	0.0	0.0	0.5	0.9	0.0
ESAT '24	3.7	22.2	0.0	11.1	7.4	14.8	11.1	11.1	7.4	0.0	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	Ion Test
NSAA 16-23 s1	0.9	0.5	2.8	0.0	9.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	2.3	2.8
ESAT '24	0.0	0.0	0.0	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0



	1	2	3	4	5	6	7	8	9	11	12	14	17	18	20	21	22	24	34	37	Ion Test
NSAA 16-23 s1	5.5	24.9	1.8	6.0	6.9	7.4	10.1	6.5	8.3	0.5	0.5	1.4	0.5	0.9	0.9	0.5	2.8	9.2	0.5	2.3	2.8
ESAT '24	3.7	22.2	0.0	11.1	7.4	14.8	11.1	11.1	7.4	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0	3.7	0.0

Comments on the distribution of marks

As the comparison with the most recent versus all of the exams, the general trends seems to be stable in which topics are examined more often.

These topics are ordered by mark frequency for the most recent exams, which all use the 2023 new exam format. These map well with all of the exams, with the exception of topic 16 (rates) which is substantially less in more recent exams, and topic 18 (HL acids and bases) which was less frequent, and is now even rarer.

By Chemistry Category

	By Chemistry Category	NSAA Section 1 2016-2023	NSAA Section 2 2016-2022	ESAT 2024
	Physical Chemistry			
AS	*1 Atomic structure*	5.5	0.7	3.7
AS	*2 Atoms, molecules and stoichiometry*	24.9	26.5	22.2
AS	*3 Chemical bonding*	1.8	4.7	0.0
AS	*4 States of matter*	6.0	2.0	11.1
AS	*5 Chemical energetics*	6.9	9.1	7.4
AS	*6 Electrochemistry*	7.4	5.0	14.8
AS	*7 Equilibria*	10.1	1.0	11.1
AS	*8 Reaction kinetics*	6.5	0.7	11.1
A2	23 Chemical energetics	0.0	8.4	0.0
A3	24 Electrochemistry	9.2	4.7	3.7
A4	25 Equilibria	0.0	6.7	0.0
A5	26 Reaction kinetics	0.0	0.0	0.0
	Physical Chemistry Totals	78.3	69.5	85.2
AS	**Inorganic Chemistry**			
AS	*9 The Periodic Table: chemical periodicity*	8.3	2.7	7.4
AS	*10 Group 2*	0.0	0.0	0.0
AS	*11 Group 17*	0.5	0.3	0.0
AS	*12 Nitrogen and sulfur*	0.5	0.0	3.7
A2	27 Group 2	0.0	0.0	0.0
A2	28 Chemistry of transition elements	0.0	1.3	0.0
	Inorganic Chemistry Totals	9.2	4.4	11.1
AS	**Organic Chemistry**			
AS	*13 An introduction to AS Level organic chemistry*	0.0	0.3	0.0
AS	*14 Hydrocarbons*	1.4	15.4	0.0
AS	*15 Halogen compounds*	0.0	0.0	0.0
AS	*16 Hydroxy compounds*	0.0	0.0	0.0
AS	*17 Carbonyl compounds*	0.5	1.0	0.0
AS	*18 Carboxylic acids and derivatives*	0.9	0.3	0.0
AS	*19 Nitrogen compounds*	0.0	0.0	0.0
AS	*20 Polymerisation*	0.9	0.3	0.0
AS	*21 Organic synthesis*	0.5	0.3	0.0
A2	29 An introduction to A Level organic chemistry	0.0	0.0	0.0
A2	30 Hydrocarbons	0.0	3.4	0.0
A2	31 Halogen compounds	0.0	0.0	0.0
A2	32 Hydroxy compounds	0.0	0.0	0.0
A2	33 Carboxylic acids and derivatives	0.0	0.0	0.0
A2	34 Nitrogen compounds	0.5	0.0	0.0
A2	35 Polymerisation	0.0	1.0	0.0
A2	36 Organic synthesis	0.0	2.0	0.0
	Organic Chemistry Totals	4.6	24.2	0.0

	By Chemistry Category	NSAA Section 1 2016-2023	NSAA Section 2 2016-2022	ESAT 2024
	Analysis			
AS	*22 Analytical techniques*	2.8	0.7	0.0
A2	37 Analytical techniques	2.3	0.7	3.7
N/A	Ions test	2.8	0.7	0.0
	Analysis Totals	7.8	2.0	3.7
	_			
AS	No longer assessed	0.0	0.0	0.0
A2	AS Total	85.3	71.1	92.6
	A2 Total	12.0	28.2	7.4
	AS+A2+Ion Tests	**100.0**	**100.0**	**100.0**
	Physical Chemistry Totals	**78.3**	**69.5**	**85.2**
	Inorganic Chemistry Totals	**9.2**	**4.4**	**11.1**
	Organic Chemistry Totals	**4.6**	**24.2**	**0.0**
	Analytical Techniques Totals	**7.8**	**2.0**	**3.7**

Tables of analysis of mark frequencies for specific syllabus topics and of experiment type

	Papers 1, 2 and 3 By Chemistry Category	P1 16-22 WTD	P1 9-15 WTD	P2 16-22 WTD	P2 9-15 WTD	P3 16-22 WTD	P3 9-15 WTD	P1,2,3 16-22 WTD	1,2,3 9-15 WTD
	Paper/s (% weighted of A Level)	**1**	**1**	**2**	**2**	**3**	**3**	**1,2,3**	**1,2,3**
	% of A Level	15.5	15.5	23.0	23.0	11.5	11.5	50.0	50.0
	Years included	16-22	9-15	16-22	9-15	16-22	9-15	16-22	9-15
	Physical Chemistry								
AS	1 Atomic structure	0.7	0.7	1.7	0.9	0.0	0.0	2.4	1.6
AS	2 Atoms, molecules and stoichiometry	0.5	0.4	1.0	1.2	0.3	0.2	1.8	1.8
AS	3 Chemical bonding	0.9	0.7	1.8	1.0	0.0	0.0	2.7	1.8
AS	4 States of matter	0.5	0.5	0.9	0.4	0.0	0.0	1.5	0.9
AS	5 Chemical energetics	0.8	0.8	1.2	1.6	0.4	0.3	2.5	2.7
AS	6 Electrochemistry	0.6	0.4	0.4	0.4	1.8	3.0	2.8	3.9
AS	7 Equilibria	1.0	1.0	1.2	2.1	1.8	1.8	4.0	4.9
AS	8 Reaction kinetics	0.6	0.6	0.7	0.3	0.6	1.8	1.9	2.6
	Physical Chemistry Totals	5.7	5.2	8.9	7.8	4.9	7.2	19.6	20.2
	Inorganic Chemistry								
AS	9 The Periodic Table: chemical periodicity	1.0	1.0	1.3	1.7	0.0	0.0	2.3	2.7
AS	10 Group 2	0.9	0.7	1.3	1.1	2.1	0.3	4.3	2.2
AS	11 Group 17	0.9	1.0	1.5	0.5	0.0	0.0	2.4	1.5
AS	12 Nitrogen and sulfur	0.5	0.6	0.8	1.5	3.9	2.8	5.2	4.9
	Inorganic Chemistry Totals	3.3	3.3	4.9	4.9	6.0	3.1	14.2	11.3
	Organic Chemistry								
AS	13 An introduction to AS Level organic chemistry	1.0	0.9	1.1	0.5	0.0	0.0	2.0	1.4
AS	14 Hydrocarbons	0.6	0.7	2.2	2.5	0.0	0.0	2.8	3.2
AS	15 Halogen compounds	0.7	0.7	0.5	0.5	0.2	0.0	1.4	1.2
AS	16 Hydroxy compounds	0.6	0.8	0.9	0.5	0.1	0.0	1.6	1.4
AS	17 Carbonyl compounds	0.9	0.5	1.0	0.5	0.1	0.1	2.0	1.1
AS	18 Carboxylic acids and derivatives	1.1	1.0	0.7	0.6	0.1	0.0	1.9	1.6
AS	19 Nitrogen compounds	0.1	0.1	0.1	0.0	0.0	0.0	0.2	0.1
AS	20 Polymerisation	0.4	0.2	0.3	0.0	0.0	0.0	0.7	0.2
AS	21 Organic synthesis	0.4	1.1	1.2	4.3	0.0	0.0	1.6	5.4
	Organic Chemistry Totals	5.7	5.9	7.9	9.5	0.5	0.1	14.2	15.4
	Analysis								
AS	22 Analytical techniques	0.4	0.0	0.9	0.0	0.0	0.0	1.3	0.0
	0								
	No longer assessed	0.3	0.9	0.3	0.8	0.0	1.1	0.6	2.8
	AS Total (if <100%, then because some material moved to A2)	15.5	15.3	23.0	23.0	11.5	11.5	50.0	49.8
	Physical Chemistry Totals	5.7	5.2	8.9	7.8	4.9	7.2	19.6	20.2
	Inorganic Chemistry Totals	3.3	3.3	4.9	4.9	6.0	3.1	14.2	11.3
	Organic Chemistry Totals	5.7	5.9	7.9	9.5	0.5	0.1	14.2	15.4
	22 Analytical techniques	0.4	0.0	0.9	0.0	0.0	0.0	1.3	0.0

	Topics Ordered by Mark Value Frequency of 2016-22 in Papers 1, 2 and 3	P1 16-22 WTD	P1 9-15 WTD	P2 16-22 WTD	P2 9-15 WTD	P3 16-22 WTD	P3 9-15 WTD	P1,2,3 16-22 WTD	1,2,3 9-15 WTD
	Paper/s (% weighted of A Level)	**1**	**1**	**2**	**2**	**3**	**3**	**1,2,3**	**1,2,3**
	% of A Level	15.5	15.5	23.0	23.0	11.5	11.5	**50.0**	50.0
	Years included	16-22	9-15	16-22	9-15	16-22	9-15	**16-22**	9-15
AS	12 Nitrogen and sulfur	0.5	0.6	0.8	1.5	3.9	2.8	**5.2**	4.9
AS	10 Group 2	0.9	0.7	1.3	1.1	2.1	0.3	**4.3**	2.2
AS	7 Equilibria	1.0	1.0	1.2	2.1	1.8	1.8	**4.0**	4.9
AS	6 Electrochemistry	0.6	0.4	0.4	0.4	1.8	3.0	**2.8**	3.9
AS	14 Hydrocarbons	0.6	0.7	2.2	2.5	0.0	0.0	**2.8**	3.2
AS	3 Chemical bonding	0.9	0.7	1.8	1.0	0.0	0.0	**2.7**	1.8
AS	5 Chemical energetics	0.8	0.8	1.2	1.6	0.4	0.3	**2.5**	2.7
AS	1 Atomic structure	0.7	0.7	1.7	0.9	0.0	0.0	**2.4**	1.6
AS	11 Group 17	0.9	1.0	1.5	0.5	0.0	0.0	**2.4**	1.5
AS	9 The Periodic Table: chemical periodicity	1.0	1.0	1.3	1.7	0.0	0.0	**2.3**	2.7
AS	13 An introduction to AS Level organic chemistry	1.0	0.9	1.1	0.5	0.0	0.0	**2.0**	1.4
AS	17 Carbonyl compounds	0.9	0.5	1.0	0.5	0.1	0.1	**2.0**	1.1
AS	8 Reaction kinetics	0.6	0.6	0.7	0.3	0.6	1.8	**1.9**	2.6
AS	18 Carboxylic acids and derivatives	1.1	1.0	0.7	0.6	0.1	0.0	**1.9**	1.6
AS	2 Atoms, molecules and stoichiometry	0.5	0.4	1.0	1.2	0.3	0.2	**1.8**	1.8
AS	16 Hydroxy compounds	0.6	0.8	0.9	0.5	0.1	0.0	**1.6**	1.4
AS	21 Organic synthesis	0.4	1.1	1.2	4.3	0.0	0.0	**1.6**	5.4
AS	4 States of matter	0.5	0.5	0.9	0.4	0.0	0.0	**1.5**	0.9
AS	15 Halogen compounds	0.7	0.7	0.5	0.5	0.2	0.0	**1.4**	1.2
AS	22 Analytical techniques	0.4	0.0	0.9	0.0	0.0	0.0	**1.3**	0.0
AS	20 Polymerisation	0.4	0.2	0.3	0.0	0.0	0.0	**0.7**	0.2
	No longer assessed	0.3	0.9	0.3	0.8	0.0	1.1	**0.6**	2.8
AS	19 Nitrogen compounds	0.1	0.1	0.1	0.0	0.0	0.0	**0.2**	0.1
	AS Total (if <TOTAL then because some material moved to A2)	15.5	15.3	23.0	23.0	11.5	11.5	**50.0**	49.8

AS and A2 CAIE 9701 Chemistry Analysis

Each exam paper, or combination, like "Papers 1, 2 and 3" use the weighting, as a fraction of the whole A Level (AS and A2 years) given in the syllabus:

Paper	% of AS/ A2	**% of ALvl**	Marks	Time in min	secs/ marks	% YEAR	% ALL A-Level/ mark (weighting)
1	31	**15.5**	40	75	112.5	0.78	0.39
2	46	**23**	60	75	75	0.77	0.38
3	23	**11.5**	40	120	180	0.58	0.29
4	77	**38.5**	100	120	72	0.77	0.39
5	23	**11.5**	30	75	150	0.77	0.38

PUM =Percentage Uniform Mark; UMS = Uniform Mark Scale (UK version of PUM)

UMS/PUM allows 2 scores from 2 different versions of the same exam paper that may have been slightly different in terms of difficulty, to be made. A student sitting a slightly harder exam paper will have a lower grade threshold compared to a student, for instance doing their exam papers in a different time zone that is slightly easier. Each grade always has the same UMS score, so an A* is always 90% UMS, but the raw score can be different, often a lower percentage. The table below shows how this threshold has changed in the last 10 years.

Variability in UMS/PUM grade thresholds from 20214s to 2023w

	Grade:	A*	A	B	C	D	E
UMS/PUM %		90%	80%	70%	60%	50%	40%
2014s to 2023w	Highest Raw % Score	79	70	62	53	44	35
	Lowest Raw % Score	62	54	46	38	30	21
	Variability	17	16	17	15	14	14
	Average Raw % Score	73	64	55	46	37	29

	Grade:	A*	A	B	C	D	E
2020m and before:	Highest Raw % Score	79	70	62	53	44	35
	Lowest Raw % Score	72	63	54	46	37	28
	Variability	7	7	8	7	7	7
	Average Raw % Score	76	67	58	49	41	32

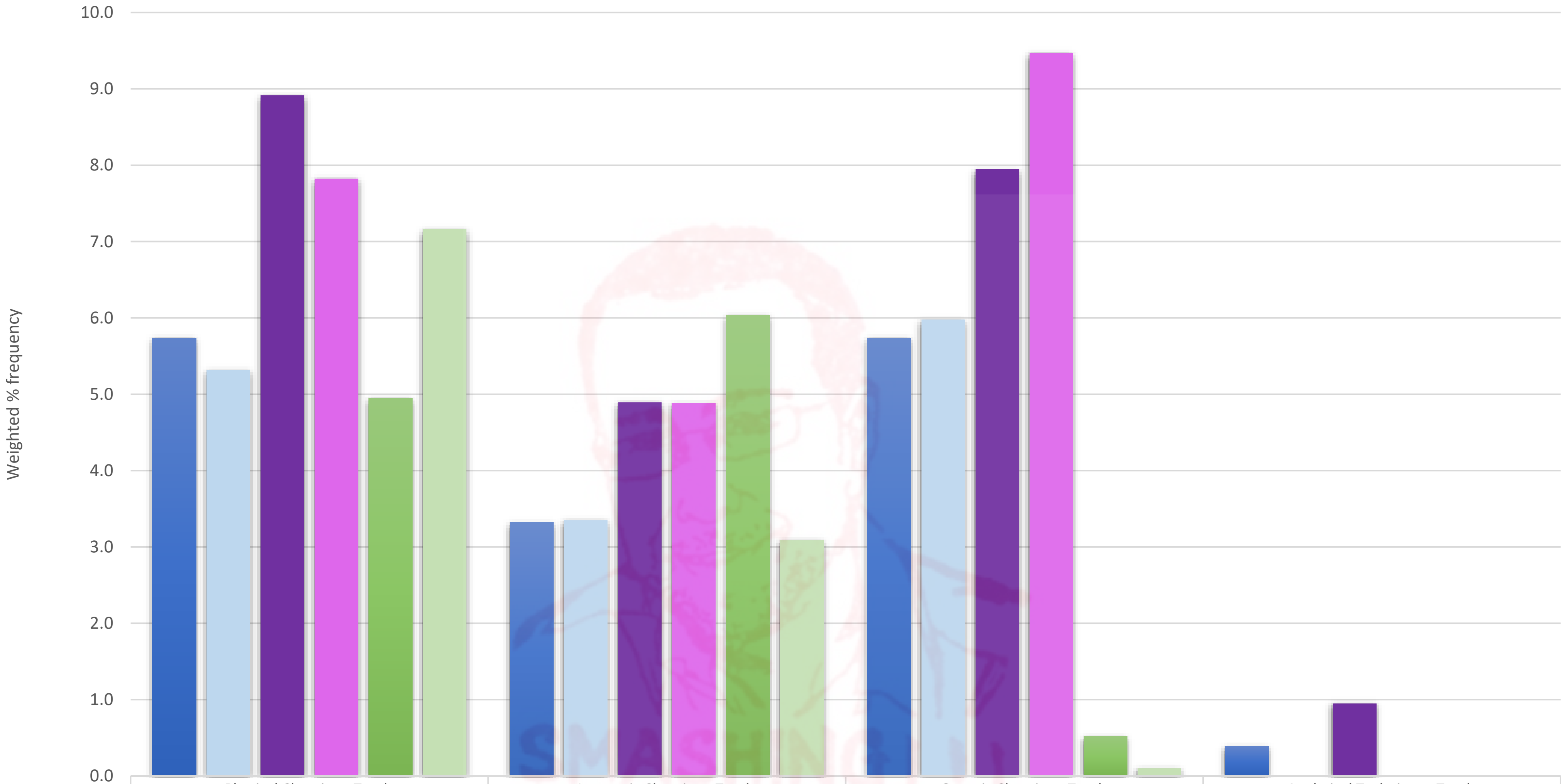
	Grade:	A*	A	B	C	D	E
2020w and later:	Highest Raw % Score	74	65	56	46	37	28
	Lowest Raw % Score	62	54	46	38	30	21
	Variability	12	11	10	9	7	7
	Average Raw % Score	69	59	49	41	32	23

Most courses and almost all universities generally do not explain if they use your UMS/PUM score, with the exception of Cambridge, which always requires you to give your UMS/PUM as additional information when you apply, but not through the UCAS form. They have also created and published a report analysing 14,000 applicants dated July 2015:

https://www.cao.cam.ac.uk/sites/www.cao.cam.ac.uk/files/ar_ums_performance_he_destination_of_cambridge_applicants.pdf

The mean average UMS/PUM score for a successful Cambridge applicant was 92% average (for the best 3 AS level subjects), but that average was about 95% for (natural) science applicants, a bar chart using their statistics follows.

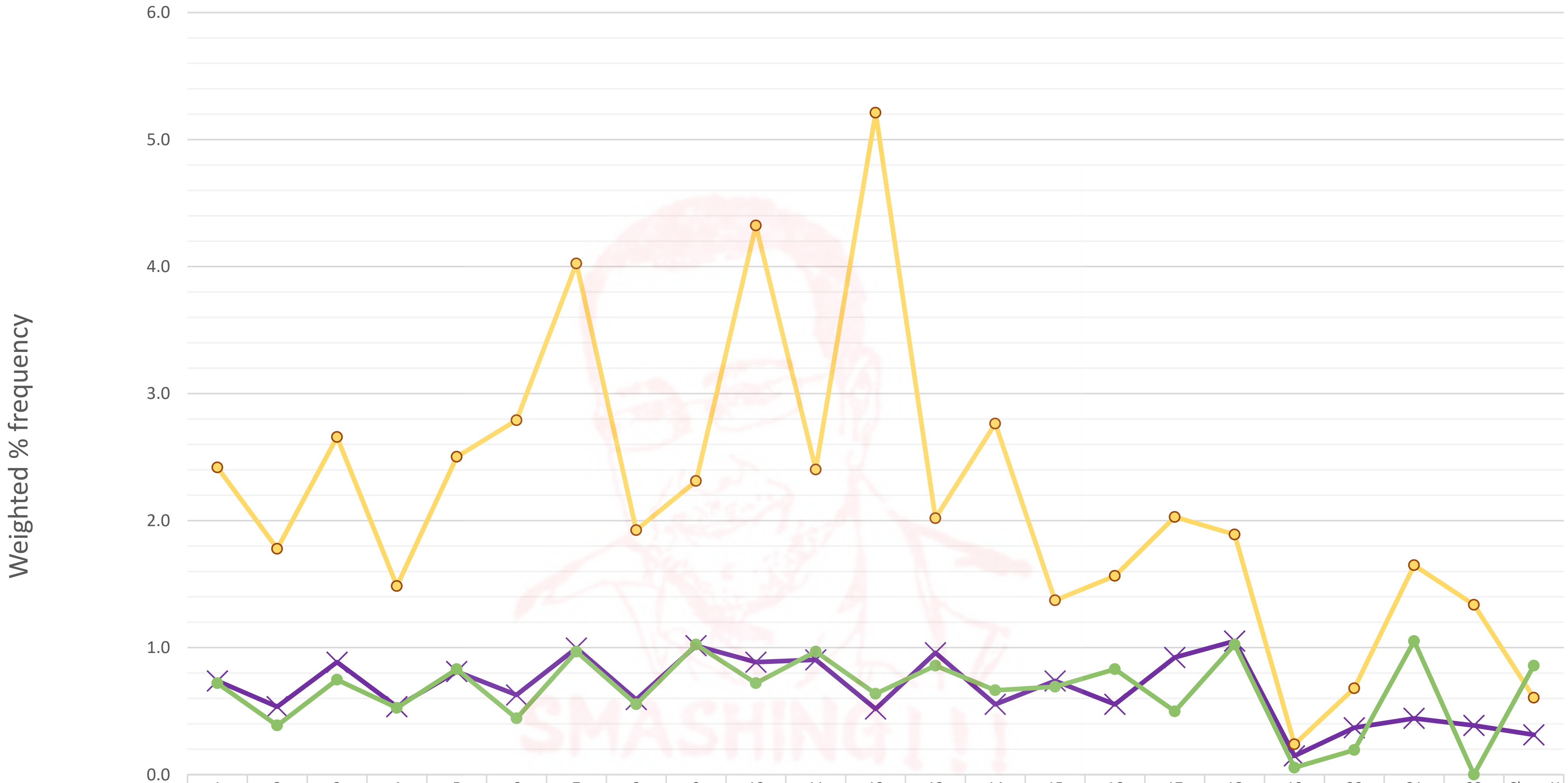
9701 Chemistry Categories Totals Weighted for Papers 1, 2 and 3



	Physical Chemistry Totals	Inorganic Chemistry Totals	Organic Chemistry Totals	Analytical Techniques Totals
P1 16-22 WTD	5.7	3.3	5.7	0.4
P1 9-15 WTD	5.3	3.3	6.0	0.0
P2 16-22 WTD	8.9	4.9	7.9	0.9
P2 9-15 WTD	7.8	4.9	9.5	0.0
P3 16-22 WTD	4.9	6.0	0.5	0.0
P3 9-15 WTD	7.2	3.1	0.1	0.0

9701 Chemistry Weighted Mark Frequency: Paper 1

2022w to 2016m in purple crosses, compared to earlier and all AS exams combined



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Chem X
P1 16-22 WTD	0.7	0.5	0.9	0.5	0.8	0.6	1.0	0.6	1.0	0.9	0.9	0.5	1.0	0.6	0.7	0.6	0.9	1.1	0.1	0.4	0.4	0.4	0.3
P1,2,3 16-22 WTD	2.4	1.8	2.7	1.5	2.5	2.8	4.0	1.9	2.3	4.3	2.4	5.2	2.0	2.8	1.4	1.6	2.0	1.9	0.2	0.7	1.6	1.3	0.6
P1 9-15 WTD	0.7	0.4	0.7	0.5	0.8	0.4	1.0	0.6	1.0	0.7	1.0	0.6	0.9	0.7	0.7	0.8	0.5	1.0	0.1	0.2	1.1	0.0	0.9

Topic Number

9701 Chemistry Weighted Mark Frequency: Paper 2

2022w to 2016m in purple crosses, compared to earlier and all AS exams combined

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Chem X
P2 16-22 WTD	1.7	1.0	1.8	0.9	1.2	0.4	1.2	0.7	1.3	1.3	1.5	0.8	1.1	2.2	0.5	0.9	1.0	0.7	0.1	0.3	1.2	0.9	0.3
P1,2,3 16-22 WTD	2.4	1.8	2.7	1.5	2.5	2.8	4.0	1.9	2.3	4.3	2.4	5.2	2.0	2.8	1.4	1.6	2.0	1.9	0.2	0.7	1.6	1.3	0.6
P2 9-15 WTD	0.9	1.2	1.0	0.4	1.6	0.4	2.1	0.3	1.7	1.1	0.5	1.5	0.5	2.5	0.5	0.5	0.5	0.6	0.0	0.0	4.3	0.0	0.8

Topic Number

Unusual Material in Exam Questions

Sometimes topic boundaries are blurred, for instance reactivity from periodicity and electrochemistry.

For section 1 most of the material mapped to AS with electrolysis in A2 Topic 24 being a notable exception.

Subject boundaries can also feel blurred, but only in very rare case. For instance, basic **trigonometry** is included with some chemistry questions e.g.:

Q# 92/ Cambridge/2022sp/Section 2/ www.SmashingScience.org

19 Bromine trifluoride, BrF_3, is a simple molecular compound containing single bonds only.

It is **not** trigonal planar.

Two of the bond lengths in this molecule are 0.181 nm, and the third is 0.172 nm.

The through-space distances between two fluorine atoms are 0.241 nm or 0.361 nm.

What is the acute bond angle in BrF_3?

A $\sin^{-1}\left(\frac{0.1205}{0.172}\right)$

B $\cos^{-1}\left(\frac{0.1205}{0.172}\right)$

C $\sin^{-1}\left(\frac{0.1205}{0.181}\right)$

D $\cos^{-1}\left(\frac{0.1205}{0.181}\right)$

E $\sin^{-1}\left(\frac{0.172}{0.1805}\right)$

F $\cos^{-1}\left(\frac{0.172}{0.1805}\right)$

G $\sin^{-1}\left(\frac{0.1805}{0.181}\right)$

H $\cos^{-1}\left(\frac{0.1805}{0.181}\right)$

Q# 92/ Cambridge/2022sp/Section 2/ www.SmashingScience.org

19 G

In addition, use of **quadratic equations** is needed for a very small number of equilibrium questions:

From the 2022 to 2024 CAIE A Level Chemistry Syllabus (page 21):

7 use the K_c and K_p expressions to carry out calculations (such calculations will not require the solving of quadratic equations)

A Level Topic # 25x **Q# 264/ Cambridge/2022sp/Section 2/ www.SmashingScience.org**

20 Ethanoic acid, ethanol and water were added to a reaction vessel and a quantity of concentrated sulfuric acid was added. The reaction mixture was then heated and an ester (ethyl ethanoate) and water were formed in equilibrium with the reactants.

$$C_2H_5OH(l) + CH_3COOH(l) \rightleftharpoons CH_3COOC_2H_5(l) + H_2O(l)$$

120 g of ethanoic acid and 92 g of ethanol were used and the mass of water present at the start of the experiment was 18 g. Assume that there is no change in volume.

At the temperature of the reaction, the equilibrium constant K_c is 2.00.

What is the mass of the ester present in the mixture at equilibrium?

(M_r values: ethanoic acid = 60; ethanol = 46; water = 18; ethyl ethanoate = 88)

A 1.00 g

B 53.0 g

C 88.0 g

D 103 g

E 106 g

F 176 g

G 209 g

H 215 g

A Level Topic # 25 Q# 265/ Cambridge/2022/Section 2/ www.SmashingScience.org

48 50 cm^3 of 0.100 mol dm^{-3} hydrochloric acid has a pH of 1.0.

What is the pH of the mixture formed when 450 cm^3 of 0.010 mol dm^{-3} calcium hydroxide solution is added?

A pH = 1.0

B 1.0 < pH < 2.0

C pH = 2.0

D 2.0 < pH < 7.0

E pH = 7.0

F pH > 7.0

Q# 264/ Cambridge/2022sp/Section 2/ www.SmashingScience.org

20 C

20 The answer is option **C**.

	CH_3COOH +	CH_3CH_2OH ⇌	$CH_3COOCH_2CH_3$ +	H_2O
mass at the start	120	92	0	18
M_r	60	46	88	18
number of moles at the start	2	2	0	1
number of moles at equilibrium	$2 - x$	$2 - x$	x	$1 + x$

The equilibrium constant is: $K_c = \dfrac{[CH_3COOCH_2CH_3][H_2O]}{[CH_3COOH][CH_3CH_2OH]}$

Substituting in the number of moles: $K_c = \dfrac{(x)(1+x)}{(2-x)(2-x)} = 2$

Rearranging:

$$x^2 + x = 2(x^2 - 4x + 4)$$

$$x^2 + x = 2x^2 - 8x + 8$$

$$x^2 - 9x + 8 = 0$$

Using the quadratic formula: $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \dfrac{-9 \pm \sqrt{9^2 - 32}}{2}$

or by factorising: $(x - 8)(x - 1) = 0$

$$x = 8 \text{ or } 1$$

A value of 8 is impossible because that would require '–6 mol' of reactants.

At equilibrium there would be just one mole of ester, which has a mass of 88 g.

Understanding and knowledge of **ions tests** is needed for a small proportion of questions. All these questions can be found at the start of this book.

Section 1 Questions

The order when you should complete these questions in:

1. Get really good at AS (and IB) MCQ questions
2. Then try Section 1 questions, if you are really good at these, continue
3. If struggling with Section 1 questions, go back and try again to get really good at AS and IB questions in the same topic
4. If really good a Section 1 questions, complete all of them
5. Make sure your personal statement is finished, or nearly finished
6. Make sure you have started to prepare for the interview by talking in English about chemistry, ideally with a teacher, and ideally with a teacher who has experience helping students with Oxbridge applications
7. Then try Section 2 MCQ questions only, remember they have 180seconds instead of about 90 seconds each
8. If really good at Section 2 MCQs, complete them for all AS topics and A2 Topic 24 and Topic 37 ONLY
9. Finally, complete the short answer questions for all AS topics and A2 Topic 24 and Topic 37 ONLY
10. Complete all Section 1 questions again
11. Complete all Section 2 questions, including the short answer questions for all AS topics and A2 Topic 24 and Topic 37 ONLY again
12. Make sure your personal statement is complete
13. Make sure you are confident and performing well in mock interviews
14. Now you could then try Section 2 questions on topics that will not appear in your ESAT, including the short answer questions on A2 material

Topic ALvl Chem Ions Test Q# 1/ Cambridge/2022/Section 1 www.SmashingScience.org

41 The following pairs of 0.1 mol dm^{-3} solutions are mixed separately in test tubes.

1 $AgNO_3$(aq) with NaI(aq)

2 Cl_2(aq) with NaI(aq)

3 HCl(aq) with NaOH(aq)

4 $MgCl_2$(aq) with NaBr(aq)

Which pair(s) of solutions, when mixed, would produce a visible chemical change?

A 1 only

B 2 only

C 3 only

D 4 only

E 1 and 2 only

F 1 and 3 only

G 2 and 4 only

H 3 and 4 only

Topic **ALvl Chem Ions Test Q# 2/** Cambridge/2021/Section 1 www.SmashingScience.org

47 X is a gaseous element. X can react explosively with hydrogen to produce a single product. When dissolved in water, this product forms an acidic aqueous solution Y. When aqueous silver nitrate is added to solution Y, a white precipitate forms.

Solution Y reacts with substance Z to form two products only. One of these products forms a white precipitate when aqueous sodium hydroxide is added to it.

Which of the following could be X and Z?

	X	*Z*
A	Br_2	$CaCO_3$
B	Br_2	CuO
C	Br_2	Mg
D	Cl_2	$CaCO_3$
E	Cl_2	CuO
F	Cl_2	Mg
G	O_2	$CaCO_3$
H	O_2	Mg

Topic **ALvl Chem Ions Test Q# 3/** Cambridge/2021/Section 1 www.SmashingScience.org

59 A mixture of both sodium nitrate and barium bromide solids, with a combined mass of 6.36 g, was stirred into water and completely dissolved.

An excess of aqueous silver nitrate was added and a precipitate formed. The precipitate was filtered and dried. The mass of dry precipitate was 3.76 g.

What was the mass of sodium nitrate in the original mixture?

(M_r values: $NaNO_3$ = 85; $BaBr_2$ = 297; AgBr = 188)

A 0.42 g

B 0.85 g

C 1.70 g

D 2.97 g

E 3.39 g

F 5.94 g

43 Which of the following tests could be used, on its own, to distinguish between all three of the following white solids: potassium carbonate, calcium chloride and sodium sulfate?

1 Add a small amount of each solid separately to a platinum wire and hold in a colourless flame.

2 Dissolve a small amount of each solid separately in deionised water and add a few drops of sodium hydroxide solution.

3 Dissolve a small amount of each solid separately in deionised water and add a few drops of hydrochloric acid, followed by barium chloride solution.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

52 10 g of a mixture of solid magnesium hydroxide, $Mg(OH)_2$, and solid sodium hydroxide, NaOH, is added to an excess of water and stirred.

One of the components of the mixture dissolves. Assume that the other is completely insoluble.

The mixture is filtered to remove the insoluble component of the mixture.

50 cm^3 of 1.0 mol dm^{-3} sulfuric acid exactly neutralises the remaining solution.

What is the mass of magnesium hydroxide in the original mixture?

(M_r values: $Mg(OH)_2 = 58$; NaOH = 40)

A 2.0 g

B 2.9 g

C 4.0 g

D 5.8 g

E 6.0 g

F 8.0 g

Topic **ALvl Chem Ions Test Q# 6/** Cambridge/2019/Section 1 www.SmashingScience.org

45 X is an anhydrous salt of iron containing one type of cation and one type of anion.

An aqueous solution of X gives a white precipitate when aqueous barium chloride is added in the presence of hydrochloric acid.

On adding aqueous sodium hydroxide to an aqueous solution of X, a brown precipitate formed immediately.

The relative atomic mass of iron is 56, and its atomic number is 26.

What is the relative molar mass of X?

(A_r values: C = 12; N = 14; O = 16; S = 32; Cl = 35.5; Br = 80)

A 127

B 152

C 162.5

D 208

E 264

F 272

G 360

H 400

Topic ALvl Chem 1 Q# 7**/** Cambridge/2024/Chemistry Section/Q#. 2/ www.SmashingScience.org/Practice Test May/

Which one of the following atoms or ions contains the same number of neutrons and electrons as $^{40}_{20}Ca^{2+}$?

- $^{35}_{17}Cl^{-}$
- $^{37}_{17}Cl$
- $^{40}_{18}Ar$
- $^{39}_{19}K^{+}$
- $^{39}_{19}K$

Topic **ALvl Chem 1 Q# 8/** Cambridge/2023/Section 1/Q#. 48/ www.SmashingScience.org/

48 A simple ion of an element has a mass number x, an atomic number $\frac{x-1}{2}$ and a charge of –1.

How many protons, neutrons and electrons are present in this ion?

	protons	*neutrons*	*electrons*
A	$\frac{x-1}{2}$	$\frac{x-1}{2}$	$\frac{x-1}{2}$
B	$\frac{x-1}{2}$	$\frac{x+1}{2}$	$\frac{x+1}{2}$
C	$\frac{x-1}{2}$	$\frac{x+1}{2}$	$\frac{x-1}{2}$
D	$\frac{x-1}{2}$	$\frac{x-1}{2}$	$\frac{x+1}{2}$
E	$\frac{x+1}{2}$	$\frac{x-1}{2}$	$\frac{x+1}{2}$
F	$\frac{x+1}{2}$	$\frac{x-1}{2}$	$\frac{x-1}{2}$

Topic **ALvl Chem 1 Q# 9/** Cambridge/2022/Section 1 www.SmashingScience.org

50 Element Z is in Group 1 of the Periodic Table.

A pure sample of element Z consists of two isotopes with mass numbers 85 and 87, and has a relative atomic mass of 85.5.

Which of the following statements is/are correct about element Z in this sample?

1 Element Z reacts with bromine to form an ionic compound with formula ZBr_2.

2 Element Z forms a basic oxide.

3 More than 70% of the atoms of element Z have mass number 85.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

53 The atomic number of fluorine is 9.

An element X forms a fluoride with the formula XF_3. Each molecule of XF_3 has 32 electrons in total.

Element X has two isotopes. One isotope has the same number of neutrons as protons and the other isotope has a number of neutrons one greater than the number of protons.

The relative abundance of the heavier isotope is 0.80 (80%).

What is the relative atomic mass of element X?

A 5.2

B 5.8

C 10.2

D 10.8

E 14.2

F 14.8

G 16.2

H 16.8

42 Consider the following three ions of calcium observed in mass spectrometry:

$^{40}Ca^{2+}$ $^{42}Ca^{2+}$ $^{43}Ca^{+}$

Which of the following statements is/are correct?

1 All three ions have the electron configuration 2,8,8

2 $^{42}Ca^{2+}$ has more neutrons than $^{40}Ca^{2+}$

3 $^{42}Ca^{2+}$ has more protons than $^{43}Ca^{+}$

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

43 The relative isotopic abundances of a sample of magnesium are shown in the table.

isotope	*percentage abundance*
^{24}Mg	80
^{25}Mg	10
^{26}Mg	10

What is the relative atomic mass (A_r) of the magnesium?

A 24.0

B 24.3

C 24.5

D 24.8

E 25.0

56 An element Z forms an ionic compound ZSO_4 which has M_r = 120.4

The ion of Z in ZSO_4 has 10 electrons.

Element Z has three isotopes, labelled L, M and N, which contain the following numbers of neutrons.

isotope	L	M	N
number of neutrons	12	13	14

The percentage abundances of isotopes M and N are the same.

What is the percentage abundance of the isotope L in the element Z in ZSO_4?

(M_r value: SO_4^{2-} = 96.1)

A 4.10%

B 10.0%

C 13.4%

D 43.3%

E 80.0%

F 91.8%

42 A simple ion of an element with atomic number x has a mass number of $(2x + 2)$.

The ion has a charge of –2.

How many protons, neutrons and electrons are present in this ion?

	protons	*neutrons*	*electrons*
A	$x - 2$	$x + 4$	$x - 2$
B	$x - 2$	$x + 4$	x
C	$x - 2$	$x + 4$	$x + 2$
D	x	$x + 2$	$x - 2$
E	x	$x + 2$	x
F	x	$x + 2$	$x + 2$

Topic **ALvl Chem 1 Q# 15/** Cambridge/2018/Section 1 www.SmashingScience.org

37 Which row in the following table gives the numbers of protons, neutrons and electrons in $^{64}_{29}Cu^{2+}$?

	number of protons	*number of neutrons*	*number of electrons*
A	27	33	27
B	27	35	29
C	29	35	27
D	29	35	29
E	31	33	29
F	31	35	29

Topic **ALvl Chem 1 Q# 16/** Cambridge/2017/Section 1 www.SmashingScience.org

37 Consider the atoms/ions below:

$^{24}_{12}Mg^{2+}$ $^{16}_{8}O^{2-}$ $^{18}_{8}O$ $^{32}_{16}S^{2-}$

Which of the following statements is/are correct?

1 Both $^{16}_{8}O^{2-}$ and $^{24}_{12}Mg^{2+}$ have the same electronic configuration.

2 $^{32}_{16}S^{2-}$ has double the number of neutrons that are in $^{18}_{8}O$.

3 The sum of the numbers of electrons in $^{16}_{8}O^{2-}$ and $^{18}_{8}O$ is equal to the number of electrons in $^{32}_{16}S^{2-}$.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

Topic **ALvl Chem 1 Q# 17/** Cambridge/2017/Section 1 www.SmashingScience.org

54 An atom of $^{1}_{1}H$ has a radius of 0.05 nanometres.

The radius of the nucleus of this atom is approximately 50 000 times smaller.

What is the approximate radius of the nucleus in femtometres?

(1 femtometre = 10^{-15} m)

A 1000

B 100

C 10

D 1

E 0.1

F 0.01

Topic **ALvl Chem 1 Q# 18/** Cambridge/2016/Section 1 www.SmashingScience.org

37 Which one of the following atoms or ions contains the same number of neutrons and electrons as $^{40}_{20}Ca^{2+}$?

A $^{35}_{17}Cl^{-}$

B $^{37}_{17}Cl$

C $^{40}_{18}Ar$

D $^{39}_{19}K^{+}$

E $^{39}_{19}K$

Topic ALvl Chem 2 Q# 19/ Cambridge/2024/Chemistry Section/Q#. 26/ www.SmashingScience.org/Practice Test May/

Complete combustion of 35 cm^3 of a straight-chain alkane vapour gave 105 cm^3 of carbon dioxide gas. Both gas volumes were measured at the same temperature and pressure.

Which of the following is the molecular formula of the alkane?

○ C_2H_4

○ C_2H_6

○ C_3H_6

○ C_3H_8

○ C_4H_{10}

Topic **ALvl Chem 2 Q# 20/** Cambridge/2024/Chemistry Section/Q#. 24/ www.SmashingScience.org/Practice Test May/

The equation summarises the reaction of copper and dilute nitric acid.

$$Cu + r\,HNO_3 \rightarrow Cu(NO_3)_2 + s\,H_2O + t\,NO_2$$

What values of s and t are needed to balance the equation?

	s	t
A	1	1
B	2	1
C	4	1
D	2	2
E	4	2

○ A

○ B

○ C

○ D

○ E

Topic **ALvl Chem 2 Q# 21/** Cambridge/2024/Chemistry Section/Q#. 23/ www.SmashingScience.org/Practice Test May/

A sample of an alkali XOH of mass 2.8 g was dissolved in water.

This solution was neutralised by 12.5 cm^3 of sulfuric acid of concentration 2.0 mol dm^{-3}.

$$2XOH(aq) + H_2SO_4(aq) \rightarrow X_2SO_4(aq) + 2H_2O(l)$$

What is the relative atomic mass of X?

(A_r values: H = 1; O = 16; S = 32)

○ 13

○ 26

○ 39

○ 52

○ 65

○ 78

Topic **ALvl Chem 2 Q# 22/** Cambridge/2024/Chemistry Section/Q#. 20/ www.SmashingScience.org/Practice Test May/

Carbon, in the form of coke, is used to reduce iron oxide in a blast furnace. The three stages are shown below:

1. $C + O_2 \rightarrow CO_2$
2. $CO_2 + C \rightarrow 2CO$
3. $3CO + Fe_2O_3 \rightarrow 2Fe + 3CO_2$

If 12 g of carbon is used in stage 2 and all the carbon monoxide produced is used in stage 3, what mass of carbon dioxide is produced in stage 3?

(A_r values: C = 12; O = 16)

- ○ 17.8 g
- ○ 35.6 g
- ○ 44 g
- ○ 88 g
- ○ 132 g

Topic **ALvl Chem 2 Q# 23/** Cambridge/2024/Chemistry Section/Q#. 16/ www.SmashingScience.org/Practice Test May/

Naturally occurring chlorine is a mixture of two isotopes with mass numbers 35 and 37. The isotope with mass number 35 is three times as common as the isotope with mass number 37.

Naturally occurring bromine is a mixture of two isotopes with mass numbers 79 and 81. They are present in equal amounts.

What fraction of the naturally occurring compound CH_2BrCl has a relative molecular mass of 128?

(A_r values: H = 1; C = 12)

- ○ $\frac{1}{8}$
- ○ $\frac{1}{4}$
- ○ $\frac{3}{8}$
- ○ $\frac{1}{2}$
- ○ $\frac{5}{8}$

Topic **ALvl Chem 2 Q# 24/** Cambridge/2024/Chemistry Section/Q#. 13/ www.SmashingScience.org/Practice Test May/

A compound of iodine and oxygen contains 63.5 g of iodine and 20.0 g of oxygen.

Which one of the following is its empirical formula?

(A_r values: I = 127; O = 16)

- ○ IO
- ○ IO_2
- ○ I_2O
- ○ I_2O_3
- ○ I_2O_5
- ○ I_5O_2

Topic **ALvl Chem 2 Q# 25/** Cambridge/2023/Section 1/Q#. 60/ www.SmashingScience.org/

60 Equal amounts of carbon dioxide and carbon monoxide are produced when 2.0 mol of propanol, C_3H_7OH, are reacted with a limited supply of oxygen. Water is the only other product in this reaction.

How many moles of oxygen molecules are used in this reaction?

A 3.5 mol

B 7.0 mol

C 7.5 mol

D 8.5 mol

E 15 mol

F 17 mol

Topic **ALvl Chem 2 Q# 26/** Cambridge/2023/Section 1/Q#. 59/ www.SmashingScience.org/

59 A sample of aluminium ore (bauxite) contains 75.0% by mass of hydrated aluminium oxide.

Hydrated aluminium oxide is one mole of aluminium oxide combined with two moles of water.

What is the minimum mass of this sample of bauxite that is required to produce 108 tonnes of aluminium?

(1 tonne = 1×10^6 g. A_r values: H = 1; O = 16; Al = 27)

A 184 tonnes

B 207 tonnes

C 272 tonnes

D 276 tonnes

E 368 tonnes

F 421 tonnes

G 592 tonnes

H 736 tonnes

Topic **ALvl Chem 2 Q# 27/** Cambridge/2023/Section 1/Q#. 51/ www.SmashingScience.org/

51 A water treatment unit processes 355 000 dm^3 of drinking water each day.

0.4 mg of chlorine gas is used to kill the bacteria in 1 dm^3 of the source water.

What volume of chlorine gas, if measured at room temperature and pressure, is used each day at the water treatment unit?

(A_r value: Cl = 35.5. Assume that one mole of a gas occupies 24 dm^3 at room temperature and pressure.)

A 6 dm^3

B 12 dm^3

C 48 dm^3

D 96 dm^3

E 300 dm^3

F 600 dm^3

Topic **ALvl Chem 2 Q# 28/** Cambridge/2023/Section 1/Q#. 45/ www.SmashingScience.org/

45 How many moles of ions are present in 20 cm^3 of 0.15 mol dm^{-3} magnesium nitrate solution?

(Ignore ions produced by dissociation of water.)

A 0.003 mol

B 0.006 mol

C 0.009 mol

D 0.018 mol

E 0.133 mol

F 0.400 mol

Topic **ALvl Chem 2 Q# 29/** Cambridge/2022/Section 1 www.SmashingScience.org

55 The equation shows the complete combustion of an alkane.

$$\text{alkane} + aO_2 \rightarrow bCO_2 + cH_2O$$

100 cm^3 of a gaseous alkane requires 650 cm^3 of oxygen for complete combustion. The volumes of both gases were measured at the same temperature and pressure.

What is the value of $a + b + c$?

A 10.5

B 12

C 14

D 15.5

E 17.5

F 19

Topic **ALvl Chem 2 Q# 30/** Cambridge/2022/Section 1 www.SmashingScience.org

58 An oxide of nitrogen can be prepared by the reaction of copper with hot nitric acid.

The other products of the reaction are copper(II) nitrate and water.

0.060 mol of copper reacted exactly with 40.0 cm^3 of 4.00 mol dm^{-3} nitric acid.

What is the empirical formula of the oxide of nitrogen produced in the reaction?

A NO

B NO_2

C NO_3

D N_2O

E N_2O_3

F N_2O_5

Topic **ALvl Chem 2 Q# 31/** Cambridge/2021/Section 1 www.SmashingScience.org

50 Chlorine gas reacts with hot concentrated aqueous sodium hydroxide to form sodium chloride, sodium chlorate(V) and water.

The **unbalanced** ionic equation for this reaction is:

$$u\mathrm{Cl_2} + v\mathrm{OH^-} \rightarrow w\mathrm{Cl^-} + x\mathrm{ClO_3^-} + y\mathrm{H_2O}$$

What is the simplest ratio of $w:x$ in the balanced equation?

A 1 : 1

B 1 : 2

C 2 : 1

D 1 : 5

E 5 : 1

F 1 : 7

G 7 : 1

52 A reaction between copper and nitric acid produces a blue solution of copper(II) nitrate, water and substance X only.

Substance X does not contain copper or hydrogen.

The balanced equation for the reaction shows that 1 mole of copper reacts to produce 2 moles of water.

What is the identity of substance X?

A N_2

B NO

C NO_2

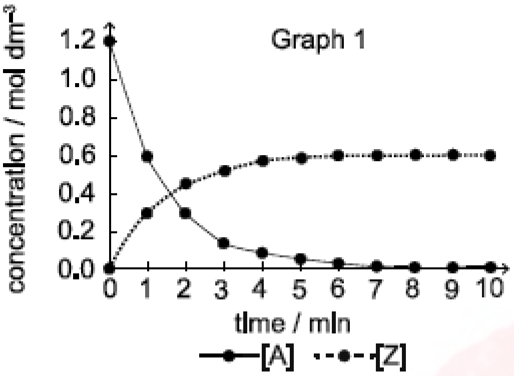
D NO_3

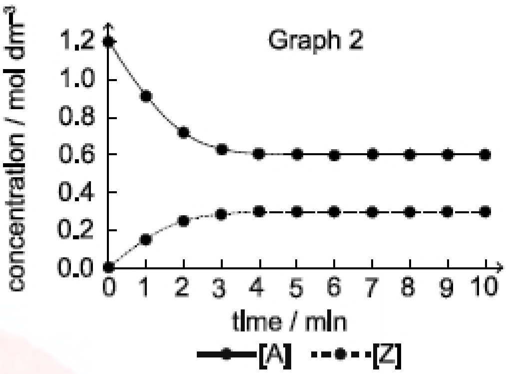
E N_2O_5

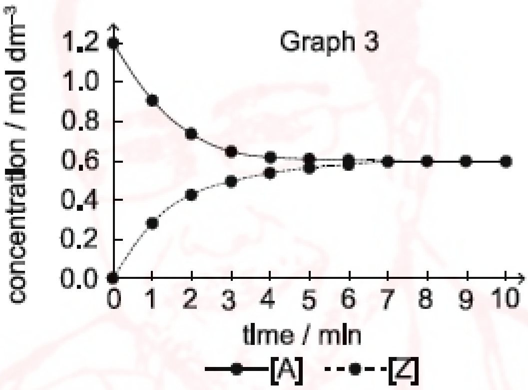
44 Chemicals A and B react to form products Y and Z. The reaction goes to completion. The equation for the reaction is:

$$2A(aq) + B(aq) \rightarrow Y(aq) + Z(aq)$$

Equimolar samples of A and B were mixed and the concentrations of A and Z were measured over time. Which of the following graphs could represent this reaction?







A Graph 1 only

B Graph 2 only

C Graph 3 only

D Graphs 1 and 2 only

E Graphs 2 and 3 only

Topic **ALvl Chem 2 Q# 34/** Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org

45 An oxide of iron has the formula Fe_3O_4 and contains both Fe^{2+} and Fe^{3+} ions.

Which one of the following is the fraction of iron ions that are in the Fe^{2+} state?

A $\frac{1}{4}$

B $\frac{1}{3}$

C $\frac{1}{2}$

D $\frac{2}{3}$

E $\frac{3}{4}$

Topic **ALvl Chem 2 Q# 35/** Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org

49 What volume of water vapour measured at room temperature and pressure would be produced from an ice cube of mass 6.00 g if it all evaporated?

(A_r values: H = 1; O = 16. Molar volume of a gas at room temperature and pressure = 24 dm^3)

A 240 cm^3

B 1800 cm^3

C 4800 cm^3

D 8000 cm^3

E 24 000 cm^3

Topic **ALvl Chem 2 Q# 36/** Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org

50 A compound of iodine and oxygen contains 63.5 g of iodine and 20.0 g of oxygen.

Which one of the following is its empirical formula?

(A_r values: I = 127; O = 16)

A IO

B IO_2

C I_2O

D I_2O_3

E I_2O_5

F I_5O_2

Topic **ALvl Chem 2 Q# 37/** Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org

52 Naturally occurring chlorine is a mixture of two isotopes with mass number 35 and 37. The isotope with mass number 35 is three times as common as the isotope with mass number 37.

Naturally occurring bromine is a mixture of two isotopes with mass numbers 79 and 81. They are present in equal amounts.

What fraction of the naturally occurring compound CH_2BrCl has a relative molecular mass of 128?

(A_r values: H = 1; C = 12)

A $\frac{1}{8}$

B $\frac{1}{4}$

C $\frac{3}{8}$

D $\frac{1}{2}$

E $\frac{5}{8}$

Topic **ALvl Chem 2 Q# 38/** Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org

54 Carbon, in the form of coke, is used to reduce iron oxide in a blast furnace. The three stages are shown below:

1 $C + O_2 \rightarrow CO_2$

2 $CO_2 + C \rightarrow 2CO$

3 $3CO + Fe_2O_3 \rightarrow 2Fe + 3CO_2$

If 12 g of carbon is used in stage 2 and all the carbon monoxide produced is used in stage 3, what mass of carbon dioxide is produced in stage 3?

(A_r values: C = 12; O = 16)

A 17.8 g

B 35.6 g

C 44 g

D 88 g

E 132 g

56 An impure sample of sodium hydroxide has a mass of 1.20 g. All the sodium hydroxide completely reacts with a minimum of 50.0 cm^3 of 0.50 mol dm^{-3} hydrochloric acid.

What is the percentage purity of the sodium hydroxide sample?

(A_r values: H = 1; O = 16; Na = 23; Cl = 35.5)

A 37.5%

B 41.6%

C 72.7%

D 75.0%

E 83.3%

F 90.4%

57 A sample of an alkali XOH of mass 2.8 g was dissolved in water.

This solution was neutralised by 12.5 cm^3 of sulfuric acid of concentration 2.0 mol dm^{-3}.

$$2XOH(aq) + H_2SO_4(aq) \rightarrow X_2SO_4(aq) + 2H_2O(l)$$

What is the relative atomic mass of X?

(A_r values: H = 1; O = 16; S = 32)

A 13

B 26

C 39

D 52

E 65

F 78

58 The equation summarises the reaction of copper and dilute nitric acid.

$$Cu + r\,HNO_3 \rightarrow Cu(NO_3)_2 + s\,H_2O + t\,NO_2$$

What values of *s* and *t* are needed to balance the equation?

	s	*t*
A	1	1
B	2	1
C	4	1
D	2	2
E	4	2

59 Complete combustion of 35 cm^3 of a straight-chain alkane vapour gave 105 cm^3 of carbon dioxide gas. Both gas volumes were measured at the same temperature and pressure.

Which of the following is the molecular formula of the alkane?

A C_2H_4

B C_2H_6

C C_3H_6

D C_3H_8

E C_4H_{10}

Topic **ALvl Chem 2 Q# 43/** Cambridge/2020/Section 1 www.SmashingScience.org

44 Molecule J is a straight-chain hydrocarbon containing one carbon-carbon double bond.

The relative atomic mass (A_r) of hydrogen is 1 and carbon is 12.

What is the **minimum** additional information that is needed in order to determine the molecular formula of molecule J?

1 The percentage by mass of carbon in the molecule.

2 The percentage by mass of hydrogen in the molecule.

3 The relative molar mass (M_r) of the molecule.

A 1 only

B 3 only

C 1 and 2 only

D 1 and 3 only

E 1, 2 and 3

Topic **ALvl Chem 2 Q# 44/** Cambridge/2020/Section 1 www.SmashingScience.org

45 Iodic acid, HIO_3, can be made from iodine in the following reaction:

$$I_2 + wH_2O + xCl_2 \rightarrow yHIO_3 + zHCl$$

What is the value of x when the equation is balanced?

A 1

B 2

C 3

D 4

E 5

F 6

Topic **ALvl Chem 2 Q# 45/** Cambridge/2020/Section 1 www.SmashingScience.org

46 Which one of the following formulae is correct for the compound given?

A aluminium sulfate, $Al(SO_4)_3$

B ammonium carbonate, $(NH_4)_2CO_3$

C calcium hydroxide, CaOH

D magnesium nitrate, $MgNO_3$

E potassium bromide, KBr_2

55 Complete combustion of 1 mol of hydrocarbon X requires exactly 8.5 mol of oxygen.

Incomplete combustion of 1 mol of hydrocarbon X, to form carbon monoxide and water only, requires exactly 5.5 mol of oxygen.

How many hydrogen atoms are there in one molecule of hydrocarbon X?

A 6

B 8

C 10

D 12

E 14

Topic **ALvl Chem 2 Q# 47/** Cambridge/2020/Section 1 www.SmashingScience.org

57 An experiment is carried out using the first three metals in Group 1: lithium, sodium and potassium.

The initial masses of three open beakers each containing 100 g samples of an alcohol are recorded.

In three separate experiments, equal small masses of lithium, sodium and potassium are added to the three beakers, which are on electronic balances.

Each metal reacts in a similar way and after the reaction is complete, the final mass of each beaker and its contents is recorded.

In each case, the final mass of the beaker and its contents is compared to the recorded initial mass before the alkali metal was added.

Which of the following statements is correct?

A The beaker with lithium added would decrease in mass the most.

B The beaker with sodium added would decrease in mass the most.

C The beaker with potassium added would decrease in mass the most.

D All three beakers would show the same decrease in mass.

E The beaker with lithium added would increase in mass the most.

F The beaker with sodium added would increase in mass the most.

G The beaker with potassium added would increase in mass the most.

H All three beakers would show the same increase in mass.

Topic **ALvl Chem 2 Q# 48/** Cambridge/2019/Section 1 www.SmashingScience.org

43 A 116 g sample of an oxide of iron contains 84 g of iron.

Which of the following is the empirical formula of this oxide of iron?

(A_r values: O = 16; Fe = 56)

A FeO

B Fe_2O_2

C Fe_3O_2

D Fe_2O_3

E Fe_3O_4

Topic **ALvl Chem 2 Q# 49/** Cambridge/2019/Section 1 www.SmashingScience.org

47 0.005 mol of a chloride of element X was dissolved in water and then reacted with excess silve nitrate solution to form a precipitate of silver chloride, AgCl. This precipitate is the only product of this reaction that contains chlorine.

After filtering, washing and drying, the mass of the precipitate was recorded to be 1.435 g.

Which of the following could be the formula of the chloride of X?

(M_r value: AgCl = 143.5)

A X_5Cl

B X_2Cl

C XCl

D XCl_2

E XCl_5

Topic **ALvl Chem 2 Q# 50/** Cambridge/2019/Section 1 www.SmashingScience.org

48 A chemical equation that represents the reaction of phosphorus with concentrated nitric acid is:

$$P_4 + w\,HNO_3 + H_2O \rightarrow x\,H_3PO_4 + y\,NO + z\,NO_2$$

What is the value of the sum $w + x + y + z$?

A 24

B 28

C 30

D 32

E 36

Topic **ALvl Chem 2 Q# 51/** Cambridge/2019/Section 1 www.SmashingScience.org

52 3.4 g of an impure sample of silicon tetrachloride is reacted with water. The mixture is then filtered and the resulting solution made up to 250 cm^3.

$$SiCl_4(l) + 2H_2O(l) \rightarrow SiO_2(s) + 4HCl(aq)$$

12.5 cm^3 of this solution is neutralised exactly by 20.0 cm^3 of 0.100 mol dm^{-3} sodium hydroxide.

What is the percentage purity of the silicon tetrachloride?

(M_r value: $SiCl_4$ = 170. Assume that the impurity does not react.)

A 1.7%

B 2.5%

C 10%

D 32%

E 50%

Topic **ALvl Chem 2 Q# 52/** Cambridge/2018/Section 1 www.SmashingScience.org

47 A student calculated the mass of anhydrous copper(II) sulfate ($CuSO_4$) required to make 250 cm^3 of an aqueous solution of concentration 0.200 mol dm^{-3}.

However, the student mistakenly made the solution using the same mass of hydrated copper(II) sulfate ($CuSO_4 \cdot 5H_2O$) instead.

What is the concentration, in mol dm^{-3}, of the solution made with the hydrated copper(II) sulfate?

(A_r values: Cu = 64; S = 32; O = 16; H = 1.0)

A 0.128 mol dm^{-3}

B 0.160 mol dm^{-3}

C 0.180 mol dm^{-3}

D 0.200 mol dm^{-3}

E 0.223 mol dm^{-3}

F 0.313 mol dm^{-3}

Topic **ALvl Chem 2 Q# 53/** Cambridge/2018/Section 1 www.SmashingScience.org

51 Copper can react with concentrated nitric acid to form the gas nitrogen monoxide.

$$3Cu + a\,HNO_3 \rightarrow b\,Cu(NO_3)_2 + c\,H_2O + d\,NO$$

What is the value of a when the equation is balanced?

A 6

B 7

C 8

D 9

E 10

F 11

G 12

Topic **ALvl Chem 2 Q# 54/** Cambridge/2018/Section 1 www.SmashingScience.org

52 A small amount of a solid mixture, containing calcium carbonate and an inert substance, was added to 50.00 cm^3 dilute hydrochloric acid of concentration 0.1000 mol dm^{-3}.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

After all of the calcium carbonate had reacted, the solution was heated to drive off the carbon dioxide.

The resulting solution was neutralised by 12.50 cm^3 of 0.1000 mol dm^{-3} sodium hydroxide solution.

What was the mass of calcium carbonate in the mixture added to the hydrochloric acid?

(M_r value: $CaCO_3$ = 100.0)

A 0.06250 g

B 0.1250 g

C 0.1875 g

D 0.3750 g

E 0.6250 g

F 0.7500 g

Topic **ALvl Chem 2 Q# 55/** Cambridge/2018/Section 1 www.SmashingScience.org

53 2.80 g of lithium metal is placed in a closed system with 1.20 dm^3 of pure oxygen gas (volume measured at room temperature and pressure).

If a complete reaction occurs between the lithium and the oxygen, what is the maximum mass of lithium oxide that can be formed?

(A_r values: Li = 7; O = 16. Assume that one mole of gas occupies 24.0 dm^3 at room temperature and pressure.)

A 1.50 g

B 3.00 g

C 3.90 g

D 4.60 g

E 6.00 g

F 12.0 g

G 15.6 g

Topic **ALvl Chem 2 Q# 56/** Cambridge/2017/Section 1 www.SmashingScience.org

46 A fluorocarbon has a relative molecular mass which is twice that of its empirical formula mass

81 g of the compound contains 57 g of fluorine.

What is the molecular formula of the compound?

(A_r values: C = 12; F = 19)

A C_2F_3

B C_2F_5

C C_3F_6

D C_3F_8

E C_4F_6

F C_4F_{10}

Topic **ALvl Chem 2 Q# 57/** Cambridge/2017/Section 1 www.SmashingScience.org

47 In which of the following reactions is there a change in volume of 24 dm^3, when measured at room temperature and pressure?

1 56 g of carbon monoxide completely reacts with an excess of oxygen
$2CO(g) + O_2(g) \rightarrow 2CO_2(g)$

2 36 g of steam is fully decomposed
$2H_2O(g) \rightarrow 2H_2(g) + O_2(g)$

3 30 g of nitrogen monoxide completely reacts with an excess of oxygen
$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$

(A_r values: C = 12; O = 16; H = 1.0; N = 14. Assume that one mole of gas occupies a volume of 24 dm^3 at room temperature and pressure.)

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

Topic **ALvl Chem 2 Q# 58/** Cambridge/2017/Section 1 www.SmashingScience.org

52 Natural samples of copper contain two isotopes: ^{63}Cu which has a relative isotopic mass of 62.93, and ^{65}Cu which has a relative isotopic mass of 64.93.

The relative atomic mass of a sample of elemental copper is 63.55.

What is the percentage abundance of each of the two isotopes to the nearest whole number?

A 27% ^{63}Cu and 73% ^{65}Cu

B 73% ^{63}Cu and 27% ^{65}Cu

C 31% ^{63}Cu and 69% ^{65}Cu

D 69% ^{63}Cu and 31% ^{65}Cu

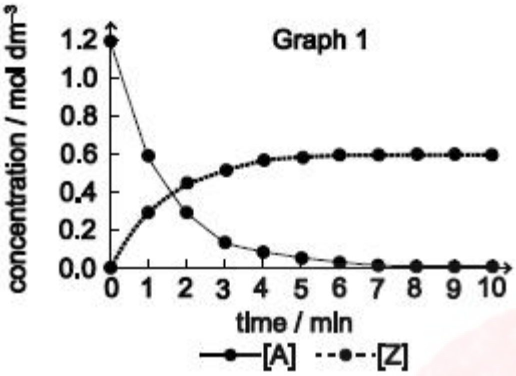
E 36% ^{63}Cu and 64% ^{65}Cu

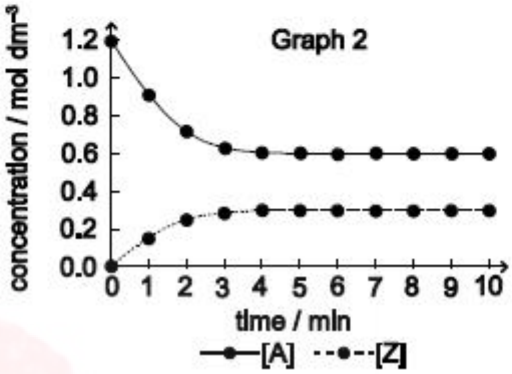
F 64% ^{63}Cu and 36% ^{65}Cu

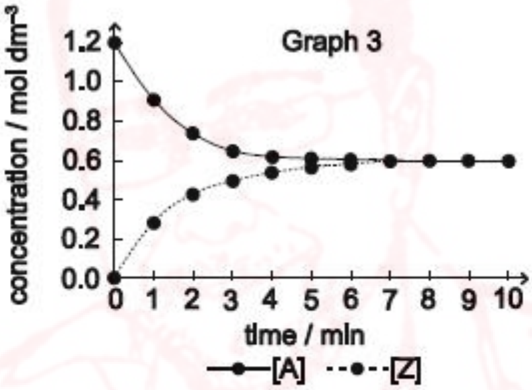
40 Chemicals A and B react to form products Y and Z. The reaction goes to completion. The equation for the reaction is:

$$2A(aq) + B(aq) \rightarrow Y(aq) + Z(aq)$$

Equimolar samples of A and B were mixed and the concentrations of A and Z were measured over time. Which of the following graphs could represent this reaction?







A Graph 1 only

B Graph 2 only

C Graph 3 only

D Graphs 1 and 2 only

E Graphs 2 and 3 only

Topic **ALvl Chem 2 Q# 60/** Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

41 An oxide of iron has the formula Fe_3O_4 and contains both Fe^{2+} and Fe^{3+} ions.

Which one of the following is the fraction of iron ions that are in the Fe^{2+} state?

A $\frac{1}{4}$

B $\frac{1}{3}$

C $\frac{1}{2}$

D $\frac{2}{3}$

E $\frac{3}{4}$

Topic **ALvl Chem 2 Q# 61/** Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

45 What volume of water vapour measured at room temperature and pressure would be produced from an ice cube of mass 6.00 g if it all evaporated?

(A_r: H = 1; O = 16, molar volume of a gas at room temperature and pressure = 24 dm^3)

A 240 cm^3

B 1800 cm^3

C 4800 cm^3

D 8000 cm^3

E 24 000 cm^3

Topic **ALvl Chem 2 Q# 62/** Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

46 A compound of iodine and oxygen contains 63.5 g of iodine and 20.0 g of oxygen.

Which one of the following is its empirical formula?

(A_r: I = 127; O = 16)

A IO

B IO_2

C I_2O

D I_2O_3

E I_2O_5

F I_5O_2

50 Carbon, in the form of coke, is used to reduce iron oxide in a blast furnace. The three stages are shown below:

1 $C + O_2 \rightarrow CO_2$

2 $CO_2 + C \rightarrow 2CO$

3 $3CO + Fe_2O_3 \rightarrow 2Fe + 3CO_2$

If 12 g of carbon is used in stage 2 and all the carbon monoxide produced is used in stage 3, what mass of carbon dioxide is produced in stage 3?

(A_r: C = 12; O = 16)

A 17.8 g

B 35.6 g

C 44 g

D 88 g

E 132 g

52 An impure sample of sodium hydroxide has a mass of 1.20 g. All the sodium hydroxide completely reacts with a minimum of 50.0 cm^3 of 0.50 mol dm^{-3} hydrochloric acid.

What is the percentage purity of the sodium hydroxide sample?

(A_r: H = 1; O = 16; Na = 23; Cl = 35.5)

A 37.5%

B 41.6%

C 72.7%

D 75.0%

E 83.3%

F 90.4%

Topic **ALvl Chem 2 Q# 65/** Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

53 A sample of an alkali XOH of mass 2.8 g was dissolved in water.

This solution was neutralised by 12.5 cm^3 of sulfuric acid of concentration 2.0 mol dm^{-3}.

$$2XOH(aq) + H_2SO_4(aq) \rightarrow X_2SO_4(aq) + 2H_2O(l)$$

What is the relative atomic mass of X?

(A_r: H = 1; O = 16; S = 32)

A 13

B 26

C 39

D 52

E 65

F 78

Topic **ALvl Chem 2 Q# 66/** Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

54 The equation summarises the reaction of copper and dilute nitric acid.

$$Cu + \boldsymbol{r}HNO_3 \rightarrow Cu(NO_3)_2 + \boldsymbol{s}H_2O + \boldsymbol{t}NO_2$$

What values of ***s*** and ***t*** are needed to balance the equation?

	s	***t***
A	1	1
B	2	1
C	4	1
D	2	2
E	4	2

41 Several oxides of bromine have been identified. Analysis of 2.4 g of one of these compounds showed it to contain 1.6 g of bromine.

What is the empirical formula of this compound?

(A_r: bromine = 80; oxygen = 16)

A Br_2O

B BrO_2

C Br_2O_5

D Br_5O_2

E Br_4O_5

F Br_5O_4

42 The most common ion of antimony, Sb^{3+}, has 48 electrons.

Antimony has two isotopes. One isotope has 70 neutrons and has an abundance of 60%. The second isotope has 72 neutrons and has an abundance of 40%.

What is the relative atomic mass of antimony?

A 70.8

B 71.0

C 71.2

D 121.8

E 122.0

F 122.2

46 Copper, Cu, reacts with concentrated nitric acid, HNO_3, to produce a solution of copper(II) nitrate, water and compound X.

Compound X does not contain copper or hydrogen.

The balanced equation for the reaction shows 3 moles of copper reacting with HNO_3 to produce 4 moles of water.

What is the identity of compound X?

A NO

B NO_2

C NO_3

D N_2O_5

E N_2O_8

50 A 1.50 g sample of impure anhydrous sodium carbonate was added to 100 cm^3 of excess dilute hydrochloric acid. The impurity is unreactive.

The volume of gas released was 240 cm^3 at room temperature and pressure.

What is the mass of the impurity?

(A_r: Na = 23; C = 12; O = 16; molar gas volume = 24 000 cm^3 at room temperature and pressure)

A 0.44 g

B 0.53 g

C 0.67 g

D 0.83 g

E 0.97 g

F 1.06 g

Topic **ALvl Chem 2 Q# 71/** Cambridge/2016/Section 1 www.SmashingScience.org

51 0.35 g of lithium metal reacts with excess water at room temperature. Any gas produced in the reaction is collected and its volume measured at room temperature and pressure.

Assuming 1 mole of gas occupies 24.0 dm^3 at room temperature and pressure, what is the volume of gas collected?

(A_r: Li = 7)

A 0.00 cm^3

B 0.60 cm^3

C 1.20 cm^3

D 25.0 cm^3

E 50.0 cm^3

F 600 cm^3

G 1200 cm^3

Topic **ALvl Chem 2 Q# 72/** Cambridge/2016/Section 1 www.SmashingScience.org

52 Sodium sulfate was prepared by neutralising 25.0 cm^3 of 0.1 mol dm^{-3} sodium hydroxide with exactly 50.0 cm^3 of sulfuric acid.

What is the concentration of the sulfuric acid in g dm^{-3}?

(M_r: H_2SO_4 = 98)

A 0.025 g dm^{-3}

B 0.050 g dm^{-3}

C 0.250 g dm^{-3}

D 2.45 g dm^{-3}

E 4.90 g dm^{-3}

F 9.80 g dm^{-3}

Topic ALvl Chem 3 Q# 73/ Cambridge/2022/Section 1 www.SmashingScience.org

43 Consider the following properties of compound X:

melting point	–114 °C
boiling point	–85 °C
conductivity as a solid	poor
conductivity as a liquid	poor
conductivity in aqueous solution	good

Which one of the following could be the identity of compound X?

A ammonium chloride, NH_4Cl

B barium chloride, $BaCl_2$

C hydrogen chloride, HCl

D potassium chloride, KCl

E tetrachloromethane, CCl_4

Topic **ALvl Chem 3 Q# 74/** Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org

43 Which substance (**A**-**E**) in the table could have a giant covalent structure?

substance	*melting point* / °C	*boiling point* / °C	*electrical conductivity*	
			when solid	*when molten*
A	1700	2200	none	none
B	800	1470	none	good
C	98	880	good	good
D	–20	58	none	none
E	–39	357	good	good

38 In which of the following solids does the bonding consist of single covalent bonds **only**?

1 graphite

2 SiO_2

3 Al_2O_3

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

39 Which substance (A–E) in the table could have a giant covalent structure?

substance	*melting point / °C*	*boiling point / °C*	*electrical conductivity*	
			when solid	*when molten*
A	1700	2200	none	none
B	800	1470	none	good
C	98	880	good	good
D	−20	58	none	none
E	−39	357	good	good

Topic ALvl Chem 4 Q# 77/ Cambridge/2024/Chemistry Section/Q#. 4/ www.SmashingScience.org/Practice Test May/

Which substance (**A-E**) in the table could have a giant covalent structure?

substance	*melting point / °C*	*boiling point / °C*	*electrical conductivity*	
			when solid	*when molten*
A	1700	2200	none	none
B	800	1470	none	good
C	98	880	good	good
D	–20	58	none	none
E	–39	357	good	good

○ A

○ B

○ C

○ D

○ E

Topic **ALvl Chem 4 Q# 78/** Cambridge/2024/Chemistry Section/Q#. 18/ www.SmashingScience.org/Practice Test May/

A mixture of equal parts of hexane (bp 68 °C) and heptane (bp 98 °C) is distilled using a fractionating column.

The temperature of the liquid in the flask and the temperature at the top of the fractionating column are measured.

Which one of the following shows the likely temperatures when the first drops of distillate are collected?

	temperature in flask / °C	*temperature at top of column / °C*
A	83	68
B	98	68
C	83	83
D	98	83
E	98	98

○ A

○ B

○ C

○ D

○ E

Topic **ALvl Chem 4 Q# 79/** Cambridge/2024/Chemistry Section/Q#. 12/ www.SmashingScience.org/Practice Test May/

What volume of water vapour measured at room temperature and pressure would be produced from an ice cube of mass 6.00 g if it all evaporated?

(A_r values: H = 1; O = 16. Molar volume of a gas at room temperature and pressure = 24 dm^3)

- ○ 240 cm^3
- ○ 1800 cm^3
- ○ 4800 cm^3
- ○ 8000 cm^3
- ○ 24 000 cm^3

Topic **ALvl Chem 4 Q# 80/** Cambridge/2023/Section 1/Q#. 46/ www.SmashingScience.org/

46 Silicon is directly below carbon in the Periodic Table and has a melting point of 1414 °C.

Which of the following statements explains why silicon has a high melting point?

A It forms ions with a charge of 4+.

B Its structure is a giant ionic lattice.

C It has a strong attraction between positive nuclei and delocalised electrons.

D It has strong intermolecular forces.

E Covalent bonds are broken on melting.

52 A typical sample of dry air is at room temperature and pressure. There is a total of 25.0 mol of gas in this sample.

One of the gases in the sample, X, contributes 1.50×10^{23} separate particles to the mixture.

A second gas in the sample, Y, would, if alone, occupy a volume of 468 dm^3 at room temperature and pressure.

What are the identities of gases X and Y, and what would be the total amount of all of the remaining gases in the sample?

(Take Avogadro's number as 6.00×10^{23}. Assume that one mole of any gas occupies a volume of 24.0 dm^3 at room temperature and pressure.)

	identity of gas X	*identity of gas Y*	*total amount of all of the remaining gases in the sample in moles*
A	Ar	N_2	5.250 mol
B	O_2	N_2	5.250 mol
C	O_2	Ar	5.250 mol
D	Ar	O_2	5.375 mol
E	Ar	N_2	5.375 mol
F	O_2	N_2	5.375 mol

60 Airbags in cars contain sodium azide (NaN_3) as a primary reagent, and potassium nitrate (KNO_3) as a secondary reagent.

The sodium azide decomposes according to the following equation to form nitrogen gas, which rapidly fills the airbag:

$$2NaN_3 \rightarrow 2Na + 3N_2$$

The sodium by-product of this first reaction then reacts with excess potassium nitrate according to this second equation:

$$10Na + 2KNO_3 \rightarrow K_2O + 5Na_2O + N_2$$

Assume that both reactions go to completion.

An airbag contains 130 g of sodium azide.

What is the total volume of nitrogen gas formed in this airbag, measured at room temperature and pressure?

(A_r values: N = 14.0; Na = 23.0. Assume that one mole of gas occupies 24.0 dm^3 at room temperature and pressure.)

A 72.0 dm^3

B 76.8 dm^3

C 84.0 dm^3

D 89.6 dm^3

E 96.0 dm^3

F 112 dm^3

G 120 dm^3

H 140 dm^3

56 The balanced equation for an oxidation of ammonia is:

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$$

50.0 dm^3 of ammonia and 50.0 dm^3 of oxygen, both at 850 °C and 1 atmosphere pressure, are mixed and allowed to react to form the products shown in the equation. No other reactions occur.

What is the maximum total volume of gases (at 850 °C and 1 atmosphere pressure) after the reaction?

(Assume that all gases have the same volume at the given temperature and pressure.)

A 100 dm^3

B 110 dm^3

C 111 dm^3

D 125 dm^3

E 200 dm^3

53 A mixture of equal parts of hexane (bp 68 °C) and heptane (bp 98 °C) is distilled using a fractionating column.

The temperature of the liquid in the flask and the temperature at the top of the fractionating column are measured.

Which one of the following shows the likely temperatures when the first drops of distillate are collected?

	temperature in flask / °C	*temperature at top of column* / °C
A	83	68
B	98	68
C	83	83
D	98	83
E	98	98

51 100 cm^3 of ethane is mixed with 1400 cm^3 of oxygen and the mixture is ignited.

All volumes are measured at atmospheric pressure and a temperature of 150 °C.

What will be the **total** volume of gas after the complete combustion?

(Assume that equal amounts of any gas at the same temperature and pressure occupy the same volume.)

A 500 cm^3

B 1250 cm^3

C 1500 cm^3

D 1550 cm^3

E 1700 cm^3

F 2000 cm^3

41 Use the following data table to answer the question.

gas	*melting point* / °C	*boiling point* / °C
hydrogen	–259	–253
nitrogen	–210	–196
oxygen	–219	–183
neon	–249	–246
argon	–189	–186

Water and carbon dioxide were removed from a sample of air and the remaining mixture was cooled to –260 °C.

The three most abundant remaining elements are to be separated by fractional distillation.

In which order would these three elements be collected?

A hydrogen, neon, nitrogen

B hydrogen, neon, oxygen

C neon, nitrogen, argon

D neon, nitrogen, oxygen

E nitrogen, argon, oxygen

F nitrogen, oxygen, argon

G oxygen, nitrogen, argon

H oxygen, argon, nitrogen

Topic **ALvl Chem 4 Q# 87/** Cambridge/2019/Section 1 www.SmashingScience.org

50 A technician needs to separate three liquids (X, Y and Z) which have been accidentally mixed together. None of the liquids react with each other.

liquid	X	Y	Z
boiling point / °C	65	51	100
density / $g\,cm^{-3}$	0.79	0.68	1.00

X and Z are miscible, but Y is immiscible with both X and Z.

The technician uses a separating funnel to separate the upper and lower layers of the mixture.

What should the technician do next to maximise separation of the three liquids?

A distil the lower layer at 51 °C

B distil the lower layer at 65 °C

C distil the lower layer at 100 °C

D distil the upper layer at 51 °C

E distil the upper layer at 65 °C

F distil the upper layer at 100 °C

Topic **ALvl Chem 4 Q# 88/** Cambridge/2018/Section 1 www.SmashingScience.org

41 The gases nitrogen, oxygen and argon can be separated from liquefied air by fractional distillation.

Given the data in the table, in which order would the gases be collected?

	melting point / °C	*boiling point* / °C
nitrogen	–210	–196
oxygen	–218	–183
argon	–189	–186

A nitrogen, oxygen, argon

B nitrogen, argon, oxygen

C oxygen, nitrogen, argon

D oxygen, argon, nitrogen

E argon, nitrogen, oxygen

F argon, oxygen, nitrogen

Topic **ALvl Chem 4 Q# 89/** Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

49 A mixture of equal parts of hexane (bp 68 °C) and heptane (bp 98 °C) is distilled using a fractionating column.

The temperature of the liquid in the flask and the temperature at the top of the fractionating column are measured.

Which one of the following shows the likely temperatures when the first drops of distillate are collected?

	temperature in flask / °C	*temperature at top of column / °C*
A	83	68
B	98	68
C	83	83
D	98	83
E	98	98

Topic ALvl Chem 5 Q# 90**/** Cambridge/2024/Chemistry Section/Q#. 9/ www.SmashingScience.org/Practice Test May/

The reaction between nitrogen and hydrogen to form ammonia is exothermic.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ ΔH is negative

The bond energies in the three molecules are as shown:

$N \equiv N$ x kJ mol^{-1}
$H - H$ y kJ mol^{-1}
$N - H$ z kJ mol^{-1}

Which statement can be deduced from this information?

○ $z > x + y$

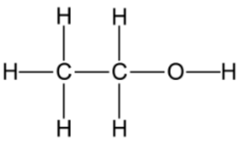
○ $2z > x + y$

○ $2z > x + 3y$

○ $6z > x + 3y$

Topic **ALvl Chem 5 Q# 91/** Cambridge/2024/Chemistry Section/Q#. 25/ www.SmashingScience.org/Practice Test May/

The structure of ethanol is given below:



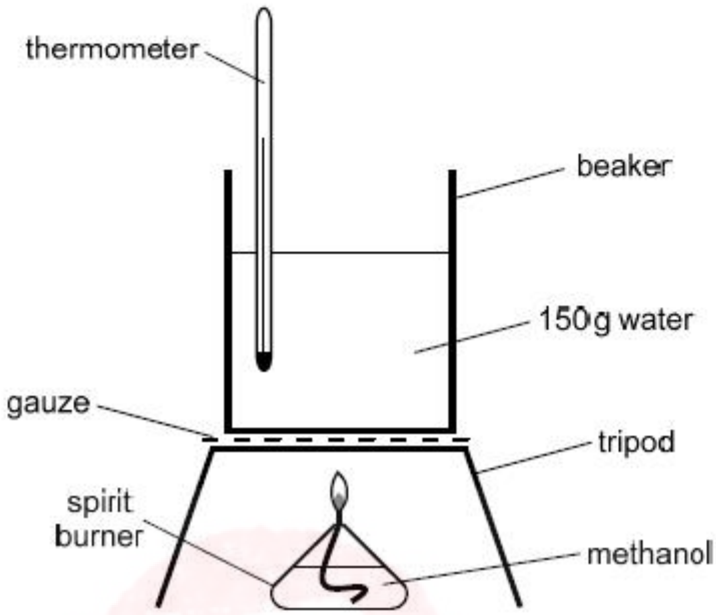
Given the equation below and the overall enthalpy change for the reaction, which option correctly identifies the bond energy of the C–O bond in ethanol?

$H_2C{=}CH_2(g) + H_2O(g) \rightarrow C_2H_5OH(g) \qquad \Delta H = -45\ \text{kJ mol}^{-1}$

(Mean bond energy (kJ mol^{-1}): H–H = +436; C–C = +346; C–H = +413; O–H = +464; C=C = +611)

- ○ 103 kJ mol^{-1}
- ○ 316 kJ mol^{-1}
- ○ 361 kJ mol^{-1}
- ○ 707 kJ mol^{-1}
- ○ 825 kJ mol^{-1}

55 When methanol is burned in the apparatus shown it gives out 720 kJ mol^{-1}. However, only 80% of the energy released is transferred into the water.



The starting temperature of the water is 12 °C.

What mass of methanol would need to be burned to give a 60 °C temperature rise in the water?

(M_r value: methanol = 32. Assume that the specific heat capacity of water = 4 J g^{-1} °C^{-1})

A 1.28 g

B 1.60 g

C 1.92 g

D 2.00 g

E 2.40 g

Topic **ALvl Chem 5 Q# 93/** Cambridge/2023/Section 1/Q#. 50/ www.SmashingScience.org/

50 Ethene gas and hydrogen gas react to form ethane gas.

The energy change for this reaction is $-150\,kJ\,mol^{-1}$.

Using the provided data, what is the mean C–H bond energy?

(Bond energy data: H–H = $430\,kJ\,mol^{-1}$; C–C = $350\,kJ\,mol^{-1}$; C=C = $600\,kJ\,mol^{-1}$)

A $115\,kJ\,mol^{-1}$

B $200\,kJ\,mol^{-1}$

C $230\,kJ\,mol^{-1}$

D $265\,kJ\,mol^{-1}$

E $400\,kJ\,mol^{-1}$

F $415\,kJ\,mol^{-1}$

G $465\,kJ\,mol^{-1}$

H $830\,kJ\,mol^{-1}$

Topic **ALvl Chem 5 Q# 94/** Cambridge/2022/Section 1 www.SmashingScience.org

57 A student mixed together $30.0\,cm^3$ of $3.0\,mol\,dm^{-3}$ hydrochloric acid and $20.0\,cm^3$ of $4.0\,mol\,dm^{-3}$ aqueous ammonia in an insulated container.

The initial temperatures of both solutions were 20.0 °C.

The maximum temperature observed was 40.0 °C.

Assume that the specific heat capacity of any aqueous solution is $4.0\,J\,g^{-1}\,°C^{-1}$ and that the density of the reaction mixture is $1.0\,g\,cm^{-3}$.

Using this information, what is the molar enthalpy change, in $kJ\,mol^{-1}$, for the reaction of hydrochloric acid and aqueous ammonia?

A $-4\,kJ\,mol^{-1}$

B $-20\,kJ\,mol^{-1}$

C $-25\,kJ\,mol^{-1}$

D $-30\,kJ\,mol^{-1}$

E $-44\,kJ\,mol^{-1}$

F $-50\,kJ\,mol^{-1}$

G $-75\,kJ\,mol^{-1}$

H $-100\,kJ\,mol^{-1}$

54 Propene burns in air. For each mole of propene burned, 2000 kJ of heat is released.

2.10 g of propene is burned to heat a 1000 g sample of olive oil.

The olive oil has an initial temperature of 23.0 °C. It takes 2.00 J to heat one gram of olive oil by 1.0 °C.

Assume that all heat is transferred to the olive oil and none is lost to the surroundings.

What is the maximum temperature reached by the oil?

(M_r value: C_3H_6 = 42.0)

A 20.0 °C

B 43.0 °C

C 48.0 °C

D 50.0 °C

E 73.0 °C

F 100 °C

G 200 °C

H 223 °C

55 What is the calculated energy change for the following reaction using appropriate values from the data provided?

$$CH_4(g) + 2H_2O(g) \rightarrow CO_2(g) + 4H_2(g)$$

bond	*bond energy* / kJ mol^{-1}
H–H	440
O–H	460
C–H	430
C–O	360
C=O	800
C≡O	1070

A +200 kJ mol^{-1}

B –200 kJ mol^{-1}

C +720 kJ mol^{-1}

D –720 kJ mol^{-1}

E +1080 kJ mol^{-1}

F –1080 kJ mol^{-1}

47 The reaction between nitrogen and hydrogen to form ammonia is exothermic.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H \text{ is negative}$$

The bond energies in the three molecules are as shown:

N≡N x kJ mol^{-1}
H–H y kJ mol^{-1}
N–H z kJ mol^{-1}

Which statement can be deduced from this information?

A $z > x + y$

B $2z > x + y$

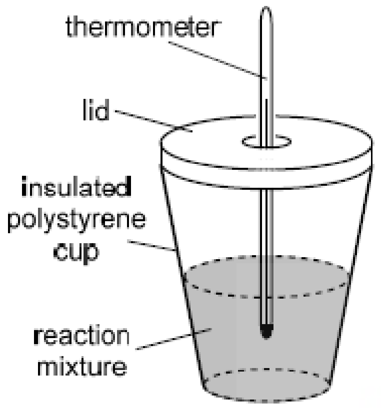
C $2z > x + 3y$

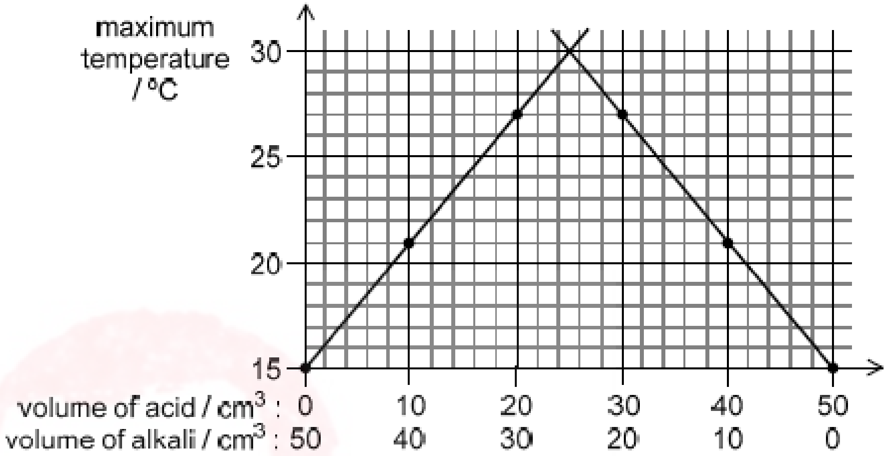
D $6z > x + 3y$

58 Four separate experiments were carried out using different quantities of 2 mol dm^{-3} hydrochloric acid and 2 mol dm^{-3} sodium hydroxide in insulated polystyrene cups.

After stirring, the maximum temperature was recorded and the results plotted on a graph as shown.

The temperatures of the acid and alkali on their own were also plotted on the graph. Two straight lines were drawn and extrapolated as shown.





What is the molar enthalpy change for the neutralisation reaction, in kJ mol^{-1}?

(Assume that the specific heat capacity of the solutions is 4 J g^{-1} °C^{-1}, the density of dilute solutions is 1 g cm^{-3}, and all heat is transferred to the solution.)

A 3 kJ mol^{-1}

B 6 kJ mol^{-1}

C 30 kJ mol^{-1}

D 60 kJ mol^{-1}

E 120 kJ mol^{-1}

F 3000 kJ mol^{-1}

53 The Haber process is represented by the following chemical equation:

$$N_2 + 3H_2 \rightarrow 2NH_3$$

What is the overall enthalpy change for the reaction?

(Bond enthalpies: $N \equiv N = 945\,kJ\,mol^{-1}$; $H-H = 435\,kJ\,mol^{-1}$; $N-H = 390\,kJ\,mol^{-1}$)

A $+90\,kJ\,mol^{-1}$

B $-90\,kJ\,mol^{-1}$

C $+990\,kJ\,mol^{-1}$

D $-990\,kJ\,mol^{-1}$

E $+1080\,kJ\,mol^{-1}$

F $-1080\,kJ\,mol^{-1}$

49 Nitrogen and hydrogen react together to form ammonia as shown below:

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

The energy released by this reaction is $93\,kJ\,mol^{-1}$.

What is the bond energy in the nitrogen molecule?

(Bond energies: $H-H = 436\,kJ\,mol^{-1}$; $N-H = 391\,kJ\,mol^{-1}$)

A $315\,kJ\,mol^{-1}$

B $513\,kJ\,mol^{-1}$

C $644\,kJ\,mol^{-1}$

D $864\,kJ\,mol^{-1}$

E $945\,kJ\,mol^{-1}$

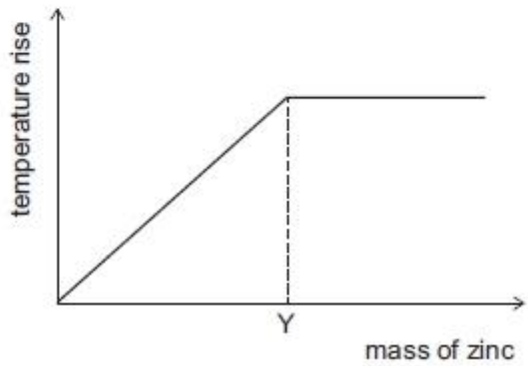
F $1131\,kJ\,mol^{-1}$

Topic **ALvl Chem 5 Q# 101/** Cambridge/2017/Section 1 www.SmashingScience.org

51 Silver nitrate solution reacts with zinc powder in an exothermic reaction:

$$2AgNO_3(aq) + Zn(s) \rightarrow 2Ag(s) + Zn(NO_3)_2(aq)$$

The graph shows the maximum temperature rise as different masses of zinc react with separate $50.0\,cm^3$ samples of $0.100\,mol\,dm^{-3}$ silver nitrate solution.



What is the mass of zinc at the position labelled Y?

(A_r value: Zn = 65)

A 0.163 g

B 0.325 g

C 0.650 g

D 1.63 g

E 3.25 g

F 6.50 g

Topic **ALvl Chem 5 Q# 102/** Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

43 The reaction between nitrogen and hydrogen to form ammonia is exothermic.

$$N_2(g) + 3H_2(g) \leftrightharpoons 2NH_3(g) \quad \Delta H \text{ is negative}$$

The bond energies in the three molecules are as shown.

N ≡ N	x kJ mol^{-1}
H – H	y kJ mol^{-1}
N – H	z kJ mol^{-1}

Which statement can be deduced from this information?

A $z > x + y$

B $2z > x + y$

C $2z > x + 3y$

D $6z > x + y$

E $6z > x + 3y$

Topic **ALvl Chem 5 Q# 103/** Cambridge/2016/Section 1 www.SmashingScience.org

48 The heat energy change for a reaction is $-100\,kJ\,mol^{-1}$, and the activation energy is $+150\,kJ\,mol^{-1}$.

What is the activation energy for the reverse reaction?

A -250 kJ mol^{-1}

B -150 kJ mol^{-1}

C -50 kJ mol^{-1}

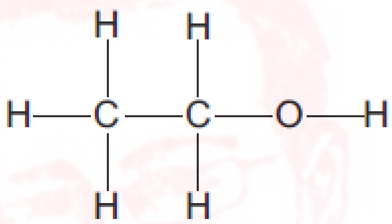
D $+50$ kJ mol^{-1}

E $+150$ kJ mol^{-1}

F $+250$ kJ mol^{-1}

Topic **ALvl Chem 5 Q# 104/** Cambridge/2016/Section 1 www.SmashingScience.org

54 The structure of ethanol is given below:



Given the equation below and the overall enthalpy change for the reaction, which option correctly identifies the bond energy of the C–O bond in ethanol?

$$H_2C{=}CH_2(g) + H_2O(g) \rightarrow C_2H_5OH(g) \qquad \Delta H = -45\,kJ\,mol^{-1}$$

(Mean bond energy (kJ mol^{-1}): H–H = +436; C–C = +346; C–H = +413; O–H = +464; C=C = +611)

A 103 kJ mol^{-1}

B 316 kJ mol^{-1}

C 361 kJ mol^{-1}

D 707 kJ mol^{-1}

E 825 kJ mol^{-1}

Topic ALvl Chem 6 Q# 105/ Cambridge/2024/Chemistry Section/Q#. 7/ www.SmashingScience.org/Practice Test May/

An oxide of iron has the formula Fe_3O_4 and contains both Fe^{2+} and Fe^{3+} ions.

Which one of the following is the fraction of iron ions that are in the Fe^{2+} state?

- ○ $\frac{1}{4}$
- ○ $\frac{1}{3}$
- ○ $\frac{1}{2}$
- ○ $\frac{2}{3}$
- ○ $\frac{3}{4}$

Topic **ALvl Chem 6 Q# 106/** Cambridge/2024/Chemistry Section/Q#. 19/ www.SmashingScience.org/Practice Test May/

The following tests were carried out on separate samples of two monoprotic acids, HX and HY. HX is a strong acid and HY is a weak acid. Both acids had a concentration of 1 mol dm^{-3}.

1. Measure the time taken for a 1 cm strip of magnesium to react completely when added to 25 cm^3 of each acid.
2. Measure the volume of 1 mol dm^{-3} sodium hydroxide solution needed to completely neutralise 20 cm^3 of each acid.
3. Measure the electrical conductance of each acid using a conductivity meter.

Each test was carried out under the same conditions.

Which of the tests, considered independently, if any, would show that HX was a stronger acid than HY?

- ○ none of them
- ○ 1 only
- ○ 2 only
- ○ 3 only
- ○ 1 and 2 only
- ○ 1 and 3 only
- ○ 2 and 3 only
- ○ 1, 2 and 3

Topic **ALvl Chem 6 Q# 107/** Cambridge/2024/Chemistry Section/Q#. 14/ www.SmashingScience.org/Practice Test May/

Copper, Cu, reacts with concentrated nitric acid, HNO_3, to produce a solution of copper(II) nitrate, water and compound X.

Compound X does not contain copper or hydrogen.

The balanced equation for the reaction shows 3 moles of copper reacting with HNO_3 to produce 4 moles of water.

What is the identity of compound X?

- ○ NO
- ○ NO_2
- ○ NO_3
- ○ N_2O_5
- ○ N_2O_8

Topic **ALvl Chem 6 Q# 108/** Cambridge/2024/Chemistry Section/Q#. 11/ www.SmashingScience.org/Practice Test May/

In which two of the following equations is the **first reactant** an oxidising agent?

1. $\mathbf{Mg} + 2HCl \rightarrow MgCl_2 + H_2$
2. $\mathbf{Cr_2O_7^{2-}} + 6Fe^{2+} + 14H^+ \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$
3. $\mathbf{2Cu^{2+}} + 4I^- \rightarrow 2CuI + I_2$
4. $\mathbf{H_2SO_3} + 2Fe^{3+} + H_2O \rightarrow H_2SO_4 + 2Fe^{2+} + 2H^+$

- ○ 1 and 2
- ○ 1 and 4
- ○ 2 and 3
- ○ 2 and 4
- ○ 3 and 4

Topic **ALvl Chem 6 Q# 109/** Cambridge/2023/Section 1/Q#. 53/ www.SmashingScience.org/

53 One mole of copper reacts completely with an excess of concentrated nitric acid.

A gaseous oxide of nitrogen is one of the products of the reaction. The volume of this gas is $48\,dm^3$ when measured at room temperature and pressure.

The oxidation state of the nitrogen in the gaseous oxide is one less than the oxidation state of the nitrogen in the nitric acid.

Which of the following could be the equation for this reaction?

(Assume that one mole of any gas occupies $24\,dm^3$ at room temperature and pressure.)

A $Cu + 2HNO_3 \rightarrow CuNO_3 + NO_2 + H_2O$

B $Cu + 2HNO_3 \rightarrow CuO + 2NO + O_2 + H_2O$

C $Cu + 2HNO_3 \rightarrow CuO + 2N_2O_4 + H_2O$

D $Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + N_2O_4 + 2H_2O$

E $Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

F $3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$

G $3Cu + 8HNO_3 \rightarrow Cu(NO_3)_2 + 2CuO + 6N_2O_4 + 4H_2O$

Topic **ALvl Chem 6 Q# 110/** Cambridge/2023/Section 1/Q#. 49/ www.SmashingScience.org/

49 Titanium metal can be extracted from titanium(IV) chloride, $TiCl_4$.

Titanium(IV) chloride is heated to 1000 °C with either sodium or magnesium metal in an atmosphere of argon.

Which one of the following statements is correct?

(A_r values: Na = 23; Mg = 24; Cl = 35.5; Ti = 48)

A A greater mass of magnesium chloride than sodium chloride is produced for each tonne of titanium made.

B The atmosphere of argon is used as a catalyst.

C In each reaction equation, the ratio of the reacting metal to titanium(IV) chloride is the same.

D Titanium is a weaker oxidising agent than either sodium or magnesium.

E A smaller mass of magnesium than sodium is required to produce 500 kg of titanium.

Topic **ALvl Chem 6 Q# 111/** Cambridge/2022/Section 1 www.SmashingScience.org

45 Which of the following chemical reactions is/are redox reactions?

1 $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

2 $PCl_5(s) + H_2O(l) \rightarrow POCl_3(l) + 2HCl(aq)$

3 $KrF_2(s) \rightarrow Kr(g) + F_2(g)$

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

Topic **ALvl Chem 6 Q# 112/** Cambridge/2021/Section 1 www.SmashingScience.org

48 Some students were trying to assign oxidation numbers to each of the four sulfur atoms in the tetrathionate ion, $S_4O_6^{2-}$.

Which of the following lists gives the possible oxidation states of the four sulfur atoms present?

A 0, 0, +6, +6

B +3, +3, +3, +3

C 0, +2, +6, +6

D 0, 0, +5, +5

E –2, –2, +7, +7

Topic **ALvl Chem 6 Q# 113/** Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org

48 In which two of the following equations is the **first reactant** an oxidising agent?

1 $\mathbf{Mg} + 2HCl \rightarrow MgCl_2 + H_2$

2 $\mathbf{Cr_2O_7^{2-}} + 6Fe^{2+} + 14H^+ \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$

3 $\mathbf{2Cu^{2+}} + 4I^- \rightarrow 2CuI + I_2$

4 $\mathbf{H_2SO_3} + 2Fe^{3+} + H_2O \rightarrow H_2SO_4 + 2Fe^{2+} + 2H^+$

A 1 and 2

B 1 and 4

C 2 and 3

D 2 and 4

E 3 and 4

Topic **ALvl Chem 6 Q# 114/** Cambridge/2020/Section 1 www.SmashingScience.org

50 Which of the following equations represent(s) a redox reaction?

1 $K_2Cr_2O_7 + 2KOH \rightarrow 2K_2CrO_4 + H_2O$

2 $8HNO_3 + 3C_2H_6O + K_2Cr_2O_7 \rightarrow 2KNO_3 + 3C_2H_4O + 7H_2O + 2Cr(NO_3)_3$

3 $H_2O + SO_2 \rightarrow H_2SO_3$

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

44 Which of the following chemical equations represent(s) a redox reaction?

1 $2Cu^{2+} + 4I^{-} \rightarrow 2CuI + I_2$

2 $Al^{3+} + 3e^{-} \rightarrow Al$

3 $2Ag^{+} + 2OH^{-} \rightarrow Ag_2O + H_2O$

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

Topic **ALvl Chem 6 Q# 116/** Cambridge/2018/Section 1 www.SmashingScience.org

43 The following equations show the main reactions that take place in a blast furnace during the extraction of iron and the removal of the impurities:

$$C + O_2 \rightarrow CO_2$$

$$\underline{CO_2} + C \rightarrow 2CO$$

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

$$\underline{CaCO_3} \rightarrow CaO + CO_2$$

$$\underline{CaO} + SiO_2 \rightarrow CaSiO_3$$

Which row in the following table correctly identifies whether the underlined substance is oxidised, or reduced, or neither?

	CO_2	$CaCO_3$	CaO
A	oxidised	reduced	neither
B	oxidised	neither	neither
C	oxidised	reduced	oxidised
D	oxidised	neither	oxidised
E	reduced	reduced	neither
F	reduced	neither	neither
G	reduced	reduced	oxidised
H	reduced	neither	oxidised

Topic **ALvl Chem 6 Q# 117/** Cambridge/2017/Section 1 www.SmashingScience.org

43 Solid copper(II) chloride contains Cu^{2+} ions and Cl^- ions only.

Solid lithium phosphate(V) contains Li^+ ions and PO_4^{3-} ions only.

Aqueous solutions of copper(II) chloride and lithium phosphate(V) are mixed to produce a precipitate of copper(II) phosphate(V) and an aqueous solution of lithium chloride.

Which of the following represents the balanced ionic equation for this process?

A $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

B $2Cu^{2+}(aq) + 3PO_4^{3-}(aq) \rightarrow Cu_2(PO_4)_3(s)$

C $2Cu^{2+}(aq) + 5PO_4^{3-}(aq) \rightarrow Cu_2(PO_4)_5(s)$

D $3Cu^{2+}(aq) + 2PO_4^{3-}(aq) \rightarrow Cu_3(PO_4)_2(s)$

E $3Cu^{2+}(aq) + 6Cl^-(aq) + 6Li^+(aq) + 2PO_4^{3-}(aq) \rightarrow Cu_3(PO_4)_2(s) + 6LiCl(aq)$

F $3CuCl_2(aq) + 2Li_3PO_4(aq) \rightarrow Cu_3(PO_4)_2(s) + 6LiCl(aq)$

Topic **ALvl Chem 6 Q# 118/** Cambridge/2017/Section 1 www.SmashingScience.org

44 Which of the following statements about the reaction of lithium with water are correct?

1 The reaction is a redox reaction.

2 7 g of lithium will react with excess water to produce 2 g of hydrogen gas.

3 The reaction produces a solution with a pH greater than that of water.

4 14 g of lithium will exactly react with 36 g of water.

(A_r values: H = 1; Li = 7; O = 16)

A 1 and 2 only

B 1 and 4 only

C 1, 2 and 3 only

D 1, 3 and 4 only

E 2 and 3 only

F 3 and 4 only

Topic **ALvl Chem 6 Q# 119/** Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

44 In which two of the following equations is the **first reactant** an oxidising agent?

1 $\mathbf{Mg} + 2HCl \rightarrow MgCl_2 + H_2$

2 $\mathbf{Cr_2O_7^{2-}} + 6Fe^{2+} + 14H^+ \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$

3 $\mathbf{2Cu^{2+}} + 4I^- \rightarrow 2CuI + I_2$

4 $\mathbf{H_2SO_3} + 2Fe^{3+} + H_2O \rightarrow H_2SO_4 + 2Fe^{2+} + 2H^+$

A 1 and 2

B 1 and 4

C 2 and 3

D 2 and 4

E 3 and 4

Topic **ALvl Chem 6 Q# 120/** Cambridge/2016/Section 1 www.SmashingScience.org

45 Two of the following equations represent redox reactions:

1 $Cl_2 + 2KI \rightarrow I_2 + 2KCl$

2 $Cl_2 + 2e^- \rightarrow 2Cl^-$

3 $HCl + AgNO_3 \rightarrow AgCl + HNO_3$

4 $Cl_2 + H_2O \rightarrow HCl + HClO$

Which two equations represent redox reactions?

A 1 and 2

B 1 and 3

C 1 and 4

D 2 and 3

E 2 and 4

F 3 and 4

Topic ALvl Chem 7 Q# 121**/** Cambridge/2024/Chemistry Section/Q#. 6/ www.SmashingScience.org/Practice Test May/

In a reversible reaction, gaseous reactants P and Q form gaseous products R and S.

An increase in temperature was found to increase both the rate of reaction and the yield at equilibrium.

An increase in pressure was found to increase the rate of reaction but the yield at equilibrium was unaffected.

Which equation could represent the reaction?

○ $3P + Q \rightleftharpoons 2R + 3S$ ΔH is +ve

○ $P + 3Q \rightleftharpoons R + 2S$ ΔH is +ve

○ $P + 2Q \rightleftharpoons 2R + S$ ΔH is +ve

○ $P + 2Q \rightleftharpoons 3R + S$ ΔH is −ve

○ $P + 2Q \rightleftharpoons R + S$ ΔH is −ve

○ $2P + Q \rightleftharpoons R + 2S$ ΔH is −ve

Topic **ALvl Chem 7 Q# 122/** Cambridge/2024/Chemistry Section/Q#. 22/ www.SmashingScience.org/Practice Test May/

An impure sample of sodium hydroxide has a mass of 1.20 g. All the sodium hydroxide completely reacts with a minimum of 50.0 cm^3 of 0.50 mol dm^{-3} hydrochloric acid.

What is the percentage purity of the sodium hydroxide sample?

(A_r values: H = 1; O = 16; Na = 23; Cl = 35.5)

- 37.5%
- 41.6%
- 72.7%
- 75.0%
- 83.3%
- 90.4%

Topic **ALvl Chem 7 Q# 123/** Cambridge/2024/Chemistry Section/Q#. 1/ www.SmashingScience.org/Practice Test May/

The colours of three indicators are shown.

indicator	*colour at*		*pH at which colour change takes place*
	low pH	*high pH*	
methyl orange	red	yellow	4.0
bromothymol blue	yellow	blue	6.5
phenolphthalein	colourless	pink	9.0

Equal volumes of these three indicators were mixed and the mixture was added to a solution of pH 5.0.

What colour would be seen?

- blue
- green
- orange
- purple
- yellow

Topic **ALvl Chem 7 Q# 124/** Cambridge/2023/Section 1/Q#. 54/ www.SmashingScience.org/

54 Two experiments were carried out using separate samples of a solution of an acid of concentration 0.40 mol dm^{-3} (36 g dm^{-3}) and the following observations were made.

- 25 cm^3 of the acid solution exactly neutralised 100 cm^3 of 0.20 mol dm^{-3} sodium hydroxide solution.
- Bubbles of gas were given off when magnesium ribbon was added to the acid solution.

Which of the following statements can be deduced from this information?

1 It is a monoprotic acid.

2 It is a strong acid.

3 The acid has a relative molar mass (M_r) of 90.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

Topic **ALvl Chem 7 Q# 125/** Cambridge/2022/Section 1 www.SmashingScience.org

48 50 cm^3 of 0.100 mol dm^{-3} hydrochloric acid has a pH of 1.0.

What is the pH of the mixture formed when 450 cm^3 of 0.010 mol dm^{-3} calcium hydroxide solution is added?

A pH = 1.0

B $1.0 < \text{pH} < 2.0$

C pH = 2.0

D $2.0 < \text{pH} < 7.0$

E pH = 7.0

F $\text{pH} > 7.0$

56 A sample of magnesium carbonate, $MgCO_3$, was reacted completely with 50 cm^3 of 0.10 mol dm^{-3} hydrochloric acid, which is an excess.

The remaining hydrochloric acid was titrated with 0.20 mol dm^{-3} sodium hydroxide solution. 5.0 cm^3 of sodium hydroxide was required for complete neutralisation.

What was the original mass of magnesium carbonate used, in mg?

(M_r value: $MgCO_3$ = 84)

A 42 mg

B 84 mg

C 168 mg

D 210 mg

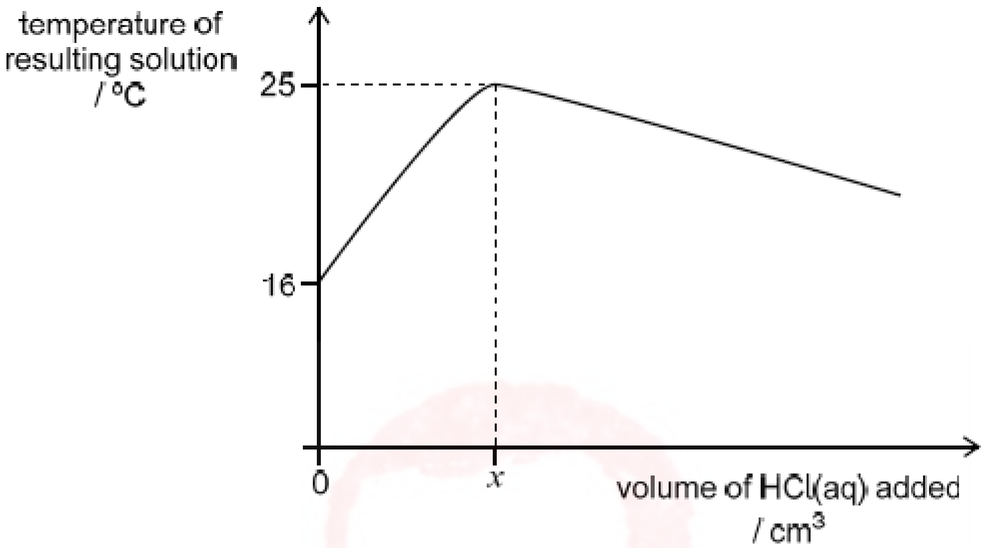
E 336 mg

F 420 mg

Topic **ALvl Chem 7 Q# 127/** Cambridge/2021/Section 1 www.SmashingScience.org

45 1.0 mol dm^{-3} hydrochloric acid was slowly added from a burette into an insulated flask containing 50 cm^3 of aqueous sodium hydroxide. The flask was gently swirled and the temperature of the resulting solution measured continuously.

The two solutions had the same initial temperature and a graph was drawn of the temperature of the resulting solution against the volume of hydrochloric acid added.



Which of the following statements explains the shape of the graph?

A The reaction has reached a state of equilibrium.

B An endothermic reaction occurs after x cm^3 of hydrochloric acid is added.

C The reaction rate decreases as the acid is used up.

D The sodium hydroxide has been neutralised by x cm^3 hydrochloric acid.

E The sodium hydroxide becomes a weaker base as the volume of the resulting solution increases.

Topic **ALvl Chem 7 Q# 128/** Cambridge/2021/Section 1 www.SmashingScience.org

53 Ethanedioic acid, $(COOH)_2$, is a weak diprotic acid.

What is the minimum volume of a 2.50 mol dm^{-3} solution of ethanedioic acid required to neutralise 25.0 cm^3 of 2.00 mol dm^{-3} sodium hydroxide solution?

A 10.0 cm^3

B 12.5 cm^3

C 20.0 cm^3

D 25.0 cm^3

E 100 cm^3

55 The following exothermic, reversible reaction is used in the manufacture of sulfuric acid from sulfur dioxide and oxygen:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

Which one of the following statements about this reaction is correct?

A Pressure has no effect on the position of equilibrium.

B Raising the temperature moves the equilibrium to the right.

C At equilibrium no sulfur dioxide is being changed into sulfur trioxide.

D The addition of a catalyst speeds up the forward reaction more than the backward reaction.

E Before equilibrium is reached, the rate of the forward reaction is greater than the rate of the backward reaction.

41 The colours of three indicators are shown.

indicator	*colour at*		*pH at which colour change takes place*
	low pH	*high pH*	
methyl orange	red	yellow	4.0
bromothymol blue	yellow	blue	6.5
phenolphthalein	colourless	pink	9.0

Equal volumes of these three indicators were mixed and the mixture was added to a solution of pH 5.0.

What colour would be seen?

A blue

B green

C orange

D purple

E yellow

54 Hydrochloric acid, sulfuric acid and phosphoric(V) acid are inorganic acids.

Phosphoric(V) acid, H_3PO_4, ionises in water in the following series of reactions:

$$H_3PO_4 \rightleftharpoons H^+ + H_2PO_4^-$$

$$H_2PO_4^- \rightleftharpoons H^+ + HPO_4^{2-}$$

$$HPO_4^{2-} \rightleftharpoons H^+ + PO_4^{3-}$$

0.1 mol dm^{-3} hydrochloric acid has a pH of 1.0 at room temperature.

Which of the following statements about these acids is/are correct?

1 The pH of 0.1 mol dm^{-3} sulfuric acid is greater than 1.0 at room temperature.

2 $H_2PO_4^-$ can act as an acid or as a base.

3 30 cm^3 of calcium hydroxide solution exactly neutralises 20 cm^3 phosphoric(V) acid solution when both solutions are the same concentration.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

Topic **ALvl Chem 7 Q# 132/** Cambridge/2020/Section 1 www.SmashingScience.org

60 X is a solution of sulfuric acid.

20.0 cm^3 of X is diluted by adding distilled water to produce 500 cm^3 of solution Y.

10.0 cm^3 of Y is exactly neutralised by 40.0 cm^3 of 0.0500 mol dm^{-3} aqueous potassium hydroxide.

What is the concentration of sulfuric acid in X?

A 0.00100 mol dm^{-3}

B 0.100 mol dm^{-3}

C 0.200 mol dm^{-3}

D 0.400 mol dm^{-3}

E 1.25 mol dm^{-3}

F 2.50 mol dm^{-3}

G 5.00 mol dm^{-3}

H 10.0 mol dm^{-3}

Topic **ALvl Chem 7 Q# 133/** Cambridge/2018/Section 1 www.SmashingScience.org

38 The following exothermic reaction reaches equilibrium at room temperature.

$$C_2H_5OH(l) + CH_3COOH(l) \rightleftharpoons CH_3COOC_2H_5(l) + H_2O(l)$$

Which of the following changes, when applied independently, will alter the position of the equilibrium?

1 increasing the temperature by 25 °C

2 adding 20 cm^3 of water to the equilibrium mixture

3 adding a catalyst

4 adding an extra 0.5 mol of ethanol (C_2H_5OH)

A 1 only

B 1 and 3 only

C 1, 2 and 4 only

D 2 and 4 only

E 1, 2, 3 and 4

45 In the Contact process, sulfur dioxide reacts with oxygen to make sulfur trioxide in a reversible reaction.

$$SO_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons SO_3(g)$$

When 5.00 mol of SO_2 and 11.0 mol of O_2 are allowed to reach equilibrium at 450 °C, 80.0% of the SO_2 is converted to SO_3.

What is the volume of the resulting mixture?

(Assume that temperature and pressure are constant, and that at this temperature the volume of one mole of gas is 60.0 dm^3.)

A 240 dm^3

B 336 dm^3

C 600 dm^3

D 720 dm^3

E 840 dm^3

F 960 dm^3

54 The following reaction between nitrogen oxide and oxygen releases 116 kJ of energy as heat for each mole of oxygen that reacts.

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$$

An excess of NO and y moles of oxygen are mixed in a sealed container. The reaction reaches equilibrium in one hour.

At equilibrium, there are z moles of NO_2.

Assume that the pressure is constant throughout the experiment.

How much heat will be released over this hour?

A 0 kJ

B 58y kJ

C 116y kJ

D 232y kJ

E 58z kJ

F 116z kJ

G 232z kJ

40 Consider the following reactions:

Reaction Q:	$CH_2{=}CH_2(g) + H_2O(g) \rightleftharpoons CH_3CH_2OH(g)$	ΔH is $-$ve
Reaction R:	$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$	ΔH is $+$ve

The following actions could be applied independently to each reaction (Q and R) above:

1 increase the pressure

2 increase the temperature

3 use a suitable catalyst

Assuming that all other conditions remain constant, which of these actions will increase the initial rate of reaction **and** increase the yield of products for **both** reactions Q and R?

A none of them

B 1 only

C 1 or 2 only

D 1 or 3 only

E 2 only

F 2 or 3 only

G 3 only

H 1, 2 or 3

Topic **ALvl Chem 7 Q# 137/** Cambridge/2017/Section 1 www.SmashingScience.org

39 Hydrochloric acid (HCl) is a strong acid. Properties of a solution of 1.00 mol dm^{-3} hydrochloric acid include:

1 It turns blue litmus indicator red.

2 On reaction with sodium carbonate gaseous carbon dioxide is evolved.

3 25.0 cm^3 of this acid solution neutralises 25.0 cm^3 of 1.00 mol dm^{-3} sodium hydroxide solution.

Ethanoic acid (CH_3COOH) is a weak acid.

Which of the three properties is/are also correct for a 1.00 mol dm^{-3} solution of ethanoic acid?

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

Topic **ALvl Chem 7 Q# 138/** Cambridge/2017/Section 1 www.SmashingScience.org

38 Which two of the following reactions involve oxidation?

1 $Ca \rightarrow Ca^{2+} + 2e^-$

2 $Cl_2 + 2e^- \rightarrow 2Cl^-$

3 $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

4 $MgCO_3 + 2HCl \rightarrow MgCl_2 + CO_2 + H_2O$

A 1 and 2 only

B 1 and 3 only

C 1 and 4 only

D 2 and 3 only

E 2 and 4 only

F 3 and 4 only

Topic **ALvl Chem 7 Q# 139/** Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

51 The following exothermic, reversible reaction is used in the manufacture of sulfuric acid from sulfur dioxide and oxygen:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

Which one of the following statements about this reaction is correct?

A Pressure has no effect on the position of equilibrium.

B Raising the temperature moves the equilibrium to the right.

C At equilibrium no sulfur dioxide is being changed into sulfur trioxide.

D The addition of a catalyst speeds up the forward reaction more than the backward reaction.

E Before equilibrium is reached, the rate of the forward reaction is greater than the rate of the backward reaction.

Topic **ALvl Chem 7 Q# 140/** Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

37 The colours of three indicators are shown.

indicator	*colour at*		*pH at which colour change takes place*
	low pH	*high pH*	
methyl orange	red	yellow	4.0
bromothymol blue	yellow	blue	6.5
phenolphthalein	colourless	pink	9.0

Equal volumes of these three indicators were mixed and the mixture was added to a solution of pH 5.0.

What colour would be seen?

A blue

B green

C orange

D purple

E yellow

Topic **ALvl Chem 7 Q# 141/** Cambridge/2016/Section 1 www.SmashingScience.org

40 In a reversible reaction, gaseous reactants P and Q form gaseous products R and S.

An increase in temperature was found to increase both the rate of reaction and the yield at equilibrium.

An increase in pressure was found to increase the rate of reaction but the yield at equilibrium was unaffected.

Which equation could represent the reaction?

A $3P + Q \rightleftharpoons 2R + 3S$ ΔH is +ve

B $P + 3Q \rightleftharpoons R + 2S$ ΔH is +ve

C $P + 2Q \rightleftharpoons 2R + S$ ΔH is +ve

D $P + 2Q \rightleftharpoons 3R + S$ ΔH is –ve

E $P + 2Q \rightleftharpoons R + S$ ΔH is –ve

F $2P + Q \rightleftharpoons R + 2S$ ΔH is –ve

Topic **ALvl Chem 7 Q# 142/** Cambridge/2016/Section 1 www.SmashingScience.org

49 The following tests were carried out on separate samples of two monoprotic acids, HX and HY. HX is a strong acid and HY is a weak acid. Both acids had a concentration of 1 mol dm^{-3}.

1 Measure the time taken for a 1 cm strip of magnesium to react completely when added to 25 cm^3 of each acid.

2 Measure the volume of 1 mol dm^{-3} sodium hydroxide solution needed to completely neutralise 20 cm^3 of each acid.

3 Measure the electrical conductance of each acid using a conductivity meter.

Each test was carried out under the same conditions.

Which of the tests, considered independently, if any, would show that HX was a stronger acid than HY?

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

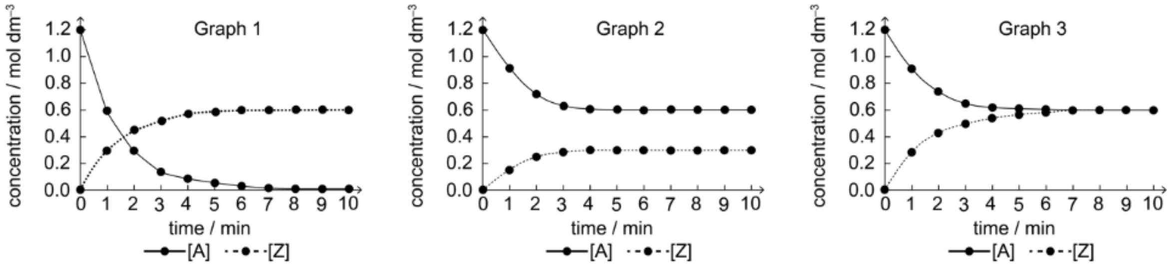
G 2 and 3 only

H 1, 2 and 3

Chemicals A and B react to form products Y and Z. The reaction goes to completion. The equation for the reaction is:

$2A(aq) + B(aq) \rightarrow Y(aq) + Z(aq)$

Equimolar samples of A and B were mixed and the concentrations of A and Z were measured over time. Which of the following graphs could represent this reaction?



- ○ Graph 1 only
- ○ Graph 2 only
- ○ Graph 3 only
- ○ Graphs 1 and 2 only
- ○ Graphs 2 and 3 only

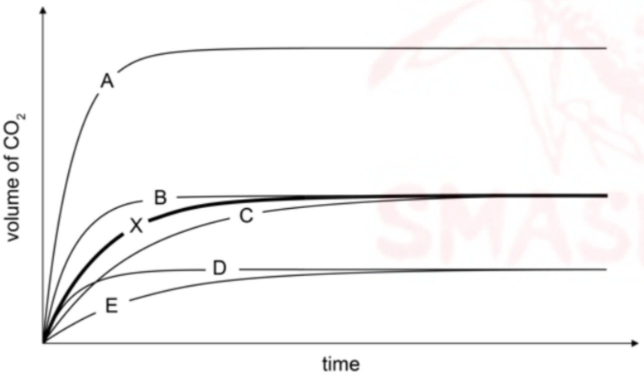
Topic **ALvl Chem 8 Q# 144/** Cambridge/2024/Chemistry Section/Q#. 27/ www.SmashingScience.org/Practice Test May/

Calcium carbonate reacts with hydrochloric acid. The reaction gives off carbon dioxide gas.

Line **X** on the graph shows the volume of carbon dioxide formed against time when 100 cm^3 of 1.0 $mol\,dm^{-3}$ of hydrochloric acid reacts with calcium carbonate chips at 20 °C. There was an excess of calcium carbonate chips.

$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O(l)$

Which line best represents the volume of carbon dioxide formed against time when the reaction is repeated with 50 cm^3 of 2.0 $mol\,dm^{-3}$ of hydrochloric acid reacting with excess calcium carbonate chips at 20 °C?



- ○ line A
- ○ line B
- ○ line C
- ○ line D
- ○ line E

Topic **ALvl Chem 8 Q# 145/** Cambridge/2024/Chemistry Section/Q#. 17/ www.SmashingScience.org/Practice Test May/

The heat energy change for a reaction is $-100\ \text{kJ mol}^{-1}$, and the activation energy is $+150\ \text{kJ mol}^{-1}$.

What is the activation energy for the reverse reaction?

- ○ $-250\ \text{kJ mol}^{-1}$
- ○ $-150\ \text{kJ mol}^{-1}$
- ○ $-50\ \text{kJ mol}^{-1}$
- ○ $+50\ \text{kJ mol}^{-1}$
- ○ $+150\ \text{kJ mol}^{-1}$
- ○ $+250\ \text{kJ mol}^{-1}$

Topic **ALvl Chem 8 Q# 146/** Cambridge/2023/Section 1/Q#. 41/ www.SmashingScience.org/

41 An experiment is carried out at two different pressures by changing the volume of the reaction vessel.

The experiment measures the rate of the reaction between molecules X and Y to form Z:

$$X(g) + Y(g) \rightarrow Z(s)$$

Assume that the experiments are carried out under exactly the same conditions apart from the difference in pressure.

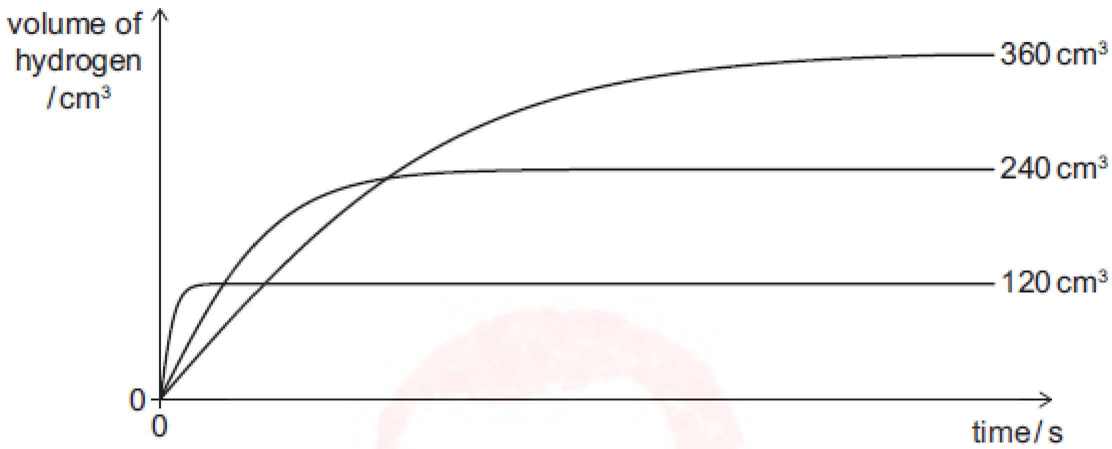
How will the rate of the reaction change with pressure, if at all, and what is the reason for this?

	difference in rate of reaction	*reason*
A	the reaction is faster at lower pressure	average kinetic energy of molecules is greater at lower pressure
B	the reaction is faster at lower pressure	the rate of collisions is greater between molecules at lower pressure
C	the reaction is slower at lower pressure	average kinetic energy of molecules is less at lower pressure
D	the reaction is slower at lower pressure	the rate of collisions between molecules is lower at lower pressure
E	the reaction rate is the same at both pressures	the average kinetic energy of molecules is the same at both pressures

46 Three samples of calcium of different masses were added separately to excess dilute hydrochloric acid and the volume of gas released, measured at room temperature and pressure, was monitored.

One sample was powdered calcium, one was granules of calcium, and one was a solid piece of calcium.

The results are shown on the graph.



What is the mass of powdered calcium used in this experiment?

(A_r value: Ca = 40. Assume that one mole of gas occupies a volume of 24 dm^3 at room temperature and pressure.)

A 0.200 g

B 0.400 g

C 0.600 g

D 1.20 g

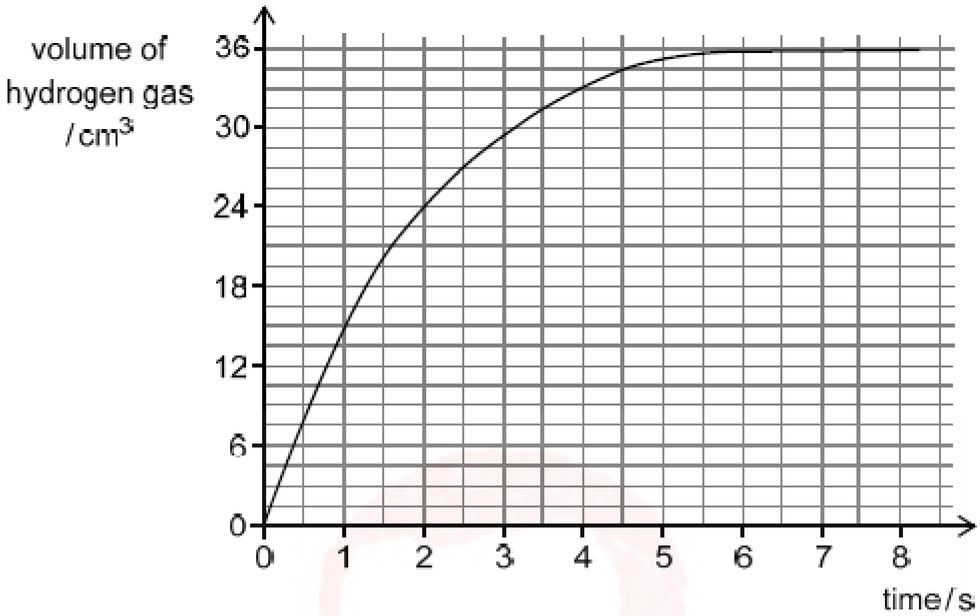
E 8.00 g

F 16.0 g

G 24.0 g

58 0.500 g of magnesium (an excess) was added to dilute hydrochloric acid.

The following graph shows the total volume of the gas released over time as the reaction progresses. All volumes were measured in cm^3 at room temperature and pressure.



What is the mass of magnesium remaining after two seconds?

(A_r value: Mg = 24. Assume that the volume of one mole of gas at room temperature and pressure is 24.0 dm^3.)

A 0.024 g

B 0.036 g

C 0.048 g

D 0.452 g

E 0.464 g

F 0.476 g

60 A spoonful of magnesium carbonate powder was added to excess hydrochloric acid in an open conical flask on an electronic balance.

$$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + CO_2(g) + H_2O(l)$$

The mass of the flask and its contents was measured initially and at 1-minute intervals. The total mass of gas produced was then calculated.

The reaction stopped at 5 minutes.

Which row in the following table could represent the total mass of gas calculated after each measurement?

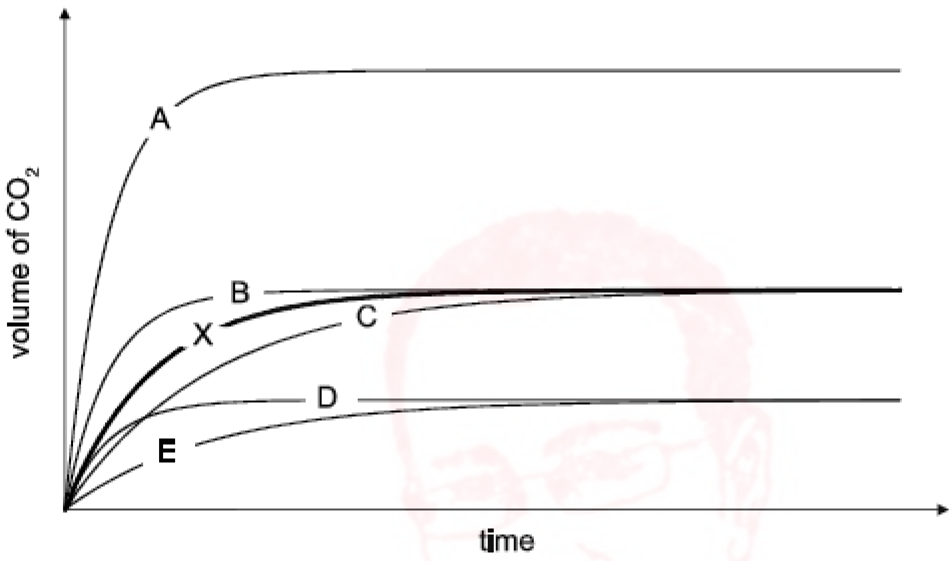
	1 minute	*2 minutes*	*3 minutes*	*4 minutes*	*5 minutes*
A	5 g	9 g	12 g	14 g	15 g
B	1 g	3 g	6 g	10 g	15 g
C	3 g	6 g	9 g	12 g	15 g
D	11 g	12 g	13 g	14 g	15 g
E	6 g	10 g	13 g	15 g	15 g

60 Calcium carbonate reacts with hydrochloric acid. The reaction gives off carbon dioxide gas.

Line **X** on the graph shows the volume of carbon dioxide formed against time when 100 cm^3 of 1.0 mol dm^{-3} of hydrochloric acid reacts with calcium carbonate chips at 20 °C. There was an excess of calcium carbonate chips.

$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O(l)$

Which line best represents the volume of carbon dioxide formed against time when the reaction is repeated with 50 cm^3 of 2.0 mol dm^{-3} of hydrochloric acid reacting with excess calcium carbonate chips at 20 °C?



A line A

B line B

C line C

D line D

E line E

53 Calcium carbonate reacts with hydrochloric acid according to the following chemical equation:

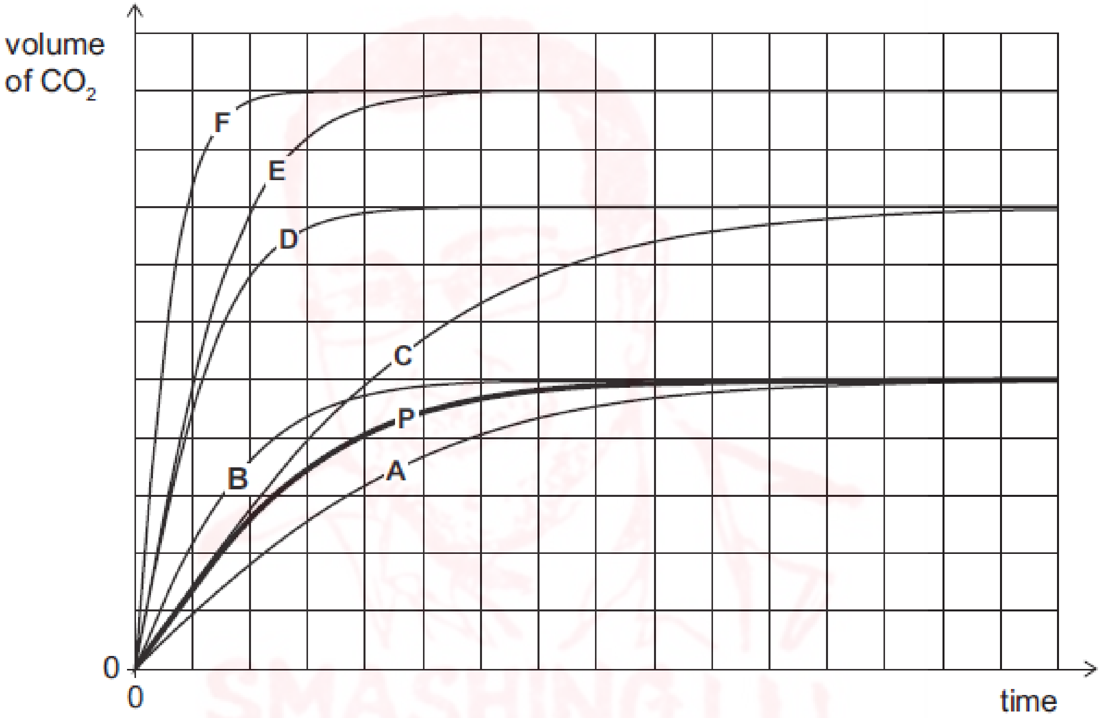
$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

Line **P** on the graph shows how the volume of carbon dioxide formed changes with time when 4.0 g of calcium carbonate reacts with 50 cm^3 of 1.0 mol dm^{-3} hydrochloric acid at 20 °C.

A second reaction was carried out under identical conditions with the same mass of calcium carbonate but using 50 cm^3 of 2.0 mol dm^{-3} hydrochloric acid.

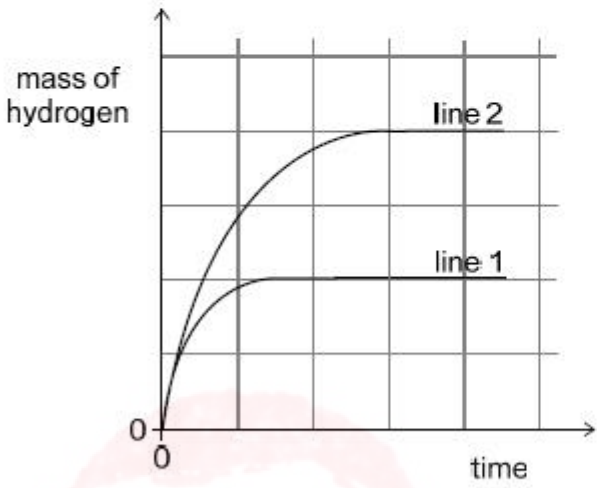
Which line (**A**-**F**) best represents how the volume of carbon dioxide formed changes with time in the second reaction?

(M_r value: $CaCO_3$ = 100)



49 A 2.40 g lump of magnesium was added to 500 cm^3 of a 2.00 mol dm^{-3} solution of HCl in a conical flask that was on an electronic balance. The neck of the flask was plugged with cotton wool, and the decrease in mass of the flask and its contents was recorded at regular intervals.

The mass of the hydrogen released (equal to the mass loss recorded) was plotted against time. The result is line 1 on the graph.



Which of the following experiments performed under the same conditions would give line 2?

(A_r value: Mg = 24.0)

A a 2.40 g lump of magnesium added to 500 cm^3 of 2.00 mol dm^{-3} H_2SO_4

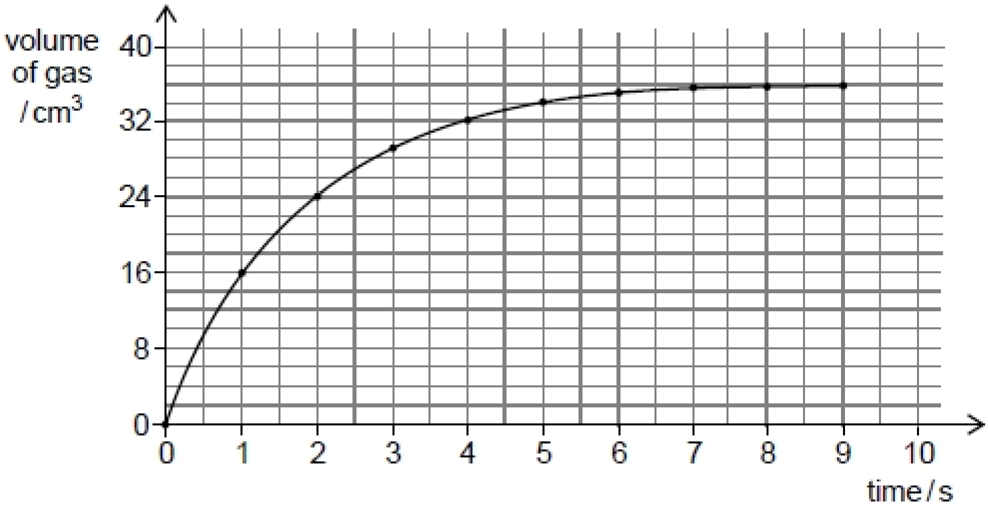
B 2.40 g of magnesium powder added to 500 cm^3 of 2.00 mol dm^{-3} HCl

C a 2.40 g lump of magnesium added to 1000 cm^3 of 2.00 mol dm^{-3} HCl

D a 4.80 g lump of magnesium added to 500 cm^3 of 2.00 mol dm^{-3} HCl

E 4.80 g of magnesium powder added to 500 cm^3 of 2.00 mol dm^{-3} HCl

50 Dilute hydrochloric acid and magnesium were mixed and the total volume of gas released was measured over time.



What is the average rate of reaction, in $g\,s^{-1}$, with respect to the magnesium over the first **two** seconds?

(A_r value: Mg = 24. Assume that the volume of one mole of gas is $24\,dm^3$.)

A $0.012\,g\,s^{-1}$

B $0.024\,g\,s^{-1}$

C $0.048\,g\,s^{-1}$

D $12\,g\,s^{-1}$

E $24\,g\,s^{-1}$

F $48\,g\,s^{-1}$

48 Magnesium reacts with sulfuric acid according to the following chemical equation:

$$Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g)$$

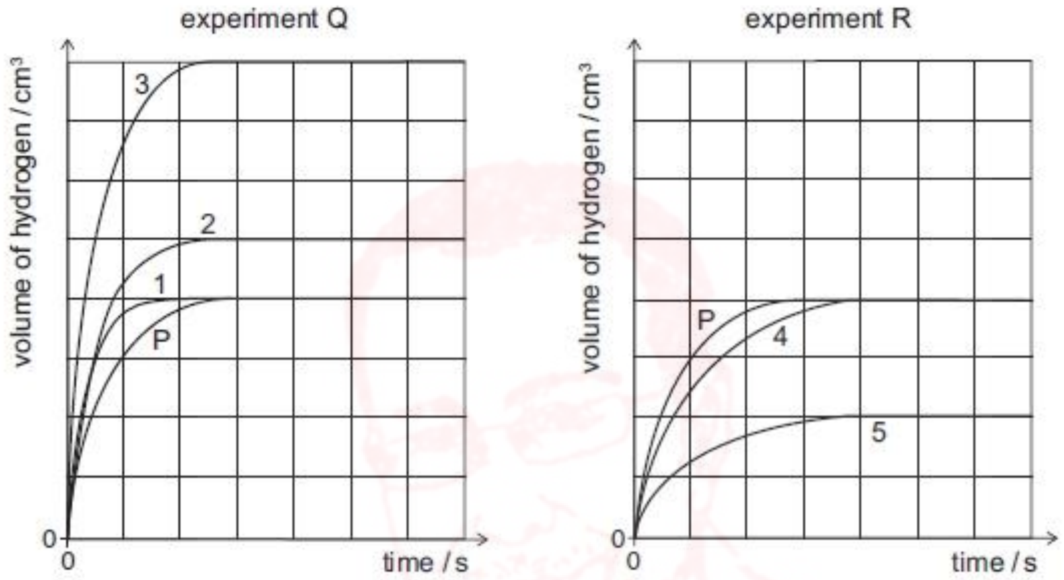
Line P on each graph shows how the volume of hydrogen formed changes with time when 1.2 g of magnesium reacts with 40 cm^3 of 1.0 mol dm^{-3} sulfuric acid at 20 °C.

(A_r value: Mg = 24)

Two further experiments were carried out and the volumes of hydrogen formed were plotted.

Experiment Q: 1.2 g of magnesium + 40 cm^3 of 2.0 mol dm^{-3} sulfuric acid at 20 °C

Experiment R: 1.2 g of magnesium + 40 cm^3 of 0.5 mol dm^{-3} sulfuric acid at 20 °C



Which lines show how the volume of hydrogen formed will change with time in each experiment?

	experiment Q	*experiment R*
A	1	4
B	1	5
C	2	4
D	2	5
E	3	4
F	3	5

53 The reaction between calcium carbonate and hydrochloric acid was used to measure the effect of changing conditions on the mass of CO_2 produced and the rate of CO_2 production.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

The experiment was carried out five times with different conditions at a constant temperature.

The following conditions were varied:

$CaCO_3$ as chips or powder

mass of $CaCO_3$

volume of HCl

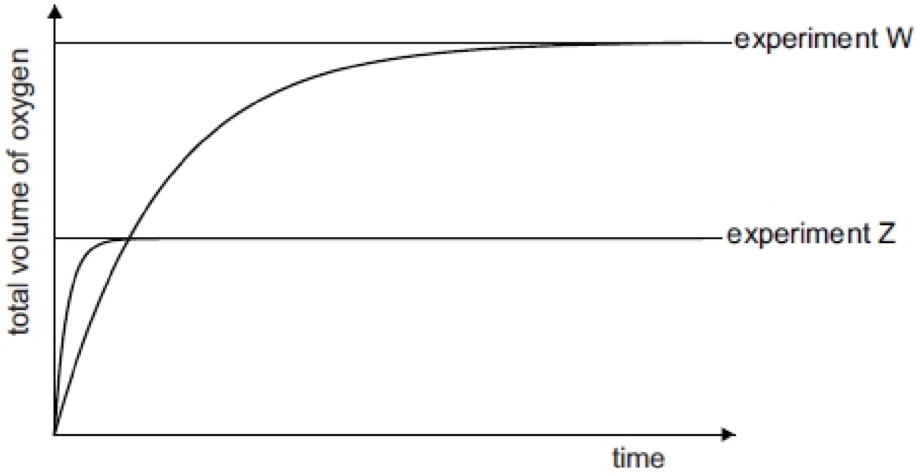
concentration of HCl

Which experiment (**A**-**E**) in the following table will produce 8.8 g of carbon dioxide in the shortest time?

(M_r values: $CaCO_3 = 100$; $CO_2 = 44$)

	$CaCO_3$		HCl	
	type	*mass* / g	*volume* / cm^3	*concentration* / $mol\,dm^{-3}$
A	chips	10	400	2.0
B	powder	20	100	2.0
C	chips	20	200	2.0
D	powder	10	200	2.0
E	chips	20	400	1.0

44 The graphs show results of two experiments (W and Z) involving the catalytic decomposition of hydrogen peroxide.



Assuming all other conditions are kept constant, which one of the following options would lead to the results shown?

	experiment W	*experiment Z*
A	100 cm^3 of 1.0 $mol\,dm^{-3}$ hydrogen peroxide	50 cm^3 of 2.0 $mol\,dm^{-3}$ hydrogen peroxide
B	catalyst is in lumps	catalyst is finely divided
C	reaction carried out at 25 °C	reaction carried out at 50 °C
D	2.0 g manganese(IV) oxide used	1.0 g manganese(IV) oxide used
E	100 cm^3 of 1.0 $mol\,dm^{-3}$ hydrogen peroxide	25 cm^3 of 2.0 $mol\,dm^{-3}$ hydrogen peroxide

Topic ALvl Chem 9 Q# 157**/** Cambridge/2024/Chemistry Section/Q#. 8/ www.SmashingScience.org/Practice Test May/

An element has a mass number of 40 and an atomic number of 20.

Which statement(s) about this element is/are correct?

1. Its atomic nucleus has a relative mass of 20.
2. It is a noble gas.
3. It would form a negative ion.
4. It is in Group 2 of the Periodic Table.
5. It is a non-metallic element.

○ 1, 2 and 3 only

○ 1, 3 and 4 only

○ 1, 4 and 5 only

○ 2, 3 and 5 only

○ 4 only

○ 5 only

Topic **ALvl Chem 9 Q# 158/** Cambridge/2024/Chemistry Section/Q#. 15/ www.SmashingScience.org/Practice Test May/

Listed are the electron configurations for the atoms of different elements.

Which one represents the most reactive non-metal?

- ○ 2,4
- ○ 2,6
- ○ 2,7
- ○ 2,8,1
- ○ 2,8,6
- ○ 2,8,7

Topic **ALvl Chem 9 Q# 159/** Cambridge/2023/Section 1/Q#. 52/ www.SmashingScience.org/

52 Element X is in Group 13, Period 4. It consists of atoms of two isotopes with mass numbers 69 and 71. The relative atomic mass of element X is 69.7.

Which of the following statements is/are correct about element X?

1 75% of the atoms of element X have mass number 69.

2 An atom of element X has three electrons in its outer shell.

3 Element X forms an oxide with formula X_2O_3 that reacts with acids.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

Topic **ALvl Chem 9 Q# 160/** Cambridge/2023/Section 1/Q#. 47/ www.SmashingScience.org/

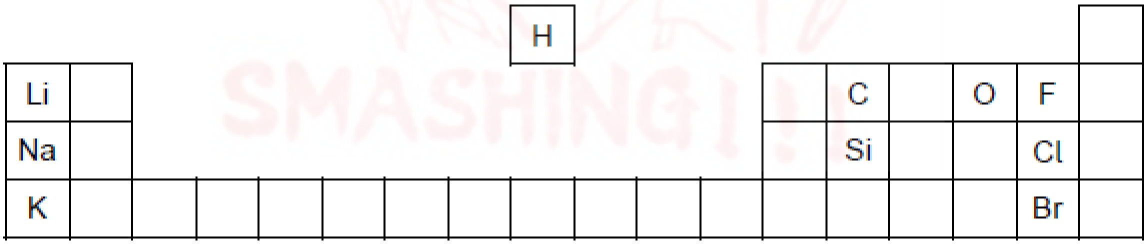
47 Atoms of element Q have two full shells of electrons and the third shell requires one more electron to gain a noble gas configuration.

Which row of the table correctly describes the elements near to Q in the Periodic Table?

	element immediately above Q	*element immediately below Q*	*element immediately to the left of Q*	*element immediately to the right of Q*
A	requires one more electron to fill a second shell of electrons	gains an electron less favourably than Q	the atom contains one fewer proton than Q	is very unreactive compared to Q
B	gains an electron more favourably than Q	the atom contains more protons than Q	is found in Period 3	is a halogen
C	requires one more electron to fill a second shell of electrons	gains an electron less favourably than Q	is an alkaline earth metal	the atom contains one more proton than Q
D	is found in Period 3	contains an extra full shell of electrons compared to Q	the atom contains one fewer proton than Q	is very unreactive compared to Q
E	gains an electron more favourably than Q	the atom contains more protons than Q	the atom has an atomic number greater than Q	is found in Period 3

Topic **ALvl Chem 9 Q# 161/** Cambridge/2021/Section 1 www.SmashingScience.org

44 A portion of the Periodic Table is given:



Which one of these trends is correct?

A Boiling point: K > Na > Li

B Electrical conductivity: NaCl(l) > NaCl(s) > Na(s)

C Reactivity: Br_2 > Cl_2 > F_2

D Melting point: SiO_2 > H_2O > Na_2O

E Number of double bonds per molecule: CO_2 > O_2 > H_2O

Topic **ALvl Chem 9 Q# 162/** Cambridge/2021/Section 1 www.SmashingScience.org

41 The following equations represent the reactions of four metals M, Q, R and T:

$$M(s) + HCl(aq) \rightarrow \text{no reaction}$$

$$R(s) + TSO_4(aq) \rightarrow RSO_4(aq) + T(s)$$

$$M(s) + QNO_3(aq) \rightarrow MNO_3(aq) + Q(s)$$

$$T(s) + 2HCl(aq) \rightarrow TCl_2(aq) + H_2(g)$$

Which option lists the order of reactivity of the four metals, from the most to the least reactive?

A M, Q, R, T

B M, R, T, Q

C Q, M, T, R

D Q, R, T, M

E R, M, T, Q

F R, T, M, Q

G T, M, R, Q

H T, R, Q, M

Topic **ALvl Chem 9 Q# 163/** Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org

46 An element has a mass number of 40 and an atomic number of 20.

Which statement(s) about this element is/are correct?

1 Its atomic nucleus has a relative mass of 20.

2 It is a noble gas.

3 It would form a negative ion.

4 It is in Group 2 of the Periodic Table.

5 It is a non-metallic element.

A 1, 2 and 3 only

B 1, 3 and 4 only

C 1, 4 and 5 only

D 2, 3 and 5 only

E 4 only

F 5 only

51 Listed are the electron configurations for the atoms of different elements.

Which one represents the most reactive non-metal?

A 2,4

B 2,6

C 2,7

D 2,8,1

E 2,8,6

F 2,8,7

42 Consider **only** the first three metals in Group 1 (Li, Na, K) and **only** the first three elements in Group 17 (F, Cl, Br).

Which of the following statements is/are correct for the compound lithium bromide?

1 It is formed from the least reactive of the three Group 17 elements.

2 It is formed from the least reactive of the three Group 1 elements and the Group 17 element (of the three) with the lowest boiling point.

3 It is formed from the Group 1 element (of the three) with the highest melting point.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

Topic **ALvl Chem 9 Q# 166/** Cambridge/2020/Section 1 www.SmashingScience.org

47 Which of the following statements about elements in the Periodic Table is/are correct?

1 When the element in Period 5, Group 2 reacts with the element that is in Period 3, Group 17, a redox reaction occurs.

2 In each Group, the elements from Period 2 are more reactive than the elements from Period 5.

3 The compound formed between the element in Period 2, Group 14 and the element in Period 3, Group 17 will have a simple molecular structure.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

Topic **ALvl Chem 9 Q# 167/** Cambridge/2019/Section 1 www.SmashingScience.org

41 The following information about metals labelled P, Q, R and S is given.

- Metals P and S can be extracted by electrolysis, but not by reaction with carbon.
- Metals Q and R can be extracted by reaction with carbon.
- Metal S forms positive ions more readily than metal P.
- Metal R reacts with the oxide of metal Q.

What is the order of reactivity of these four metals, starting with the most reactive?

A P, S, Q, R

B P, S, R, Q

C Q, R, P, S

D Q, R, S, P

E R, Q, P, S

F R, Q, S, P

G S, P, Q, R

H S, P, R, Q

Topic **ALvl Chem 9 Q# 168/** Cambridge/2019/Section 1 www.SmashingScience.org

51 In each of the following procedures an excess of the metal is added to 1.0 dm^3 of a 1.0 $mol\,dm^{-3}$ solution of the acid.

copper added to sulfuric acid

iron added to hydrochloric acid

magnesium added to sulfuric acid

zinc added to hydrochloric acid

Which row in the following table identifies combinations of metal and acid that will react and produce the largest, and the smallest, theoretical mass of anhydrous salt?

(M_r values: $CuSO_4$ = 160; $FeCl_2$ = 127; $MgSO_4$ = 120; $ZnCl_2$ = 136)

	reaction that produces the largest mass of salt	*reaction that produces the smallest mass of salt*
A	Cu and H_2SO_4	Fe and HCl
B	Cu and H_2SO_4	Mg and H_2SO_4
C	Fe and HCl	Zn and HCl
D	Mg and H_2SO_4	Fe and HCl
E	Mg and H_2SO_4	Zn and HCl
F	Zn and HCl	Mg and H_2SO_4

Topic **ALvl Chem 9 Q# 169/** Cambridge/2018/Section 1 www.SmashingScience.org

42 Concentrated aqueous sodium chloride was electrolysed. After a few minutes, the remaining electrolyte solution was tested with a pH probe at 25 °C.

The gases produced at the electrodes were collected and tested with a colourless aqueous solution of sodium bromide.

Which row in the following table best describes the observations in these tests?

	pH of the remaining solution	*test of gas from anode (positive electrode)*	*test of gas from cathode (negative electrode)*
A	2	no observable change	no observable change
B	2	no observable change	orange solution forms
C	7	orange solution forms	no observable change
D	7	orange solution forms	orange solution forms
E	12	orange solution forms	no observable change
F	12	no observable change	orange solution forms

Topic **ALvl Chem 9 Q# 170/** Cambridge/2018/Section 1 www.SmashingScience.org

44 X, Y and Z have the **same** electron configuration.

X is an atom, Y is a monatomic anion and Z is a monatomic cation.

Which of the following statements is **always** correct?

A Anion Y has fewer protons than atom X.

B Cation Z has more electrons than protons.

C X, Y and Z are in the same group of the Periodic Table.

D X, Y and Z have consecutive atomic numbers.

E X, Y and Z have the same mass number.

Topic **ALvl Chem 9 Q# 171/** Cambridge/2018/Section 1 www.SmashingScience.org

46 The non-metallic element phosphorus forms two stable chlorides: PCl_3 (boiling point 76 °C) and PCl_5 (boiling point 161 °C).

Which of the following statements explain(s) the difference in boiling points?

1 There are more covalent bonds in PCl_5 so more energy is required to break them.

2 The forces between the molecules in liquid PCl_5 are stronger.

3 The covalent bonds in PCl_3 are weaker so less energy is required to break them.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

42 Element X has atomic number 20. Consider only the **simple oxide** of X.

Which of the following options identifies the formula, the type of bonding and the acid-base character of the oxide of element X?

	formula of oxide	*type of bonding in oxide*	*acid-base character of oxide*
A	X_2O	ionic	basic
B	X_2O	covalent	basic
C	XO	ionic	basic
D	XO	covalent	acidic
E	XO_2	ionic	acidic
F	XO_2	covalent	acidic
G	X_2O_3	ionic	basic
H	X_2O_3	covalent	acidic

Topic **ALvl Chem 9 Q# 173/** Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

42 An element has a mass number of 40 and an atomic number of 20.

Which statement(s) about this element is/are correct?

1 Its atomic nucleus has a relative mass of 20.

2 It is a noble gas.

3 It would form a negative ion.

4 It is in group 2 of the periodic table.

5 It is a non-metallic element.

A 1, 2 and 3 only

B 1, 3 and 4 only

C 1, 4 and 5 only

D 2, 3 and 5 only

E 4 only

F 5 only

Topic **ALvl Chem 9 Q# 174/** Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

47 Listed are the electronic configurations for the atoms of different elements.

Which one represents the most reactive non-metal?

A 2, 4

B 2, 6

C 2, 7

D 2, 8, 1

E 2, 8, 6

F 2, 8, 7

Topic ALvl Chem 11 Q# 175**/** Cambridge/2023/Section 1/Q#. 44/ www.SmashingScience.org/

44 In this question, all solutions have the same concentration in $mol\,dm^{-3}$.

Three separate experiments were set up using the same volume of each solution:

experiment 1:	$LiCl(aq)$ and $AgNO_3(aq)$
experiment 2:	$NaCl(aq)$ and $AgNO_3(aq)$
experiment 3:	$KCl(aq)$ and $AgNO_3(aq)$

For each experiment, the solid formed was filtered, washed, dried, and weighed.

Which of the following statements is/are correct?

1 Experiment 3 forms the greatest mass of solid.

2 Experiment 3 has a noticeably greater rate of reaction than the others.

3 The reaction taking place in each experiment is a redox reaction.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

The following exothermic, reversible reaction is used in the manufacture of sulfuric acid from sulfur dioxide and oxygen:

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

Which one of the following statements about this reaction is correct?

- ○ Pressure has no effect on the position of equilibrium.
- ○ Raising the temperature moves the equilibrium to the right.
- ○ At equilibrium, no sulfur dioxide is being changed into sulfur trioxide.
- ○ The addition of a catalyst speeds up the forward reaction more than the backward reaction.
- ○ Before equilibrium is reached, the rate of the forward reaction is greater than the rate of the backward reaction.

Topic **ALvl Chem 14 Q# 177/** Cambridge/2022/Section 1 www.SmashingScience.org

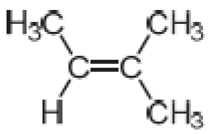
54 1 mol of compound X undergoes complete combustion to produce 144 dm^3 of carbon dioxide (measured at room temperature and pressure).

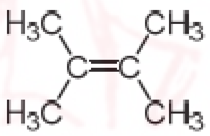
1 mol of X can also undergo an addition reaction with 1 mol of hydrogen to form a saturated compound that has one branch.

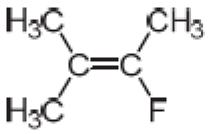
X undergoes addition polymerisation. A section of the addition polymer containing three repeating units has an M_r value greater than 200 but less than 300.

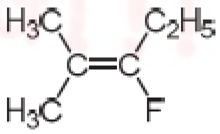
Which one of the following structural formulae could be that of compound X?

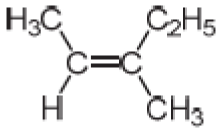
(A_r values: C = 12; H = 1; F = 19. Assume that one mole of any gas occupies a volume of 24 dm^3 at room temperature and pressure.)

A 

B 

C 

D 

E 

Topic **ALvl Chem 14 Q# 178/** Cambridge/2022/Section 1 www.SmashingScience.org

59 One mole of an unsaturated hydrocarbon reacts with exactly one mole of bromine to form a compound that contains $\frac{6}{15}$ carbon, $\frac{1}{15}$ hydrogen and $\frac{8}{15}$ bromine by mass.

What is the relative molar mass (M_r) of this product?

(A_r values: C = 12; H = 1; Br = 80)

A 150

B 210

C 220

D 290

E 300

F 420

G 440

H 713

Topic **ALvl Chem 14 Q# 179/** Cambridge/2019/Section 1 www.SmashingScience.org

37 HBr reacts with pent-2-ene in an addition reaction.

Which of the following products is/are formed in the reaction?

1 $CH_3CHBrCH_2CH_2CH_3$

2 $CH_2BrCH_2CH_2CH_2CH_3$

3 $CH_3CH_2CHBrCH_2CH_3$

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

Topic **ALvl Chem 17 Q# 180/** Cambridge/2018/Section 1 www.SmashingScience.org

48 Bromine is an element in Group 17 of the Periodic Table.

Which of the following statements is/are correct about the element bromine?

1 Bromine will oxidise chloride ions in aqueous solution to form chlorine.

2 Bromine has a lower boiling point than chlorine.

3 Bromine reacts with calcium (Group 2) to form a compound containing 80% bromine by mass.

(A_r values: Cl = 35.5; Ca = 40; Br = 80)

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

Topic **ALvl Chem 18 Q# 181/** Cambridge/2022/Section 1 www.SmashingScience.org

49 Carboxylic acid X reacts with propanol in the presence of an acid catalyst to form compound Y.

Compound Y has a relative molar mass of 116.

What is the relative molar mass (M_r) of X?

(A_r values: C = 12; H = 1; O = 16)

A 45

B 46

C 55

D 56

E 59

F 60

G 73

H 74

Topic **ALvl Chem 18 Q# 182/** Cambridge/2021/Section 1 www.SmashingScience.org

49 The table shows the reagents in three organic reactions.

Which of the rows correctly show(s) the product(s) obtained from the specified reactants?

	reactants	*product(s)*
1	$CH_3CH{=}CH_2$ and HBr	1,2-dibromopropane (only)
2	C_2H_5COOH and CH_3OH, in the presence of an $H^+(aq)$ catalyst	methyl propanoate and water
3	C_2H_5OH and Na	sodium ethanoate and hydrogen

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

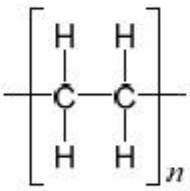
G 2 and 3 only

H 1, 2 and 3

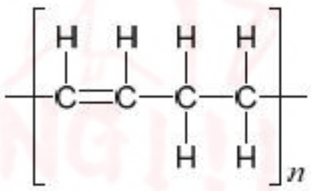
Topic **ALvl Chem 20 Q# 183/** Cambridge/2023/Section 1/Q#. 42/ www.SmashingScience.org/

42 Which of the following represents the structure of the addition polymer formed from but-1-ene?

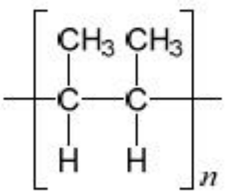
A



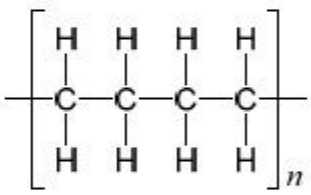
B



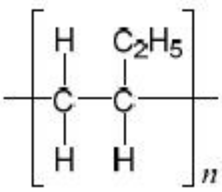
C



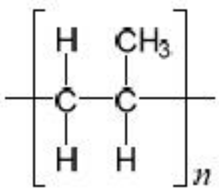
D



E

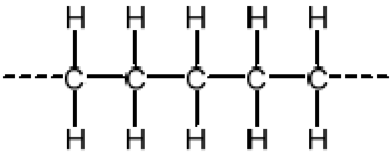


F

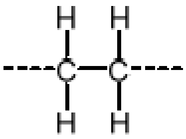


46 Which one of the following represents the repeating unit of poly(pent-2-ene)?

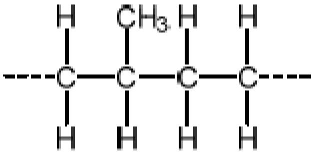
A



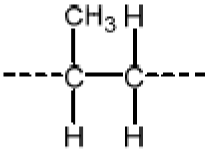
B



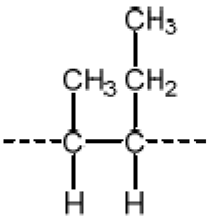
C



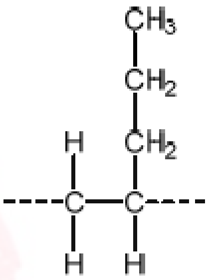
D



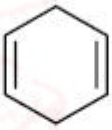
E



F



57 The structure of cyclohexa-1,4-diene is:



Bromine is dissolved in inert organic solvent to form 0.250 mol dm^{-3} of bromine solution.

What is the minimum volume of this bromine solution required to react completely with 0.10 cm^3 of cyclohexa-1,4-diene?

(M_r value: cyclohexa-1,4-diene = 80. Density of cyclohexa-1,4-diene = 0.84 g cm^{-3})

A 0.042 cm^3

B 0.084 cm^3

C 0.0042 cm^3

D 0.0084 cm^3

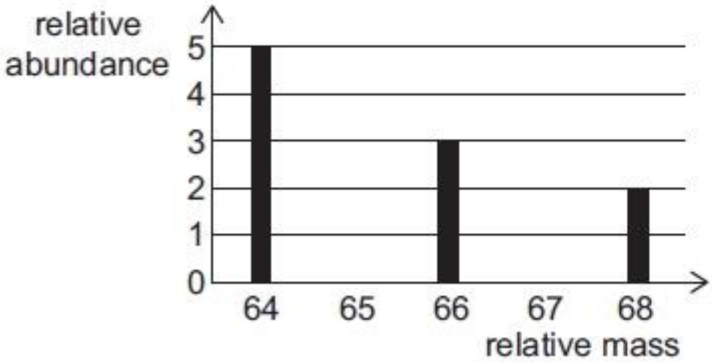
E 0.042 dm^3

F 0.084 dm^3

G 0.0042 dm^3

H 0.0084 dm^3

43 The chart shows the relative abundances of the isotopes of an element.



What is the relative atomic mass (A_r) of this element?

A 64.0

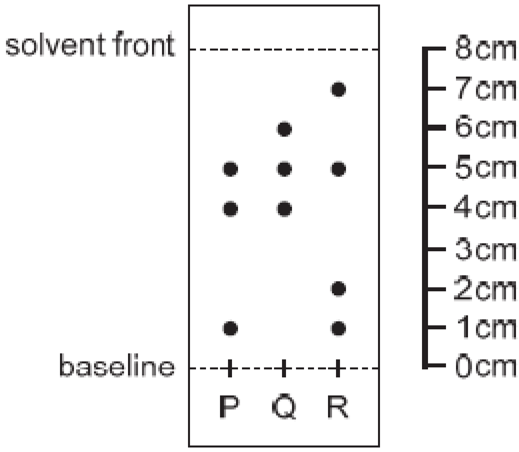
B 65.4

C 65.8

D 66.0

E 66.6

51 Three mixtures (P, Q and R) of amino acids were separated using paper chromatography.



The test was repeated with the same mixtures, paper and solvent but this time the distance travelled by the common component of the mixtures was 7.5 cm.

How far did the most mobile component of mixture Q travel in the second test?

A 6.0 cm

B 8.5 cm

C 9.0 cm

D 9.6 cm

E 10.5 cm

F 12.0 cm

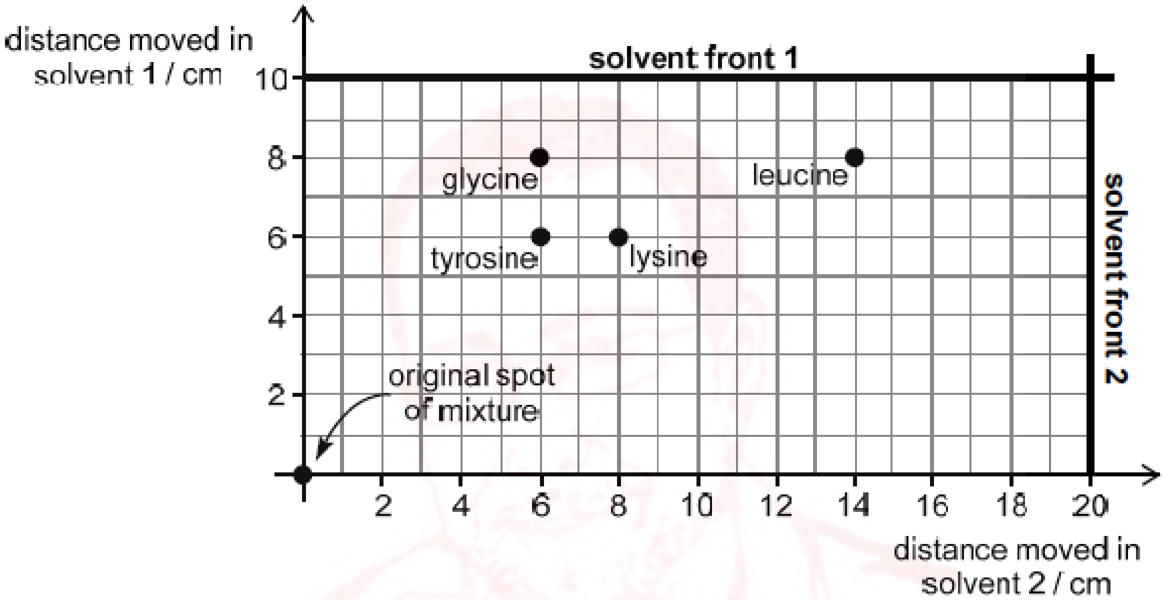
51 An experiment was carried out to separate the four amino acids present in a mixture of amino acids.

A spot of this mixture was placed on chromatography paper. The bottom of the paper was placed in solvent 1 and left until the solvent nearly reached the top of the paper.

The paper was then thoroughly dried and turned by 90°. The procedure was then repeated with solvent 2.

The amino acids were then identified with reference to known R_f values in the respective solvents.

The final positions of the amino acids on the chromatograph are shown on the following diagram.



Which of the following statements is correct?

A Leucine travels further relative to the solvent front in solvent 2 than in solvent 1.

B Lysine has a greater R_f value in solvent 1 than it has in solvent 2.

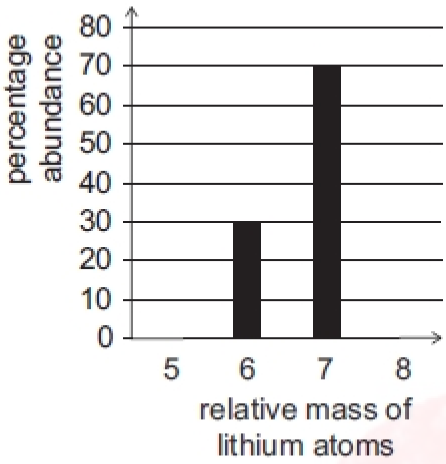
C Solvent 1 alone could be used to separate all four amino acids.

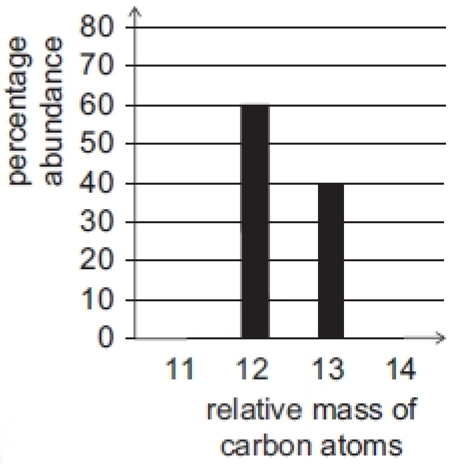
D Solvent 2 alone could be used to separate all four amino acids.

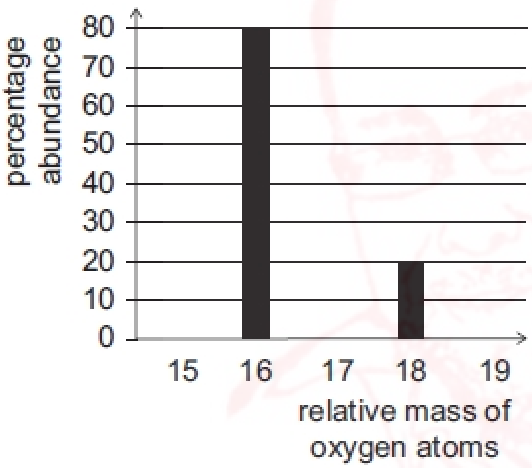
E The R_f value of tyrosine in solvent 1 is 0.6 and in solvent 2 is 0.7.

40 A mass spectrometer is a device that can measure the mass of isotopes. It shows this data as a spectrum, giving both the relative mass and the percentage abundance of each isotope.

The charts indicate the relative mass and percentage abundance for lithium atoms, carbon atoms and oxygen atoms found in a sample taken from a nuclear reactor.







Using this data, what is the largest possible relative molar mass of lithium carbonate?

A 35

B 38

C 45

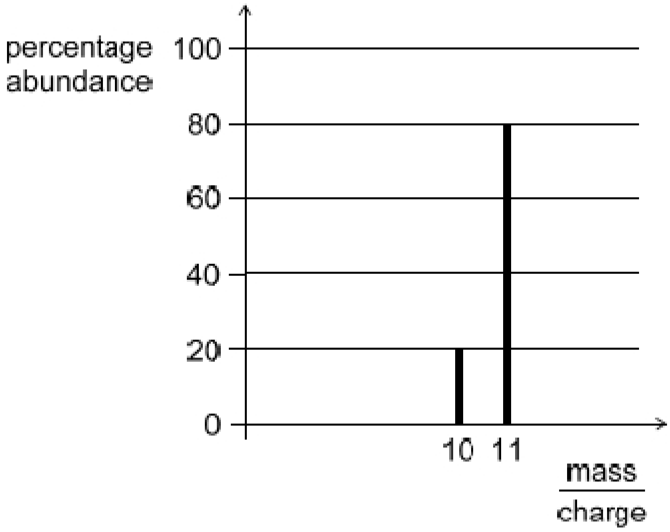
D 67

E 74

F 75

G 81

40 A mass spectrum of a sample of element X with atomic number 5 is shown.



Using the data, which row in the following table best describes the position of X in the Periodic Table and the relative atomic mass of this sample of X?

	Period	*Group*	*relative atomic mass*
A	1	15	10.2
B	1	15	10.8
C	2	13	10.2
D	2	13	10.8
E	3	2	10.2
F	3	2	10.8

Topic **ALvl Chem 22 Q# 191/** Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

48 Naturally occurring chlorine is a mixture of two isotopes with mass number 35 and 37. The isotope with mass number 35 is three times as common as the isotope with mass number 37.

Naturally occurring bromine is a mixture of two isotopes with mass numbers 79 and 81. They are present in equal amounts.

What fraction of the naturally occurring compound CH_2BrCl has a relative molecular mass of 128?

(A_r: H = 1; C = 12)

A $\frac{1}{8}$

B $\frac{1}{4}$

C $\frac{3}{8}$

D $\frac{1}{2}$

E $\frac{5}{8}$

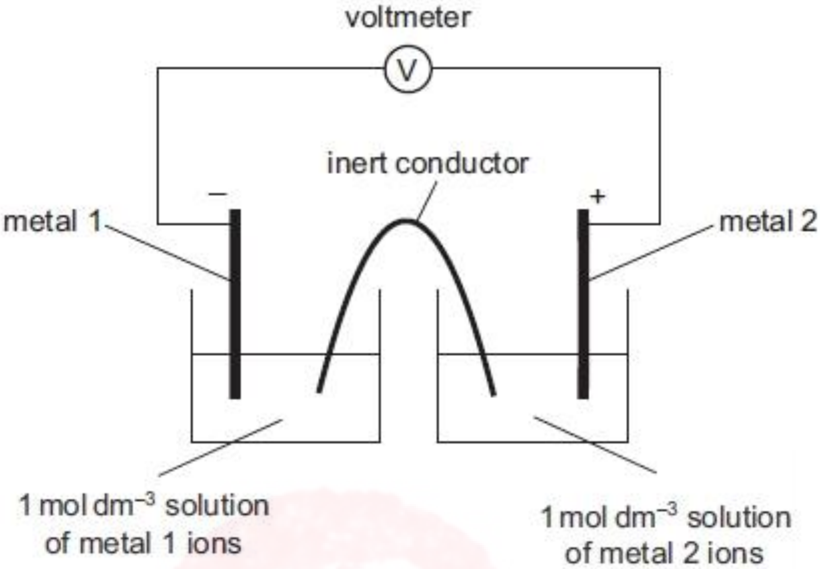
Topic ALvl Chem 24 Q# 192**/** Cambridge/2024/Chemistry Section/Q#. 3/ www.SmashingScience.org/Practice Test May/

When concentrated aqueous sodium chloride solution is electrolysed using inert electrodes, a reaction occurs at each electrode.

Which is the correct combination of elements actually produced at the electrodes in this electrolysis?

- ○ positive electrode = chlorine; negative electrode = hydrogen
- ○ positive electrode = chlorine; negative electrode = sodium
- ○ positive electrode = oxygen; negative electrode = hydrogen
- ○ positive electrode = oxygen; negative electrode = sodium
- ○ positive electrode = sodium; negative electrode = chlorine

58 The relative tendency for metals to form positive ions in solution can be measured using the following apparatus:



Electrons can pass from metal 1 to metal 2 via the external circuit. The difference in the tendency of the metals to form positive ions is given by the reading on the voltmeter. The higher the reading on the voltmeter the greater the **difference** in the tendency of the pair of metals to form positive ions.

Results from three experiments are given in the following table.

experiment	*metal 1*	*metal 2*	*reading on voltmeter* / V
1	P	Q	+0.62
2	S	Q	+0.30
3	S	R	+1.24

Using the information in the table, what is the order of reactivity of the four metals P, Q, R and S, from most reactive to least reactive?

A P, Q, R, S

B P, Q, S, R

C P, S, Q, R

D P, S, R, Q

E S, P, Q, R

F S, P, R, Q

G S, R, Q, P

H S, R, P, Q

56 A student electroplates a solid metal ball with copper.

The student dissolves 80.0 g of anhydrous copper(II) sulfate in water and makes up the solution to exactly 500 cm^3 to use as the electrolyte.

Two electrodes are placed in this solution. One electrode is the ball to be electroplated and the other electrode is an inert graphite electrode. The electrodes are connected to a battery.

After some time, the ball is removed and is found to be coated with 8.00 g of copper. Water is added to the remaining solution to give a final volume of exactly 500 cm^3.

What is the final concentration of the copper(II) ions in solution?

(A_r values: O = 16; S = 32; Cu = 64)

A 0.25 mol dm^{-3}

B 0.38 mol dm^{-3}

C 0.45 mol dm^{-3}

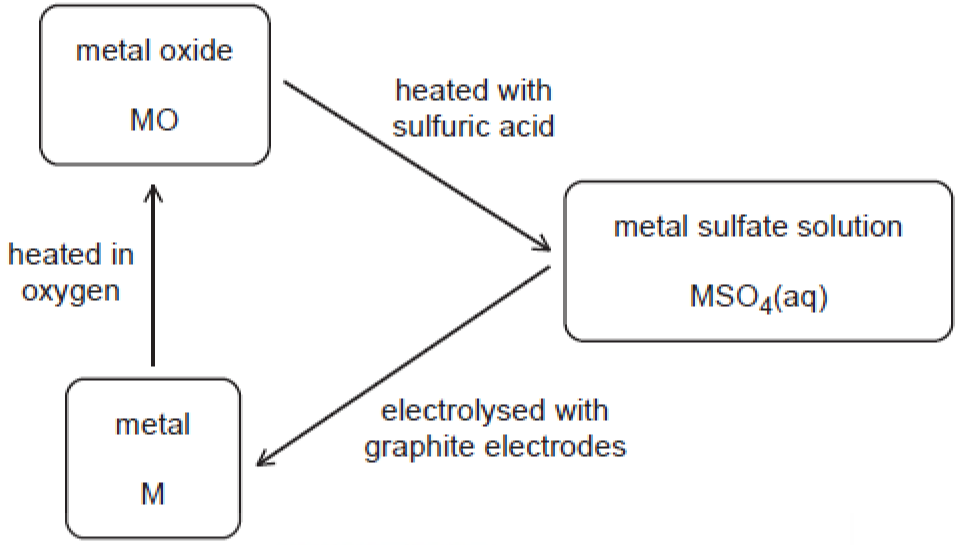
D 0.50 mol dm^{-3}

E 0.75 mol dm^{-3}

F 0.90 mol dm^{-3}

G 1.0 mol dm^{-3}

42 Some reactions of metal M and its compounds are shown in the following diagram.



Which one of the following could be the identity of metal M?

A aluminium

B copper

C magnesium

D potassium

E silver

Topic **ALvl Chem 24 Q# 196/** Cambridge/2022/Section 1 www.SmashingScience.org

44 Which of the following statements about losing electrons is/are correct?

1 During the electrolysis of a molten binary compound the ions attracted to the cathode (negative electrode) lose electrons at that electrode.

2 Descending Group 1 of the Periodic Table from lithium to caesium, the atoms of the elements lose electrons more easily.

3 When a substance is acting as a reducing agent it loses electrons.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

Topic **ALvl Chem 24 Q# 197/** Cambridge/2022/Section 1 www.SmashingScience.org

47 Concentrated aqueous solutions of three compounds are electrolysed with inert electrode

The constituent elements of which of the following compounds may be collected using thi process?

1 copper(II) bromide

2 hydrogen chloride

3 potassium chloride

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

Topic **ALvl Chem 24 Q# 198/** Cambridge/2021/Section 1 www.SmashingScience.org

57 The electrolysis of molten potassium chloride in an inert atmosphere produces potassium at the negative electrode and chlorine at the positive electrode.

The electrolysis of aqueous copper(II) sulfate solution deposits copper on the negative electrode.

The masses of potassium, chlorine and copper produced or deposited in these experiments were recorded.

Assume that the same number of electrons is transferred during the electrolysis of molten potassium chloride and aqueous copper(II) sulfate solution.

Which of the following gives the elements arranged in order of the mass produced/deposited during these electrolysis experiments, from lowest mass to highest mass?

(A_r values: Cl = 35.5; K = 39.0; Cu = 63.5)

A chlorine, copper, potassium

B chlorine, potassium, copper

C copper, chlorine, potassium

D copper, potassium, chlorine

E potassium, chlorine, copper

F potassium, copper, chlorine

Topic **ALvl Chem 24 Q# 199/** Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org

42 When concentrated aqueous sodium chloride solution is electrolysed using inert electrodes a reaction occurs at each electrode.

Which is the correct combination of elements actually produced at the electrodes in this electrolysis?

A positive electrode = chlorine; negative electrode = hydrogen

B positive electrode = chlorine; negative electrode = sodium

C positive electrode = oxygen; negative electrode = hydrogen

D positive electrode = oxygen; negative electrode = sodium

E positive electrode = sodium; negative electrode = chlorine

Topic **ALvl Chem 24 Q# 200/** Cambridge/2020/Section 1 www.SmashingScience.org

48 Some dilute aqueous solutions were electrolysed using graphite electrodes.

Which of the rows in the table show(s) the correct products of electrolysis?

	aqueous electrolyte	*products of electrolysis*	
		at the cathode (negative electrode)	*at the anode (positive electrode)*
1	potassium hydroxide	potassium	oxygen
2	copper(II) chloride	chlorine	copper
3	sodium sulfate	hydrogen	sulfur

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

Topic **ALvl Chem 24 Q# 201/** Cambridge/2020/Section 1 www.SmashingScience.org

59 An electric current is the flow of charged particles.

In an electrolysis of aluminium oxide using inert electrodes, the current flows at 5.00×10^{-6} moles of electrons per second.

Assume that only aluminium oxide is present and the aluminium is a single isotope ${}^{27}_{13}\text{Al}$.

What mass of aluminium is produced in 48 seconds?

A 0.04 mg

B 0.09 mg

C 0.52 mg

D 1.04 mg

E 1.08 mg

F 2.16 mg

G 3.12 mg

H 6.48 mg

46 In the electrolysis of dilute sulfuric acid, hydrogen gas is formed at the negative electrode (cathode) and oxygen gas is formed at the positive electrode (anode).

If 100 g of hydrogen gas is formed in the electrolysis of dilute sulfuric acid, what mass of oxygen gas is also formed?

(A_r values: H = 1; O = 16)

A 50 g

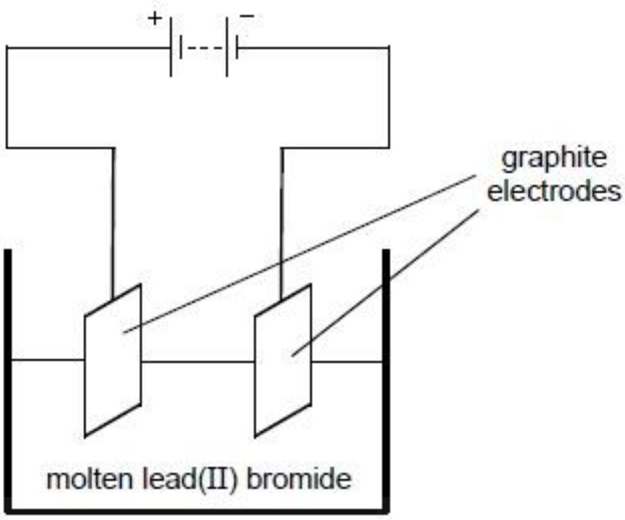
B 100 g

C 200 g

D 800 g

E 1600 g

54 The diagram shows the electrolysis of molten lead(II) bromide, $PbBr_2$, using graphite electrodes to separate the compound into its elements.



Which of the following statements about this electrolysis is/are correct?

1 Lead is formed at the negative electrode.

2 Electrons flow through the external circuit away from the positive electrode towards the negative electrode.

3 Bromine molecules and lead are produced in a 2 : 1 molar ratio.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

39 What is the overall process that takes place at the cathode (negative electrode) in the electrolysis of dilute aqueous sodium sulfate?

A $2H^+ + 2e^- \rightarrow H_2$

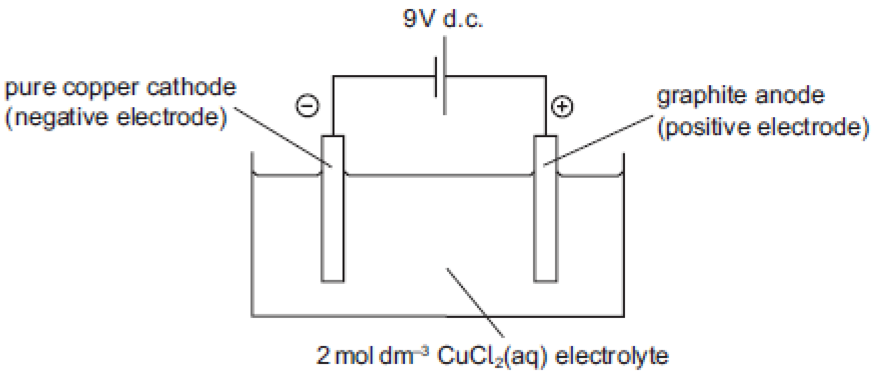
B $2O^{2-} \rightarrow O_2 + 4e^-$

C $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$

D $Na^+ + e^- \rightarrow Na$

E $SO_4^{2-} \rightarrow SO_2 + O_2 + 2e^-$

45 Consider this electrochemical cell containing an aqueous copper(II) chloride electrolyte:



Which row in the following table identifies the reactions occurring at the electrodes?

	cathode (negative electrode)	*anode (positive electrode)*
A	$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$
B	$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$	$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$
C	$2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$	$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$
D	$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	$2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$
E	$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$	$2OH^-(aq) \rightarrow H_2(g) + O_2(g) + 2e^-$

Topic **ALvl Chem 24 Q# 206/** Cambridge/2017/Section 1 www.SmashingScience.org

50 Consider the following two electrolytic processes:

electrolysis of molten lead(II) chloride

electrolysis of brine (sodium chloride solution)

Which of the following statements is/are correct?

1 In both processes, reduction takes place at the negative electrode.

2 If 20.0 g of product is formed at the negative electrode in each process, then both processes produce the same volume of chlorine gas, measured at room temperature and pressure.

3 In both processes, a metal is produced at the negative electrode.

(A_r values: Cl = 35.5; H = 1.00; Na = 23.0; Pb = 207. Assume that one mole of gas occupies 24.0 dm^3 at room temperature and pressure.)

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

Topic **ALvl Chem 24 Q# 207/** Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

38 When concentrated aqueous sodium chloride solution is electrolysed using inert electrodes a reaction occurs at each electrode.

Which is the correct combination of elements actually produced at the electrodes in this electrolysis?

A positive electrode = chlorine; negative electrode = hydrogen

B positive electrode = chlorine; negative electrode = sodium

C positive electrode = oxygen; negative electrode = hydrogen

D positive electrode = oxygen; negative electrode = sodium

E positive electrode = sodium; negative electrode = chlorine

38 Solid titanium oxide does not conduct electricity and cannot be electrolysed.

When molten, titanium oxide is a conductor and can be electrolysed.

During electrolysis 7.2 g of titanium are formed for every 3.6 dm^3 of oxygen at room temperature and pressure.

Which of the following statements, if any, are correct?

1 After electrolysis, the titanium atoms produced have a noble gas electron configuration.

2 When molten, titanium oxide electrons are delocalised and so they move to carry the charge.

3 The empirical formula of titanium oxide is TiO_2.

(A_r: Ti = 48; molar gas volume = 24 dm^3 at room temperature and pressure)

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2, and 3

Topic **ALvl Chem 24 Q# 209/** Cambridge/2016/Section 1 www.SmashingScience.org

39 In which, if any, of the following reactions are covalent bonds both broken and formed?

1 burning sodium in oxygen

2 electrolysis of aqueous sodium chloride

3 displacement of iron from iron oxide by heating with aluminium powder

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2

F 1 and 3

G 2 and 3

H 1, 2 and 3

Topic **ALvl Chem 24 Q# 210/** Cambridge/2016/Section 1 www.SmashingScience.org

47 During the electrolysis of a saturated solution of sodium chloride, 2.4 dm^3 of hydrogen gas was collected in time *t* at one of the electrodes.

Assuming no products dissolve, which row in the table correctly gives the mass or volume of the given product collected at the given electrode in time *t*?

(A_r: Na = 23; Cl = 35.5; H = 1, 1 mole of gas occupies 24 dm^3 at room temperature and pressure)

	mass or volume	*product*	*electrode*
A	0.1 g	hydrogen	negative
B	2.3 g	sodium	negative
C	2.4 dm^3	chlorine	positive
D	2.4 dm^3	chlorine	negative
E	2.4 dm^3	oxygen	positive
F	3.55 g	chlorine	positive
G	1.2 dm^3	oxygen	negative

53 During electrolysis of an aqueous solution of sodium sulfate the half equations for the electrode reactions are:

Anode (positive electrode): $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$

Cathode (negative electrode): $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$

Which of the following deductions, if any, can be made from these equations?

1 The ratio by moles of hydrogen to oxygen produced at the electrodes is 1:1.

2 The sodium sulfate solution will become more concentrated as the electrolysis proceeds.

3 The whole solution will become acidic due to formation of H^+ ions at the anode.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

49 A paper chromatogram is set up with an orange food colouring spotted on the baseline.

Ten minutes after the start, the solvent front has moved 15.0 cm up the paper from the baseline and a yellow spot is 12.0 cm above the baseline.

Five minutes later, the solvent front has moved up a further 10.0 cm.

How far from the baseline will the yellow spot be 15 minutes after the start?

A 8.0 cm

B 12.0 cm

C 15.0 cm

D 20.0 cm

E 22.0 cm

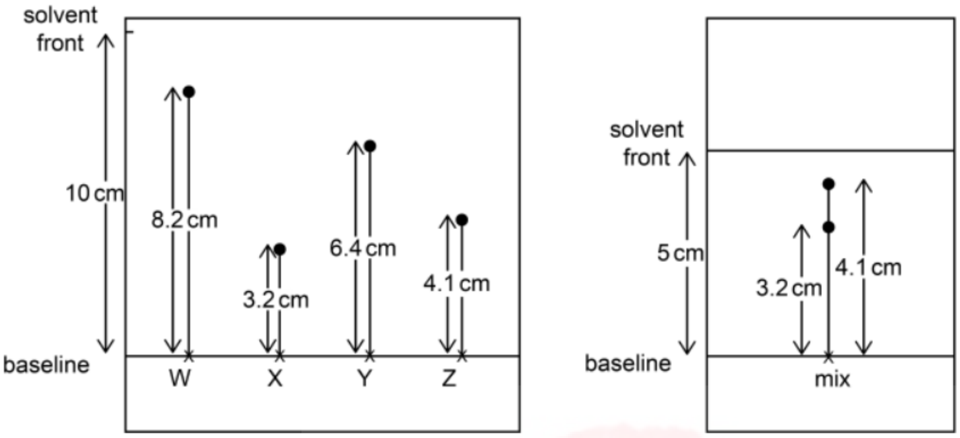
F 25.0 cm

G 31.3 cm

A chromatogram was produced for 4 separate dyes (W, X, Y and Z) using filter paper and a water solvent.

A second chromatogram was produced using a mixture of two of the dyes, again using filter paper and a water solvent:

[diagram not to scale]

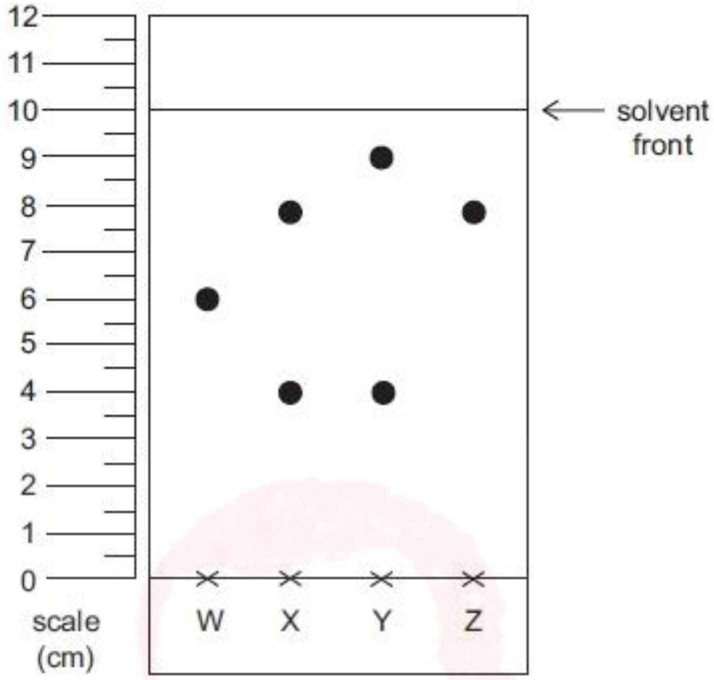


Which of the following statements, if any, are correct?

1. The concentration of dye W must be twice the concentration of dye Z.
2. The mobile phase is the filter paper.
3. The mixture in the second chromatogram contained dyes W and Y.

- ○ none of them
- ○ 1 only
- ○ 2 only
- ○ 3 only
- ○ 1 and 2 only
- ○ 1 and 3 only
- ○ 2 and 3 only
- ○ 1, 2 and 3

39 Four samples, labelled W, X, Y and Z, were investigated using paper chromatography with a solvent that caused any mixtures present to be fully separated. The results are shown in the chromatogram.



What is the R_f value of the spot with the strongest attraction to the mobile phase relative to the stationary phase **and** that is from a sample containing only one substance?

A 0.50

B 0.60

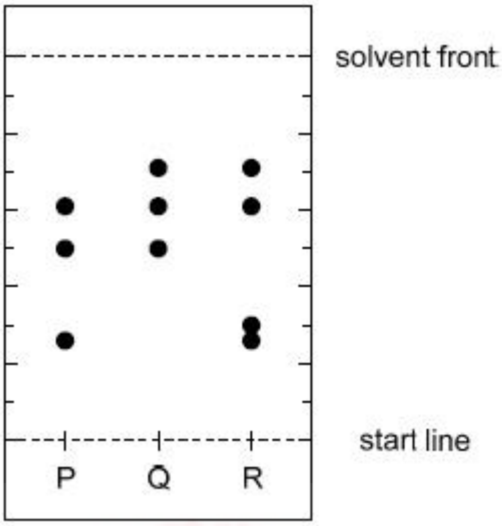
C 0.67

D 0.75

E 0.80

F 0.90

49 Paper chromatography was used to separate three mixtures of amino acids. The mixtures were labelled P, Q and R.



Each mixture contains some of the five amino acids in the following table. The R_f values were measured for each amino acid with the solvent used to produce the chromatogram.

amino acid	*R_f value*
asparagine	0.50
glutamic acid	0.30
glycine	0.26
leucine	0.71
valine	0.61

Which of the following statements is/are correct?

1 Mixture P contains valine and glycine.

2 Leucine is found in all three mixtures.

3 Glutamic acid is the least mobile amino acid with this solvent.

4 Mixtures P and Q both contain asparagine.

A 1 and 2 only

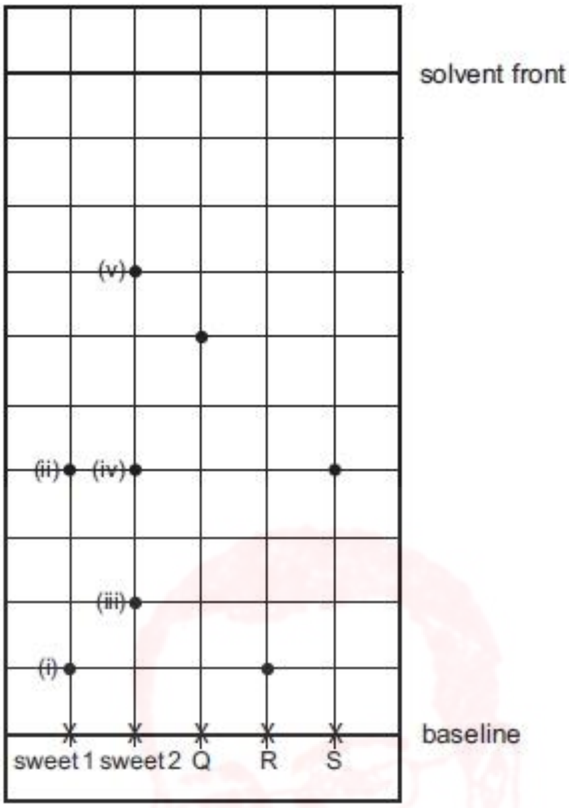
B 1 and 4 only

C 2 and 3 only

D 3 only

E 4 only

41 Study the chromatogram below showing the spots obtained, labelled (i) to (v), from two sweets and pure samples of the food additives, labelled Q, R and S.



Which of the following statements about the chromatogram is/are correct?

1 Both sweet 1 and 2 contain additives R and S.

2 The R_f value for spot (iv) is half that for spot (iii).

3 The R_f value for spot (v) is 0.7.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

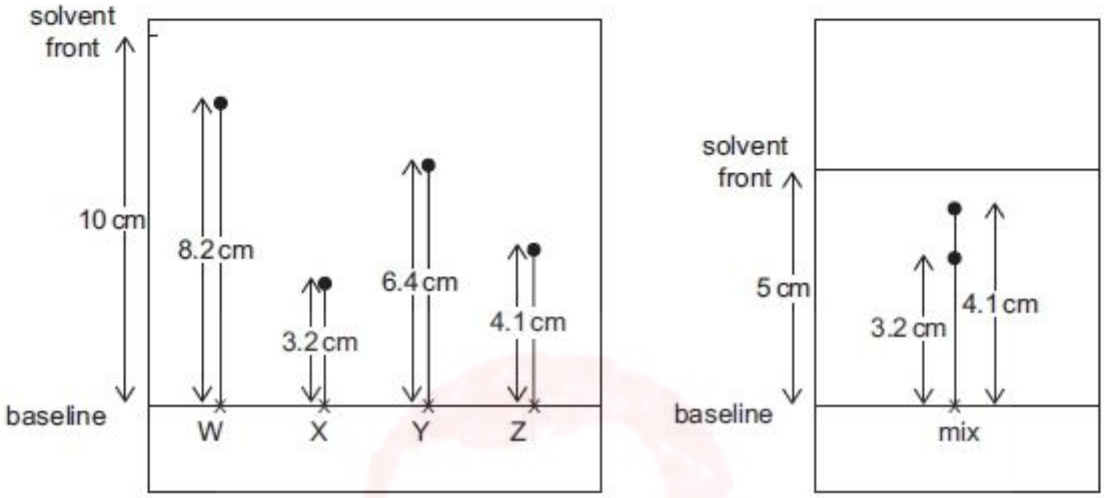
G 2 and 3 only

H 1, 2 and 3

43 A chromatogram was produced for 4 separate dyes (W, X, Y and Z) using filter paper and a water solvent.

A second chromatogram was produced using a mixture of two of the dyes, again using filter paper and a water solvent:

[diagram not to scale]



Which of the following statements, if any, are correct?

1 The concentration of dye W must be twice the concentration of dye Z.

2 The mobile phase is the filter paper.

3 The mixture in the second chromatogram contained dyes W and Y.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

Section 2 Questions

The order when you should complete these questions in:

15. Get really good at AS (and IB) MCQ questions
16. Then try Section 1 questions, if you are really good at these, continue
17. If struggling with Section 1 questions, go back and try again to get really good at AS and IB questions in the same topic
18. If really good a Section 1 questions, complete all of them
19. Make sure your personal statement is finished, or nearly finished
20. Make sure you have started to prepare for the interview by talking in English about chemistry, ideally with a teacher, and ideally with a teacher who has experience helping students with Oxbridge applications
21. Then try Section 2 MCQ questions only, remember they have 180seconds instead of about 90 seconds each
22. If really good at Section 2 MCQs, complete them for all AS topics and A2 Topic 24 and Topic 37 ONLY
23. Finally, complete the short answer questions for all AS topics and A2 Topic 24 and Topic 37 ONLY
24. Complete all Section 1 questions again
25. Complete all Section 2 questions, including the short answer questions for all AS topics and A2 Topic 24 and Topic 37 ONLY again
26. Make sure your personal statement is complete
27. Make sure you are confident and performing well in mock interviews
28. Now you could then try Section 2 questions on topics that will not appear in your ESAT, including the short answer questions on A2 material

Section 2 Question Topic **ALvl Chem Ions Test Q# 218/** Cambridge/2022/Section 2/ www.SmashingScience.org

41 The following pairs of 0.1 mol dm^{-3} solutions are mixed separately in test tubes.

1 $AgNO_3$(aq) with NaI(aq)

2 Cl_2(aq) with NaI(aq)

3 HCl(aq) with NaOH(aq)

4 $MgCl_2$(aq) with NaBr(aq)

Which pair(s) of solutions, when mixed, would produce a visible chemical change?

A 1 only

B 2 only

C 3 only

D 4 only

E 1 and 2 only

F 1 and 3 only

G 2 and 4 only

H 3 and 4 only

43 Which of the following tests could be used, on its own, to distinguish between all three of the following white solids: potassium carbonate, calcium chloride and sodium sulfate?

1 Add a small amount of each solid separately to a platinum wire and hold in a colourless flame.

2 Dissolve a small amount of each solid separately in deionised water and add a few drops of sodium hydroxide solution.

3 Dissolve a small amount of each solid separately in deionised water and add a few drops of hydrochloric acid, followed by barium chloride solution.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

32 The first ionisation energy of five elements is measured.

Which row matches the five elements to their first ionisation energy?

	first ionisation energy / kJ mol^{-1}				
	577	736	1000	1060	1680
A	F	Mg	Al	P	S
B	F	P	S	Mg	Al
C	F	P	S	Al	Mg
D	Mg	Al	S	P	F
E	Mg	Al	P	S	F
F	Al	Mg	P	S	F
G	Al	Mg	S	P	F
H	S	P	Al	Mg	F

56 An element Z forms an ionic compound ZSO_4 which has M_r = 120.4

The ion of Z in ZSO_4 has 10 electrons.

Element Z has three isotopes, labelled L, M and N, which contain the following numbers of neutrons.

isotope	L	M	N
number of neutrons	12	13	14

The percentage abundances of isotopes M and N are the same.

What is the percentage abundance of the isotope L in the element Z in ZSO_4?

(M_r value: SO_4^{2-} = 96.1)

A 4.10%

B 10.0%

C 13.4%

D 43.3%

E 80.0%

F 91.8%

14 Thionyl chloride, $SOCl_2$, is the only product of the reaction between sulfur trioxide, chlorine and sulfur dichloride.

Thionyl chloride reacts with water to make hydrogen chloride and one other gaseous product, which is triatomic.

$2.0\,dm^3$ of chlorine gas (measured at room temperature and pressure) was reacted completely with sulfur trioxide and sulfur dichloride.

The product was isolated, dissolved in water and made up to $200\,cm^3$.

What is the maximum concentration of HCl in the resulting solution?

(Assume that one mole of gas at room temperature and pressure occupies $24\,dm^3$.)

A $0.28\,mol\,dm^{-3}$

B $0.50\,mol\,dm^{-3}$

C $0.83\,mol\,dm^{-3}$

D $1.25\,mol\,dm^{-3}$

E $2.50\,mol\,dm^{-3}$

F $5.00\,mol\,dm^{-3}$

Section 2 Question Topic **ALvl Chem 2 Q# 223/** Cambridge/2022sp/Section 2/ www.SmashingScience.org

17 In 1836, James Marsh devised a test to allow the detection of very small traces of arsenic.

The first stage of the Marsh test involves the reaction of arsenic trioxide, As_2O_3, with zinc under acidic conditions. One of the products is compound X.

The **unbalanced** equation for the reaction is:

$$As_2O_3(s) + Zn(s) + H^+(aq) \rightarrow X(g) + Zn^{2+}(aq) + H_2O(l)$$

In the **balanced** equation, 1.0 mol of arsenic trioxide reacts with 6.0 mol of zinc, and produces 2.0 mol of X and 6.0 mol of zinc ions. Only the zinc and the arsenic change oxidation state in this reaction.

If 1.98 g of arsenic trioxide reacts with an excess of zinc and acid in this reaction, what is the maximum mass of X that could be produced?

(A_r values: H = 1; O = 16; Zn = 65; As = 75)

A 0.39 g

B 0.75 g

C 0.78 g

D 1.50 g

E 1.56 g

F 1.66 g

Section 2 Question Topic **ALvl Chem 2 Q# 224/** Cambridge/2022/Section 2/ www.SmashingScience.org

58 An oxide of nitrogen can be prepared by the reaction of copper with hot nitric acid.

The other products of the reaction are copper(II) nitrate and water.

0.060 mol of copper reacted exactly with 40.0 cm^3 of 4.00 $mol\,dm^{-3}$ nitric acid.

What is the empirical formula of the oxide of nitrogen produced in the reaction?

A NO

B NO_2

C NO_3

D N_2O

E N_2O_3

F N_2O_5

Section 2 Question Topic **ALvl Chem 2 Q# 225/** Cambridge/2022/Section 2/ www.SmashingScience.org

53 The atomic number of fluorine is 9.

An element X forms a fluoride with the formula XF_3. Each molecule of XF_3 has 32 electrons in total.

Element X has two isotopes. One isotope has the same number of neutrons as protons and the other isotope has a number of neutrons one greater than the number of protons.

The relative abundance of the heavier isotope is 0.80 (80%).

What is the relative atomic mass of element X?

A 5.2

B 5.8

C 10.2

D 10.8

E 14.2

F 14.8

G 16.2

H 16.8

Section 2 Question Topic **ALvl Chem 2 Q# 226/** Cambridge/2021/Section 2/ www.SmashingScience.org

21 A Group 1 metal hydrogencarbonate contains the HCO_3^- ion and decomposes at 200 °C.

When dilute hydrochloric acid is added to the residue from the thermal decomposition of this metal hydrogencarbonate, a gas is released that turns limewater cloudy. The residue also gives a yellow-orange colour in a flame test.

8.4 g of this metal hydrogencarbonate is heated to constant mass at 200 °C.

How much mass is lost in this reaction?

(A_r values: H = 1; C = 12; O = 16; Li = 7; Na = 23; K = 39)

A 2.2 g

B 2.6 g

C 3.1 g

D 4.0 g

E 4.4 g

F 5.3 g

G 6.2 g

24 A sample of hydrated cobalt(II) sulfate, $CoSO_4{\cdot}xH_2O$, with a mass of 5.62 g, was heated to convert the sample completely to 3.10 g of anhydrous cobalt(II) sulfate.

What is the value of x?

(A_r values: H = 1.0; O = 16.0; S = 32.1; Co = 58.9)

A 2

B 3

C 4

D 5

E 6

F 7

G 8

H 9

30 Iron(II) sulfate is used as a moss treatment on lawns and sports pitches. The recommended amount of iron is 2.5 kg per 10^4 m^2.

Analysis of a particular sports pitch showed it to contain 0.05 g of iron per m^2.

A pitch care company supplies three hydrated formulations:

- $FeSO_4 \cdot 7H_2O$ which contains 20% of iron by mass
- $FeSO_4 \cdot 4H_2O$ which contains 25% of iron by mass
- $FeSO_4 \cdot H_2O$ which contains 33% of iron by mass

A 25 kg sack of one of the iron(II) sulfate formulations is to be used on the sports pitch but unfortunately it has lost its label. A small sample was heated to constant mass to form a white solid, and the mass of the sample decreased by more than 40% in this process.

The sports pitch is 90 m long and 60 m wide.

What mass of the iron(II) sulfate formulation (in kg) should be added to ensure that the iron content is at the recommended level?

(M_r values: $FeSO_4$ = 152; H_2O = 18)

A 1.08 kg

B 1.35 kg

C 3.60 kg

D 4.32 kg

E 5.40 kg

F 6.75 kg

37 Cats are unable to synthesise the amino acid taurine in their bodies, so they must obtain it from their food. It is often added to cat food as an additive.

Taurine is a monoprotic acid with the following molecular structure:

$M_r = 125$

Dietary studies suggest that a cat should consume 10 mg of taurine per kilogram of body mass per day.

Brand X cat food contains taurine at a level of 0.008% by mass, but this level is too low for a cat to acquire a sufficient amount from a healthy amount of food.

Magnesium taurate is an ionic salt which liberates taurine in the body. 8 cm^3 of a 0.5 mol dm^{-3} aqueous solution of magnesium taurate was added to a 10 kg bag of brand X cat food and thoroughly mixed.

A particular cat bowl can hold a 50 g serving of cat food. A particular cat of mass 4000 g always eats a full serving.

What is the minimum number of bowls of cat food that this cat must eat to ensure that it has consumed its daily requirement of taurine?

(Assume that the addition of the solution does not significantly alter the total mass of the bag of cat food.)

A 2

B 3

C 4

D 5

E 6

F 7

G 8

40 Consider the following chemical equation:

$$vQ + wP_4 + xH_2O \rightarrow yPH_4I + zH_3PO_4$$

where Q is a binary compound.

The molecules of Q are hexatomic and contain phosphorus in the +2 oxidation state.

Using the lowest integer values for all the coefficients v, w, x, y and z, what is the value of w when the equation is balanced?

A 1

B 2

C 13

D 16

E 24

F 26

14 Thionyl chloride, $SOCl_2$, is the only product of the reaction between sulfur trioxide, chlorine and sulfur dichloride.

Thionyl chloride reacts with water to make hydrogen chloride and one other gaseous product, which is triatomic.

2.0 dm^3 of chlorine gas (measured at room temperature and pressure) was reacted completely with sulfur trioxide and sulfur dichloride.

The product was isolated, dissolved in water and made up to 200 cm^3.

What is the maximum concentration of HCl in the resulting solution?

(Assume that one mole of gas at room temperature and pressure occupies 24 dm^3.)

A 0.28 mol dm^{-3}

B 0.50 mol dm^{-3}

C 0.83 mol dm^{-3}

D 1.25 mol dm^{-3}

E 2.50 mol dm^{-3}

F 5.00 mol dm^{-3}

15 Tollens' reagent, $[Ag(NH_3)_2]NO_3(aq)$, can be used to coat glass surfaces with silver metal (A_r = 108) to make decorative objects. It is a reducing agent and reacts by oxidising aldehydes to carboxylic acids.

The half-equation for the organic oxidation can be represented as (R = alkyl group):

$$\underset{\text{aldehyde}}{RCHO} + H_2O \rightarrow \underset{\text{carboxylic acid}}{RCOOH} + 2H^+ + 2e^-$$

All of the inside surface of a beaker is to be coated in a uniform layer of silver metal of thickness 0.01 cm. The beaker can be modelled as a cylinder of height 10 cm and radius 5 cm.

The density of silver metal is 10.5 g cm^{-3}.

Which of the following expressions gives the minimum number of moles of aldehyde required?

(Assume that the yield of any reaction is 100%.)

A $\dfrac{10.5\times1.25\times\pi}{2\times108}$

B $\dfrac{10.5\times1.25\times\pi}{108}$

C $\dfrac{2\times10.5\times1.25\times\pi}{108}$

D $\dfrac{108\times10.5\times1.25\times\pi}{2}$

E $\dfrac{10.5\times1.5\times\pi}{2\times108}$

F $\dfrac{2\times10.5\times1.5\times\pi}{108}$

G $\dfrac{10.5\times1.5\times\pi}{108}$

H $\dfrac{108\times10.5\times1.5\times\pi}{2}$

17 In 1836, James Marsh devised a test to allow the detection of very small traces of arsenic.

The first stage of the Marsh test involves the reaction of arsenic trioxide, As_2O_3, with zinc under acidic conditions. One of the products is compound X.

The **unbalanced** equation for the reaction is:

$$As_2O_3(s) + Zn(s) + H^+(aq) \rightarrow X(g) + Zn^{2+}(aq) + H_2O(l)$$

In the **balanced** equation, 1.0 mol of arsenic trioxide reacts with 6.0 mol of zinc, and produces 2.0 mol of X and 6.0 mol of zinc ions. Only the zinc and the arsenic change oxidation state in this reaction.

If 1.98 g of arsenic trioxide reacts with an excess of zinc and acid in this reaction, what is the maximum mass of X that could be produced?

(A_r values: H = 1; O = 16; Zn = 65; As = 75)

A 0.39 g

B 0.75 g

C 0.78 g

D 1.50 g

E 1.56 g

F 1.66 g

45 Iodic acid, HIO_3, can be made from iodine in the following reaction:

$$I_2 + wH_2O + xCl_2 \rightarrow yHIO_3 + zHCl$$

What is the value of x when the equation is balanced?

A 1

B 2

C 3

D 4

E 5

F 6

Section 2 Question Topic **ALvl Chem 2 Q# 235/** Cambridge/2020/Section 2/ www.SmashingScience.org

46 Which one of the following formulae is correct for the compound given?

A aluminium sulfate, $Al(SO_4)_3$

B ammonium carbonate, $(NH_4)_2CO_3$

C calcium hydroxide, CaOH

D magnesium nitrate, $MgNO_3$

E potassium bromide, KBr_2

Section 2 Question Topic **ALvl Chem 2 Q# 236/** Cambridge/2020/Section 2/ www.SmashingScience.org

52 10 g of a mixture of solid magnesium hydroxide, $Mg(OH)_2$, and solid sodium hydroxide, NaOH, is added to an excess of water and stirred.

One of the components of the mixture dissolves. Assume that the other is completely insoluble.

The mixture is filtered to remove the insoluble component of the mixture.

50 cm^3 of 1.0 mol dm^{-3} sulfuric acid exactly neutralises the remaining solution.

What is the mass of magnesium hydroxide in the original mixture?

(M_r values: $Mg(OH)_2$ = 58; NaOH = 40)

A 2.0 g

B 2.9 g

C 4.0 g

D 5.8 g

E 6.0 g

F 8.0 g

60 X is a solution of sulfuric acid.

$20.0\,cm^3$ of X is diluted by adding distilled water to produce $500\,cm^3$ of solution Y.

$10.0\,cm^3$ of Y is exactly neutralised by $40.0\,cm^3$ of $0.0500\,mol\,dm^{-3}$ aqueous potassium hydroxide.

What is the concentration of sulfuric acid in X?

A $0.00100\,mol\,dm^{-3}$

B $0.100\,mol\,dm^{-3}$

C $0.200\,mol\,dm^{-3}$

D $0.400\,mol\,dm^{-3}$

E $1.25\,mol\,dm^{-3}$

F $2.50\,mol\,dm^{-3}$

G $5.00\,mol\,dm^{-3}$

H $10.0\,mol\,dm^{-3}$

Question C1

Data: Assume that the molar gas volume = $24.0\,dm^3\,mol^{-1}$ at room temperature and pressure (rtp).

This question concerns the chemistry of tellurium, an element in Group 16 of the Periodic Table.

Tellurium reacts directly with fluorine gas to form a dense gas, **A**, in which each molecule contains a single tellurium atom bonded to several fluorine atoms. In an experiment, $50\ cm^3$ of gas **A** is formed from $150\ cm^3$ of fluorine and a certain mass of tellurium, with all measurements made at room temperature and pressure.

d) Calculate the formula of the gas **A**.

[2 marks]

Answer: ....

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....

e) Predict the value(s) of the F–Te–F bond angles in **A**.

[1 mark]

Answer: ....

f) Calculate the minimum mass of tellurium needed to produce $50\ cm^3$ of **A**.

[2 marks]

Answer: ....

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g) Calculate the density of gas **A** in $g\ cm^{-3}$ at room temperature and pressure.

[2 marks]

Answer: ....

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h) Calculate how many times denser gas **A** is than oxygen gas at room temperature and pressure.

[1 mark]

Answer: ....

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In another experiment, 5.0 g of tellurium is oxidised and dissolved in water to form 9.0 g of an acid with general formula H_mTeO_n. On neutralisation with aqueous KOH, 18 g of a salt is formed with general formula K_mTeO_n.

i) Give an expression, in terms of m and n, for the oxidation state of the tellurium in the acid H_mTeO_n.

[1 mark]

Answer: ....

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j) Calculate the relative molecular mass of the acid H_mTeO_n.

[1 mark]

Answer: ....

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k) Calculate the values of m and n, and hence the formulae of the acid H_mTeO_n and the salt formed on neutralisation.

[2 marks]

Answer: ....

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l) Calculate the volume of a 2.0 mol dm^{-3} aqueous solution of KOH that would be needed to neutralise the 9.0 g of acid formed from 5.0 g of tellurium.

[2 marks]

Answer: ....

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d) The reaction between dimethylglyoxime and Ni^{2+} ions can be used to determine the nickel content of alloys by weighing the amount of the red precipitate produced from a known mass of a sample of an alloy.

A sample of mass 1.50 g of an alloy was dissolved in dilute acid and an excess of dimethylglyoxime was then added to the resulting solution. The pH was then adjusted to make the solution mildly alkaline, and this resulted in the formation of a red precipitate. The precipitate was carefully filtered off, dried and then weighed. The mass of the dry precipitate was 0.368 g.

Determine the nickel content of the alloy, expressed as a percentage by mass.

[4 marks]

Answer: ....

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e) Other metal ions, such as Pd^{2+} or Pt^{2+}, also react with dimethylglyoxime to give insoluble precipitates. What effect would the presence of palladium in the alloy have on the value of the nickel content determined using the method in part **d)**?

[2 marks]

Answer: ....

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Question C2

a) Write a balanced chemical equation for the reaction between CO_2(g) and OH^-(aq), giving CO_3^{2-}(aq) as one of the products.

[1 mark]

Answer: ....

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b) An organic molecule is known to contain C, H and O only. A sample of mass 0.100 g is carefully burnt in the presence of excess oxygen. The resulting gases are passed over a desiccant (drying agent), and it is observed that the mass of the desiccant increases by 0.0931 g.

After passing through the desiccant the gases are bubbled through 25.0 cm^3 of a solution of 1.00 mol dm^{-3} NaOH. The solution is then titrated against 1.00 mol dm^{-3} HCl, and the end point is found to be when 14.7 cm^3 of the acid has been added.

(i) Calculate the amount in moles of H_2O produced by the combustion.

[2 marks]

Answer: ....

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(ii) Calculate the amount in moles of CO_2 absorbed by the NaOH solution.

[4 marks]

Answer: ....

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(iii) Hence determine the empirical formula of the organic molecule.

[6 marks]

Answer: ....

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Section 2 Question Topic **ALvl Chem 2 Q# 241/** Cambridge/2017/Section 2/ www.SmashingScience.org

b) Substance **A** reacts with aluminium chloride to form lithium aluminium hydride ($LiAlH_4$) and one other by-product.

c) When 3.8 g of lithium aluminium hydride is heated to 125 °C, it decomposes to give three substances: 1.8 g of aluminium metal, 2.4 dm^3 of a flammable gas (measured at rtp), and substance **B**.

Determine the formula for substance **B**. **[5 marks]**

Answer: ....

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Question C1

Data: Assume that the molar gas volume = 24.0 $dm^3\,mol^{-1}$ at room temperature and pressure (rtp).

a) When lithium metal and hydrogen gas are heated together, a single substance, **A**, is formed as colourless crystals with a melting point of 688 °C. Molten **A** conducts electricity, and electrolysis of the molten substance re-forms the elements.

(i) Give an equation for the formation of **A**. **[1 mark]**

Answer: ....

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(ii) Classify the structure of **A** as either molecular covalent, giant covalent, or ionic. Briefly justify your answer. **[2 marks]**

Answer: ....

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(iii) During the electrolysis of molten **A**, which element appears at the positive electrode (the anode) and which appears at the negative electrode (the cathode)? **[1 mark]**

Answer: ....

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b) Substance **A** reacts with aluminium chloride to form lithium aluminium hydride ($LiAlH_4$) and one other by-product.

Give a balanced chemical equation for the formation of lithium aluminium hydride from **A** and aluminium chloride. **[2 marks]**

Answer: ....

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Question 4

a) Arsenic oxide As_2O_3 is prepared on an industrial scale by roasting arsenic-containing ores such as arsenopyrite, FeAsS, in air. The other products formed are iron(III) oxide and sulfur dioxide.

b) As_2O_3 is moderately soluble in water; one dm^3 of a saturated solution at 25 °C contains 20.6 g. When dissolved in water, the oxide reacts to form arsenous acid, H_3AsO_3.

(ii) Give an equation for the formation of arsenous acid from As_2O_3 when dissolved in water. **[2 marks]**

Answer: ....

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(iii) Calculate the concentration of the arsenous acid, in mol dm^{-3}, in the saturated solution. **[2 marks]**

Answer: ....

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c) Homeopathic medicines are made by preparing an extremely dilute solution of some compound, such as As_2O_3. Typically a saturated solution is diluted by a factor of 10^{30}.

(i) Assuming that the solution referred to in **(b)** is diluted by a factor of 10^{30}, calculate the mass (in g) of As_2O_3 present in a 100 cm^3 of the diluted solution. **[2 marks]**

Answer: ....

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(ii) Given that 0.1 g of As_2O_3 is usually fatal, calculate the volume (in m^3) of the diluted solution that would be needed for a fatal dose of As_2O_3. Also express your answer as a fraction of the volume of the Earth (approximately 1.08×10^{12} km^3). **[4 marks]**

Answer: ....

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(iii) The diluted solution is usually sold in 'one ounce' bottles (1 ounce = $28\,cm^3$). Calculate how many bottles of the solution need to be bought in order, on average, to purchase one atom of arsenic. **[4 marks]**

Answer: ....

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b) Breakfast cereals frequently have elemental iron added to them as a dietary supplement. A method for making a quantitative measurement of the amount of iron is to use the reaction between $Fe^{3+}(aq)$ and thiocyanate, $SCN^{-}(aq)$, which gives the deep red complex $FeSCN^{2+}(aq)$.

$$Fe^{3+}(aq) + SCN^{-}(aq) \rightarrow FeSCN^{2+}(aq)$$

The depth of the colour can be measured using a *spectrophotometer* which gives a value for the *absorbance* that is proportional to the concentration of the complex:

$$\text{absorbance} = \text{constant} \times [FeSCN^{2+}] \qquad \textbf{Equation 1}$$

The constant can be found by measuring the absorbance of a solution of known concentration.

(i) The absorbance of a solution of the complex with concentration 2.5×10^{-4} mol dm^{-3} was measured to be 1.85; determine the value of the constant in Equation 1. **[2 marks]**

Answer: ....

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100 g of breakfast cereal was mixed with sufficient dilute acid to dissolve all of the iron. The solution was carefully filtered and mixed with sufficient oxidising agent to convert all of the iron to Fe^{3+}. The solution was made up to a total volume of 250 cm^3. 10.0 cm^3 of this solution was mixed with 10.0 cm^3 of a solution of thiocyanate; you may assume that all of the iron is converted to the complex. The absorbance of the resulting solution was measured as 0.519.

(ii) Using the value of the constant found in **(i)**, calculate the concentration of Fe^{3+} in the solution for which the absorbance was measured. **[2 marks]**

Answer: ....

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(iii) Hence calculate the concentration of Fe^{3+} in the solution prepared from the cereal.

[2 marks]

Answer: ....

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(iv) Hence calculate the mass of iron present in the 100 g of breakfast cereal (A_r: Fe = 55.85).

[4 marks]

Answer: ....

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19 Bromine trifluoride, BrF_3, is a simple molecular compound containing single bonds only.

It is **not** trigonal planar.

Two of the bond lengths in this molecule are 0.181 nm, and the third is 0.172 nm.

The through-space distances between two fluorine atoms are 0.241 nm or 0.361 nm.

What is the acute bond angle in BrF_3?

A $\sin^{-1}\left(\frac{0.1205}{0.172}\right)$

B $\cos^{-1}\left(\frac{0.1205}{0.172}\right)$

C $\sin^{-1}\left(\frac{0.1205}{0.181}\right)$

D $\cos^{-1}\left(\frac{0.1205}{0.181}\right)$

E $\sin^{-1}\left(\frac{0.172}{0.1805}\right)$

F $\cos^{-1}\left(\frac{0.172}{0.1805}\right)$

G $\sin^{-1}\left(\frac{0.1805}{0.181}\right)$

H $\cos^{-1}\left(\frac{0.1805}{0.181}\right)$

Section 2 Question Topic **ALvl Chem 3 Q# 246/** Cambridge/2022/Section 2/ www.SmashingScience.org

43 Consider the following properties of compound X:

melting point	–114 °C
boiling point	–85 °C
conductivity as a solid	poor
conductivity as a liquid	poor
conductivity in aqueous solution	good

Which one of the following could be the identity of compound X?

A ammonium chloride, NH_4Cl

B barium chloride, $BaCl_2$

C hydrogen chloride, HCl

D potassium chloride, KCl

E tetrachloromethane, CCl_4

Section 2 Question Topic **ALvl Chem 3 Q# 247/** Cambridge/2022/Section 2/ www.SmashingScience.org

50 Element Z is in Group 1 of the Periodic Table.

A pure sample of element Z consists of two isotopes with mass numbers 85 and 87, and has a relative atomic mass of 85.5.

Which of the following statements is/are correct about element Z in this sample?

1 Element Z reacts with bromine to form an ionic compound with formula ZBr_2.

2 Element Z forms a basic oxide.

3 More than 70% of the atoms of element Z have mass number 85.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

Section 2 Question Topic **ALvl Chem 3 Q# 248/** Cambridge/2021/Section 2/ www.SmashingScience.org

22 Which of the following statements is correct for the bond angle (θ) in gaseous germanium(II) chloride, $GeCl_2$, molecules as predicted by the VSEPR model?

A $\theta = 90°$

B $90° < \theta < 120°$

C $\theta = 120°$

D $120° < \theta < 180°$

E $\theta = 180°$

Section 2 Question Topic **ALvl Chem 3 Q# 249/** Cambridge/2021/Section 2/ www.SmashingScience.org

31 A compound contains potassium cations, and anions that contain only boron and fluorine. Each anion contains one boron atom.

0.630 g of this compound contains 0.195 g of potassium and 0.055 g of boron.

What is the shape of the anions in this compound?

(A_r values: B = 11; F = 19; K = 39)

A linear

B bent (V-shaped)

C trigonal planar

D trigonal pyramidal

E tetrahedral

F square planar

19 Bromine trifluoride, BrF_3, is a simple molecular compound containing single bonds only.

It is **not** trigonal planar.

Two of the bond lengths in this molecule are 0.181 nm, and the third is 0.172 nm.

The through-space distances between two fluorine atoms are 0.241 nm or 0.361 nm.

What is the acute bond angle in BrF_3?

A $\sin^{-1}\left(\frac{0.1205}{0.172}\right)$

B $\cos^{-1}\left(\frac{0.1205}{0.172}\right)$

C $\sin^{-1}\left(\frac{0.1205}{0.181}\right)$

D $\cos^{-1}\left(\frac{0.1205}{0.181}\right)$

E $\sin^{-1}\left(\frac{0.172}{0.1805}\right)$

F $\cos^{-1}\left(\frac{0.172}{0.1805}\right)$

G $\sin^{-1}\left(\frac{0.1805}{0.181}\right)$

H $\cos^{-1}\left(\frac{0.1805}{0.181}\right)$

Question 3

Parts **a)**, **b)** and **c)** can be answered independently of one another.

a) Draw two alternative 'dot and cross' diagrams to describe the bonding in the linear thiocyanate anion SCN^{-}. In one diagram place the negative charge on the sulfur, and in the other place the negative charge on the nitrogen. **[5 marks]**

Answer:

52 A typical sample of dry air is at room temperature and pressure. There is a total of 25.0 mol of gas in this sample.

One of the gases in the sample, X, contributes 1.50×10^{23} separate particles to the mixture.

A second gas in the sample, Y, would, if alone, occupy a volume of $468\,dm^3$ at room temperature and pressure.

What are the identities of gases X and Y, and what would be the total amount of all of the remaining gases in the sample?

(Take Avogadro's number as 6.00×10^{23}. Assume that one mole of any gas occupies a volume of $24.0\,dm^3$ at room temperature and pressure.)

	identity of gas X	*identity of gas Y*	*total amount of all of the remaining gases in the sample in moles*
A	Ar	N_2	5.250 mol
B	O_2	N_2	5.250 mol
C	O_2	Ar	5.250 mol
D	Ar	O_2	5.375 mol
E	Ar	N_2	5.375 mol
F	O_2	N_2	5.375 mol

60 Airbags in cars contain sodium azide (NaN_3) as a primary reagent, and potassium nitrate (KNO_3) as a secondary reagent.

The sodium azide decomposes according to the following equation to form nitrogen gas, which rapidly fills the airbag:

$$2NaN_3 \rightarrow 2Na + 3N_2$$

The sodium by-product of this first reaction then reacts with excess potassium nitrate according to this second equation:

$$10Na + 2KNO_3 \rightarrow K_2O + 5Na_2O + N_2$$

Assume that both reactions go to completion.

An airbag contains 130 g of sodium azide.

What is the total volume of nitrogen gas formed in this airbag, measured at room temperature and pressure?

(A_r values: N = 14.0; Na = 23.0. Assume that one mole of gas occupies 24.0 dm^3 at room temperature and pressure.)

A 72.0 dm^3

B 76.8 dm^3

C 84.0 dm^3

D 89.6 dm^3

E 96.0 dm^3

F 112 dm^3

G 120 dm^3

H 140 dm^3

41 Use the following data table to answer the question.

gas	*melting point* / °C	*boiling point* / °C
hydrogen	–259	–253
nitrogen	–210	–196
oxygen	–219	–183
neon	–249	–246
argon	–189	–186

Water and carbon dioxide were removed from a sample of air and the remaining mixture was cooled to –260 °C.

The three most abundant remaining elements are to be separated by fractional distillation.

In which order would these three elements be collected?

A hydrogen, neon, nitrogen

B hydrogen, neon, oxygen

C neon, nitrogen, argon

D neon, nitrogen, oxygen

E nitrogen, argon, oxygen

F nitrogen, oxygen, argon

G oxygen, nitrogen, argon

H oxygen, argon, nitrogen

51 100 cm^3 of ethane is mixed with 1400 cm^3 of oxygen and the mixture is ignited.

All volumes are measured at atmospheric pressure and a temperature of 150 °C.

What will be the **total** volume of gas after the complete combustion?

(Assume that equal amounts of any gas at the same temperature and pressure occupy the same volume.)

A 500 cm^3

B 1250 cm^3

C 1500 cm^3

D 1550 cm^3

E 1700 cm^3

F 2000 cm^3

Question 4

a) Arsenic oxide As_2O_3 is prepared on an industrial scale by roasting arsenic-containing ores such as arsenopyrite, FeAsS, in air. The other products formed are iron(III) oxide and sulfur dioxide.

b) As_2O_3 is moderately soluble in water; one dm^3 of a saturated solution at 25 °C contains 20.6 g. When dissolved in water, the oxide reacts to form arsenous acid, H_3AsO_3.

(i) Given that other measurements show all the hydrogen atoms in H_3AsO_3 to be in the same environment, suggest a structure for the acid. What is the geometry around the arsenic atom? **[2 marks]**

Answer: ....

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11 A methane gas burner heats objects with only 20% efficiency.

The gas burner is used to heat a 500 g copper pan containing 400 g water from 20 °C to 80 °C.

specific heat capacities: copper = 0.4 $J g^{-1} °C^{-1}$; water = 4 $J g^{-1} °C^{-1}$

standard enthalpy change of combustion of methane = −900 $kJ mol^{-1}$

What is the minimum mass of methane gas required?

(M_r value: methane = 16)

A 1.92 g

B 2.40 g

C 8.53 g

D 9.60 g

E 11.4 g

F 12.8 g

G 21.12 g

12 Mercury(II) fulminate, $HgC_2N_2O_2$, can decompose to produce carbon monoxide and two different elements only.

The enthalpy change for the decomposition of one mole of mercury(II) fulminate is –606 kJ.

The enthalpy change of formation for mercury(II) fulminate is +386 $kJ mol^{-1}$.

What is the enthalpy change of formation of carbon monoxide?

(Assume that all data is given at the same temperature and pressure.)

A –110 $kJ mol^{-1}$

B +110 $kJ mol^{-1}$

C –166 $kJ mol^{-1}$

D +166 $kJ mol^{-1}$

E –220 $kJ mol^{-1}$

F +220 $kJ mol^{-1}$

G –496 $kJ mol^{-1}$

H +496 $kJ mol^{-1}$

16 The following information should be used in calculating the answer to this question:

- Standard enthalpy change of formation of ethanol:

  $\Delta_f H°(CH_3CH_2OH(l)) = -277\,kJ\,mol^{-1}$

- Standard enthalpy change of vaporisation of ethanol, $CH_3CH_2OH(l) \rightarrow CH_3CH_2OH(g)$:

  $\Delta_{vap} H°(CH_3CH_2OH(l)) = +39\,kJ\,mol^{-1}$

- Standard enthalpy change of atomisation of carbon, $C(s) \rightarrow C(g)$:

  $\Delta_{at} H°(C(s)) = +715\,kJ\,mol^{-1}$

The table provides some average bond enthalpy data:

bond	C–C	C–O	H–H	O–H	O=O
average bond enthalpy / $kJ\,mol^{-1}$	346	358	436	463	498

Using the data provided, which of the following is the average bond enthalpy of the C–H bond?

A $342\,kJ\,mol^{-1}$

B $412\,kJ\,mol^{-1}$

C $417\,kJ\,mol^{-1}$

D $419\,kJ\,mol^{-1}$

E $461\,kJ\,mol^{-1}$

F $481\,kJ\,mol^{-1}$

G $483\,kJ\,mol^{-1}$

H $673\,kJ\,mol^{-1}$

57 A student mixed together 30.0 cm^3 of 3.0 mol dm^{-3} hydrochloric acid and 20.0 cm^3 of 4.0 mol dm^{-3} aqueous ammonia in an insulated container.

The initial temperatures of both solutions were 20.0 °C.

The maximum temperature observed was 40.0 °C.

Assume that the specific heat capacity of any aqueous solution is 4.0 J g^{-1} °C^{-1} and that the density of the reaction mixture is 1.0 g cm^{-3}.

Using this information, what is the molar enthalpy change, in kJ mol^{-1}, for the reaction of hydrochloric acid and aqueous ammonia?

A –4 kJ mol^{-1}

B –20 kJ mol^{-1}

C –25 kJ mol^{-1}

D –30 kJ mol^{-1}

E –44 kJ mol^{-1}

F –50 kJ mol^{-1}

G –75 kJ mol^{-1}

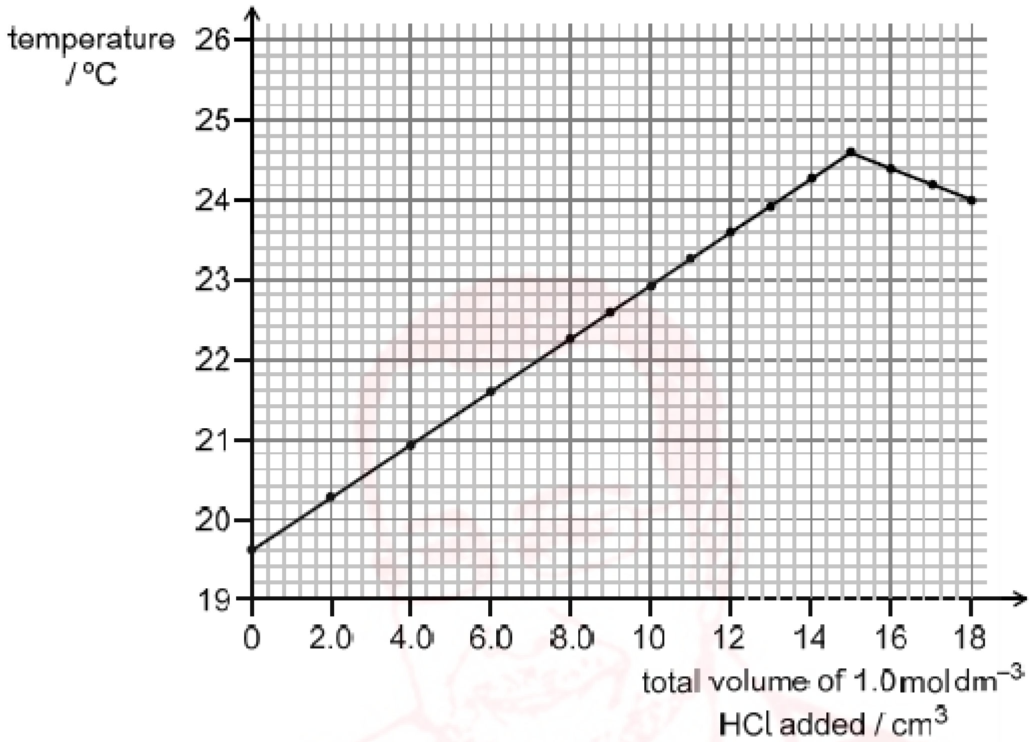
H –100 kJ mol^{-1}

27 25.0 cm^3 of sodium hydroxide solution is placed in a polystyrene cup with a thermometer.

1.00 mol dm^{-3} hydrochloric acid is added from a burette to the stirred solution of sodium hydroxide.

Both solutions are at the same temperature before mixing.

The temperature is recorded each time a measured amount of hydrochloric acid is added, and the data is plotted on a graph.



Assuming that no heat is lost from the cup, what is the enthalpy change of reaction when one mole of aqueous sodium hydroxide is neutralised?

(Assume that all solutions have density 1.0 g cm^{-3} and specific heat capacity 4.2 J g^{-1} °C^{-1}.)

A –56.0 kJ

B –49.3 kJ

C –35.0 kJ

D –33.6 kJ

E –21.0 kJ

34 The standard enthalpy change of formation of hydrogen iodide is +26 kJ mol^{-1}.

For the reaction of gaseous iodine with hydrogen

$$I_2(g) + H_2(g) \rightleftharpoons 2HI(g)$$

the enthalpy change of reaction can be calculated using bond enthalpy values.

The bond enthalpies are:

bond	*bond enthalpy* / kJ mol^{-1}
H–H	436
I–I	151
H–I	299

The sublimation of iodine is represented by: $I_2(s) \rightarrow I_2(g)$

Using the data provided, what is the enthalpy change for the sublimation of iodine?

(All data is given at room temperature and pressure.)

A –262 kJ mol^{-1}

B –236 kJ mol^{-1}

C –41 kJ mol^{-1}

D +37 kJ mol^{-1}

E +41 kJ mol^{-1}

F +63 kJ mol^{-1}

G +236 kJ mol^{-1}

Section 2 Question Topic **ALvl Chem 5 Q# 263/** Cambridge/2020SP/Section 2/ www.SmashingScience.org

11 A methane gas burner heats objects with only 20% efficiency.

The gas burner is used to heat a 500 g copper pan containing 400 g of water from 20 °C to 80 °C.

specific heat capacities: copper = $0.4\,J\,g^{-1}\,°C^{-1}$; water = $4\,J\,g^{-1}\,°C^{-1}$

standard enthalpy change of combustion of methane = $-900\,kJ\,mol^{-1}$

What is the minimum mass of methane gas required?

(M_r value: methane = 16)

A 1.92 g

B 2.40 g

C 8.53 g

D 9.60 g

E 11.4 g

F 12.8 g

G 21.12 g

Section 2 Question Topic **ALvl Chem 5 Q# 264/** Cambridge/2020SP/Section 2/ www.SmashingScience.org

12 Mercury(II) fulminate, $HgC_2N_2O_2$, can decompose to produce carbon monoxide and two different elements only.

The enthalpy change for the decomposition of one mole of mercury(II) fulminate is –606 kJ.

The enthalpy change of formation for mercury(II) fulminate is $+386\,kJ\,mol^{-1}$.

What is the enthalpy change of formation of carbon monoxide?

(Assume that all data is given at the same temperature and pressure.)

A $-110\,kJ\,mol^{-1}$

B $+110\,kJ\,mol^{-1}$

C $-166\,kJ\,mol^{-1}$

D $+166\,kJ\,mol^{-1}$

E $-220\,kJ\,mol^{-1}$

F $+220\,kJ\,mol^{-1}$

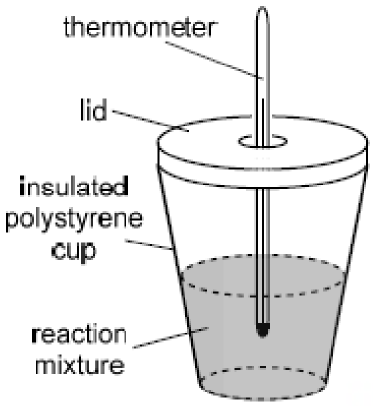
G $-496\,kJ\,mol^{-1}$

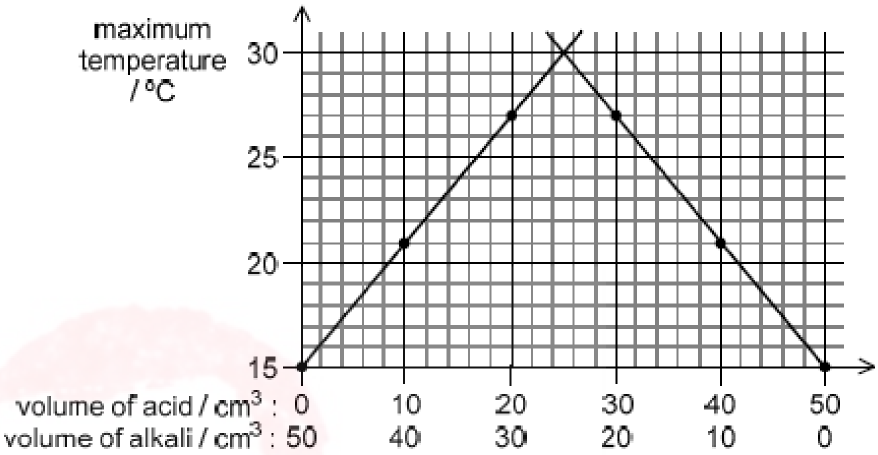
H $+496\,kJ\,mol^{-1}$

58 Four separate experiments were carried out using different quantities of 2 mol dm^{-3} hydrochloric acid and 2 mol dm^{-3} sodium hydroxide in insulated polystyrene cups.

After stirring, the maximum temperature was recorded and the results plotted on a graph as shown.

The temperatures of the acid and alkali on their own were also plotted on the graph. Two straight lines were drawn and extrapolated as shown.





What is the molar enthalpy change for the neutralisation reaction, in kJ mol^{-1}?

(Assume that the specific heat capacity of the solutions is 4 J g^{-1} °C^{-1}, the density of dilute solutions is 1 g cm^{-3}, and all heat is transferred to the solution.)

A 3 kJ mol^{-1}

B 6 kJ mol^{-1}

C 30 kJ mol^{-1}

D 60 kJ mol^{-1}

E 120 kJ mol^{-1}

F 3000 kJ mol^{-1}

Section 2 Question Topic **ALvl Chem 5 Q# 266/** Cambridge/2016SP/Section 2/ www.SmashingScience.org

d) The table below gives values of the standard enthalpies of combustion, $\Delta_c H^\circ$, of **A**, **B**, carbon (as graphite) and hydrogen.

	A	*B*	*C(s) (graphite)*	*$H_2(g)$*
$\Delta_c H^\circ$ / kJ mol^{-1}	−2058	−2091	−393.5	−241.8

(i) Give the balanced chemical equation for the complete combustion of C_3H_6. **[2 marks]**

Answer: ....

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(ii) Calculate the standard enthalpy of formation, $\Delta_f H^\circ$, of **A**. **[3 marks]**

Answer: ....

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(iii) Calculate the standard enthalpy of formation of **B**. **[3 marks]**

Answer: ....

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(iv) Calculate the standard enthalpy change for the reaction **B** → **A**. Comment on the value you obtain. **[2 marks]**

Answer: ....

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e) The standard enthalpy of combustion of C_6H_{12} is $-3920\,kJ\,mol^{-1}$. Using this value and the corresponding value for **B**, calculate the average contribution $\Delta_c H^\circ$ per CH_2 group for the two compounds. Comment on your result. **[4 marks]**

Answer: ....

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Samples of the six alkenes, in a random order, are labelled **P**, **Q**, **R**, **S**, **T**, and **U**. You will be able to identify which isomer *some* of these correspond to using the information and data throughout the rest of the question.

Alkenes **P**, **Q**, and **R** react with hydrogen gas and a metal catalyst to give the same alkane **A**; alkenes **S**, **T**, and **U** react under the same conditions to give a different alkane **B**.

Both alkanes **A** and **B** react with chlorine gas under UV light to form chloroalkanes with the formula $C_5H_{11}Cl$. Under such conditions, alkane **A** forms *four* different structural isomers, whereas **B** gives *three*.

f) Use the data to calculate the standard enthalpy change of combustion of alkene **P**.

[4 marks]

Answer: ....

45 Which of the following chemical reactions is/are redox reactions?

1 $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

2 $PCl_5(s) + H_2O(l) \rightarrow POCl_3(l) + 2HCl(aq)$

3 $KrF_2(s) \rightarrow Kr(g) + F_2(g)$

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

39 Lanthanum iodate(V), $La(IO_3)_3$, decomposes when heated to 600 °C to give a product that contains the ion Q.

An **unbalanced** ionic equation for the reaction is:

$$IO_3^- \rightarrow \text{ion Q} + I_2 + O_2$$

Ion Q contains only iodine in the +7 oxidation state and oxygen in the –2 oxidation state.

The oxidation state of the lanthanum does not change in the reaction.

0.005 mol of $La(IO_3)_3$ is fully decomposed by heating. The iodine produced is titrated against a 0.4 mol dm^{-3} solution of sodium thiosulfate ($Na_2S_2O_3$). 30.0 cm^3 of the sodium thiosulfate solution is needed to reach the end-point. The equation for the reaction between iodine and sodium thiosulfate is:

$$I_2 + 2Na_2S_2O_3 \rightarrow 2NaI + Na_2S_4O_6$$

What is the formula of the product that contains ion Q?

A $LaIO_5$

B $LaIO_6$

C $La(IO_4)_3$

D $La_3(IO_6)_5$

E $La_5(IO_4)_3$

F $La_5(IO_6)_3$

50 Which of the following equations represent(s) a redox reaction?

1 $K_2Cr_2O_7 + 2KOH \rightarrow 2K_2CrO_4 + H_2O$

2 $8HNO_3 + 3C_2H_6O + K_2Cr_2O_7 \rightarrow 2KNO_3 + 3C_2H_4O + 7H_2O + 2Cr(NO_3)_3$

3 $H_2O + SO_2 \rightarrow H_2SO_3$

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

Question 4

a) Arsenic oxide As_2O_3 is prepared on an industrial scale by roasting arsenic-containing ores such as arsenopyrite, FeAsS, in air. The other products formed are iron(III) oxide and sulfur dioxide.

(i) What is the oxidation state of the arsenic in As_2O_3? **[1 mark]**

Answer: ....

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(ii) Give a balanced chemical equation for the industrial production of As_2O_3 from FeAsS. **[2 marks]**

Answer: ....

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c) Hydrogen peroxide, H_2O_2, is used as the oxidising agent to convert Fe^{2+} to Fe^{3+} in the assay described in **b)(ii)**.

(i) Determine the oxidation state of oxygen in H_2O_2. **[2 marks]**

Answer: ....

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(ii) When H_2O_2 acts as an oxidising agent in acidic solution, what is the oxygen-containing species that is produced and what is the oxidation state of oxygen in this species?

[4 marks]

Answer: ....

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(iii) Write a balanced chemical equation describing the oxidation of Fe^{2+}(aq) to Fe^{3+}(aq) by H_2O_2 in acidic solution. **[4 marks]**

Answer: ....

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Section 2 Question Topic **ALvl Chem 7 Q# 273/** Cambridge/2022/Section 2/ www.SmashingScience.org

56 A sample of magnesium carbonate, $MgCO_3$, was reacted completely with 50 cm^3 of 0.10 mol dm^{-3} hydrochloric acid, which is an excess.

The remaining hydrochloric acid was titrated with 0.20 mol dm^{-3} sodium hydroxide solution. 5.0 cm^3 of sodium hydroxide was required for complete neutralisation.

What was the original mass of magnesium carbonate used, in mg?

(M_r value: $MgCO_3$ = 84)

A 42 mg

B 84 mg

C 168 mg

D 210 mg

E 336 mg

F 420 mg

20 Ethanoic acid, ethanol and water were added to a reaction vessel and a quantity of concentrated sulfuric acid was added. The reaction mixture was then heated and an ester (ethyl ethanoate) and water were formed in equilibrium with the reactants.

$$C_2H_5OH(l) + CH_3COOH(l) \rightleftharpoons CH_3COOC_2H_5(l) + H_2O(l)$$

120 g of ethanoic acid and 92 g of ethanol were used and the mass of water present at the start of the experiment was 18 g. Assume that there is no change in volume.

At the temperature of the reaction, the equilibrium constant K_c is 2.00.

What is the mass of the ester present in the mixture at equilibrium?

(M_r values: ethanoic acid = 60; ethanol = 46; water = 18; ethyl ethanoate = 88)

A 1.00 g

B 53.0 g

C 88.0 g

D 103 g

E 106 g

F 176 g

G 209 g

H 215 g

16 Deuterium, D, is an isotope of hydrogen. It has one neutron and one proton in its nucleus ($^{2}_{1}H$ is an alternative representation).

Like the more common isotope of hydrogen, $^{1}_{1}H$, deuterium reacts with oxygen to form water.

Consider the following information about hydrogen, deuterium and water:

	bond energy / $kJ\,mol^{-1}$
H–H	436
D–D	443
O–H	464
O–D	471

	boiling point / °C
H_2	–252.8
D_2	–249.7
H_2O	100.0
D_2O	101.4

Both H_2O and D_2O dissociate into ions, according to the following equations:

$$H_2O \rightleftharpoons H^+ + OH^- \qquad D_2O \rightleftharpoons D^+ + OD^-$$

At a given temperature, the equilibrium constant for H_2O dissociation is greater than that for D_2O dissociation.

Under the same conditions, which of the following comparisons is/are correct?

1 The reaction of D_2 with oxygen releases less energy than H_2 with oxygen.

2 H_2O is more acidic than D_2O when measured at the same temperature.

3 The boiling points of D_2 and D_2O are higher than H_2 and H_2O, respectively, because the individual bond energies are higher.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

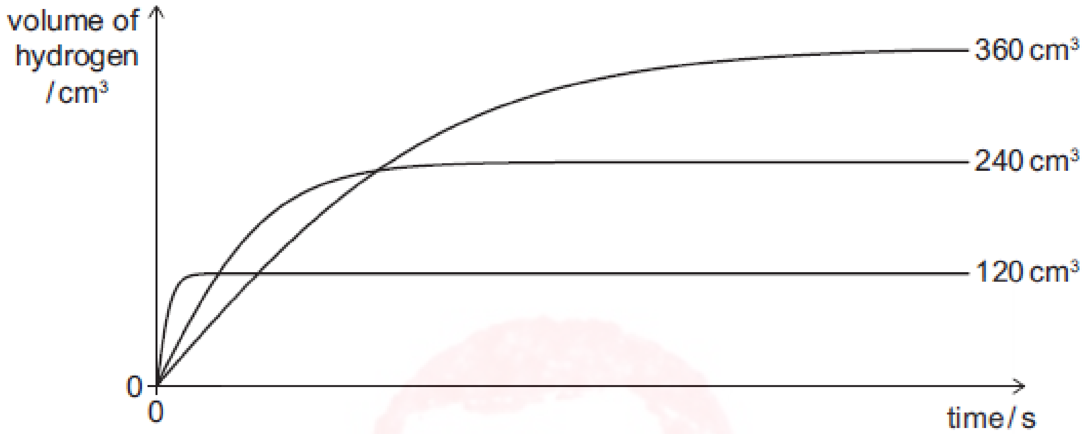
G 2 and 3 only

H 1, 2 and 3

46 Three samples of calcium of different masses were added separately to excess dilute hydrochloric acid and the volume of gas released, measured at room temperature and pressure, was monitored.

One sample was powdered calcium, one was granules of calcium, and one was a solid piece of calcium.

The results are shown on the graph.



What is the mass of powdered calcium used in this experiment?

(A_r value: Ca = 40. Assume that one mole of gas occupies a volume of 24 dm^3 at room temperature and pressure.)

A 0.200 g

B 0.400 g

C 0.600 g

D 1.20 g

E 8.00 g

F 16.0 g

G 24.0 g

53 Calcium carbonate reacts with hydrochloric acid according to the following chemical equation:

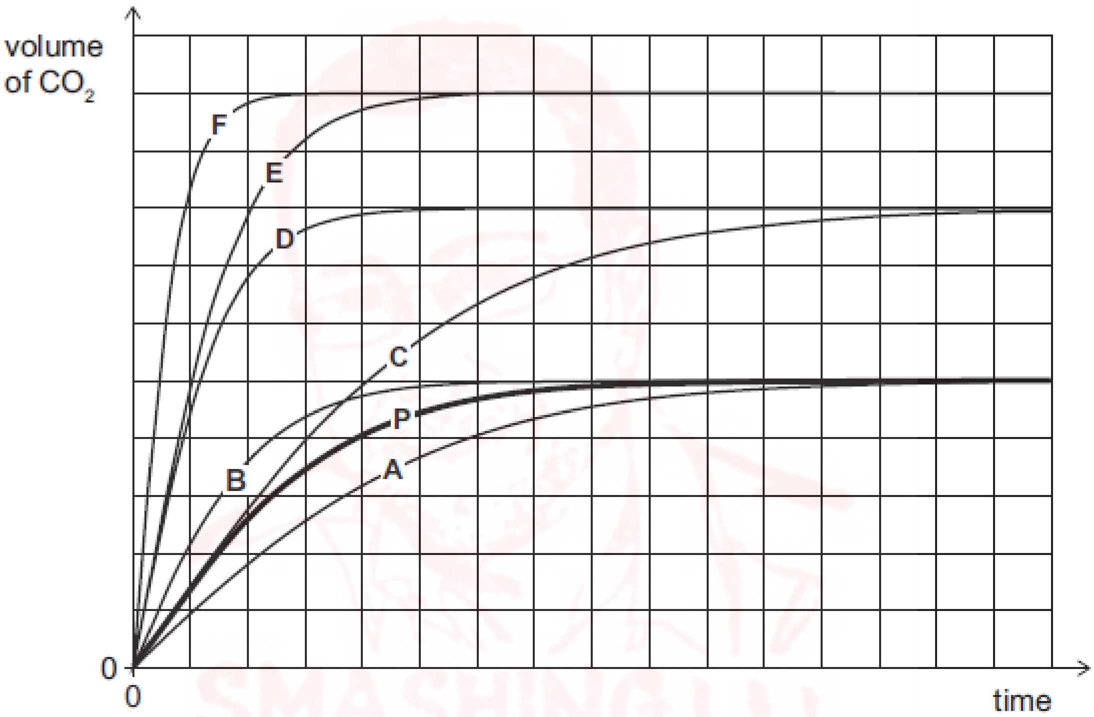
$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

Line **P** on the graph shows how the volume of carbon dioxide formed changes with time when 4.0 g of calcium carbonate reacts with 50 cm^3 of 1.0 mol dm^{-3} hydrochloric acid at 20 °C.

A second reaction was carried out under identical conditions with the same mass of calcium carbonate but using 50 cm^3 of 2.0 mol dm^{-3} hydrochloric acid.

Which line (**A**-**F**) best represents how the volume of carbon dioxide formed changes with time in the second reaction?

(M_r value: $CaCO_3$ = 100)



57 An experiment is carried out using the first three metals in Group 1: lithium, sodium and potassium.

The initial masses of three open beakers each containing 100 g samples of an alcohol are recorded.

In three separate experiments, equal small masses of lithium, sodium and potassium are added to the three beakers, which are on electronic balances.

Each metal reacts in a similar way and after the reaction is complete, the final mass of each beaker and its contents is recorded.

In each case, the final mass of the beaker and its contents is compared to the recorded initial mass before the alkali metal was added.

Which of the following statements is correct?

A The beaker with lithium added would decrease in mass the most.

B The beaker with sodium added would decrease in mass the most.

C The beaker with potassium added would decrease in mass the most.

D All three beakers would show the same decrease in mass.

E The beaker with lithium added would increase in mass the most.

F The beaker with sodium added would increase in mass the most.

G The beaker with potassium added would increase in mass the most.

H All three beakers would show the same increase in mass.

47 Which of the following statements about elements in the Periodic Table is/are correct?

1 When the element in Period 5, Group 2 reacts with the element that is in Period 3, Group 17, a redox reaction occurs.

2 In each Group, the elements from Period 2 are more reactive than the elements from Period 5.

3 The compound formed between the element in Period 2, Group 14 and the element in Period 3, Group 17 will have a simple molecular structure.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

Question C1

Data: Assume that the molar gas volume = 24.0 $dm^3 mol^{-1}$ at room temperature and pressure (rtp).

This question concerns the chemistry of tellurium, an element in Group 16 of the Periodic Table.

a) What do you expect will be the maximum and minimum oxidation states of tellurium? Briefly explain your answer.

[3 marks]

Answer: ....

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b) How do the electronegativities of the elements vary on descending Group 16?

[1 mark]

Answer: ....

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c) Which hydride, H_2O or H_2Te, has the higher boiling point? Briefly explain your answer.

[2 marks]

Answer: ....

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42 Consider **only** the first three metals in Group 1 (Li, Na, K) and **only** the first three elements in Group 17 (F, Cl, Br).

Which of the following statements is/are correct for the compound lithium bromide?

1 It is formed from the least reactive of the three Group 17 elements.

2 It is formed from the least reactive of the three Group 1 elements and the Group 17 element (of the three) with the lowest boiling point.

3 It is formed from the Group 1 element (of the three) with the highest melting point.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

Section 2 Question Topic ALvl Chem 13 Q# 282/ Cambridge/2022/Section 2/ www.SmashingScience.org

55 The equation shows the complete combustion of an alkane.

$$\text{alkane} + aO_2 \rightarrow bCO_2 + cH_2O$$

100 cm^3 of a gaseous alkane requires 650 cm^3 of oxygen for complete combustion. The volumes of both gases were measured at the same temperature and pressure.

What is the value of $a + b + c$?

A 10.5

B 12

C 14

D 15.5

E 17.5

F 19

59 One mole of an unsaturated hydrocarbon reacts with exactly one mole of bromine to form a compound that contains $\frac{6}{15}$ carbon, $\frac{1}{15}$ hydrogen and $\frac{8}{15}$ bromine by mass.

What is the relative molar mass (M_r) of this product?

(A_r values: C = 12; H = 1; Br = 80)

A 150

B 210

C 220

D 290

E 300

F 420

G 440

H 713

Section 2 Question Topic **ALvl Chem 14 Q# 284/** Cambridge/2020/Section 2/ www.SmashingScience.org

44 Molecule J is a straight-chain hydrocarbon containing one carbon-carbon double bond.

The relative atomic mass (A_r) of hydrogen is 1 and carbon is 12.

What is the **minimum** additional information that is needed in order to determine the molecular formula of molecule J?

1 The percentage by mass of carbon in the molecule.

2 The percentage by mass of hydrogen in the molecule.

3 The relative molar mass (M_r) of the molecule.

A 1 only

B 3 only

C 1 and 2 only

D 1 and 3 only

E 1, 2 and 3

Section 2 Question Topic **ALvl Chem 14 Q# 285/** Cambridge/2020/Section 2/ www.SmashingScience.org

55 Complete combustion of 1 mol of hydrocarbon X requires exactly 8.5 mol of oxygen.

Incomplete combustion of 1 mol of hydrocarbon X, to form carbon monoxide and water only, requires exactly 5.5 mol of oxygen.

How many hydrogen atoms are there in one molecule of hydrocarbon X?

A 6

B 8

C 10

D 12

E 14

Section 2 Question Topic **ALvl Chem 14 Q# 286/** Cambridge/2019/Section 2/ www.SmashingScience.org

Question C2

Trifluoroethanoic acid, TFEA, is a carboxylic acid often used in organic chemistry and has the formula CF_3COOH. The density of TFEA is 1.489 g cm^{-3}.

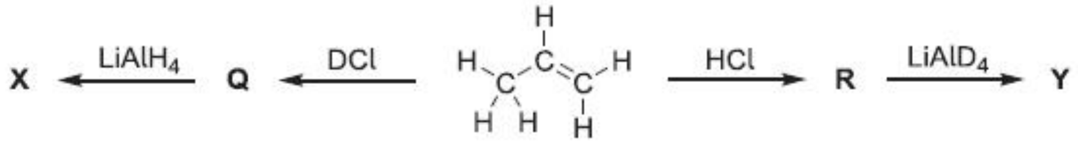
a) Draw the structure for trifluoroethanoic acid (TFEA). Indicate on your structure the approximate bond angles around each carbon.

[2 marks]

Answer:

d) Lithium aluminium deuteride can be prepared if deuterium gas is used in place of normal hydrogen. Deuterium, often given the symbol D, is the non-radioactive isotope of hydrogen, i.e. D = ^{2}H. The formula for lithium aluminium deuteride can be written $LiAlD_4$. Both $LiAlH_4$ and $LiAlD_4$ are common reducing agents and the latter is useful for preparing deuterium-containing compounds.

Isomers of mono-deuterated propane, **X** and **Y**, may be prepared from propene according to the following scheme which also uses hydrogen chloride, HCl, and deuterium chloride, DCl. In the scheme, only the carbon-containing compounds are shown; other by-products are not.



Give the structures of **X** and **Y** and the intermediates **Q** and **R** formed during the syntheses.

[4 marks]

Answer:

e) 2,2-dideuterated propane may be prepared easily in two steps, from a mono-deuterated propene, **Z**. (The formula for **Z** is C_3H_5D.)

(i) Draw the structures of all the alkenes with formula C_3H_5D. **[2 marks]**

Answer:

(ii) Give a synthesis of 2,2-dideuterated propane starting from **Z** showing reagents and intermediates in each step, making sure to give the displayed formula for **Z**. **[3 marks]**

Answer: ....

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Question 3

a) There are two compounds with the formula C_3H_8. Write out the structures of these molecules as a displayed formula and as a skeletal formula. Give the names of the two compounds and identify the particular class of compounds each belongs to. **[4 marks]**

Answer: ....

b) Like every other member in its class, one isomer of C_3H_8, isomer **A**, reacts rapidly with bromine to form a single product, **F**. Draw the structure of **A** as a skeletal formula and also the structure of the product formed when **A** reacts with bromine. **[3 marks]**

Answer: ....

c) The second isomer of C_3H_6, isomer **B**, has a number of unique properties. The other members in the same class of compounds only react with bromine in the presence of light and form HBr as a side product. However, **B** reacts with bromine in the absence of light (but much less rapidly than **A**) and forms a single compound **G**. **F** and **G** are isomers. Draw the structures of **B** and **G** as skeletal formulae. **[4 marks]**

Answer: ....

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Question 4

There are six isomers with the formula C_5H_{10} that are alkenes. The alkenes all have different enthalpies of formation, all of which are negative.

a) Draw the structures of the six alkenes (skeletal or displayed structures are acceptable).

[6 marks]

Answer:

Samples of the six alkenes, in a random order, are labelled **P**, **Q**, **R**, **S**, **T**, and **U**. You will be able to identify which isomer *some* of these correspond to using the information and data throughout the rest of the question.

Alkenes **P**, **Q**, and **R** react with hydrogen gas and a metal catalyst to give the same alkane **A**; alkenes **S**, **T**, and **U** react under the same conditions to give a different alkane **B**.

Both alkanes **A** and **B** react with chlorine gas under UV light to form chloroalkanes with the formula $C_5H_{11}Cl$. Under such conditions, alkane **A** forms *four* different structural isomers, whereas **B** gives *three*.

b) Draw the structures of alkanes **A** and **B**. Also draw the structures of the four isomers arising from the chlorination of **A**, and the three isomers arising from the chlorination of **B**. **[6 marks]**

Answer:

Samples of the six alkenes, in a random order, are labelled **P**, **Q**, **R**, **S**, **T**, and **U**. You will be able to identify which isomer *some* of these correspond to using the information and data throughout the rest of the question.

Alkenes **P**, **Q**, and **R** react with hydrogen gas and a metal catalyst to give the same alkane **A**; alkenes **S**, **T**, and **U** react under the same conditions to give a different alkane **B**.

Both alkanes **A** and **B** react with chlorine gas under UV light to form chloroalkanes with the formula $C_5H_{11}Cl$. Under such conditions, alkane **A** forms *four* different structural isomers, whereas **B** gives *three*.

The alkenes react with HBr to form bromoalkanes with the formula $C_5H_{11}Br$; the reaction proceeds via a carbocation intermediate. Alkenes **S** and **T** give a mix of *two* structural isomers, whereas alkene **U** gives only one.

c) Give the structure of alkene **U**. **[4 marks]**

Answer:

A general rule for isomeric alkenes is that the more carbon atoms directly bonded to the double bond (or the lower the number of hydrogen atoms directly bonded), the more negative (that is, the more exothermic) the enthalpy of formation of the alkene.

d) Out of **P**, **Q** and **R**, **R** has the most negative (most exothermic) enthalpy of formation. Give the structure of **R**. **[1 mark]**

Answer:

Consider the following thermodynamic data:

	value / $kJ\,mol^{-1}$
standard enthalpy change of hydrogenation for alkene **P**	–113
standard enthalpy change of hydrogenation for alkene **Q**	–119
standard enthalpy change of combustion for alkane **A**	–3528
standard enthalpy change of formation of $H_2O(l)$	–286

e) Use the data to deduce the structure of: **(i)** alkene **P**; and **(ii)** alkene **Q**. **[4 marks]**

Answer: ....

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15 Tollens' reagent, $[Ag(NH_3)_2]NO_3(aq)$, can be used to coat glass surfaces with silver metal (A_r = 108) to make decorative objects. It is a reducing agent and reacts by oxidising aldehydes to carboxylic acids.

The half-equation for the organic oxidation can be represented as (R = alkyl group):

$$\underset{\text{aldehyde}}{RCHO} + H_2O \rightarrow \underset{\text{carboxylic acid}}{RCOOH} + 2H^+ + 2e^-$$

All of the inside surface of a beaker is to be coated in a uniform layer of silver metal of thickness 0.01 cm. The beaker can be modelled as a cylinder of height 10 cm and radius 5 cm.

The density of silver metal is 10.5 g cm^{-3}.

Which of the following expressions gives the minimum number of moles of aldehyde required?

(Assume that the yield of any reaction is 100%.)

A $\dfrac{10.5 \times 1.25 \times \pi}{2 \times 108}$

B $\dfrac{10.5 \times 1.25 \times \pi}{108}$

C $\dfrac{2 \times 10.5 \times 1.25 \times \pi}{108}$

D $\dfrac{108 \times 10.5 \times 1.25 \times \pi}{2}$

E $\dfrac{10.5 \times 1.5 \times \pi}{2 \times 108}$

F $\dfrac{2 \times 10.5 \times 1.5 \times \pi}{108}$

G $\dfrac{10.5 \times 1.5 \times \pi}{108}$

H $\dfrac{108 \times 10.5 \times 1.5 \times \pi}{2}$

23 Propanal can be reduced to propan-1-ol with hydrogen gas at high pressure and a platinum catalyst.

Radioactive propan-1-ol can be made if the hydrogen gas is replaced by pure tritium gas. Tritium, ^{3}H, is the radioactive isotope of hydrogen.

All of the atoms other than ^{3}H in the radioactive propan-1-ol are the most abundant isotope for the element. The most abundant isotopes of carbon, hydrogen and oxygen are ^{12}C, ^{1}H and ^{16}O.

How many neutrons are there in one molecule of this radioactive propan-1-ol?

A 26

B 28

C 30

D 32

E 34

F 40

G 42

33 A yellow precipitate is formed when alkaline aqueous iodine reacts with alcohols that have the structure R-CH(OH)CH_3, where R is a carbon chain or H.

There are a number of structural isomers with the molecular formula $C_5H_{12}O$ that are alcohols.

Of these structural isomeric alcohols:

(i) how many will form a yellow precipitate when reacted with alkaline aqueous iodine;

(ii) how many, following mild oxidation and immediate distillation, will produce a silver mirror with Tollens' reagent?

	(i) *forms yellow precipitate*	(ii) *produces silver mirror*
A	1	1
B	2	3
C	2	4
D	2	7
E	3	3
F	3	4
G	3	7
H	4	4

Section 2 Question Topic ALvl Chem 18 Q# 295/ Cambridge/2022/Section 2/ www.SmashingScience.org

49 Carboxylic acid X reacts with propanol in the presence of an acid catalyst to form compound Y.

Compound Y has a relative molar mass of 116.

What is the relative molar mass (M_r) of X?

(A_r values: C = 12; H = 1; O = 16)

A 45

B 46

C 55

D 56

E 59

F 60

G 73

H 74

Section 2 Question Topic ALvl Chem 20 Q# 296/ Cambridge/2022/Section 2/
www.SmashingScience.org

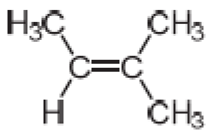
54 1 mol of compound X undergoes complete combustion to produce 144 dm^3 of carbon dioxide (measured at room temperature and pressure).

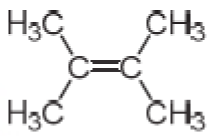
1 mol of X can also undergo an addition reaction with 1 mol of hydrogen to form a saturated compound that has one branch.

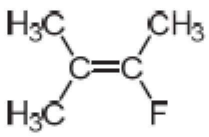
X undergoes addition polymerisation. A section of the addition polymer containing three repeating units has an M_r value greater than 200 but less than 300.

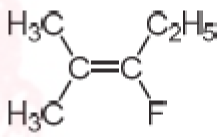
Which one of the following structural formulae could be that of compound X?

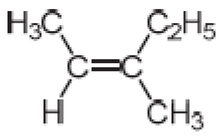
(A_r values: C = 12; H = 1; F = 19. Assume that one mole of any gas occupies a volume of 24 dm^3 at room temperature and pressure.)

A 

B 

C 

D 

E 

Section 2 Question Topic ALvl Chem 21 Q# 297/ Cambridge/2020SP/Section 2/
www.SmashingScience.org

18 Compound P, with molecular formula C_5H_{10}, reacts with hydrogen bromide in an addition reaction to form compound Q as the only major product.

Q undergoes a substitution reaction with aqueous sodium hydroxide to form compound R.

After R is completely oxidised using acidified potassium dichromate(VI), the resulting product does **not** react with aqueous sodium carbonate.

R undergoes an elimination reaction to form a mixture of products: P and S.

S has no stereoisomers.

What is compound P?

A pent-1-ene

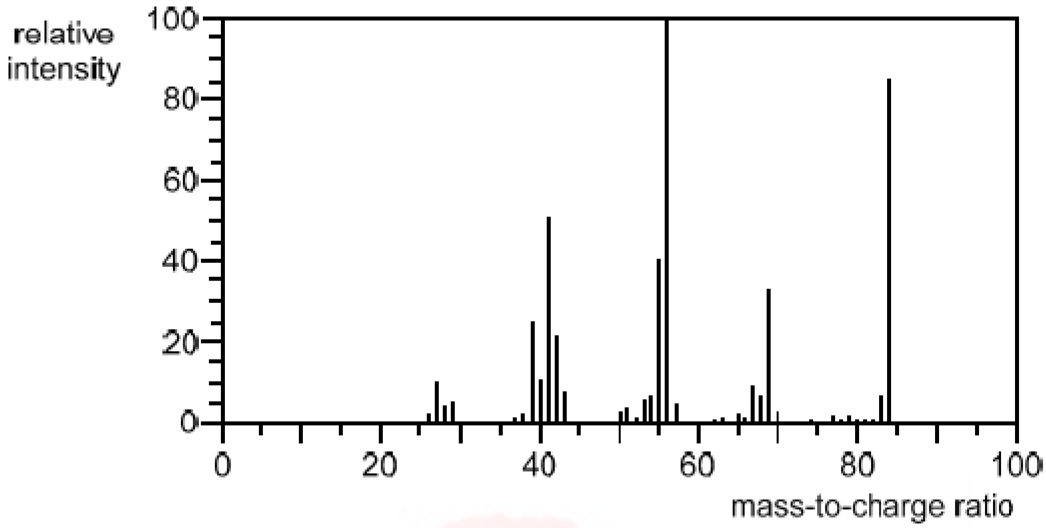
B pent-2-ene

C 2-methylbut-1-ene

D 2-methylbut-2-ene

E 3-methylbut-1-ene

13 The mass spectrum of a hydrocarbon, X, is shown.



X contains 14.3% by mass of hydrogen and does **not** decolourise aqueous bromine.

Which of the following could be the identity of X?

1 hex-2-ene

2 cyclohexane

3 cyclobutane

(A_r values: H = 1; C = 12)

A 1 only

B 2 only

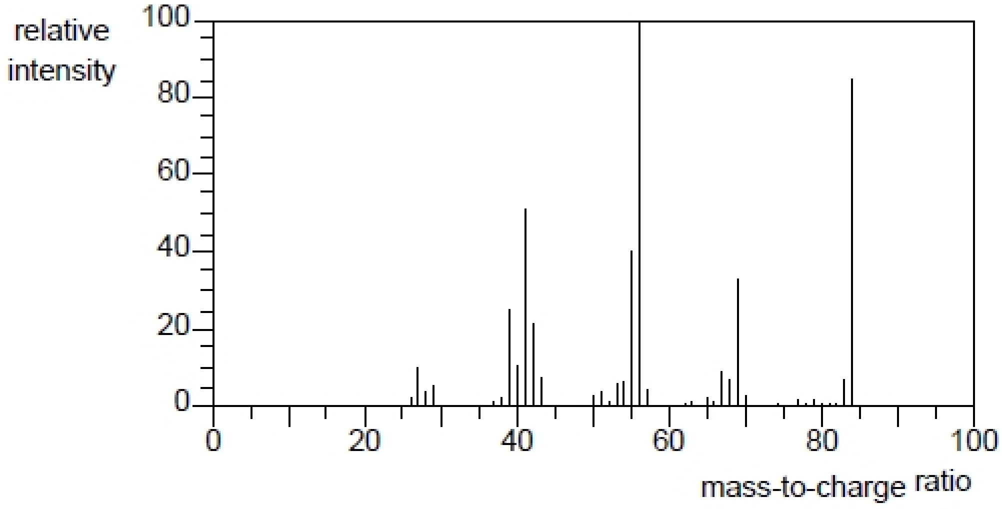
C 3 only

D 1 and 2 only

E 1 and 3 only

F 2 and 3 only

13 The mass spectrum of a hydrocarbon, X, is shown.



X contains 14.3% by mass of hydrogen and does **not** decolourise aqueous bromine.

Which of the following could be the identity of X?

1 hex-2-ene

2 cyclohexane

3 cyclobutane

(A_r values: H = 1; C = 12)

A 1 only

B 2 only

C 3 only

D 1 and 2 only

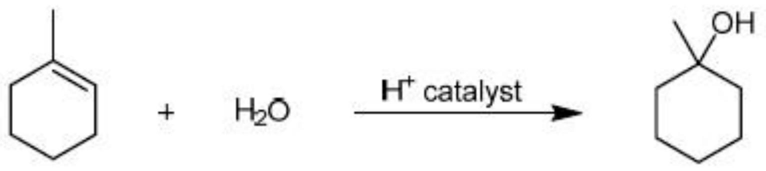
E 1 and 3 only

F 2 and 3 only

These questions cover material that is not in the ESAT syllabus.
They are only helpful to students who have completed everything else, and teachers who are teaching this material in the A2 year as potentially an interesting hook in a lesson to very capable students.

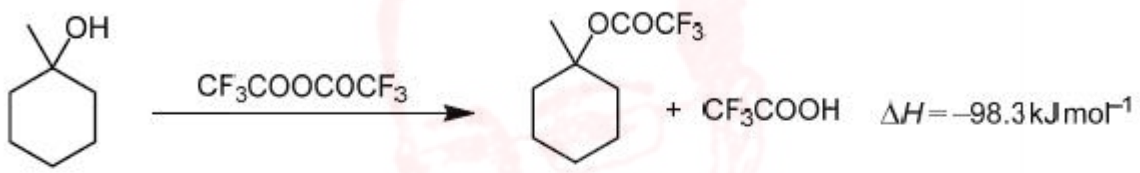
A mixture of TFEA and trifluoroethanoic anhydride, $CF_3COOCOCF_3$, was used as the solvent system in a series of experiments to determine the standard enthalpy changes of hydration of various alkenes.

1-methylcyclohexene, **A**, may be hydrated in an acid-catalysed reaction as shown below:



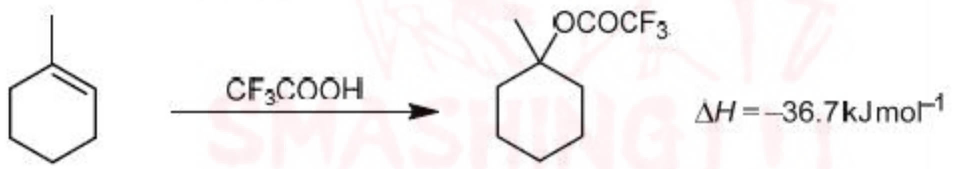
A **B**

In a mixture of TFEA and trifluoroethanoic anhydride, **B** reacts with the trifluoroethanoic anhydride to form **C** and TFEA as shown below. The standard enthalpy change for this reaction is –98.3 kJ mol^{-1}.



B **C**

Compound **C** may also be formed in the same mixture of TFEA and trifluoroethanoic anhydride from the reaction between 1-methylcyclohexene and TFEA. The standard enthalpy change for this reaction is –36.7 kJ mol^{-1}.



A **C**

The standard enthalpy change for the reaction between one mole of water and one mole of trifluoroethanoic anhydride is –75.6 kJ mol^{-1}.

j) Give the equation for the reaction between one mole of water and one mole of trifluoroethanoic anhydride.

[1 mark]

Answer: ....

....

....

k) By constructing an appropriate energy cycle, calculate the standard enthalpy change for the hydration of alkene **A**.

[4 marks]

Answer: ....

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Question C2

Read the following carefully before proceeding to answer the question.

In their solid (crystalline) form many inorganic salts (such as NaCl or MgF_2) can be thought of as consisting of a giant lattice in which positive ions (e.g. Na^+, Mg^{2+}) and negative ions (e.g. Cl^-, F^-) are arranged in a regular pattern, called a *lattice*. The ions are held together by electrostatic forces arising from the favourable interactions between ions of opposite charge.

The lattice enthalpy is the enthalpy change for a process in which the **solid** material is formed from ions in the gas phase. For NaCl(s) this is the process

$$Na^+(g) + Cl^-(g) \rightarrow NaCl(s)$$

and for MgF_2 the process is

$$Mg^{2+}(g) + 2F^-(g) \rightarrow MgF_2(s)$$

The lattice enthalpy is invariably large and negative.

The lattice enthalpy in $kJ\,mol^{-1}$ can be estimated using the following expression:

$$\frac{-1.07\times10^5\times n_{ions}\times z_+\times z_-}{r_+ + r_-} \qquad \textbf{Equation 1}$$

In this expression, r_+ is the radius of the positive ion, in pm (1 pm = 10^{-12} m), and r_- is the radius of the negative ion, also given in pm.

n_{ions} is the number of ions in the formula unit; for example, for NaCl $n_{ions} = 2$, but for MgF_2 $n_{ions} = 3$.

z_+ is the charge number on the positive ion; for example for Na^+ it is 1, but for Mg^{2+} it is 2. Likewise z_- is the **absolute value** of the charge number on the negative ion: for Cl^- it is 1 (**not** −1).

a) Use Equation 1 to calculate the lattice enthalpy for CuF_2 given the following data:

$$r_+ = 73\,\text{pm},\ \ r_- = 133\,\text{pm}$$

[3 marks]

Answer: ....

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b) Use Equation 1 to calculate the lattice enthalpy for CuF_3 given the following data:

$$r_+ = 54\,\text{pm},\ \ r_- = 133\,\text{pm}$$

[3 marks]

Answer: ....

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c) Calculated values of the lattice enthalpy can be used to estimate the enthalpy change of hypothetical reactions, such as

$$CuF_2(s) + \tfrac{1}{2}F_2(g) \rightarrow CuF_3(s) \qquad \textbf{Equation 2}$$

Determine the oxidation state of copper in each of the species and hence classify what kind of reaction this is. **[3 marks]**

Answer: ....

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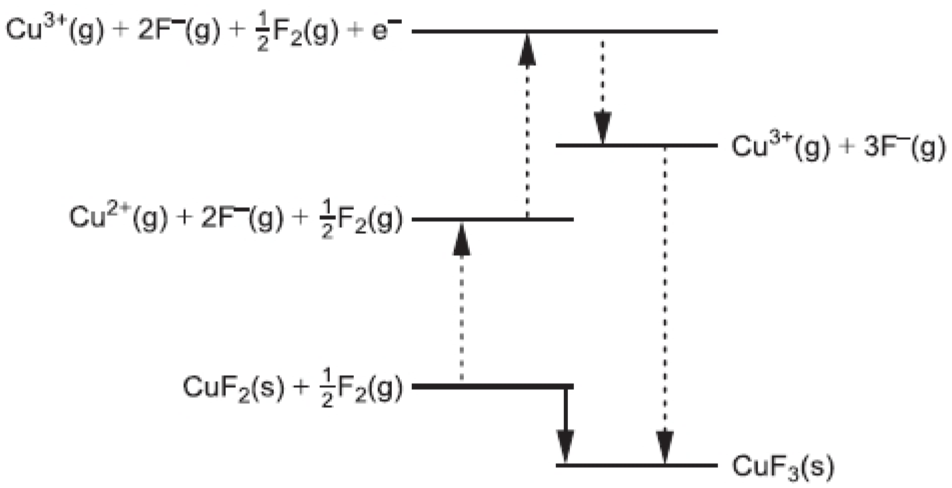
d) The enthalpy change for the reaction in Equation 2 can be calculated using the following Hess's Law cycle.



Using your results from **a)** and **b)**, and given the following enthalpy changes

$$F_2(g) + 2e^- \rightarrow 2F^-(g) \qquad \Delta H = -540\ \text{kJ mol}^{-1}$$
$$Cu^{2+}(g) \rightarrow Cu^{3+}(g) + e^- \qquad \Delta H = 3555\ \text{kJ mol}^{-1}$$

calculate the enthalpy change for:

$$CuF_2(s) + \tfrac{1}{2}F_2(g) \rightarrow CuF_3(s)$$

[5 marks]

Answer: ....

e) Use the data given below to calculate the enthalpy change for the following reaction (M is an unspecified metallic element).

$$2MF_2(s) \rightarrow MF_3(s) + MF(s)$$

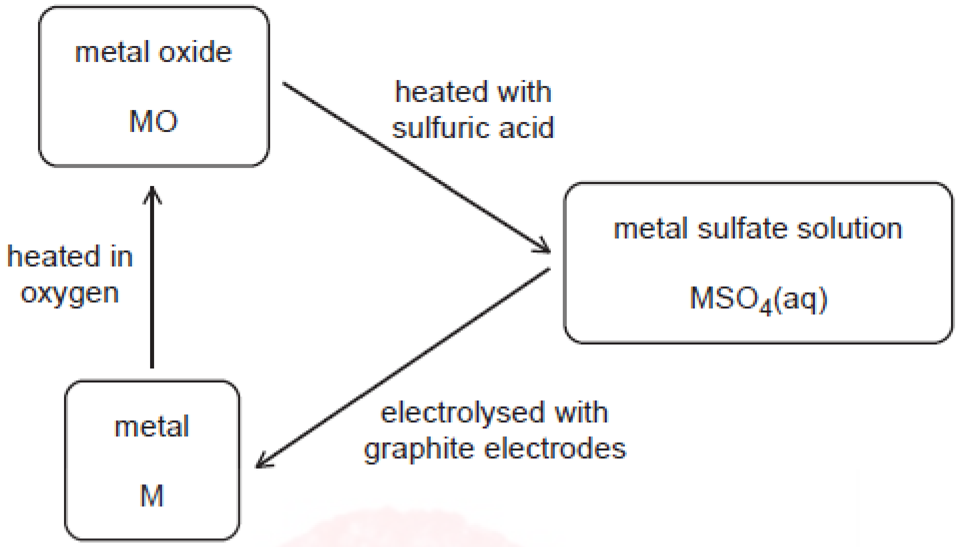
You may find it helpful to start by constructing an appropriate Hess's Law cycle.

$MF_2(s) \rightarrow M^{2+}(g) + 2F^-(g)$	$\Delta H = 3000\,kJ\,mol^{-1}$
$MF_3(s) \rightarrow M^{3+}(g) + 3F^-(g)$	$\Delta H = 7000\,kJ\,mol^{-1}$
$MF(s) \rightarrow M^+(g) + F^-(g)$	$\Delta H = 1000\,kJ\,mol^{-1}$
$M^+(g) \rightarrow M^{2+}(g) + e^-$	$\Delta H = 2000\,kJ\,mol^{-1}$
$M^{2+}(g) \rightarrow M^{3+}(g) + e^-$	$\Delta H = 3000\,kJ\,mol^{-1}$

[6 marks]

Answer: ....

42 Some reactions of metal M and its compounds are shown in the following diagram.



Which one of the following could be the identity of metal M?

A aluminium

B copper

C magnesium

D potassium

E silver

Section 2 Question Topic **ALvl Chem 24 Q# 303/** Cambridge/2022/Section 2/ www.SmashingScience.org

44 Which of the following statements about losing electrons is/are correct?

1 During the electrolysis of a molten binary compound the ions attracted to the cathode (negative electrode) lose electrons at that electrode.

2 Descending Group 1 of the Periodic Table from lithium to caesium, the atoms of the elements lose electrons more easily.

3 When a substance is acting as a reducing agent it loses electrons.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

Section 2 Question Topic **ALvl Chem 24 Q# 304/** Cambridge/2022/Section 2/ www.SmashingScience.org

47 Concentrated aqueous solutions of three compounds are electrolysed with inert electrodes

The constituent elements of which of the following compounds may be collected using this process?

1 copper(II) bromide

2 hydrogen chloride

3 potassium chloride

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

48 Some dilute aqueous solutions were electrolysed using graphite electrodes.

Which of the rows in the table show(s) the correct products of electrolysis?

	aqueous electrolyte	*products of electrolysis*	
		at the cathode (negative electrode)	*at the anode (positive electrode)*
1	potassium hydroxide	potassium	oxygen
2	copper(II) chloride	chlorine	copper
3	sodium sulfate	hydrogen	sulfur

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

59 An electric current is the flow of charged particles.

In an electrolysis of aluminium oxide using inert electrodes, the current flows at 5.00×10^{-6} moles of electrons per second.

Assume that only aluminium oxide is present and the aluminium is a single isotope $^{27}_{13}Al$.

What mass of aluminium is produced in 48 seconds?

A 0.04 mg

B 0.09 mg

C 0.52 mg

D 1.04 mg

E 1.08 mg

F 2.16 mg

G 3.12 mg

H 6.48 mg

c) Determine the oxidation state of the metal atom or atoms in the following species.

(i) MnO_4^{2-}

[1 mark]

Answer: ....

....

(ii) $K_2Cr_2O_7$

[2 marks]

Answer: ....

....

....

....

d) Write a balanced chemical equation in which Fe^{2+} is oxidised to Fe^{3+} by MnO_4^- in an **acidic aqueous solution** and in which the Mn is reduced to a species with oxidation state +2. Your equation must balance for both atoms and charge, and you may **not** use free electrons (e^-) to achieve this.

[4 marks]

Answer: ....

....

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20 Ethanoic acid, ethanol and water were added to a reaction vessel and a quantity of concentrated sulfuric acid was added. The reaction mixture was then heated and an ester (ethyl ethanoate) and water were formed in equilibrium with the reactants.

$$C_2H_5OH(l) + CH_3COOH(l) \rightleftharpoons CH_3COOC_2H_5(l) + H_2O(l)$$

120 g of ethanoic acid and 92 g of ethanol were used and the mass of water present at the start of the experiment was 18 g. Assume that there is no change in volume.

At the temperature of the reaction, the equilibrium constant K_c is 2.00.

What is the mass of the ester present in the mixture at equilibrium?

(M_r values: ethanoic acid = 60; ethanol = 46; water = 18; ethyl ethanoate = 88)

A 1.00 g

B 53.0 g

C 88.0 g

D 103 g

E 106 g

F 176 g

G 209 g

H 215 g

48 50 cm^3 of 0.100 $mol\,dm^{-3}$ hydrochloric acid has a pH of 1.0.

What is the pH of the mixture formed when 450 cm^3 of 0.010 $mol\,dm^{-3}$ calcium hydroxide solution is added?

A pH = 1.0

B 1.0 < pH < 2.0

C pH = 2.0

D 2.0 < pH < 7.0

E pH = 7.0

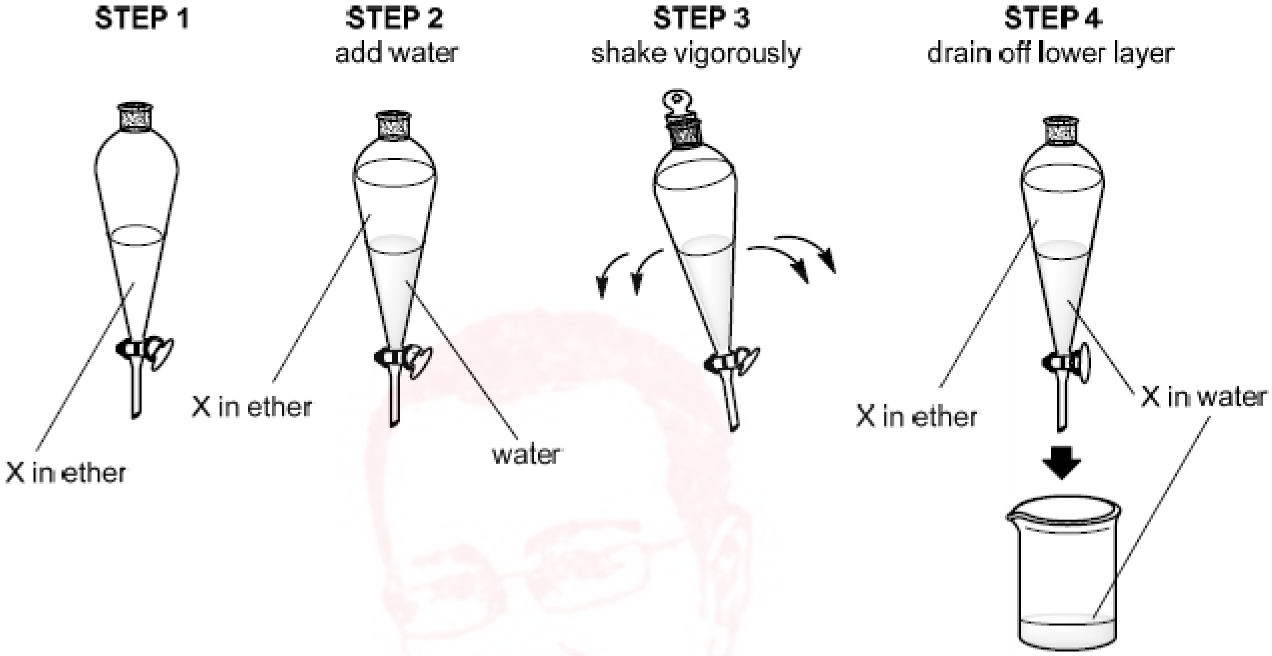
F pH > 7.0

28 Consider the distribution of a solute X between two immiscible solvents: water and ether.

$$X(aq) \rightleftharpoons X(ether)$$

The equilibrium constant, K_c, is 0.15 at 25 °C.

50 cm^3 of a solution of X in ether at 25 °C contains 21.5 g of X. 100 cm^3 of water is added, shaken with the ether solution and allowed to reach equilibrium at 25 °C.



What is the maximum mass of X that can be transferred into the aqueous layer?

A 4.96 g

B 14.3 g

C 18.7 g

D 20.0 g

E 20.5 g

35 Sodium hydrogencarbonate, $NaHCO_3$, and sodium carbonate are both used as antacids. They react with hydrochloric acid in the stomach to form the same products.

The contents of a person's stomach has a pH of 1.0, which is a concentration of 0.1 mol dm^{-3} HCl. The stomach contained 80 cm^3 of aqueous solution when the pH was measured.

Which of the following amounts of sodium hydrogencarbonate would bring the stomach contents into the normal range of pH 2.0-3.0?

(A_r values: H = 1; C = 12; O = 16; Na = 23)

A 0.0038 mol

B 0.0075 mol

C 0.0080 mol

D 0.016 mol

E 0.095 mol

54 Hydrochloric acid, sulfuric acid and phosphoric(V) acid are inorganic acids.

Phosphoric(V) acid, H_3PO_4, ionises in water in the following series of reactions:

$$H_3PO_4 \rightleftharpoons H^+ + H_2PO_4^-$$

$$H_2PO_4^- \rightleftharpoons H^+ + HPO_4^{2-}$$

$$HPO_4^{2-} \rightleftharpoons H^+ + PO_4^{3-}$$

0.1 mol dm^{-3} hydrochloric acid has a pH of 1.0 at room temperature.

Which of the following statements about these acids is/are correct?

1 The pH of 0.1 mol dm^{-3} sulfuric acid is greater than 1.0 at room temperature.

2 $H_2PO_4^-$ can act as an acid or as a base.

3 30 cm^3 of calcium hydroxide solution exactly neutralises 20 cm^3 phosphoric(V) acid solution when both solutions are the same concentration.

A none of them

B 1 only

C 2 only

D 3 only

E 1 and 2 only

F 1 and 3 only

G 2 and 3 only

H 1, 2 and 3

Section 2 Question Topic **ALvl Chem 25 Q# 313/** Cambridge/2019/Section 2/ www.SmashingScience.org

Question C2

Trifluoroethanoic acid, TFEA, is a carboxylic acid often used in organic chemistry and has the formula CF_3COOH. The density of TFEA is 1.489 g cm^{-3}.

An aqueous solution of TFEA is made up by mixing 0.0700 mol of the pure acid with water and making the solution up to 100.0 cm^3.

b) Calculate the volume of pure TFEA needed to make the solution.

[3 marks]

Answer: ....

....

....

....

....

....

c) Give an equation for the ionisation of TFEA in water.

[1 mark]

Answer: ....

....

....

d) Give an expression for the equilibrium constant for the ionisation of TFEA in water.

[2 marks]

Answer: ....

....

....

....

e) Given that the measured concentration of H^+ ions is 0.4119 mol dm^{-3}, calculate the value of the equilibrium constant. You may ignore the self-dissociation of water.

[3 marks]

Answer: ....

....

....

....

....

....

Section 2 Question Topic **ALvl Chem 25 Q# 314/** Cambridge/2016SP/Section 2/ www.SmashingScience.org

Question 4

a) Arsenic oxide As_2O_3 is prepared on an industrial scale by roasting arsenic-containing ores such as arsenopyrite, FeAsS, in air. The other products formed are iron(III) oxide and sulfur dioxide.

b) As_2O_3 is moderately soluble in water; one dm^3 of a saturated solution at 25 °C contains 20.6 g. When dissolved in water, the oxide reacts to form arsenous acid, H_3AsO_3.

d) Diluted hydrochloric acid is also sold as a homeopathic medicine. The pH of a solution may be calculated using the following equation:

$$pH = -\log_{10} [H^+]$$

where $[H^+]$ is the total concentration of hydrogen ions, in mol dm^{-3}, in aqueous solution. Rearranging this equation allows us to calculate the total concentration of hydrogen ions from the pH of the solution:

$$[H^+] = 10^{-pH}$$

(i) What is the pH of pure water at room temperature? Calculate $[H^+]$ for pure water.

[3 marks]

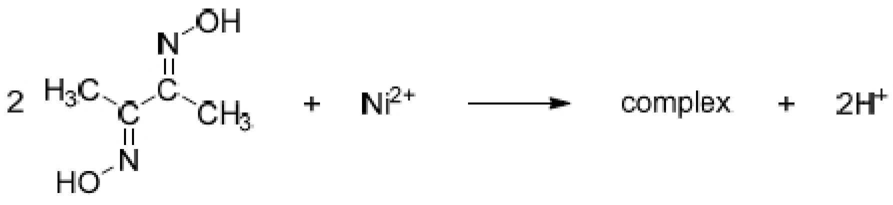
Answer: ....

(ii) Assuming the original stock solution before dilution has a concentration of 1.0 mol dm^{-3}, what is the concentration of HCl and pH obtained by the following dilutions of the stock solution: **1)** dilution by a factor of 10^2; **2)** dilution by a factor of 10^6; **3)** dilution by a factor of 10^{10}.

[3 marks]

Answer: ....

c) Dimethylglyoxime reacts with Ni^{2+} ions in aqueous solution under mildly basic conditions to give a complex which is an insoluble red precipitate. The reaction involves two molecules of dimethylglyoxime and also results in the production of two H^+ ions.



dimethylglyoxime

Assuming that the above equation is balanced, determine the **molecular formula** of the complex and its relative molecular mass; a structural formula is **not** required.

(Relative atomic mass data is given in the Periodic Table on page 14.)

[4 marks]

Answer: ....

....

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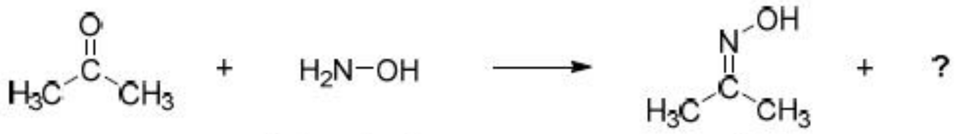
Question C1

a) Ketones react with hydroxylamine, NH_2OH, to give oximes. An example of such a reaction involving the ketone propanone is shown below:



propanone (a ketone) hydroxylamine an oxime

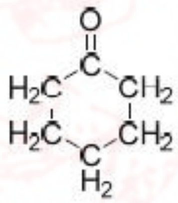
(i) In addition to the oxime, this reaction produces a second product. Suggest what this molecule might be.

[1 mark]

Answer: ....

....

(ii) Draw the structure of the oxime that you would expect to be formed from the reaction of the ketone cyclohexanone with hydroxylamine.

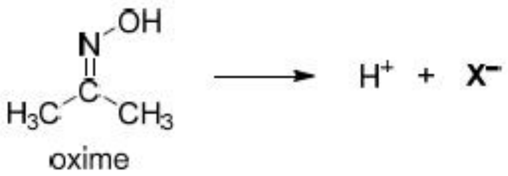


cyclohexanone

[2 marks]

Answer:

(iii) Oximes are weakly acidic. For the oxime below, explain which hydrogen atom will be the most acidic and draw the structure of the resulting anion $\mathbf{X^-}$.



[3 marks]

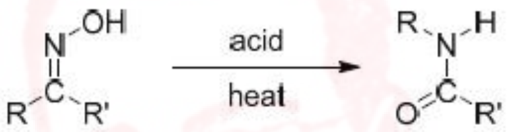
Answer: ....

....

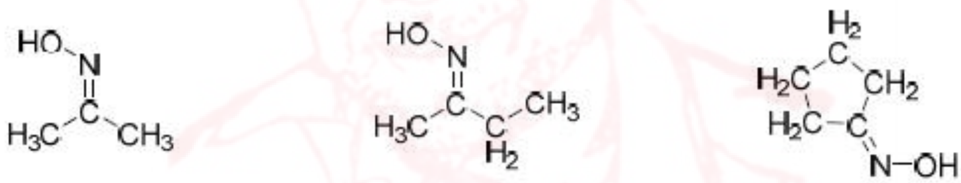
....

....

b) Under acidic conditions, oximes undergo the following rearrangement reaction (note carefully that there are two different groups R and R').



Give the analogous structures into which each of the following oximes rearrange under the same conditions.

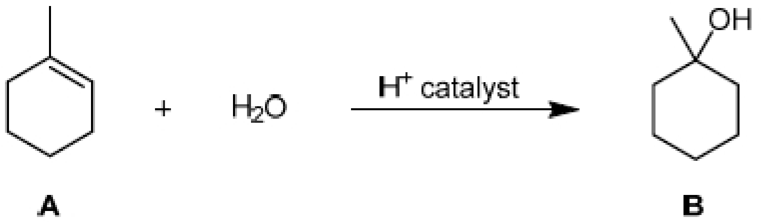


[4 marks]

Answer:

A mixture of TFEA and trifluoroethanoic anhydride, $CF_3COOCOCF_3$, was used as the solvent system in a series of experiments to determine the standard enthalpy changes of hydration of various alkenes.

1-methylcyclohexene, **A**, may be hydrated in an acid-catalysed reaction as shown below:



f) How may this reaction be classified? Choose from: *addition*, *elimination*, *substitution*, *oxidation*, *addition polymerisation*.

[1 mark]

Answer: ....

g) Draw the structure of the intermediate initially formed when the H^+ catalyst reacts with alkene **A**.

[1 mark]

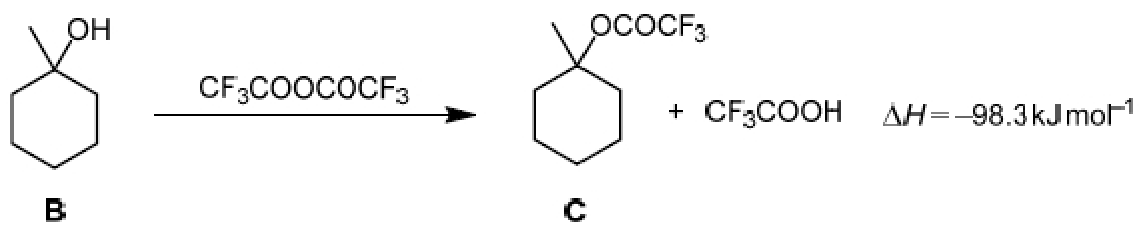
Answer:

h) The same product **B** is formed when an alkene isomer of **A** is treated under identical conditions. Suggest a structure for this isomer.

[1 mark]

Answer:

In a mixture of TFEA and trifluoroethanoic anhydride, **B** reacts with the trifluoroethanoic anhydride to form **C** and TFEA as shown below. The standard enthalpy change for this reaction is –98.3 kJ mol^{-1}.



i) Draw the structure of trifluoroethanoic anhydride.

[1 mark]

Answer:

Section 2 Question Topic **ALvl Chem 36 Q# 318/** Cambridge/2022sp/Section 2/ www.SmashingScience.org

18 Compound P, with molecular formula C_5H_{10}, reacts with hydrogen bromide in an addition reaction to form compound Q as the major product.

Q undergoes a substitution reaction with aqueous sodium hydroxide to form compound R.

After R is completely oxidised using acidified potassium dichromate(VI), the resulting product does **not** react with aqueous sodium carbonate.

R undergoes an elimination reaction to form a mixture of products: P and S.

S has no stereoisomers.

What is compound P?

A pent-1-ene

B pent-2-ene

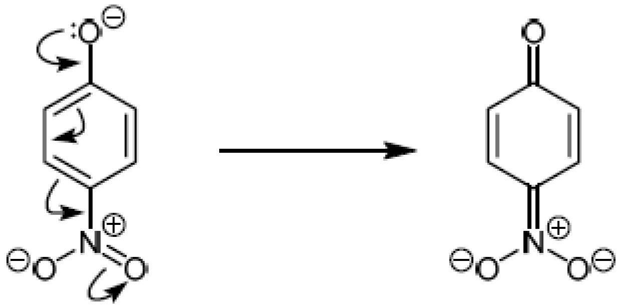
C 2-methylbut-1-ene

D 2-methylbut-2-ene

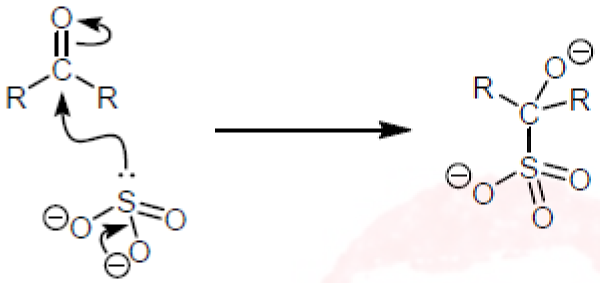
E 3-methylbut-1-ene

25 Which of the following does **not** give the species shown?

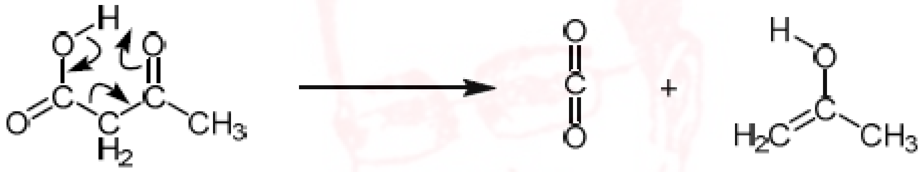
A



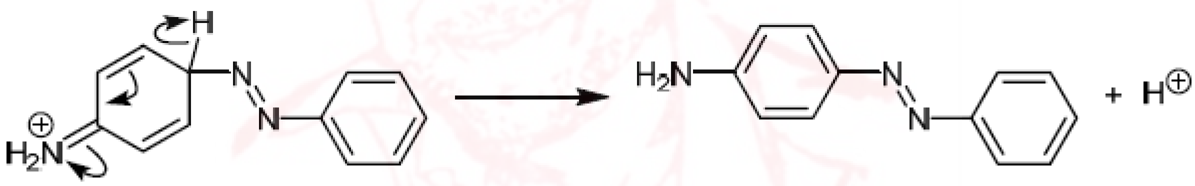
B



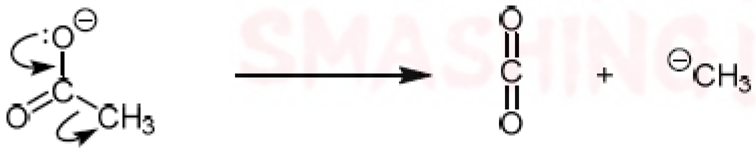
C



D



E



26 0.4 mol of a halogenoalkane reacted completely with hot, ethanolic potassium hydroxide to give 28 g of a single organic product X in 100% yield.

What percentage of all of the structural isomers with both the same functional group and molecular formula as X would show geometric (*E*/*Z*) isomerism?

(A_r values: H = 1; C = 12)

A 17%

B 20%

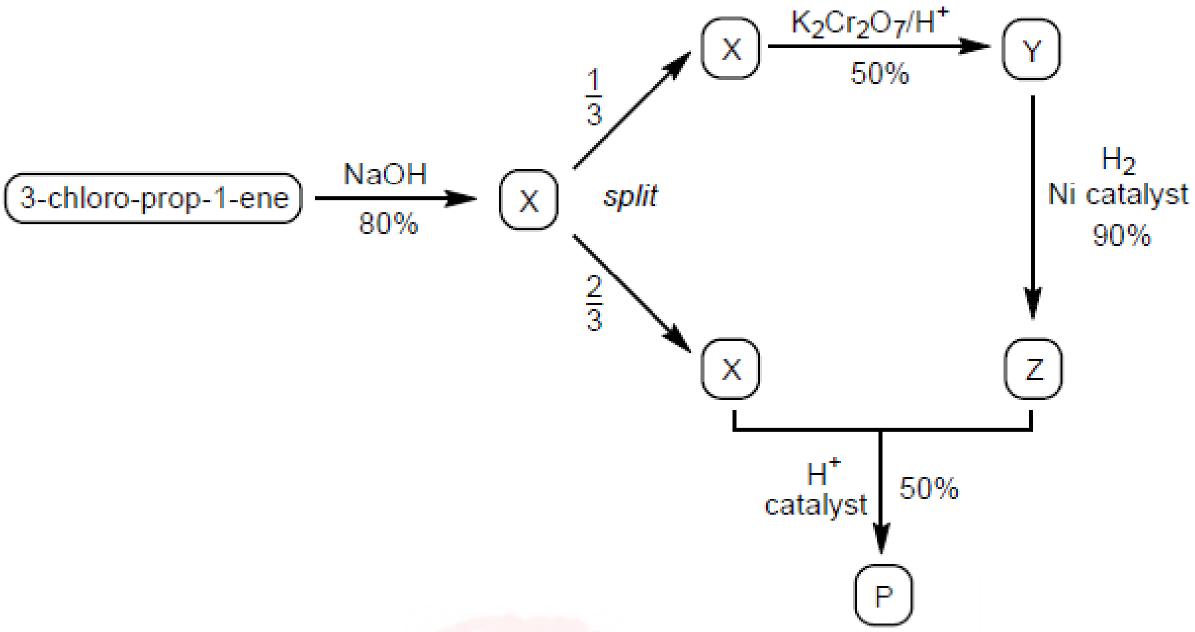
C 25%

D 33%

E 40%

F 50%

29



5.0 mol of 3-chloro-prop-1-ene (M_r = 76.5) was reacted with excess sodium hydroxide to form a single product X in 80% yield.

One third of compound X was heated with excess acidified potassium dichromate(VI) under reflux to form a single product Y in 50% yield.

All of compound Y was reacted with hydrogen gas at high temperature in the presence of nickel to form a single product Z in 90% yield.

The remaining quantity of compound X was reacted with all of compound Z in the presence of an acid catalyst to form product P in 50% yield.

What is the maximum mass of product P that could be produced from this synthesis?

(A_r values: H = 1; C = 12; O = 16; Cl = 35.5)

A 2.74 g

B 5.48 g

C 23.0 g

D 34.2 g

E 114 g

F 123 g

G 152 g

36 X is a **di**carboxylic acid. When in aqueous solution, 2.36 g of X reacts with excess sodium carbonate to produce 480 cm^3 of carbon dioxide, measured at room temperature and pressure. Assume that no gas dissolves in the water present.

Y is a liquid organic compound containing only one functional group. 1 mol of Y reacts exactly with 1 mol of sodium, giving off a gas that pops with a lighted splint. Aqueous Y does not change the colour of blue or red litmus papers.

When 50.0 cm^3 of gaseous Y is combusted in excess oxygen, 150 cm^3 of carbon dioxide and 200 cm^3 of water vapour are the only products formed. All volumes are measured at the same temperature and pressure.

When heated in the presence of concentrated sulfuric acid, 1 mol of X reacts completely with 2 mol of Y to give 1 mol of organic product Z. Water is also produced in the reaction.

What is the relative molar mass of Z?

(A_r values: H = 1; C = 12; O = 16. Assume that one mole of gas occupies 24 dm^3 at room temperature and pressure.)

A 101

B 160

C 166

D 170

E 202

F 220

38 Analysis of hydrocarbon P showed it to contain 0.60 g of carbon and 0.10 g of hydrogen, and to have a relative molecular mass of 70.

P reacts with hydrogen bromide to form a mixture of Q and R. However, the main product was Q.

Q reacts with warm, aqueous sodium hydroxide to form S.

S reacts with warm, acidified potassium dichromate(VI) to form T. T does not produce a silver mirror with Tollens' reagent and does not produce bubbles when sodium carbonate is added.

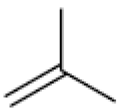
S undergoes dehydration on reaction with hot, concentrated sulfuric acid to form the original hydrocarbon P and a new compound U. Both P and U do not have stereoisomers.

What is the structure of compound U?

(A_r values: H = 1; C = 12)

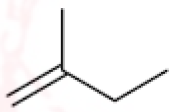
A 

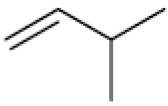
B 

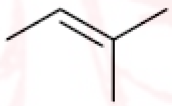
C 

D 

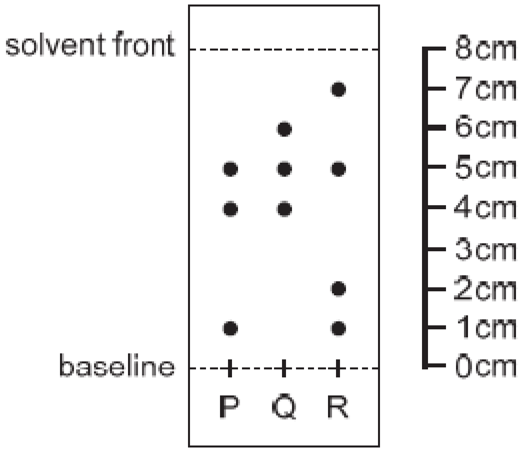
E 

F 

G 

H 

51 Three mixtures (P, Q and R) of amino acids were separated using paper chromatography.



The test was repeated with the same mixtures, paper and solvent but this time the distance travelled by the common component of the mixtures was 7.5 cm.

How far did the most mobile component of mixture Q travel in the second test?

A 6.0 cm

B 8.5 cm

C 9.0 cm

D 9.6 cm

E 10.5 cm

F 12.0 cm

Section 2 Question Topic **ALvl Chem 37 Q# 325/** Cambridge/2020/Section 2/ www.SmashingScience.org

49 A paper chromatogram is set up with an orange food colouring spotted on the baseline.

Ten minutes after the start, the solvent front has moved 15.0 cm up the paper from the baseline and a yellow spot is 12.0 cm above the baseline.

Five minutes later, the solvent front has moved up a further 10.0 cm.

How far from the baseline will the yellow spot be 15 minutes after the start?

A 8.0 cm

B 12.0 cm

C 15.0 cm

D 20.0 cm

E 22.0 cm

F 25.0 cm

G 31.3 cm

Section 1 Mark Scheme

Q# 1/ **Cambridge/2022/Section 1 www.SmashingScience.org**

Q41	E

Q# 2/ **Cambridge/2021/Section 1 www.SmashingScience.org**

Q47	F

Q# 3/ **Cambridge/2021/Section 1 www.SmashingScience.org**

Q59	E

Q# 4/ **Cambridge/2020/Section 1 www.SmashingScience.org**

Q43	F	CHEM

Q# 5/ **Cambridge/2020/Section 1 www.SmashingScience.org**

Q52	E	CHEM

Q# 6/ **Cambridge/2019/Section 1 www.SmashingScience.org**

45	H

Q# 7/ Cambridge/2024/Chemistry Section/Q#. 2/ www.SmashingScience.org/Practice Test May/

Solution

The lower number is the atomic number and gives the number of protons in the atom/ion. The upper number is the mass number and shows the number of neutrons added to the number of protons in the atom/ion. The difference between the mass number and atomic number gives the number of neutrons in the atom/ion.

In an atom the number of protons equals the number of electrons, as all atoms are neutral.
In an ion a negative charge shows that electron(s) equal to the size of the charge have been added to the atom, a positive charge shows that electron(s) equal to the size of the charge have been removed from the atom.

In $^{40}_{20}Ca^{2+}$ there are 20 neutrons and 18 (20–2) electrons.

Using the above information, only $^{37}_{17}Cl$, $^{39}_{19}K^+$ and $^{39}_{19}K$ have 20 neutrons but of these species only $^{39}_{19}K^+$ has 18 electrons (19–1), so the answer is $^{39}_{19}K^+$

Q# 8/ Cambridge/2023/Section 1/Q#. 48/ www.SmashingScience.org/

Q48	B	CHEM

Q50	G

Q# 9/

Q# 10/ Cambridge/2022/Section 1 www.SmashingScience.org

Q53	D

Q# 11/ Cambridge/2021/Section 1 www.SmashingScience.org

Q42	C

Q# 12/ Cambridge/2021/Section 1 www.SmashingScience.org

Q43	B

Q# 13/ Cambridge/2020/Section 1 www.SmashingScience.org

Q56	E	CHEM

Q# 14/ Cambridge/2019/Section 1 www.SmashingScience.org

42	F

Q# 15/ Cambridge/2018/Section 1 www.SmashingScience.org

37	C

Q# 16/ Cambridge/2017/Section 1 www.SmashingScience.org

37	F

Q# 17/ Cambridge/2017/Section 1 www.SmashingScience.org

54	D

Q# 18/ Cambridge/2016/Section 1 www.SmashingScience.org

37	D

Q# 19/ Cambridge/2024/Chemistry Section/Q#. 26/ www.SmashingScience.org/Practice Test May/

Solution

The answer is C_3H_8.

The volume of CO_2 gas produced (105 cm^3) is three times that of the alkane vapour (35 cm^3) at the same temperature and pressure.

Using the reacting volumes of gases ratio, the mole ratio of alkane : CO_2 is 1 : 3

As this is complete combustion, all of the carbon atoms in the alkane will form CO_2, so it can be deduced that there are 3 carbon atoms in the alkane molecule.

The general formula of alkanes is C_nH_{2n+2}, so the alkane formula is C_3H_8.

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$$

The answer is option D.

The number of moles of each element on each side of the equation is:

	H	N	O
left-hand side	r	r	$3r$
right-hand side	$2s$	$2 + t$	$6 + s + 2t$

These numbers must balance for each element:

For H, $r = 2s$
For N, $r = 2 + t$
For O, $3r = 6 + s + 2t$

Substituting $r = 2s$ into $3r = 6 + s + 2t$, we get $3 \times (2 + t) = 6 + s + 2t$

Rearranging: $6 + 3t = 6 + s + 2t$, therefore $t = s$

Moles of H and N are equal (r), so $2s = 2 + t$

Substituting $t = s$ into this, we get $2s = 2 + s$ and therefore $s = 2$

It follows that $t = 2$ and $r = 4$

Solution

The answer is 39.

Various approaches can be used to calculate the correct answer, of which one is shown below.

Number of moles H_2SO_4 used $= \frac{12.5}{1000} \times 2.0 = 0.025$

Molar ratio in the reaction is 2 XOH : 1 H_2SO_4

So, the number of moles of XOH present $= 0.025 \times 2 = 0.05$

Number of moles $= \frac{\text{mass in g}}{M_r}$, so $0.05 = \frac{2.8}{M_r}$

Rearranging, $M_r = \frac{2.8}{0.05} = \frac{28}{0.5} = 56$

M_r of XOH $= A_r(\text{X}) + 16 + 1 = 56$

$A_r(\text{X}) = 39$

Q# 22/ Cambridge/2024/Chemistry Section/Q#. 20/ www.SmashingScience.org/Practice Test May/

Solution

The answer is 88 g.

In this question, stage 1 can be ignored.

In stage 2, the stoichiometry of the equation shows that 1 mole of C will produce 2 moles of CO.

12 g of C (A_r 12) is 1 mole.

M_r of CO is 12+16 = 28, so 2 moles of CO is 28×2 = 56 g.

In stage 3, the stoichiometry of the equation shows that 3 moles of CO will produce 3 moles of CO_2, i.e. a 1 : 1 molar ratio.

56 g (2 moles) of CO will make 2 moles of CO_2.

M_r of CO_2 is 12+(16×2) = 44, so 2 moles of CO_2 is 44×2 = 88 g.

Q# 23/ Cambridge/2024/Chemistry Section/Q#. 16/ www.SmashingScience.org/Practice Test May/

Solution

The answer is $\frac{3}{8}$.

This question is about identifying which possible isotopes can give rise to CH_2BrCl with M_r = 128, and the proportion of these isotopes that exist, to identify which isotope combinations give M_r = 128 and those that do not.

The combined total mass of bromine and chlorine (removing CH_2) must total 128 – 14 = 114

The only combination of isotopes with this total mass is ^{79}Br combined with ^{35}Cl. As these are the isotopes with the lowest mass for each element, any other possibilities would result in a higher M_r for the compound.

The fraction occurring is directly related to probability. We want the probability that Br = ^{79}Br AND Cl = ^{35}Cl, in CH_2BrCl, and these events are independent of each other.

^{35}Cl is three times as common as ^{37}Cl, and the question states that there are only two isotopes to be considered (3 : 1), so the relative frequency of ^{35}Cl is $\frac{3}{4}$, and for ^{37}Cl it is $\frac{1}{4}$. We can treat these as probabilities.

For bromine, the relative frequency of ^{79}Br is $\frac{1}{2}$, and it is the same for ^{81}Br.

Hence $P(^{79}Br \text{ AND } ^{35}Cl) = P(Br={}^{79}Br) \times P(Cl={}^{35}Cl) = \frac{1}{2} \times \frac{3}{4} = \frac{3}{8}$

Q# 24/ Cambridge/2024/Chemistry Section/Q#. 13/ www.SmashingScience.org/Practice Test May/

Solution

The answer is I_2O_5.

There are several methods that will give the correct answer, of which one is shown below:

	I	O
number of moles:	$\frac{63.5}{127} = 0.5$	$\frac{20.0}{16} = 1.25$
ratio (÷0.5)	1	2.5
smallest whole number ratio (×2)	2	5

Therefore the empirical formula is I_2O_5.

Q# 25/ Cambridge/2023/Section 1/Q#. 60/ www.SmashingScience.org/

Q60	C	CHEM

Q# 26/ Cambridge/2023/Section 1/Q#. 59/ www.SmashingScience.org/

Q59	E	CHEM

Q# 27/ Cambridge/2023/Section 1/Q#. 51/ www.SmashingScience.org/

Q51	C	CHEM

Q# 28/ Cambridge/2023/Section 1/Q#. 45/ www.SmashingScience.org/

Q45	C	CHEM

Q# 29/ Cambridge/2022/Section 1 www.SmashingScience.org

Q55	D

Q# 30/ Cambridge/2022/Section 1 www.SmashingScience.org

Q58	A

Q# 31/ Cambridge/2021/Section 1 www.SmashingScience.org

Q50	E

Q# 32/ Cambridge/2021/Section 1 www.SmashingScience.org

Q52	C

Q# 33/ Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org

44 A

44

The answer is option **A**.

The reaction is stated to go to completion.

At the start of the reaction there is a concentration of A of 1.2 mol dm^{-3}. The equation gives the ratio of A **:** Z as 2 **:** 1. This means that for every unit of A that is reacted, only 0.5 as much Z is produced.

In a complete reaction, all of A will be used up and the final concentration of Z will be 0.6 mol dm^{-3}, so graph 1 must be correct.

As the chemical A is reacted, Z is produced. Graph 2 shows that an equilibrium state has been reached with the concentration of A being twice that of Z; this is incorrect.

Graph 3 shows that an equilibrium state has been reached with equal concentrations of A and Z; this is incorrect.

Q# 34/ Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org

45 B

45

The answer is option **B**.

One method for solving the problem would be as follows:

The oxide ion has a charge of -2, O^{2-}.

A compound formed from Fe^{3+} and O^{2-} ions must have the formula Fe_2O_3.

A compound formed from Fe^{2+} and O^{2-} ions must have the formula FeO.

A 1 **:** 1 mixture of these compounds would give a compound of formula Fe_3O_4 (Fe_2O_3 + FeO).

So the molar ratio Fe^{3+} **:** Fe^{2+} must be 2 **:** 1, making Fe^{2+} $\frac{1}{3}$ of the iron ion total.

Q# 35/ Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org

49 D

49

The answer is option **D**.

1 mole of H_2O has a mass of $(2\times 1)+16 = 18\,g$

The volume of 1 mole of a gas at room temperature and pressure is $24\,dm^3$

6.00 g of H_2O is $\frac{6}{18} = \frac{1}{3}$ mol, and therefore occupies a volume of $\frac{24}{3} = 8\,dm^3$

$8\,dm^3 = 8000\,cm^3$

Q# 36/ Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org

50 E

50

The answer is option **E**.

There are several methods that will give the correct answer, of which one is shown below:

	I	O
number of moles:	$\frac{63.5}{127} = 0.5$	$\frac{20.0}{16} = 1.25$
ratio ($\div 0.5$)	1	2.5
smallest whole number ratio ($\times 2$)	2	5

Therefore the empirical formula is I_2O_5.

Q# 37/ Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org

52 C

52

The answer is option **C**.

This question is about identifying which possible isotopes can give rise to CH_2BrCl with $M_r = 128$, and the proportion of these isotopes that exist, to identify which isotope combinations give $M_r = 128$ and those that do not.

The combined total mass of bromine and chlorine (removing CH_2) must total $128 - 14 = 114$

The only combination of isotopes with this total mass is ^{79}Br combined with ^{35}Cl. As these are the isotopes with lowest mass for each element, any other possibilities would result in a higher M_r for the compound.

The fraction occurring is directly related to probability. We want the probability that $Br = {}^{79}Br$ AND $Cl = {}^{35}Cl$, in CH_2BrCl and these events are independent of each other.

^{35}Cl is three times as common as ^{37}Cl, and the question states that there are only two isotopes to be considered (3 : 1), so the relative frequency of ^{35}Cl is $\frac{3}{4}$, and for ^{37}Cl it is $\frac{1}{4}$. We can treat these as probabilities.

For bromine, the relative frequency of ^{79}Br is $\frac{1}{2}$, and it is the same for ^{81}Br.

Hence $P(^{79}Br \text{ AND } ^{35}Cl) = P(Br = {}^{79}Br) \times P(Cl = {}^{35}Cl) = \frac{1}{2} \times \frac{3}{4} = \frac{3}{8}$

Q# 38/ Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org

54 D

54

The answer is option **D**.

In this question, stage 1 can be ignored.

In stage 2, the stoichiometry of the equation shows that 1 mole of C will produce 2 moles of CO.

12 g of C (A_r 12) is 1 mole

M_r of CO is $12 + 16 = 28$, so 2 moles of CO is $28 \times 2 = 56$ g

In stage 3, the stoichiometry of the equation shows that 3 moles of CO will produce 3 moles of CO_2, i.e. a 1 : 1 molar ratio.

56 g (2 moles) of CO will make 2 moles CO_2

M_r of CO_2 is $12 + (16 \times 2) = 44$, so 2 moles of CO_2 is $44 \times 2 = 88$ g

Q# 39/ Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org

56 E

56

The answer is option **E**.

The chemical equation for the reaction is: $NaOH + HCl \rightarrow NaCl + H_2O$

Molar ratio is 1 NaOH **:** 1 HCl

Number of moles of HCl $= \dfrac{\text{vol. in cm}^3}{1000} \times \text{conc.} = \dfrac{50.0}{1000} \times 0.5 = 0.025$

Therefore, the number of moles of NaOH is also 0.025

A_r of NaOH is $23 + 1 + 16 = 40$, so 1 mole of NaOH has a mass of 40 g

In the question, the number of moles of NaOH present $= 0.025 \times 40 = 1.0\,\text{g}$

Percentage purity $= \dfrac{1.0}{1.20} \times 100 = 83.3\%$

Q# 40/ **Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org**

57 C

57

The answer is option **C**.

Various approaches can be used to calculate the correct answer, of which one is shown below.

Number of moles H_2SO_4 used $= \dfrac{12.5}{1000} \times 2.0 = 0.025$

Molar ratio in the reaction is 2 XOH **:** 1 H_2SO_4

So, the number of moles of XOH present $= 0.025 \times 2 = 0.05$

Number of moles $= \dfrac{\text{mass in g}}{M_r}$, so $0.05 = \dfrac{2.8}{M_r}$

Rearranging, $M_r = \dfrac{2.8}{0.05} = \dfrac{28}{0.05} = 56$

M_r of XOH $= A_r(\text{X}) + 16 + 1 = 56$

$A_r(\text{X}) = 39$

Q# 41/ **Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org**

58 D

58

The answer is option **D**.

The number of moles of each element on each side of the equation is:

	H	N	O
left-hand side	r	r	$3r$
right-hand side	$2s$	$2 + t$	$6 + s + 2t$

These numbers must balance for each element:

For H, $r = 2s$

For N, $r = 2 + t$

For O, $3r = 6 + s + 2t$

Substituting $r = 2s$ into $3r = 6 + s + 2t$, we get $3 \times (2 + t) = 6 + s + 2t$

Rearranging: $6 + 3t = 6 + s + 2t$, therefore $t = s$

Moles of H and N are equal (r), so $2s = 2 + t$

Substituting $t = s$ into this, we get $2s = 2 + s$ and therefore $s = 2$

It follows that $t = 2$ and $r = 4$

Q# 42/ Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org

59 D

59

The answer is option **D**.

The volume of CO_2 gas produced (105 cm^3) is three times that of the alkane vapour (35 cm^3) at the same temperature and pressure.

Using the reacting volumes of gases ratio, the mole ratio of alkane **:** CO_2 is 1 **:** 3

As this is complete combustion, all of the carbon atoms in the alkane will form CO_2, so it can be deduced that there are 3 carbon atoms in the alkane molecule.

The general formula of alkanes is C_nH_{2n+2}, so the alkane formula is C_3H_8.

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$$

Q# 43/ Cambridge/2020/Section 1 www.SmashingScience.org

Q44	B	CHEM

Q# 44/ Cambridge/2020/Section 1 www.SmashingScience.org

Q45	E	CHEM

Q# 45/ Cambridge/2020/Section 1 www.SmashingScience.org

Q46	B	CHEM

Q# 46/ Cambridge/2020/Section 1 www.SmashingScience.org

Q55	C	CHEM

Q# 47/ Cambridge/2020/Section 1 www.SmashingScience.org

Q57	G	CHEM

Q# 48/ Cambridge/2019/Section 1 www.SmashingScience.org

43	E

Q# 49/ Cambridge/2019/Section 1 www.SmashingScience.org

47	D

Q# 50/ Cambridge/2019/Section 1 www.SmashingScience.org

48	A

Q# 51/ Cambridge/2019/Section 1 www.SmashingScience.org

52	E

Q# 52/ Cambridge/2018/Section 1 www.SmashingScience.org

47	A

Q# 53/ Cambridge/2018/Section 1 www.SmashingScience.org

51	C

Q# 54/ Cambridge/2018/Section 1 www.SmashingScience.org

52	C

Q# 55/ Cambridge/2018/Section 1 www.SmashingScience.org

53	B

Q# 56/ Cambridge/2017/Section 1 www.SmashingScience.org

46	E

Q# 57/ Cambridge/2017/Section 1 www.SmashingScience.org

47	E

Q# 58/ Cambridge/2017/Section 1 www.SmashingScience.org

52	D

Q# 59/ Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

40 A

Q# 60/ Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

41 B

Q# 61/ Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

45 D

Q# 62/ Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

46 E

Q# 63/ Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

50 D

Q# 64/ Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

52 E

Q# 65/ Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

53 C

Q# 66/ Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

54 D

Q# 67/ Cambridge/2016/Section 1 www.SmashingScience.org

41	C

Q# 68/ Cambridge/2016/Section 1 www.SmashingScience.org

42	D

Q# 69/ Cambridge/2016/Section 1 www.SmashingScience.org

46	A

Q# 70/ Cambridge/2016/Section 1 www.SmashingScience.org

50	A

Q# 71/ Cambridge/2016/Section 1 www.SmashingScience.org

51	F

Q# 72/ Cambridge/2016/Section 1 www.SmashingScience.org

52	D

Q43	C

Q# 73/

Q# 74/ Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org

43 A

43

The answer is option **A**.

Assessment of each option:

A: The high melting and boiling points, together with non-conductivity in the solid and molten states, indicates a giant covalent structure.

B: The high melting and boiling points indicate a giant structure. No conductivity when solid but having conductivity when molten is typical of a giant ionic structure.

C: Despite the relatively low melting and boiling points, the fact that it conducts electricity when solid and molten means that it is a giant metallic structure.

D: With low melting and boiling points, no electrical conductivity and being a liquid at room temperature and pressure, the substance is typical of a simple molecular structure.

E: Despite the very low melting point, the good conductivity when solid and molten indicates a metallic structure. In fact, **E** is mercury.

Q# 75/ Cambridge/2019/Section 1 www.SmashingScience.org

38	C

Q# 76/ Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

39 A

Q# 77/ Cambridge/2024/Chemistry Section/Q#. 4/ www.SmashingScience.org/Practice Test May/

Solution

The answer is option A.

Assessment of each option:

A. The high melting and boiling points, together with non-conductivity in the solid and molten states, indicates a giant covalent structure.

B. The high melting and boiling points indicate a giant structure. No conductivity when solid but having conductivity when molten is typical of a giant ionic structure.

C. Despite the relatively low melting and boiling points, the fact that it conducts electricity when solid and molten means that it is a giant metallic structure.

D. With low melting and boiling points, no electrical conductivity and being a liquid at room temperature and pressure, the substance is typical of a simple molecular structure.

E. Despite the very low melting point, the good conductivity when solid and molten indicates a metallic structure. In fact, E is mercury.

Q# 78/ Cambridge/2024/Chemistry Section/Q#. 18/ www.SmashingScience.org/Practice Test May/

Solution

The answer is option A.

When using a fractionating column, the flask is at the bottom and is heated. The temperature is highest at the bottom of the column and lowest at the top.

The hexane has the lowest boiling point and so will evaporate first in the flask and will rise to the top of the column first (68 °C). The liquid mixture in the flask must be boiling so the temperature must be at least 68 °C, but less than 98 °C, so that only the hexane is vapourised.

Q# 79/ Cambridge/2024/Chemistry Section/Q#. 12/ www.SmashingScience.org/Practice Test May/

The answer is 8000 cm^3.

1 mole of H_2O has a mass of $(2 \times 1) + 16 = 18$ g

The volume of 1 mole of a gas at room temperature and pressure is 24 dm^3

6.00 g of H_2O is $\frac{6}{18} = \frac{1}{3}$ mol, and therefore occupies a volume of $\frac{24}{3} = 8$ dm^3

8 dm^3 = 8000 cm^3

Q# 80/ Cambridge/2023/Section 1/Q#. 46/ www.SmashingScience.org/

Q46	E	CHEM

Q# 81/ **Cambridge/2022/Section 1 www.SmashingScience.org**

Q52	A

Q# 82/ **Cambridge/2022/Section 1 www.SmashingScience.org**

Q60	B

Q# 83/ **Cambridge/2021/Section 1 www.SmashingScience.org**

Q56	B

Q# 84/ **Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org**

53 A

53

The answer is option **A**.

When using a fractionating column, the flask is at the bottom and is heated. The temperature is highest at the bottom of the column and lowest at the top.

The hexane has the lowest boiling point and so will evaporate first in the flask and will rise to the top of the column first (68 °C). The liquid mixture in the flask must be boiling so the temperature must be at least 68 °C, but less than 98 °C, so that only the hexane is vapourised.

Q# 85/ **Cambridge/2020/Section 1 www.SmashingScience.org**

Q51	D	CHEM

Q# 86/ Cambridge/2020/Section 1 www.SmashingScience.org

Q41	E	CHEM

Q# 87/ Cambridge/2019/Section 1 www.SmashingScience.org

50	B

Q# 88/ Cambridge/2018/Section 1 www.SmashingScience.org

41	B

Q# 89/ Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

49 A

Q# 90/ Cambridge/2024/Chemistry Section/Q#. 9/ www.SmashingScience.org/Practice Test May/

Solution

The answer is $6z > x + 3y$

Bond breaking is an endothermic process, whilst bond making is an exothermic process.

The reaction is exothermic overall, which means that more energy is released when bonds are made than is needed for bonds to be broken.

The bonds to be broken are on the left of the equation (1 × N ≡ N and 3 × N — H) and those made are on the right of the equation (2 × 3 × N — H). This means that the 6 N — H bond energies must be greater than the N_2 and 3 × H_2 bond energies in total.

Looking at the number of bonds from the mole ratios in the equation (1 : 3 : 2), the inequality $6z > x + 3y$ is satisfied.

Q# 91/ Cambridge/2024/Chemistry Section/Q#. 25/ www.SmashingScience.org/Practice Test May/

Solution

We can calculate the energy change for a reaction using the equation:

enthalpy change = sum of bonds broken in reactants (energy absorbed) – sum of bonds formed in products (energy released)

The value for the C–O bond in ethanol is then as follows:

$H_2C{=}CH_2(g) + H_2O(g) \rightarrow C_2H_5OH(g)$ $\Delta H = -45$ kJ mol^{-1}

Sum of energy absorbed / bonds broken in reactants:
1 x C=C = 611
4 x C–H = 4 x 413 = 1652
2 x O–H = 2 x 464 = 928
Total = 3191

Sum of energy released / bonds formed in ethanol (excluding unknown C–O bond):
1 x C–C = 346
5 x C–H = 5 x 413 = 2065
1 x O–H = 464
Total = 2875

3191 − (2875 + x) = −45

Therefore, to find the unknown C–O bond value (x) we must re-arrange the equation so that:

(2875 + x) = 3191 − (−45)

x = 3191 − (−45) − 2875

x = 361

Hence, the correct answer is: 361 kJ mol^{-1}

Q# 92/ Cambridge/2023/Section 1/Q#. 55/ www.SmashingScience.org/

Q55	D	CHEM

Q# 93/ Cambridge/2023/Section 1/Q#. 50/ www.SmashingScience.org/

Q50	F	CHEM

Q# 94/ Cambridge/2022/Section 1 www.SmashingScience.org

Q57	F

Q# 95/ Cambridge/2021/Section 1 www.SmashingScience.org

Q54	E

Q# 96/ Cambridge/2021/Section 1 www.SmashingScience.org

Q55	A

Q# 97/ Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org

47 D

47

The answer is option **D**.

Bond breaking is an endothermic process, whilst bond making is an exothermic process.

The reaction is exothermic overall, which means that more energy is released when bonds are made than is needed for bonds to be broken.

The bonds to be broken are on the left of the equation $(1 \times N \equiv N \text{ and } 3 \times H{-}H)$ and those made are on the right of the equation $(2 \times 3 \times N{-}H)$. This means that the 6 N—H bond energies must be greater than the N_2 and 3 × H_2 bond energies in total.

Looking at the number of bonds from the mole ratios in the equation (1 **:** 3 **:** 2), the inequality $6z > x + 3y$ is satisfied.

Q# 98/ Cambridge/2020/Section 1 www.SmashingScience.org

Q58	D	CHEM

Q# 99/ Cambridge/2019/Section 1 www.SmashingScience.org

53	B

Q# 100/ Cambridge/2017/Section 1 www.SmashingScience.org

49	E

Q# 101/ Cambridge/2017/Section 1 www.SmashingScience.org

51	A

Q# 102/ Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

43 E

Q# 103/ Cambridge/2016/Section 1 www.SmashingScience.org

48	F

Q# 104/ Cambridge/2016/Section 1 www.SmashingScience.org

54	C

Q# 105/ Cambridge/2024/Chemistry Section/Q#. 7/ www.SmashingScience.org/Practice Test May/

Solution

The answer is $\frac{1}{3}$.

One method for solving the problem would be as follows:

The oxide ion has a charge of −2, O^{2-}.

A compound formed from Fe^{3+} and O^{2-} ions must have the formula Fe_2O_3.

A compound formed from Fe^{2+} and O^{2-} ions must have the formula FeO.

A 1 : 1 mixture of these compounds would give a compound of formula Fe_3O_4 (Fe_2O_3 + FeO).

So the molar ratio Fe^{3+} : Fe^{2+} must be 2 : 1, making Fe^{2+} $\frac{1}{3}$ of the iron ion total.

Q# 106/ Cambridge/2024/Chemistry Section/Q#. 19/ www.SmashingScience.org/Practice Test May/

Solution

An acid is a substance that dissolves in water to release hydrogen ions.
$HX + aq \rightleftharpoons H+(aq) + X^-(aq)$

The strength of an acid depends on the extent of the ionisation of the acid molecules in water. A strong acid will ionise completely. In a weak acid only a small fraction of the molecules will ionise.

Test 1 will work because the rate of reaction between the acid and the magnesium depends on the concentration of hydrogen ions.
$2H^+(aq) + Mg(s) \rightarrow H_2(g) + Mg^{2+}(aq)$

Test 2 will not work as two acids with the same concentration and volume will react to produce the same moles of hydrogen ions, therefore they will need the same volume of 1 mol dm^{-3} sodium hydroxide solution for complete neutralisation.
$NaOH + HX \rightarrow NaX + H_2O$

Test 3 will work because the electrical conductivity of a solution depends on the concentration of ions. A weak acid will have a lower number of ions per mole of acid than a strong acid.

The correct answer is: 1 and 3 only.

Q# 107/ Cambridge/2024/Chemistry Section/Q#. 14/ www.SmashingScience.org/Practice Test May/

Solution

The formula of copper(II) nitrate is $Cu(NO_3)_2$

Hence the equation as we have it at the moment is: $3Cu + ?HNO_3 \rightarrow ?Cu(NO_3)_2 + X + 4H_2O$

To balance the H's we need $8HNO_3$

To balance the Cu's we need $3Cu(NO_3)_2$

So the equation now looks like: $3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + X + 4H_2O$

To balance the equation X must contain 2N's and 2O's

X must be N_2O_2 or NO (i.e. 2NO in the equation). Hence the only correct answer is NO

Q# 108/ Cambridge/2024/Chemistry Section/Q#. 11/ www.SmashingScience.org/Practice Test May/

Solution

The answer is 2 and 3.

Oxidising agents accept electrons. Reducing agents lose (or donate) electrons.

Looking at each equation for the first reactant in the equation in turn:

1: Mg is transformed into Mg^{2+}. Electrons are being lost and so Mg is a reducing agent.

2: The oxidation state of chromium in the first compound is +6 and it is transformed into Cr^{3+}. Electrons are being accepted and so $Cr_2O_7^{2-}$ is an oxidising agent.

3: Cu^{2+} is transformed into Cu^{+}. Electrons are being accepted and so Cu^{2+} is a oxidising agent.

4: The oxidation state of sulfur in the first compound is +4 and it is transformed into a compound where it is +6. Electrons are being lost and so the first compound is a reducing agent.

Equations 2 and 3 are correct.

(Construction of half-equations is another valid solution method with the same conclusion.)

Q# 109/ Cambridge/2023/Section 1/Q#. 53/ www.SmashingScience.org/

Q53	E	CHEM

Q# 110/ Cambridge/2023/Section 1/Q#. 49/ www.SmashingScience.org/

Q49	E	CHEM

Q45	D

Q# 111/

Q# 112/ **Cambridge/2021/Section 1 www.SmashingScience.org**

Q48	D

Q# 113/ **Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org**

48 C

48

The answer is option **C**.

Equations 2 and 3 are correct.

(Construction of half-equations is another valid solution method with the same conclusion.)

Oxidising agents accept electrons. Reducing agents lose (or donate) electrons.

Looking at each equation for the first reactant in the equation in turn:

1: Mg is transformed into Mg^{2+}. Electrons are being lost and so Mg is a reducing agent.

2: The oxidation state of chromium in the first compound is +6 and it is transformed into Cr^{3+}. Electrons are being accepted and so $Cr_2O_7^{2-}$ is an oxidising agent.

3: Cu^{2+} is transformed into Cu^{+}. Electrons are being accepted and so Cu^{2+} is a oxidising agent.

4: The oxidation state of sulfur in the first compound is +4 and it is transformed into a compound where it is +6. Electrons are being lost and so the first compound is a reducing agent.

Q# 114/ **Cambridge/2020/Section 1 www.SmashingScience.org**

Q50	C	CHEM

Q# 115/ **Cambridge/2019/Section 1 www.SmashingScience.org**

44	B

Q# 116/ **Cambridge/2018/Section 1 www.SmashingScience.org**

43	F

Q# 117/ **Cambridge/2017/Section 1 www.SmashingScience.org**

43	D

Q# 118/ **Cambridge/2017/Section 1 www.SmashingScience.org**

44	D

Q# 119/ **Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)**

44 C

Q# 120/ **Cambridge/2016/Section 1 www.SmashingScience.org**

45	C

Q# 121/ Cambridge/2024/Chemistry Section/Q#. 6/ www.SmashingScience.org/Practice Test May/

Solution

For an increase in temperature to increase the yield, according to Le Chatelier's principle, the reaction must be endothermic in order to shift the equilibrium to the right and so increase the yield.

For there to be no increase in yield when the pressure is increased, the reaction must be have the same number of gaseous reactant moles and gaseous product moles.

Both increasing temperature and pressure will increase the rate for any gaseous reaction.

The answer is:

$P + 2Q \rightleftharpoons 2R + S \quad \Delta H$ is +ve

This is the only reaction which is endothermic and equimolar in terms of reactants and products.

Q# 122/ Cambridge/2024/Chemistry Section/Q#. 22/ www.SmashingScience.org/Practice Test May/

Solution

The answer is 83.3%.

The chemical equation for the reaction is: $NaOH + HCl \rightarrow NaCl + H_2O$

Molar ratio is 1 NaOH : 1 HCl

Number of moles of HCl = $\frac{\text{vol. in cm}^3}{1000} \times \text{conc.} = \frac{50.0}{1000} \times 0.5 = 0.025$

Therefore, the number of moles of NaOH is also 0.025

A_r of NaOH is 23 + 1 + 16 = 40, so 1 mole of NaOH has a mass of 40 g

In the question, the number of moles of NaOH present = 0.025 × 40 = 1.0 g

Percentage purity = $\frac{1.0}{1.20} \times 100 = 83.3\%$

Q# 123/ Cambridge/2024/Chemistry Section/Q#. 1/ www.SmashingScience.org/Practice Test May/

Solution

The answer is yellow.

The pH scale is a measure of the acidity or alkalinity of an aqueous solution.

All indicators in the mixture experience a pH of 5.0.

Methyl orange (colour changes at 4.0) will be yellow at pH 5.0.

Bromothymol blue (colour changes at 6.5) will be yellow at pH 5.0.

Phenolphthalein (colour changes at 9.0) will be colourless at pH 5.0.

In order: yellow + yellow + colourless = yellow.

Q# 124/ Cambridge/2023/Section 1/Q#. 54/ www.SmashingScience.org/

Q54	D	CHEM

Q# 125/

Q48	F

Q# 126/ **Cambridge/2022/Section 1 www.SmashingScience.org**

Q56	C

Q# 127/ **Cambridge/2021/Section 1 www.SmashingScience.org**

Q45	D

Q# 128/ **Cambridge/2021/Section 1 www.SmashingScience.org**

Q53	A

Q# 129/ **Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org**

55 E

55

The answer is option **E**.

A: False. There is a different number of molecules on the two sides of the equation so altering the pressure will shift the equilibrium position.

B: False. The reaction is exothermic and so increasing the temperature will move the equilibrium position to the left.

C: False. Chemical equilibrium is dynamic so reactants are constantly changing to products and products are constantly changing back to reactants.

D: False. A catalyst increases the rate at which equilibrium is reached but does not shift the position of equilibrium.

E: Correct. Until equilibrium is reached, the forward reaction will be faster than the backward reaction.

Q# 130/ Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org

41 E

41

The answer is option **E**.

The pH scale is a measure of the acidity or alkalinity of an aqueous solution.

All indicators in the mixture experience a pH of 5.0.

Methyl orange (colour change at 4.0) will be yellow at pH 5.0.

Bromothymol blue (colour changes at 6.5) will be yellow at pH of 5.0.

Phenolphthalein (colour changes at 9.0) will be colourless at pH of 5.0.

In order: yellow + yellow + colourless = yellow.

Q# 131/ Cambridge/2020/Section 1 www.SmashingScience.org

Q54	G	CHEM

Q# 132/ Cambridge/2020/Section 1 www.SmashingScience.org

Q60	F	CHEM

Q# 133/ Cambridge/2018/Section 1 www.SmashingScience.org

38	C

Q# 134/ Cambridge/2018/Section 1 www.SmashingScience.org

45	E

Q# 135/ Cambridge/2018/Section 1 www.SmashingScience.org

54	E

Q# 136/ Cambridge/2017/Section 1 www.SmashingScience.org

40	A

Q# 137/ Cambridge/2017/Section 1 www.SmashingScience.org

39	H

Q# 138/ Cambridge/2017/Section 1 www.SmashingScience.org

38	B

Q# 139/ Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

51 E

Q# 140/ Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

37 E

Q# 141/ Cambridge/2016/Section 1 www.SmashingScience.org

40	C

Q# 142/ Cambridge/2016/Section 1 www.SmashingScience.org

49	F

Q# 143/ Cambridge/2024/Chemistry Section/Q#. 5/ www.SmashingScience.org/Practice Test May/

Solution

The answer is Graph 1 only.

The reaction is stated to go to completion.

At the start of the reaction there is a concentration of A of 1.2 mol dm^{-3}. The equation gives the ratio of A : Z as 2 : 1. This means that for every unit of A that is reacted, only 0.5 as much Z is produced.

In a complete reaction, all of A will be used up and the final concentration of Z will be 0.6 mol dm^{-3}, so graph 1 must be correct.

As the chemical A is reacted, Z is produced. Graph 2 shows that an equilibrium state has been reached with the concentration of A being twice that of Z; this is incorrect.

Graph 3 shows that an equilibrium state has been reached with equal concentrations of A and Z; this is incorrect.

Q# 144/ Cambridge/2024/Chemistry Section/Q#. 27/ www.SmashingScience.org/Practice Test May/

Solution

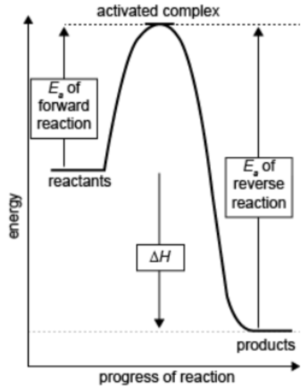
The answer is line B.

The reaction is faster than the original as it is hotter and the acid is more concentrated. The number of moles of acid reacting is the same, as the volume is half of the original but the concentration is double. Given that the acid is the limiting reagent with the calcium carbonate in excess, the volume of carbon dioxide formed will be the same as the original.

Q# 145/ Cambridge/2024/Chemistry Section/Q#. 17/ www.SmashingScience.org/Practice Test May/

Solution

As this reaction gives out heat it must be exothermic, as shown in the diagram and as indicated by the negative value of the heat energy change (ΔH). E_a denotes activation energy.



The reverse reaction will have the same profile but it will go in the opposite direction. This means that the activation energy will be the sum of the heat energy taken in the reverse reaction (+100 kJ mol^{-1}) and the activation energy for the forward reaction (+150 kJ mol^{-1}), which equals +250 kJ mol^{-1}.

Q# 146/ Cambridge/2023/Section 1/Q#. 41/ www.SmashingScience.org/

Q41	D	CHEM

Q# 147/

Q46	A

Q# 148/ Cambridge/2021/Section 1 www.SmashingScience.org

Q58	F

Q# 149/ Cambridge/2021/Section 1 www.SmashingScience.org

Q60	A

Q# 150/ Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org

60 B

60

The answer is option **B**.

The reaction is faster than the original as it is hotter and the acid is more concentrated. The number of moles of acid reacting is the same as the volume is half of the original but the concentration double. Given that the acid is the limiting reagent with the calcium carbonate in excess, the volume of carbon dioxide formed will be the same as the original.

Q# 151/ Cambridge/2020/Section 1 www.SmashingScience.org

Q53	D	CHEM

Q# 152/ Cambridge/2019/Section 1 www.SmashingScience.org

49	D

Q# 153/ Cambridge/2018/Section 1 www.SmashingScience.org

50	A

Q# 154/ Cambridge/2017/Section 1 www.SmashingScience.org

48	D

Q# 155/ Cambridge/2017/Section 1 www.SmashingScience.org

53	C

Q# 156/ Cambridge/2016/Section 1 www.SmashingScience.org

44	E

Q# 157/ Cambridge/2024/Chemistry Section/Q#. 8/ www.SmashingScience.org/Practice Test May/

Solution

The answer is 4 only

Mass number = number of protons + number of neutrons = 40

Atomic number = number of protons = 20

Number of protons = 20, so number of electrons = 20 to balance charge.

Number of neutrons = 40 − 20 = 20

Using the above information and applying it to each statement:

1. Incorrect. The relative mass of the nucleus is 40.

2. Incorrect. A total of 20 electrons would give an electronic configuration of 2,8,8,2. The incomplete outer shell containing two electrons indicates that is in Group 2. Group 2 elements are not noble gases, they are alkaline earth metals.

3. Incorrect. Group 2 elements form 2+ ions by loss of the outer two electrons.

4. Correct.

5. Incorrect. Group 2 elements are metals.

Q# 158/ Cambridge/2024/Chemistry Section/Q#. 15/ www.SmashingScience.org/Practice Test May/

Solution

The answer is: 2,7

Electron configurations of atoms can be used to identify the position of an element in the Periodic Table. The number of electrons in the outer shell determines the group. The number of shells determines in which period the element is.

If we label each option from A to F, and consider the position in the Periodic Table of each element:

A: 2,4 Group 14, where non-metals are at the top of the group and metals are at the bottom
B: 2,6 Group 16, a non-metal
C: 2,7 Group 17, a non-metal
D: 2,8,1 Group 1, a metal
E: 2,8,6 Group 16, a non-metal
F: 2,8,7 Group 17, a non-metal

Only option D can be eliminated.

Non-metals react to gain electrons and acquire the configurations of noble gases.

The fewer the electrons to gain, the more reactive the element. This narrows the choice down to option C and option F, as both atoms only need to gain one electron.

Option C is the smaller atom (two shells) so there is more attraction between the nucleus and the electron to be gained, compared with option F. Option C will therefore be more reactive. (The element is fluorine.)

Q# 159/ Cambridge/2023/Section 1/Q#. 52/ www.SmashingScience.org/

Q52	G	CHEM

Q# 160/ Cambridge/2023/Section 1/Q#. 47/ www.SmashingScience.org/

Q47	A	CHEM

Q# 161/ **Cambridge/2021/Section 1 www.SmashingScience.org**

Q44	E

Q# 162/ **Cambridge/2021/Section 1 www.SmashingScience.org**

Q41	F

Q# 163/ **Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org**

46 E

46

The answer is option **E**.

Mass number = number of protons + number of neutrons = 40

Atomic number = number of protons = 20

Number of protons = 20, so number of electrons = 20 to balance charge.

Number of neutrons = 40 – 20 = 20

Using the above information and applying it to each statement:

1: Incorrect. The relative mass of the nucleus is 40.

2: Incorrect. A total of 20 electrons would give an electronic configuration of 2,8,8,2. The incomplete outer shell containing two electrons indicates that is in Group 2. Group 2 elements are not noble gases, they are alkaline earth metals.

3: Incorrect. Group 2 elements form 2+ ions by loss of the outer two electrons.

4: Correct.

5: Incorrect. Group 2 elements are metals.

Q# 164/ Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org

51 C

51

The answer is option **C**.

Electron configurations of atoms can be used to identify the position of an element in the Periodic Table. The number of electrons in the outer shell determines the group. The number of shells determines in which period the element is.

A: 2,4 Group 14, where non-metals are at the top of the group and metals are at the bottom

B: 2,6 Group 16, a non-metal

C: 2,7 Group 17, a non-metal

D: 2,8,1 Group 1, a metal

E: 2,8,6 Group 16, a non-metal

F: 2,8,7 Group 17, a non-metal

Only **D** can be eliminated. Non-metals react to gain electrons and acquire the configurations of noble gases.

The fewer the electrons to gain, the more reactive the element. This narrows the choice down to **C** and **F**, as both atoms only need to gain one electron.

C is the smaller atom (two shells) so there is more attraction between the nucleus and the electron to be gained, compared with **F**. **C** will therefore be more reactive. The element is fluorine.

Q# 165/ Cambridge/2020/Section 1 www.SmashingScience.org

Q42	F	CHEM

Q# 166/ Cambridge/2020/Section 1 www.SmashingScience.org

Q47	F	CHEM

Q# 167/ Cambridge/2019/Section 1 www.SmashingScience.org

41	H

Q# 168/ Cambridge/2019/Section 1 www.SmashingScience.org

51	D

Q# 169/ Cambridge/2018/Section 1 www.SmashingScience.org

42	E

Q# 170/ Cambridge/2018/Section 1 www.SmashingScience.org

44	A

Q# 171/ Cambridge/2018/Section 1 www.SmashingScience.org

46	C

Q# 172/ Cambridge/2017/Section 1 www.SmashingScience.org

42	C

Q# 173/ Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

42 E

Q# 174/ Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

47 C

Q# 175/ Cambridge/2023/Section 1/Q#. 44/ www.SmashingScience.org/

Q44	A	CHEM

Q# 176/ Cambridge/2024/Chemistry Section/Q#. 21/ www.SmashingScience.org/Practice Test May/

Solution

The answer is: Before equilibrium is reached, the rate of the forward reaction is greater than the rate of the backward reaction.

The first statement is false. There is a different number of molecules on the two sides of the equation so altering the pressure will shift the equilibrium position.

The second statement is false. The reaction is exothermic and so increasing the temperature will move the equilibrium position to the left.

The third statement is false. Chemical equilibrium is dynamic so reactants are constantly changing to products and products are constantly changing back to reactants.

The fourth statement is false. A catalyst increases the rate at which equilibrium is reached but does not shift the position of equilibrium.

The fifth statement is correct. Until equilibrium is reached, the forward reaction will be faster than the backward reaction.

Q# 177/ Cambridge/2022/Section 1 www.SmashingScience.org

Q54	E

Q# 178/ Cambridge/2022/Section 1 www.SmashingScience.org

Q59	E

Q# 179/ Cambridge/2019/Section 1 www.SmashingScience.org

37	F

Q# 180/ Cambridge/2018/Section 1 www.SmashingScience.org

48	D

Q# 181/

Q49	H

Q# 182/ **Cambridge/2021/Section 1 www.SmashingScience.org**

Q49	C

Q# 183/ Cambridge/2023/Section 1/Q#. 42/ www.SmashingScience.org/

Q42	E	CHEM

Q# 184/ **Cambridge/2021/Section 1 www.SmashingScience.org**

Q46	E

Q# 185/ Cambridge/2023/Section 1/Q#. 57/ www.SmashingScience.org/

Q57	H	CHEM

Q# 186/ Cambridge/2023/Section 1/Q#. 43/ www.SmashingScience.org/

Q43	B	CHEM

Q# 187/ **Cambridge/2022/Section 1 www.SmashingScience.org**

Q51	C

Q# 188/ **Cambridge/2021/Section 1 www.SmashingScience.org**

Q51	B

Q# 189/ **Cambridge/2019/Section 1 www.SmashingScience.org**

40	G

Q# 190/ **Cambridge/2018/Section 1 www.SmashingScience.org**

40	D

Q# 191/ **Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)**

48 C

Q# 192/ Cambridge/2024/Chemistry Section/Q#. 3/ www.SmashingScience.org/Practice Test May/

Solution

The answer is: positive electrode = chlorine; negative electrode = hydrogen.

Aqueous sodium chloride contains two cations (Na^+ and H^+) and two anions (Cl^- and OH^-).

The positive electrode (anode) attracts anions and the negative electrode (cathode) attracts cations.

When two ions are attracted to an electrode, only one can be discharged as atoms. This is called preferential discharge.

In this case:

- chlorine is discharged in preference to oxygen at the positive electrode (anode);
- hydrogen is discharged in preference to sodium at the negative electrode (cathode).

Q# 193/ Cambridge/2023/Section 1/Q#. 58/ www.SmashingScience.org/

Q58	C	CHEM

Q# 194/ Cambridge/2023/Section 1/Q#. 56/ www.SmashingScience.org/

Q56	E	CHEM

Q42	B

Q# 195/

Q44	G

Q# 196/

Q47	E

Q# 197/

Q# 198/ Cambridge/2021/Section 1 www.SmashingScience.org

Q57	C

Q# 199/ Cambridge/2020sp (2020sp (Specimen) Paper)/Section 1 www.SmashingScience.org

42 A

42

The answer is option **A**.

Aqueous sodium chloride contains two cations (Na^+ and H^+) and two anions (Cl^- and OH^-).

The positive electrode (anode) attracts anions and the negative electrode (cathode) attracts cations.

When two ions are attracted to an electrode, only one can be discharged as atoms. This is called preferential discharge.

In this case:

chlorine is discharged in preference to oxygen at the positive electrode (anode);

hydrogen is discharged in preference to sodium at the negative electrode (cathode).

Q# 200/ Cambridge/2020/Section 1 www.SmashingScience.org

Q48	A	CHEM

Q# 201/ Cambridge/2020/Section 1 www.SmashingScience.org

Q59	F	CHEM

Q# 202/ Cambridge/2019/Section 1 www.SmashingScience.org

46	D

Q# 203/ Cambridge/2019/Section 1 www.SmashingScience.org

54	E

Q# 204/ Cambridge/2018/Section 1 www.SmashingScience.org

39	A

Q# 205/ Cambridge/2017/Section 1 www.SmashingScience.org

45	D

Q# 206/ Cambridge/2017/Section 1 www.SmashingScience.org

50	B

Q# 207/ Cambridge/2016sp/Section 1 www.SmashingScience.org (Specimen Paper)

38 A

Q# 208/ Cambridge/2016/Section 1 www.SmashingScience.org

38	D

Q# 209/ **Cambridge/2016/Section 1 www.SmashingScience.org**

39	C

Q# 210/ **Cambridge/2016/Section 1 www.SmashingScience.org**

47	C

Q# 211/ **Cambridge/2016/Section 1 www.SmashingScience.org**

53	C

Q# 212/ **Cambridge/2020/Section 1 www.SmashingScience.org**

Q49	D	CHEM

Q# 213/ Cambridge/2024/Chemistry Section/Q#. 10/ www.SmashingScience.org/Practice Test May/

Solution

Considering the first chromatogram, the distance travelled by dye W is twice that travelled by Z. However, R_f value is not affected by concentration. Statement 1 is incorrect.

The filter paper is the stationary phase, the solvent (water) is the mobile phase. Statement 2 is incorrect.

The two chromatograms need to be compared. As the distance between baseline and solvent front is different in each case, R_f values must be considered.

From chromatogram 1:

W:R_f = 8.2 / 10 = 0.82
X:R_f = 3.2 / 10 = 0.32
Y:R_f = 6.4 / 10 = 0.64
Z:R_f = 4.1 / 10 = 0.41

On the second chromatogram two spots have developed at 3.2 cm and 4.1 cm

R_f values are 3.2 / 5 = 0.64 and 4.1 / 5 = 0.82 which correspond to dyes Y and W respectively.

Statement 3 is therefore correct.

The answer is: 3 only.

Q# 214/ **Cambridge/2019/Section 1 www.SmashingScience.org**

39	E

Q# 215/ **Cambridge/2018/Section 1 www.SmashingScience.org**

49	B

Q# 216/ **Cambridge/2017/Section 1 www.SmashingScience.org**

41	D

Q# 217/ **Cambridge/2016/Section 1 www.SmashingScience.org**

43	D

Section 2 Mark Scheme

Q# 218/ Cambridge/2022/Section 2/ www.SmashingScience.org

Q41	E

Q# 219/ Cambridge/2020/Section 2/ www.SmashingScience.org

Q43	F

Q# 220/ Cambridge/2021/Section 2/ www.SmashingScience.org

Q32	G

Q# 221/ Cambridge/2020/Section 2/ www.SmashingScience.org

Q56	E

Q# 222/ Cambridge/2022sp/Section 2/ www.SmashingScience.org

14 E

14 The answer is option **E**.

From the information provided in the question the formulae in the chemical equation can be deduced to be:

$$?SO_3 + ?Cl_2 + ?SCl_2 \rightarrow ?SOCl_2$$

Balancing: $$SO_3 + Cl_2 + 2SCl_2 \rightarrow 3SOCl_2$$

Number of moles Cl_2 gas $= \frac{2}{24} = \frac{1}{12}$

Mole ratio $Cl_2 : SOCl_2$ $= 1:3$

Number of moles of $SOCl_2$ $= \frac{1}{12} \times 3 = 0.25\,\text{mol}$

$SOCl_2$ is collected in water, where it reacts. It produces HCl, which will dissolve to form hydrochloric acid, and another gaseous product, which can be deduced to be sulfur dioxide:

$$SOCl_2 + H_2O \rightarrow 2HCl + SO_2$$

Mole ratio $SOCl_2$: HCl $= 1:2$

Number of moles of HCl $= 0.25 \times 2 = 0.50\,\text{mol}$

Concentration of HCl $= \frac{\text{number of moles}}{\text{volume}} = \frac{0.50}{\left(\frac{200}{1000}\right)} = 2.50\,\text{mol}\,\text{dm}^{-3}$

Q# 223/ Cambridge/2022sp/Section 2/ www.SmashingScience.org

17 E

17 The answer is option **E**.

Putting the known coefficients into the equation:

$$As_2O_3(s) + 6Zn(s) + H^+(aq) \rightarrow 6Zn^{2+}(aq) + 2X(g) + H_2O(l)$$

Six zinc atoms each increase their oxidation state by 2 in being oxidised to zinc ions. This gives a total increase in oxidation state of 12.

To balance this, the two arsenics in As_2O_3 must collectively reduce their oxidation states by 12 (i.e. each arsenic in As_2O_3 must reduce its oxidation state by 6).

The oxidation state of arsenic in As_2O_3 is +3 (because the oxidation state of the oxygen is –2). Hence each of the two arsenics in X must have an oxidation state of –3.

The only possible arsenic-containing product in this reaction that gives arsenic an oxidation state of –3 is AsH_3.

The balanced equation for the reaction is therefore:

$$As_2O_3(s) + 6Zn(s) + 12H^+(aq) \rightarrow 6Zn^{2+}(aq) + 2AsH_3(g) + 3H_2O(l)$$

The M_r of As_2O_3 is 198 and the M_r of AsH_3 is 78.

From the stoichiometry of the reaction, 198 g of As_2O_3 would produce 156 g of AsH_3.

Hence, 1.98 g of As_2O_3 would produce 1.56 g of AsH_3.

Q# 224/ Cambridge/2022/Section 2/ www.SmashingScience.org

Q58	A

Q# 225/ Cambridge/2022/Section 2/ www.SmashingScience.org

Q53	D

Q# 226/ Cambridge/2021/Section 2/ www.SmashingScience.org

Q21	C

Q# 227/ Cambridge/2021/Section 2/ www.SmashingScience.org

Q24	F

Q# 228/ Cambridge/2021/Section 2/ www.SmashingScience.org

Q30	E

Q# 229/ Cambridge/2021/Section 2/ www.SmashingScience.org

Q37	D

Q# 230/ Cambridge/2021/Section 2/ www.SmashingScience.org

Q40	C

Q# 231/ Cambridge/2020SP/Section 2/ www.SmashingScience.org

14 E

Q# 232/ Cambridge/2020SP/Section 2/ www.SmashingScience.org

15 A

Q# 233/ Cambridge/2020SP/Section 2/ www.SmashingScience.org

17 E

Q# 234/ Cambridge/2020/Section 2/ www.SmashingScience.org

Q45	E

Q# 235/ Cambridge/2020/Section 2/ www.SmashingScience.org

Q46	B

Q# 236/ Cambridge/2020/Section 2/ www.SmashingScience.org

Q52	E

Q# 237/ Cambridge/2020/Section 2/ www.SmashingScience.org

Q60	F

Q# 238/ Cambridge/2019/Section 2/ www.SmashingScience.org

d) Since only one Te atom present molecule, 3 moles of F2 form 1 mol of gas A. So 1 mol of A must containt 6 mols of F, i.e. A is TeF_6. **[2]**

e) Octahedral stucture, so F—Te—F must be 90°. **[1]**

f) Moles of A = 50/24000. Mass of Te = 127.6 x 50/24000 = 0.266 g **[2]**

g) Density = [127.6+(6x19)]/24000 = 0.01007 g cm^{-3}. **[2]**

h) Ratio of densities = ratio of molar masses = [(6x19)+127.6]/32 = 7.55 **[1]**

i) 2n – m **[1]**

j) 9.0 g of acid contains 5.0 g of Te. So one mole of Te (127.6 g) would be in 127.6 x 9.0 / 5.0 = 230 g. **[1]**

k) RMM of salt = 127.6 x 18 / 5.0 = 459.

459 – 230 = 39m – m
so m = 6.0
n = [230 -127.6 – 6]/16 = 6
Formulae are H_6TeO_6 and K_6TeO_6. **[2]**

l) moles of acid = 5 / 127.6
moles of KOH needed = 6 x 5 / 127.6
volume needed = 6 x 5 x 1000 / (127.6 x 2) = 117 cm^3. **[2]**

d) The reaction between dimethylglyoxime and Ni^{2+} ions can be used to determine the nickel content of alloys by weighing the amount of the red precipitate produced from a known mass of a sample of an alloy.

A sample of mass 1.50 g of an alloy was dissolved in dilute acid and an excess of dimethylglyoxime was then added to the resulting solution. The pH was then adjusted to make the solution mildly alkaline, and this resulted in the formation of a red precipitate. The precipitate was carefully filtered off, dried and then weighed. The mass of the dry precipitate was 0.368 g.

Determine the nickel content of the alloy, expressed as a percentage by mass.

[4 marks]

Answer: $\frac{0.368}{288.922} = 1.2737 \times 10^{-3}$ mol [1]

Amount of Ni = 1.2737×10^{-3} mol [1]

Mass of Ni = 0.07475 g [1]

% Mass of Ni = 4.98356 % [1]

e) Other metal ions, such as Pd^{2+} or Pt^{2+}, also react with dimethylglyoxime to give insoluble precipitates. What effect would the presence of palladium in the alloy have on the value of the nickel content determined using the method in part **d)**?

[2 marks]

Answer: Pd / Pt will precipitate → increase in mass. [1]

Make the Ni (%) look too high = wrong answer [1]

for Ni value.

Question C2

a) Write a balanced chemical equation for the reaction between $CO_2(g)$ and $OH^-(aq)$, giving $CO_3^{2-}(aq)$ as one of the products.

[1 mark]

Answer: $CO_2(g) + 2OH^-(aq) \rightarrow CO_3^{2-}(aq) + H_2O(l)$ [1]

Accept: no state symbols

$CO_2 + OH^- \rightarrow CO_3^{2-} + H^+$

but this is incorrect for (b)(ii) and (b)(iii)

b) An organic molecule is known to contain C, H and O only. A sample of mass 0.100 g is carefully burnt in the presence of excess oxygen. The resulting gases are passed over a desiccant (drying agent), and it is observed that the mass of the desiccant increases by 0.0931 g.

After passing through the desiccant the gases are bubbled through 25.0 cm^3 of a solution of 1.00 mol dm^{-3} NaOH. The solution is then titrated against 1.00 mol dm^{-3} HCl, and the end point is found to be when 14.7 cm^3 of the acid has been added.

(i) Calculate the amount in moles of H_2O produced by the combustion.

[2 marks]

Answer: $m_{H_2O} = 0.0931\,g$ [1]

$n_{H_2O} = \dfrac{0.0931g}{16.00 + 2\times1.008} = 5.1676287\,74 \times 10^{-3}$ mol

$\approx 5.17 \times 10^{-3}$ mol [1]

(ii) Calculate the amount in moles of CO_2 absorbed by the NaOH solution.

[4 marks]

Answer: $n_{HCl} = 14.7 \times 10^{-3}\,dm^3 \times 1.00$ mol dm^{-3}

$= 14.7 \times 10^{-3}$ mol $= 0.0147$ mol [1]

$n_{OH^-\ titrated} = n_{HCl} = 14.7 \times 10^{-3}$ mol [1]

$n_{OH^-\ reacted\ with\ CO_2} = (25.0 \times 10^{-3}\,dm^3 \times 1.00$ mol $dm^{-3})$

$- 14.7 \times 10^{-3}$ mol [1]

$= 10.3 \times 10^{-3}$ mol $= 0.0103$ mol

$2NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$

2 : 1

$n_{CO_2} = 10.3 \times 10^{-3}$ mol $\times \frac{1}{2} = 5.15 \times 10^{-3}$ mol

$= 0.00515$ mol [1]

If 1 : 1 ratio in a), accept e.c.f.: 10.3×10^{-3} mol [1]

19 [Turn over

SMASHING!!!

(iii) Hence determine the empirical formula of the organic molecule.

[6 marks]

Answer: $n_C = n_{CO_2} = 5.15 \times 10^{-3}$ mol [1]

$n_H = 2 \times n_{H_2O} = 2 \times 5.1676 \times 10^{-3}$ mol $= 10.335 \times 10^{-3}$ mol [1]

Mass of O in sample:

$0.100\ g - (5.15 \times 10^{-3}\ mol \times 12.00\ g\ mol^{-1})$

$- (10.335 \times 10^{-3}\ mol \times 1.008\ g\ mol^{-1}) = 0.02778\ g$ [1]

$\therefore n_O = \dfrac{0.02778\ g}{16.00\ g\ mol^{-1}} = 1.7364 \times 10^{-3}$ mol [1]

$n_C : n_H : n_O = 3 : 6 : 1$ [1]

Empirical formula: C_3H_6O [1]

Q# 241/ Cambridge/2017/Section 2/ www.SmashingScience.org

c) When 3.8 g of lithium aluminium hydride is heated to 125 °C, it decomposes to give three substances: 1.8 g of aluminium metal, 2.4 dm^3 of a flammable gas (measured at rtp), and substance **B**.

Determine the formula for substance **B**.

[5 marks]

Answer: 2.4 dm^3 of gas at rtp corresponds to 2.4/24.0 = 0.10 mol of the gas ....

.........$M_r(LiAlH_4) = 6.94 + 26.98 + 4 \times 1.008 = 37.952\ g\ mol^{-1}$ ....

...... 3.8 g of $LiAlH_4$ corresponds to 3.8/37.952 = 0.10 mol ....

.........1.8 g of Al corresponds to 1.8/26.98 = 0.067 mol ....

.... flammable gas likely to be H_2 ....

.... $3LiAlH_4(s) \rightarrow 2Al(m) + 3H_2 + \mathbf{Li_3AlH_6}$ ....

............1 mol ...... 2/3 mol ..1 mol...**B** ....

Question 1

Data: Assume that the molar gas volume = 24.0 $dm^3 mol^{-1}$ at room temperature and pressure (rtp).

a) When lithium metal and hydrogen gas are heated together, a single substance, **A**, is formed as colourless crystals with a melting point of 688 °C. Molten **A** conducts electricity, and electrolysis of the molten substance re-forms the elements.

(i) Give an equation for the formation of **A**.

[1 mark]

Answer: .... $2Li(m) + H_2(g) \rightarrow 2LiH(s)$ (**A**) ....

....

(ii) Classify the structure of **A** as either molecular covalent, giant covalent, or ionic. Briefly justify your answer.

[2 marks]

Answer: .... **ionic** because (1) high melting point and (2) conducts on melting ....

....

....

....

(iii) During the electrolysis of molten **A**, which element appears at the positive electrode (the anode) and which appears at the negative electrode (the cathode)?

[1 mark]

Answer: .... anode = oxidation: H_2 appears ....

.... cathode = reduction: Li appears ....

b) Substance **A** reacts with aluminium chloride to form lithium aluminium hydride ($LiAlH_4$) and one other by-product.

Give a balanced chemical equation for the formation of lithium aluminium hydride from **A** and aluminium chloride.

[2 marks]

Answer: ....

.... $4LiH(s) + AlCl_3(s) \rightarrow LiAlH_4(s) + 3LiCl(s)$ ....

.... **A** ....

Q# 243/ Cambridge/2016SP/Section 2/ www.SmashingScience.org

Mark Scheme Unavailable ☹

b) Breakfast cereals frequently have elemental iron added to them as a dietary supplement. A method for making a quantitative measurement of the amount of iron is to use the reaction between Fe^{3+}(aq) and thiocyanate, SCN^-(aq), which gives the deep red complex $FeSCN^{2+}$(aq).

$$Fe^{3+}(aq) + SCN^-(aq) \rightarrow FeSCN^{2+}(aq)$$

The depth of the colour can be measured using a *spectrophotometer* which gives a value for the *absorbance* that is proportional to the concentration of the complex:

$$\text{absorbance} = \text{constant} \times [FeSCN^{2+}] \qquad \textbf{Equation 1}$$

The constant can be found by measuring the absorbance of a solution of known concentration.

(i) The absorbance of a solution of the complex with concentration 2.5×10^{-4} mol dm^{-3} was measured to be 1.85; determine the value of the constant in Equation 1. **[2 marks]**

Answer: ....

$$\text{constant} = \frac{1.85}{2.5 \times 10^{-4}} = 7400 \text{ mol}^{-1}\text{dm}^3$$

Units not expected; any reasonable sig. fig. acceptable.

100 g of breakfast cereal was mixed with sufficient dilute acid to dissolve all of the iron. The solution was carefully filtered and mixed with sufficient oxidising agent to convert all of the iron to Fe^{3+}. The solution was made up to a total volume of 250 cm^3. 10.0 cm^3 of this solution was mixed with 10.0 cm^3 of a solution of thiocyanate; you may assume that all of the iron is converted to the complex. The absorbance of the resulting solution was measured as 0.519.

(ii) Using the value of the constant found in **(i)**, calculate the concentration of Fe^{3+} in the solution for which the absorbance was measured. **[2 marks]**

Answer: ....

There are many possible approaches to this: full credit for any valid approach. Full marks for valid approach and correct answer. Any reasonable sig. fig. for answer acceptable.

$$[Fe^{3+}] \text{ in the measured solution} = \frac{0.519}{7400} = 7.0135 \times 10^{-5} \text{ mol dm}^{-3}$$

(iii) Hence calculate the concentration of Fe^{3+} in the solution prepared from the cereal.

[2 marks]

Answer: ....

....

$[Fe^{3+}]$ in the 10 cm^3 portion of the extract is twice this = 1.403×10^{-4} mol dm^{-3}; this is the concentration in the 250 cm^3 of extract that was made.

....

(iv) Hence calculate the mass of iron present in the 100 g of breakfast cereal (A_r: Fe = 55.85).

[4 marks]

Answer: ....

....

$$\text{no. of moles in 250 cm}^3\text{solution with this conc} = 1.403 \times 10^{-4} \times \frac{250}{1000} = 3.507 \times 10^{-5}$$

convert this to mass of Fe

$$\text{mass of Fe in 250 cm}^3\text{solution with this conc} = 3.507 \times 10^{-5} \times 55.85 = \mathbf{1.96 \times 10^{-3}\ g}$$

This is the mass in 100 g of cereal.

Q# 245/ Cambridge/2022sp/Section 2/ www.SmashingScience.org

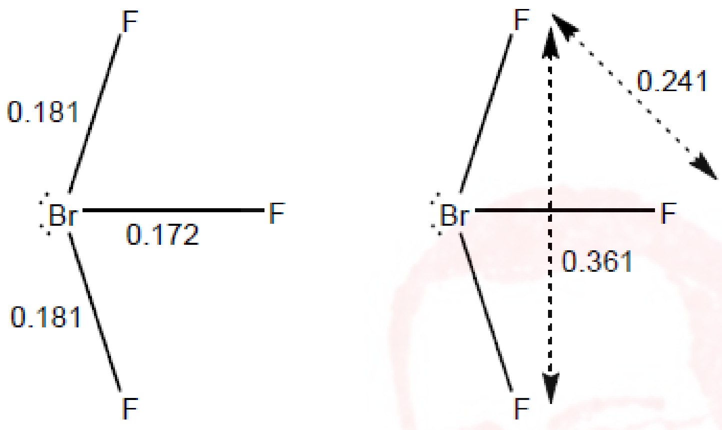
19 G

19 The answer is option **G**.

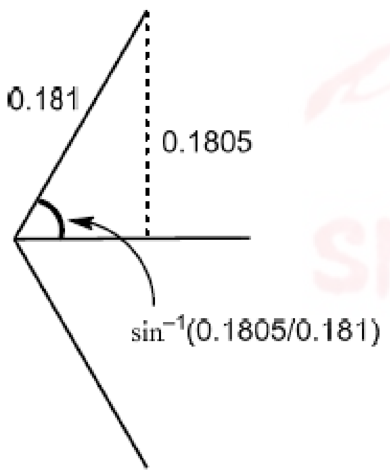
Both bromine and fluorine are in Group 17. F is more electronegative than Br and can form multiple bonds.

Bromine contributes 7 outer electrons to bonding, and the three F atoms contribute one further electron each. So there are 10 outer electrons around the Br centre, i.e. 5 pairs of electron density.

The structure is therefore based on a trigonal bipyramid. As there are only three bonds, two of these regions of electron density are lone pairs. There are several possible shapes that could form according to VSEPR, but only T-shaped would be faithful to the symmetry if only two bond lengths are equal and the third is not.



Finding a right-angled triangle using appropriate distances, and using the inverse sine function ($\sin^{-1}$), gives the bond angle as $\sin^{-1}\left(\frac{0.1805}{0.181}\right)$ (= 86°)



Q# 246/

Q43	C

Q# 247/ Cambridge/2022/Section 2/ www.SmashingScience.org

Q50	G

Q# 248/ Cambridge/2021/Section 2/ www.SmashingScience.org

Q22	B

Q# 249/ Cambridge/2021/Section 2/ www.SmashingScience.org

Q31	E

Q# 250/ Cambridge/2020SP/Section 2/ www.SmashingScience.org

19 G

Q# 251/ Cambridge/2016/Section 2/ www.SmashingScience.org

19.

CHEMISTRY

Question 3

Parts **a)**, **b)** and **c)** can be answered independently of one another.

a) Draw two alternative 'dot and cross' diagrams to describe the bonding in the linear thiocyanate anion SCN^-. In one diagram place the negative charge on the sulfur, and in the other place the negative charge on the nitrogen. **[5 marks]**

Answer:

Any variant on these (using lines to represent bonds and/or dot/cross pairs) is acceptable. Crucial thing is to have electron count correct and correct location of lone pairs.

(designed to be 'easy marks')

Q# 252/ Cambridge/2022/Section 2/ www.SmashingScience.org

Q52	A

Q# 253/ Cambridge/2022/Section 2/ www.SmashingScience.org

Q60	B

Q# 254/ Cambridge/2020/Section 2/ www.SmashingScience.org

Q41	E

Q# 255/ Cambridge/2020/Section 2/ www.SmashingScience.org

Q51	D

Q# 256/ Cambridge/2016SP/Section 2/ www.SmashingScience.org

Mark Scheme Unavailable ☹

Q# 257/ Cambridge/2022sp/Section 2/ www.SmashingScience.org

11 D

11 The answer is option **D**.

The heat required to warm the copper container and that required to warm the water are calculated separately using the expression $Q = mc\Delta T$

Copper: $Q_1 = 500 \times 0.4 \times 60 = 12\,000\,\text{J} = 12\,\text{kJ}$

Water: $Q_2 = 400 \times 4 \times 60 = 96\,000\,\text{J} = 96\,\text{kJ}$

Total heat transfer $= Q_1 + Q_2 = 12 + 96 = 108\,\text{kJ}$

This is only 20% of the heat released by burning the methane.

So, total heat released from burning $= 108 \times \dfrac{100}{20} = 540\,\text{kJ}$

Number of moles of methane burned to release this amount of heat $= \dfrac{540}{900} = 0.6\,\text{mol}$

Mass of methane $= 0.6 \times 16 = 9.60\,\text{g}$

Q# 258/ Cambridge/2022sp/Section 2/ www.SmashingScience.org

12 A

12 The answer is option **A**.

$\Delta_r H$ is the enthalpy of reaction and $\Delta_f H$ is the enthalpy of formation.

Deduce reaction equation: $HgC_2N_2O_2 \rightarrow Hg + N_2 + 2CO \qquad \Delta_r H = -606\ \text{kJ mol}^{-1}$

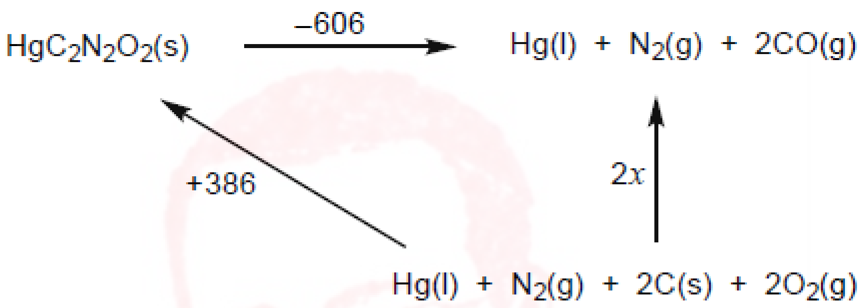
Deduce equation for enthalpy of formation of mercury(II) fulminate:

$$Hg(l) + 2C(s) + N_2(g) + O_2(g) \rightarrow HgC_2N_2O_2(s) \qquad \Delta_f H = +386\ \text{kJ mol}^{-1}$$

Deduce equation for enthalpy of formation of carbon monoxide:

$$C(s) + \frac{1}{2}O_2(g) \rightarrow CO(g) \qquad \Delta_f H = x\ \text{kJ mol}^{-1}$$

Construct a Hess cycle:



$2x = (+386) + (-606) = -220$

$x = -110\ \text{kJ mol}^{-1}$

Q# 259/ Cambridge/2022sp/Section 2/ www.SmashingScience.org

16 B

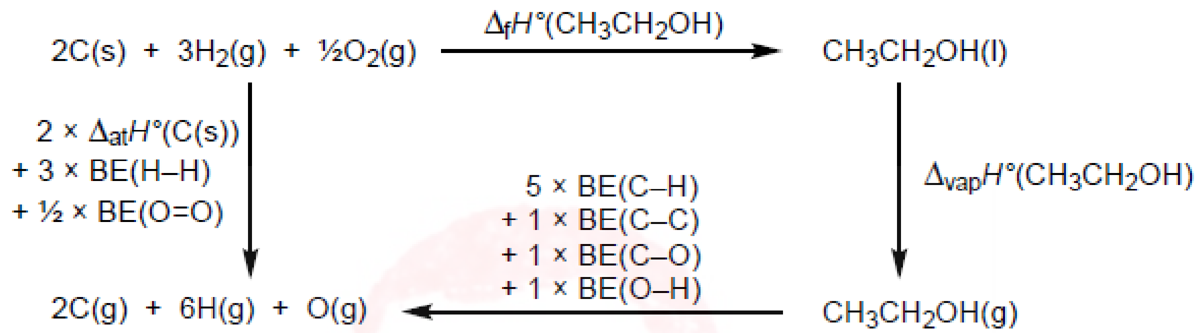
16 The answer is option **B**.

Hess's Law can be used to solve this by creating a Hess Cycle.

The equation for the enthalpy change of formation of ethanol can be set up at the top of the cycle. This enthalpy change is known.

The enthalpy change of vaporisation of ethanol should be included, as by definition the bond enthalpy data is for gaseous covalent bonds.

The gaseous atoms are included such that bond enthalpy (BE) data and atomisation of carbon data can be utilised and the cycle completed:



$$\Delta_f H^\circ(CH_3CH_2OH(l)) = [2(\Delta_{at}H^\circ(C(s)) + 3(BE(H-H)) + 0.5(BE(O{=}O))]$$

$$- [5(BE(C-H)) + BE(C-C) + BE(C-O) + BE(O-H)]$$

$$- [\Delta_{vap}H^\circ(CH_3CH_2OH(l))]$$

$$-277 = [2987] - [5(BE(C-H)) + 1167] - [39]$$

$$5(BE(C-H)) = +277 + 2987 - 1167 - 39$$

$$= +2058$$

$$BE(C-H) = +\frac{2058}{5}$$

$$= +412\ kJ\ mol^{-1}$$

Q# 260/ Cambridge/2022/Section 2/ www.SmashingScience.org

Q57	F

Q# 261/ Cambridge/2021/Section 2/ www.SmashingScience.org

Q27	A

Q# 262/ Cambridge/2021/Section 2/ www.SmashingScience.org

Q34	F

Q# 263/ Cambridge/2020SP/Section 2/ www.SmashingScience.org

11 D

Q# 264/ Cambridge/2020SP/Section 2/ www.SmashingScience.org

12 A

Q# 265/ Cambridge/2020/Section 2/ www.SmashingScience.org

Q58	D

Q# 266/ Cambridge/2016SP/Section 2/ www.SmashingScience.org

Mark Scheme Unavailable ☹

Q# 267/ Cambridge/2016/Section 2/ www.SmashingScience.org

f) Use the data to calculate the standard enthalpy change of combustion of alkene P.

[4 marks]

Answer: ....

$C_5H_{10} + H_2 \rightarrow C_5H_{12}$ $\Delta H_1 = -113$

$C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$ $\Delta H_2 = -3528$

$H_2O \rightarrow H_2 + ½O_2$ $\Delta H_3 = +286$

Adding all three gives

$C_5H_{10} + (7/2)O_2 \rightarrow 5CO_2 + 5H_2O$ $\Delta H = \Delta H_1 + \Delta H_2 + \Delta H_3 = -113 -3528 +286 =$ **-3355 kJ mol^{-1}**

Q# 268/

Q45	D

Q# 269/ Cambridge/2021/Section 2/ www.SmashingScience.org

Q39	F

Q# 270/ Cambridge/2020/Section 2/ www.SmashingScience.org

Q50	C

Q# 271/ Cambridge/2016SP/Section 2/ www.SmashingScience.org

Mark Scheme Unavailable ☹

Q# 272/ Cambridge/2016/Section 2/ www.SmashingScience.org

c) Hydrogen peroxide, H_2O_2, is used as the oxidising agent to convert Fe^{2+} to Fe^{3+} in the assay described in **b)(ii)**.

(i) Determine the oxidation state of oxygen in H_2O_2. **[2 marks]**

Answer:

Let x be the oxidation state of O, assume oxidation state of H is +1; species is neutral so

$$2 \times (+1) + 2 \times x = 0$$

Hence $x = -1$

(ii) When H_2O_2 acts as an oxidising agent in acidic solution, what is the oxygen-containing species that is produced and what is the oxidation state of oxygen in this species? **[4 marks]**

Answer:

(ii) H_2O_2 is reduced to $\mathbf{H_2O}$. Oxidation state of O in H_2O is **−2**.

2 marks for each

(iii) Write a balanced chemical equation describing the oxidation of $Fe^{2+}(aq)$ to $Fe^{3+}(aq)$ by H_2O_2 in acidic solution. **[4 marks]**

Answer:

(iii) $2Fe^{2+}(aq) + H_2O_2(aq) + 2H^+(aq) \rightarrow 2Fe^{3+}(aq) + 2H_2O(l)$

Looking for charges and atoms to balance; not worried about (aq) etc; H_3O^+ fine instead of H^+.

Q# 273/ Cambridge/2022/Section 2/ www.SmashingScience.org

Q56	C

Q# 274/ Cambridge/2020SP/Section 2/ www.SmashingScience.org

20	C

Q# 275/ Cambridge/2020SP/Section 2/ www.SmashingScience.org

16	C

Q# 276/

Q46	A

Q# 277/ Cambridge/2020/Section 2/ www.SmashingScience.org

Q53	D

Q# 278/ Cambridge/2020/Section 2/ www.SmashingScience.org

Q57	G

Q# 279/ Cambridge/2020/Section 2/ www.SmashingScience.org

Q47	F

Q# 280/ Cambridge/2019/Section 2/ www.SmashingScience.org

a) Minimum oxidation state = -2 (Te needs 2 electrons for noble gas configuration) Maximum oxidation state = +6 (all six of its valence electrons being used in bond formation). **[3]**

b) Electronegativity decreases on moving down a group. **[1]**

c) (Generally boiling points for analogous hydrides in a group would increase with the mass of the molecule), but due to hydrogen bonding. H_2O would have the higher boiling point. **[2]**

Q# 281/ Cambridge/2020/Section 2/ www.SmashingScience.org

Q42	F

Q# 282/ Cambridge/2022/Section 2/ www.SmashingScience.org

Q55	D

Q# 283/ Cambridge/2022/Section 2/ www.SmashingScience.org

Q59	E

Q# 284/ Cambridge/2020/Section 2/ www.SmashingScience.org

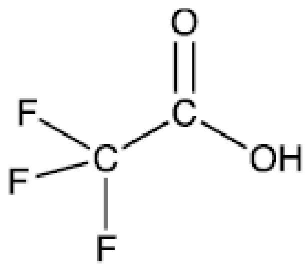
Q44	B

Q# 285/ Cambridge/2020/Section 2/ www.SmashingScience.org

Q55	C

Q# 286/ Cambridge/2019/Section 2/ www.SmashingScience.org

Answers for Question 2

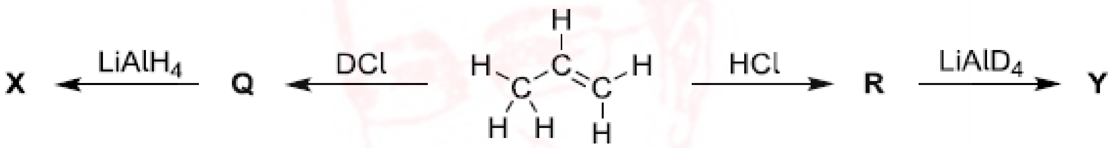
a) 

Angles round CF3 carbon approximately 109.5°.
Angles round carbonyl carbon approximately 120°. **[2]**

Q# 287/ Cambridge/2017/Section 2/ www.SmashingScience.org

d) Lithium aluminium deuteride can be prepared if deuterium gas is used in place of normal hydrogen. Deuterium, often give the symbol D, is the non-radioactive isotope of hydrogen, *i.e.* D = ^{2}H. The formula for lithium aluminium deuteride can be written $LiAlD_4$. Both $LiAlH_4$ and $LiAlD_4$ are common reducing agents and the latter is useful for preparing deuterium-containing compounds.

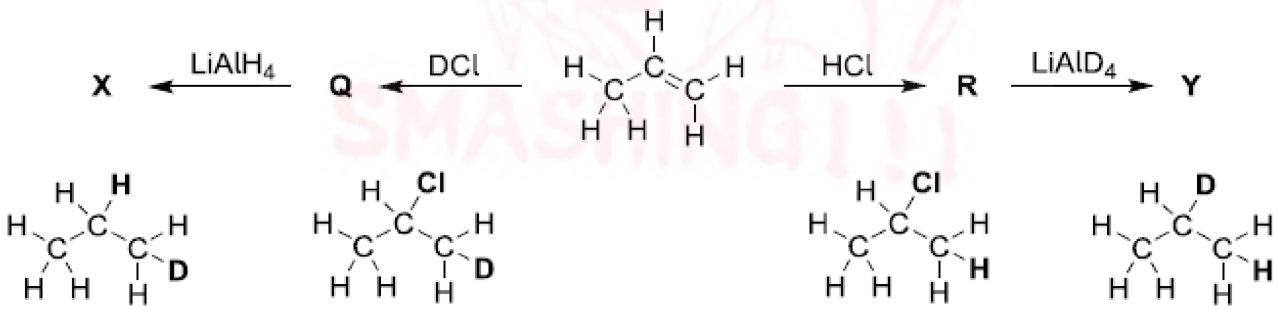
Isomers of mono-deuterated propane, **X** and **Y**, may be prepared from propene according to the following scheme which also uses hydrogen chloride, HCl, and deuterium chloride, DCl. In the scheme, only the carbon-containing compounds are shown; other by-products are not.



Give the structures of **X** and **Y** and the intermediates **Q** and **R** formed during the syntheses.

[4 marks]

Answer: ....

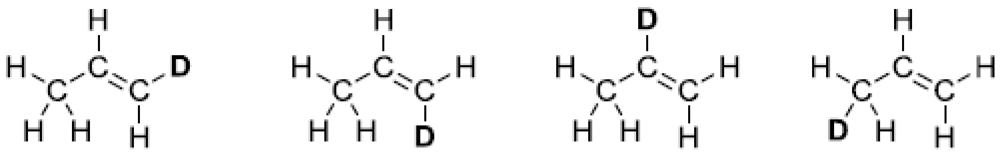


e) 2,2-dideuterated propane may be prepared easily in two steps, from a mono-deuterated propene, **Z**. (The formula for **Z** is C_3H_5D.)

(i) Draw the structures of all the alkenes with formula C_3H_5D.

[2 marks]

Answer: ......

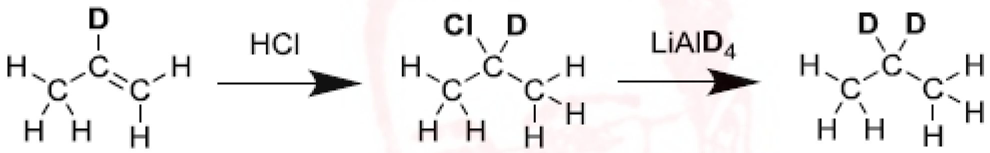


....

(ii) Give a synthesis of 2,2-dideuterated propane starting from **Z** showing reagents and intermediates in each step.

[3 marks]

Answer: ....



Z

....

Q# 288/ Cambridge/2016SP/Section 2/ www.SmashingScience.org

Mark Scheme Unavailable ☹

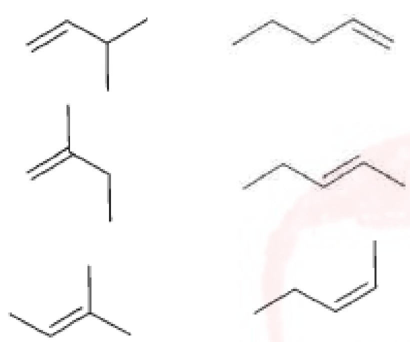
Question 4

There are six isomers with the formula C_5H_{10} that are alkenes. The alkenes all have different enthalpies of formation, all of which are negative.

a) Draw the structures of the six alkenes (skeletal or displayed structures are acceptable).

[6 marks]

Answer:

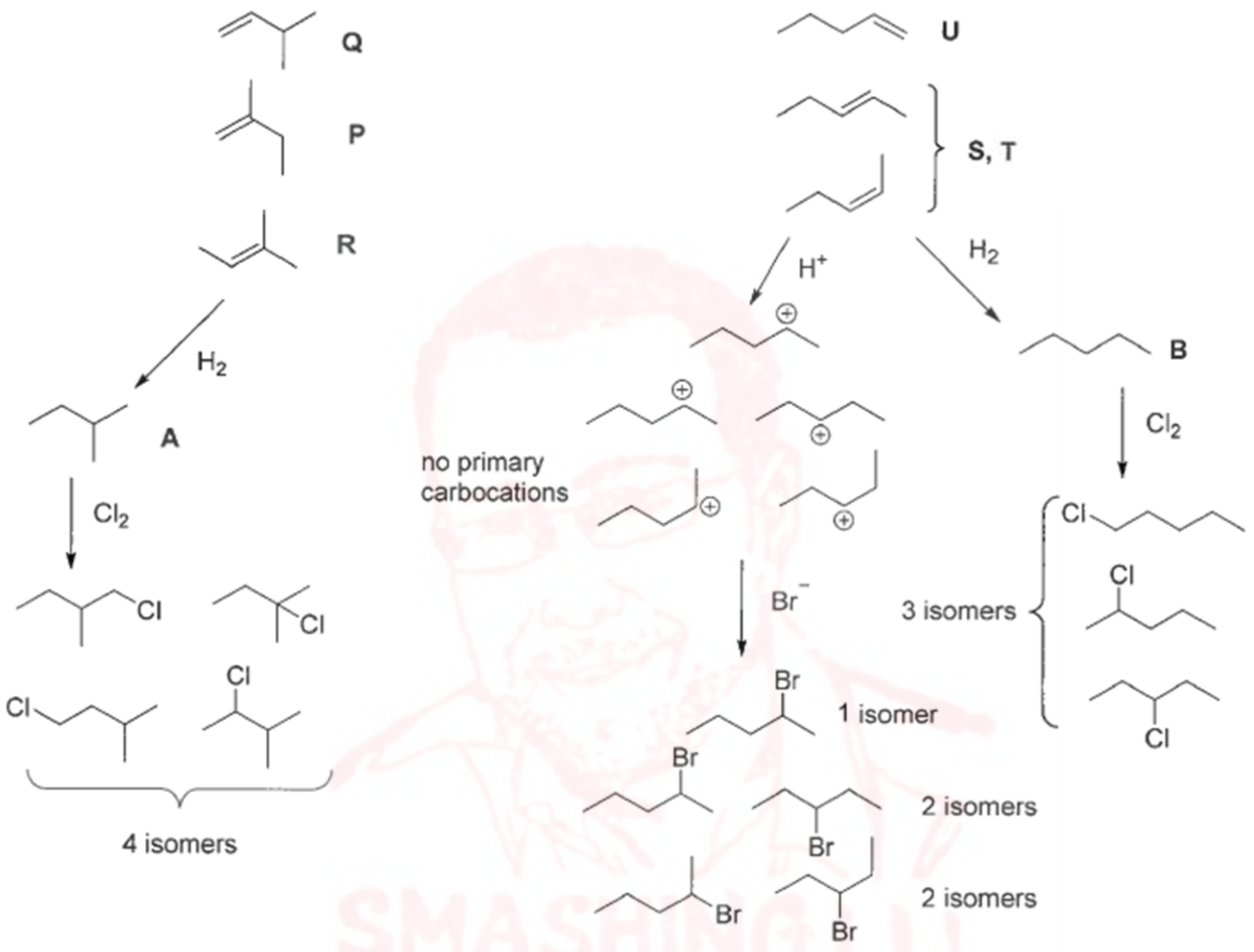


Other ways of writing out the structures are fine as long as they are clear

CHEMISTRY

Guidance for markers — not the expected answer from candidates

The overall scheme is



Samples of the six alkenes, in a random order, are labelled **P**, **Q**, **R**, **S**, **T**, and **U**. You will be able to identify which isomer *some* of these correspond to using the information and data throughout the rest of the question.

Alkenes **P**, **Q**, and **R** react with hydrogen gas and a metal catalyst to give the same alkane **A**; alkenes **S**, **T**, and **U** react under the same conditions to give a different alkane **B**.

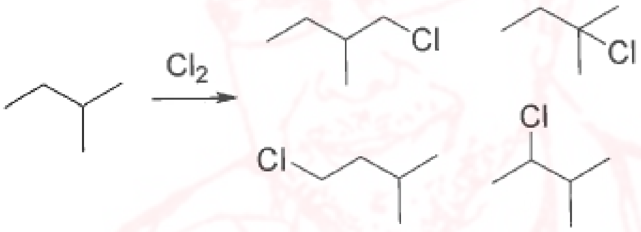
Both alkanes **A** and **B** react with chlorine gas under UV light to form chloroalkanes with the formula $C_5H_{11}Cl$. Under such conditions, alkane **A** forms *four* different structural isomers, whereas **B** gives *three*.

b) Draw the structures of alkanes **A** and **B**. Also draw the structures of the four isomers arising from the chlorination of **A**, and the three isomers arising from the chlorination of **B**. **[6 marks]**

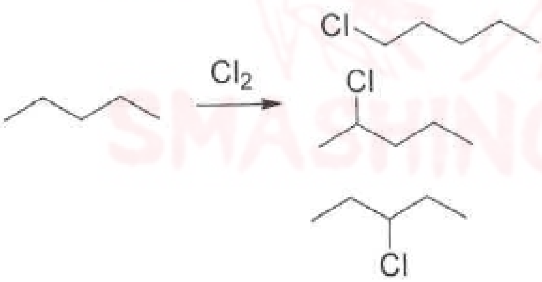
Answer:

Realise that there are only two hydrogenation products

Chlorination of these gives several products corresponding to putting one Cl onto each distinct carbon



gives 4 isomers



gives 3 isomers

Identifies

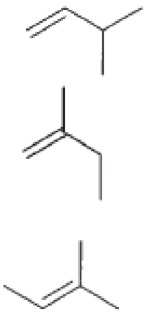
A B

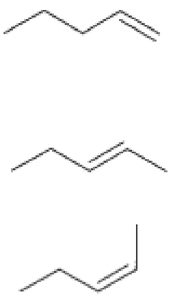
N.B. reasoning is not requested or required

The alkenes react with HBr to form bromoalkanes with the formula $C_5H_{11}Br$; the reaction proceeds via a carbocation intermediate. Alkenes **S** and **T** give a mix of *two* structural isomers, whereas alkene **U** gives only one.

c) Give the structure of alkene **U**. **[4 marks]**

Answer:

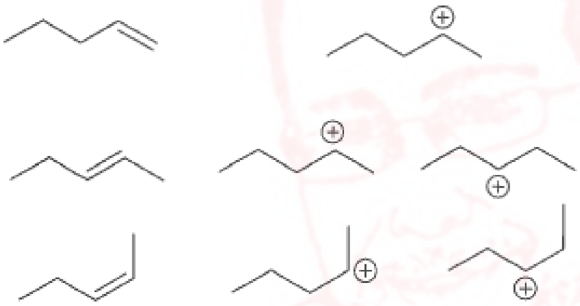




from (b) identify these groupings

P, Q, R **S, T, U**

The cations arising from **S, T, U** group are (primary excluded)



U

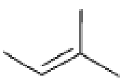
Only the first one will give one isomer on subsequent reaction with Br^-, identifying

A general rule for isomeric alkenes is that the more carbon atoms directly bonded to the double bond (or the lower the number of hydrogen atoms directly bonded), the more negative (that is, the more exothermic) the enthalpy of formation of the alkene.

d) Out of **P**, **Q** and **R**, **R** has the most negative (most exothermic) enthalpy of formation. Give the structure of **R**. **[1 mark]**

Answer:

Out of **P, Q** and **R**, the one with the most carbons attached to the double bond is



R

R has the most negative (most exothermic) enthalpy of formation.

Consider the following thermodynamic data:

	value / kJ mol^{-1}
standard enthalpy change of hydrogenation for alkene **P**	–113
standard enthalpy change of hydrogenation for alkene **Q**	–119
standard enthalpy change of combustion for alkane **A**	–3528
standard enthalpy change of formation of $H_2O(l)$	–286

e) Use the data to deduce the structure of: **(i)** alkene P; and **(ii)** alkene Q. **[4 marks]**

Answer: ....

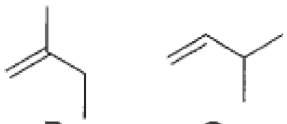
....

Hydrogenation of both **P** and **Q** gives **A**, we can assess the enthalpies of formation of **P** and **Q** by comparing their enthalpies of hydrogenation.

P/Q + H_2 → **A**

ΔH for this reaction is $\Delta_r H$(hydrogenation) = $\Delta_f H$(**A**) – $\Delta_f H$(**P/Q**)
hence $\Delta_f H$(**P/Q**) = $\Delta_f H$(**A**) – $\Delta_r H$(hydrogenation).

Since $\Delta_r H$(hydrogenation) is more negative for **Q** than for **P**, – $\Delta_r H$(hydrogenation) is more positive for **Q** than for **P**. It follows that $\Delta_f H$(**Q**) is larger than $\Delta_f H$(**P**) i.e. $\Delta_f H$(**Q**) is less negative than $\Delta_f H$(**P**). **P** therefore has the more substituted double bond



P **Q**

An alternative is to work out $\Delta_r H$ for **P** → **Q** in the following way

$\Delta_r H$(hydrogenation **P**) = $\Delta_f H$(**A**) – $\Delta_f H$(**P**) –113 kJ mol^{-1}
$\Delta_r H$(hydrogenation **Q**) = $\Delta_f H$(**A**) – $\Delta_f H$(**Q**) –119 kJ mol^{-1}

subtracting second from first gives

$\Delta_r H$(hydrogenation **P**) – $\Delta_r H$(hydrogenation **Q**) = $\Delta_f H$(**Q**) – $\Delta_f H$(**P**) –113 + 119 = 6 kJ mol^{-1}

This is $\Delta_r H$ for **P** → **Q**. The positive value implies that $\Delta_f H$(**P**) is more negative than $\Delta_f H$(**Q**): **P** has the more substituted double bond.

Q# 292/ Cambridge/2022sp/Section 2/ www.SmashingScience.org

15 A

15 The answer is option **A**.

The oxidation state of silver in Tollens' reagent is +1, as NH_3 is a neutral species and the nitrate anion has a charge of –1.

It acts as a reducing agent as shown by the half-equation: $Ag^+(aq) + e^- \rightarrow Ag(s)$

Combining this with the organic oxidation half-equation shows that the overall reaction has the stoichiometry:

$$2Ag^+(aq) + RCHO + H_2O \rightarrow 2Ag(s) + RCOOH + 2H^+$$

The internal surface area of the beaker is the area of the circular base added to the curved sides.

Surface area to be coated $= \pi r^2 + 2\pi rh = 25\pi + 100\pi = 125\pi\,cm^2$

Volume of silver required $=$ surface area $\times$ thickness $= 125\pi\,cm^2 \times 0.01\,cm = 1.25\pi\,cm^3$

Mass of silver required in g $=$ volume $\times$ density $= 1.25\pi\,cm^3 \times 10.5\,g\,cm^{-3}$

Number of moles of Ag(s) required $= \dfrac{\text{mass in g}}{A_r\,(Ag)} = \dfrac{10.5\times1.25\times\pi}{108}$

So, the number of moles of aldehyde required $= \dfrac{1}{2} \times \dfrac{10.5\times1.25\times\pi}{108}$

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Q23	C

Q# 294/ Cambridge/2021/Section 2/ www.SmashingScience.org

Q33	C

Q# 295/ Cambridge/2022/Section 2/ www.SmashingScience.org

Q49	H

Q# 296/ Cambridge/2022/Section 2/ www.SmashingScience.org

Q54	E

Q# 297/ Cambridge/2020SP/Section 2/ www.SmashingScience.org

18 E

Q# 298/ Cambridge/2022sp/Section 2/ www.SmashingScience.org

13 B

13 The answer is option **B**.

The hydrocarbon contains 14.3% by mass of H, so must contain 85.7% by mass of C.

The empirical formula of X is found by considering the ratio C : H which is $\frac{85.7}{12} : \frac{14.3}{1}$, cancelling to 2 : 1 by approximation.

Therefore the empirical formula is CH_2.

The mass spectrum shows the molecular ion peak at $m/z = 84$, so $M_r = 84$.

The molecular mass of cyclobutane (C_4H_8) is 56. This corresponds to the highest intensity peak, but that does not correspond to the molecular ion.

Molecular formula of X is therefore: C_6H_{12}

X does not react with bromine, so it is not an alkene. X cannot be hex-2-ene.

X must be a cycloalkane with 6 C atoms, such as cyclohexane.

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13 B

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j) $CF_3COOCOCF_3 + H_2O \longrightarrow 2\ CF_3COOH$ **[1]**

k) $\Delta H = -36.7 - 75.6 + 98.3 = -14.0$ kJ mol^{-1}. **[4]**

Question 2

Read the preamble carefully before proceeding to answer the question.

In their solid (crystalline) form many inorganic salts (such as NaCl or MgF_2) can be thought of as consisting of a giant lattice in which positive ions (*e.g.* Na^+, Mg^{2+}) and negative ions (*e.g.* Cl^-, F^-) are arranged in a regular pattern, called a *lattice*. The ions are held together by electrostatic forces arising from the favourable interactions between ions of opposite charge.

The lattice enthalpy is the enthalpy change for a process in which the *solid* material is formed from ions in the gas phase. For NaCl(s) this is the process

$$Na^+(g) + Cl^-(g) \rightarrow NaCl(s)$$

and for MgF_2 the process is

$$Mg^{2+}(g) + 2F^-(g) \rightarrow MgF_2(s)$$

The lattice enthalpy is invariably large and negative.

The lattice enthalpy in $kJ\,mol^{-1}$ can be estimated using the following expression

$$\frac{-1.07\times10^5 \times n_{ions} \times z_+ \times z_-}{r_+ + r_-} \qquad \textbf{Equation 1}$$

In this expression, r_+ is the radius of the positive ion, in pm ($1\,pm = 10^{-12}\,m$), and r_- is the radius of the negative ion, also given in pm.

n_{ions} is the number of ions in the formula unit; for example, for NaCl $n_{ions} = 2$, but for MgF_2 $n_{ions} = 3$.

z_+ is the charge number on the positive ion; for example for Na^+ it is 1, but for Mg^{2+} it is 2. z_- is likewise the *absolute value* of the charge number on the negative ion: for Cl^- it is 1 (*not* -1).

a) Use Equation 1 to calculate the lattice enthalpy for CuF_2 given the following data:

$$r_+ = 73\,pm, \quad r_- = 133\,pm$$

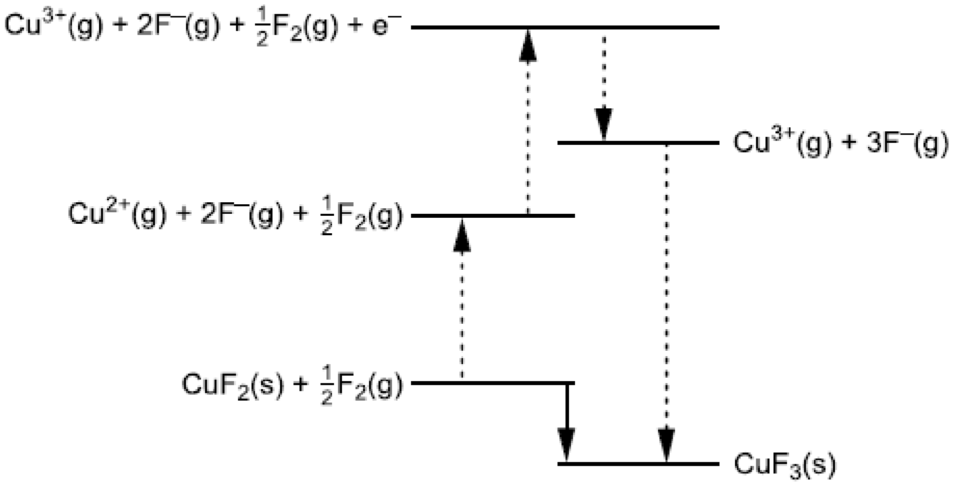
[3 marks]

Answer: ....

.... $\frac{-1.07\times10^5 \times 3 \times 2 \times 1}{73+133} = -3120\,kJ\,mol^{-1}$ ....

....

d) The enthalpy change for the reaction in Equation 2 can be calculated using the following Hess's Law cycle.



Using your results from parts **a)** and **b)**, and given the following enthalpy changes below

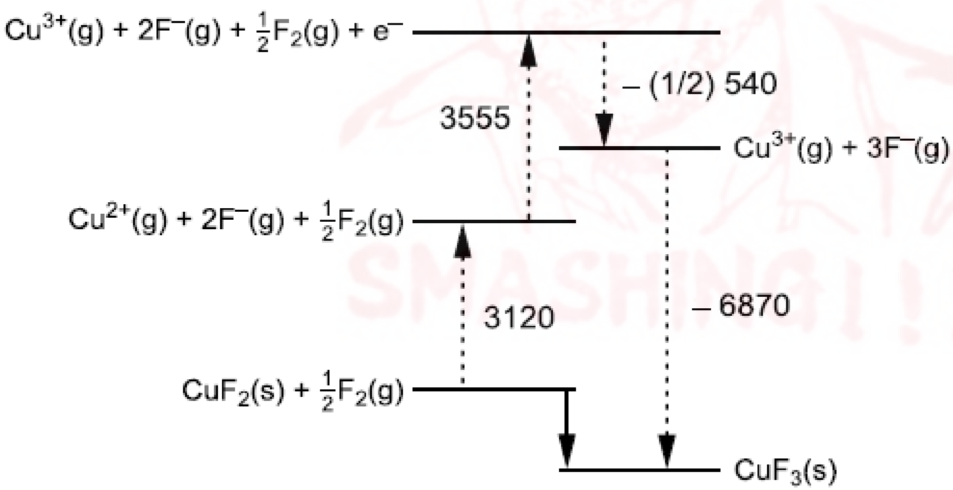
$$F_2(g) + 2e^- \rightarrow 2F^-(g) \qquad \Delta H = -540\ \text{kJ mol}^{-1}$$
$$Cu^{2+}(g) \rightarrow Cu^{3+}(g) + e^- \qquad \Delta H = 3555\ \text{kJ mol}^{-1}$$

calculate the enthalpy change for:

$$CuF_2(s) + \tfrac{1}{2}F_2(g) \rightarrow CuF_3(s)$$

[5 marks]

Answer: ...



...

...Required value is 3120 + 3555 – (1/2) 540 – 6870 = **– 465 kJ mol^{-1}**....

b) Use Equation 1 to calculate the lattice enthalpy for CuF_3 given the following data:

$$r_+ = 54\,\text{pm}, \quad r_- = 133\,\text{pm}$$

[3 marks]

Answer: ....

$$\frac{-1.07\times10^5\times4\times3\times1}{54+133} = -6870\ \text{kJ mol}^{-1}$$

c) Calculated values of the lattice enthalpy can be used to estimate the enthalpy change of hypothetical reactions, such as

$$CuF_2(s) + \tfrac{1}{2}F_2(g) \rightarrow CuF_3(s)$$ **Equation 2**

Determine the oxidation state of copper in each of the species and hence classify what kind of reaction this is.

[3 marks]

Answer: ....

CuF_2: assume F = −1, so Cu is +2 (as species neutral)

CuF_3: assume F = −1, so Cu is +3 (as species neutral)

This is a redox reaction

e) Use the data given below to calculate the enthalpy change for the following reaction (M is an unspecified metallic element).

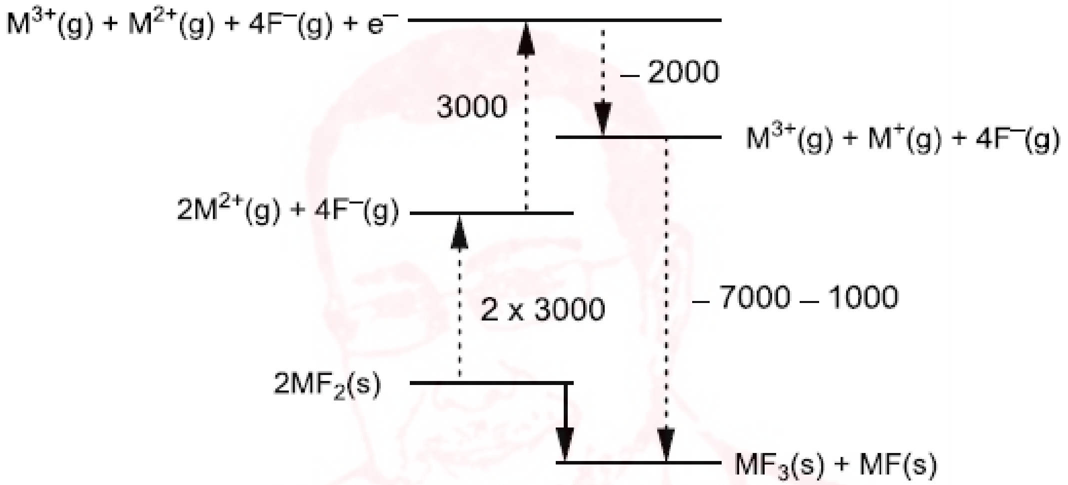
$$2MF_2(s) \rightarrow MF_3(s) + MF(s)$$

You may find it helpful to start by constructing an appropriate Hess's Law cycle.

$$MF_2(s) \rightarrow M^{2+}(g) + 2F^-(g) \qquad \Delta H = 3000\,kJ\,mol^{-1}$$
$$MF_3(s) \rightarrow M^{3+}(g) + 3F^-(g) \qquad \Delta H = 7000\,kJ\,mol^{-1}$$
$$MF(s) \rightarrow M^+(g) + F^-(g) \qquad \Delta H = 1000\,kJ\,mol^{-1}$$
$$M^+(g) \rightarrow M^{2+}(g) + e^- \qquad \Delta H = 2000\,kJ\,mol^{-1}$$
$$M^{2+}(g) \rightarrow M^{3+}(g) + e^- \qquad \Delta H = 3000\,kJ\,mol^{-1}$$

[6 marks]

Answer: ....



....

....

Required value is $2 \times 3000 + 3000 - 2000 - 7000 - 1000 =$ **– 1000 kJ mol^{-1}**............................

Q# 302/

Q42	B

Q# 303/

Q44	G

Q# 304/ Cambridge/2022/Section 2/ www.SmashingScience.org

Q47	E

Q# 305/ Cambridge/2020/Section 2/ www.SmashingScience.org

Q48	A

Q# 306/ Cambridge/2020/Section 2/ www.SmashingScience.org

Q59	F

Q# 307/ Cambridge/2018/Section 2/ www.SmashingScience.org

c) Determine the oxidation state of the metal atom or atoms in the following species.

(i) MnO_4^{2-}

[1 mark]

Answer: $-2 - (-2) \times 4 = +6$ [1]

(ii) $K_2Cr_2O_7$

[2 marks]

Answer: K: +1 [1]

Cr: $(-2 - (-2) \times 7) \div 2 = +6$ [1]

d) Write a balanced chemical equation in which Fe^{2+} is oxidised to Fe^{3+} by MnO_4^- in an **acidic aqueous solution** and in which the Mn is reduced to a species with oxidation state +2. Your equation must balance for both atoms and charge, and you may **not** use free electrons (e^-) to achieve this.

[4 marks]

Answer: $Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + e^-$

$MnO_4^-(aq) + 5e^- + 8H^+(aq) \rightarrow Mn^{2+}(aq) + 4H_2O(l)$

$\Rightarrow 5Fe^{2+}(aq) + 8H^+(aq) + MnO_4^-(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(l)$

[4] if all correct

If not, $\underline{5}Fe^{2+} \rightarrow \underline{5}Fe^{3+}$ [1]

$MnO_4^- \rightarrow Mn^{2+}$ [1]

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20 C

20 The answer is option **C**.

	CH_3COOH +	CH_3CH_2OH ⇌	$CH_3COOCH_2CH_3$ +	H_2O
mass at the start	120	92	0	18
M_r	60	46	88	18
number of moles at the start	2	2	0	1
number of moles at equilibrium	$2 - x$	$2 - x$	x	$1 + x$

The equilibrium constant is: $K_c = \dfrac{[CH_3COOCH_2CH_3][H_2O]}{[CH_3COOH][CH_3CH_2OH]}$

Substituting in the number of moles: $K_c = \dfrac{(x)(1+x)}{(2-x)(2-x)} = 2$

Rearranging: $x^2 + x = 2(x^2 - 4x + 4)$

$x^2 + x = 2x^2 - 8x + 8$

$x^2 - 9x + 8 = 0$

Using the quadratic formula: $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \dfrac{-9 \pm \sqrt{9^2 - 32}}{2}$

or by factorising: $(x - 8)(x - 1) = 0$

$x = 8$ or 1

A value of 8 is impossible because that would require '–6 mol' of reactants.

At equilibrium there would be just one mole of ester, which has a mass of 88 g.

Q# 309/ Cambridge/2022/Section 2/ www.SmashingScience.org

Q48	F

Q# 310/ Cambridge/2021/Section 2/ www.SmashingScience.org

Q28	D

Q# 311/ Cambridge/2021/Section 2/ www.SmashingScience.org

Q35	B

Q# 312/ Cambridge/2020/Section 2/ www.SmashingScience.org

Q54	G

Q# 313/ Cambridge/2019/Section 2/ www.SmashingScience.org

b) RMM of TFEA = 114. Mass of TFEA needed = 0.0700 x 114 = 7.98 g
1.489 g has a volume of 1 cm3. So 7.98 g has a volume of 7.98/1.489 = 5.36 cm^3. **[3]**

c) $CF_3COOH(aq) \rightleftharpoons CF_3COO^-(aq) + H^+(aq)$ **[1]**

d) K_{eq} = [CF_3COO^-][H^+] / [CF_3COOH] **[2]**

e) [CF_3COO^-] = [H^+] = 0.4119 mol dm^{-3}.

[CF_3COOH] = 0.700 – 0.4119 = 0.2881 mol dm^{-3}.

K_{eq} = 0.4119^2 / 0.2881 = 0.589 **[3]**

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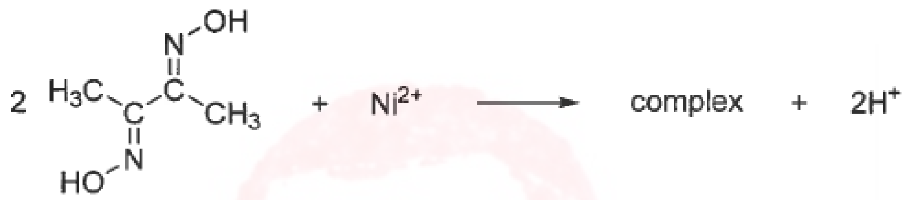
Q# 315/ Cambridge/2018/Section 2/ www.SmashingScience.org

c) Dimethylglyoxime reacts with Ni^{2+} ions in aqueous solution under mildly basic conditions to give a complex which is an insoluble red precipitate. The reaction involves two molecules of dimethylglyoxime and also results in the production of two H^+ ions.



dimethylglyoxime

Assuming that the above equation is balanced, determine the **molecular formula** of the complex and its relative molecular mass; a structural formula is **not** required.

(Relative atomic mass data is given in the Periodic Table on page 14.)

[4 marks]

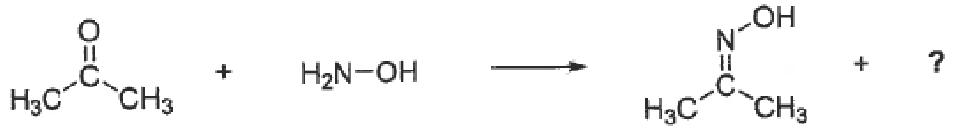
Answer: $Ni(C_4O_2N_2H_7)_2$ = $NiC_8O_4N_4H_{14}$ [2]

Mass = 288.922 [2]

Chemistry

Question C1

a) Ketones react with hydroxylamine, NH_2OH, to give oximes. An example of such a reaction involving the ketone propanone is shown below:



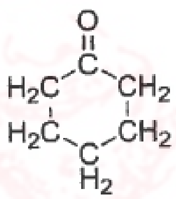
propanone (a ketone) hydroxylamine an oxime

(i) In addition to the oxime, this reaction produces a second product. Suggest what this molecule might be.

[1 mark]

Answer: H_2O or water [1]

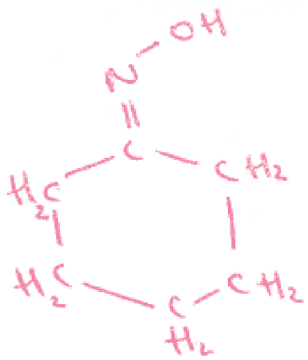
(ii) Draw the structure of the oxime that you would expect to be formed from the reaction of the ketone cyclohexanone with hydroxylamine.



cyclohexanone

[2 marks]

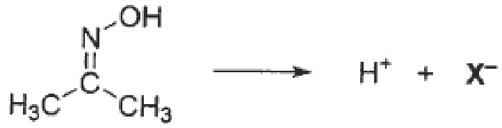
Answer:



oxime = [1]

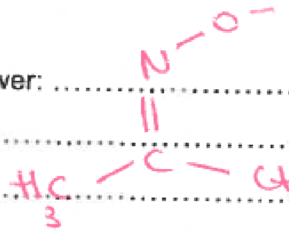
cycle = [1]

(iii) Oximes are weakly acidic. For the oxime below, explain which hydrogen atom will be the most acidic and draw the structure of the resulting anion **X**⁻.



oxime

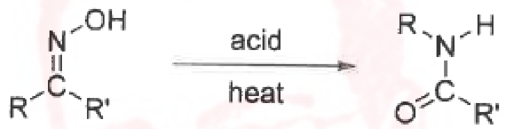
[3 marks]

Answer: 

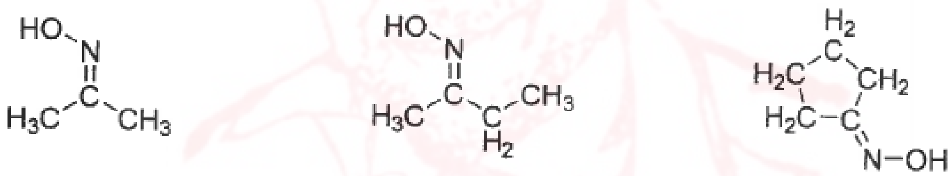
[1] O is electronegative [1]

Stabilises negative charge [1]

b) Under acidic conditions, oximes undergo the following rearrangement reaction (note carefully that there are two different groups R and R').



Give the analogous structures into which each of the following oximes rearrange under the same conditions.



[4 marks]

Answer:

[1] [1] [1] [1]

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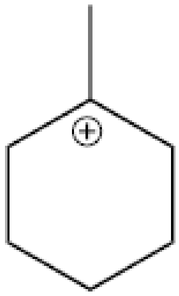
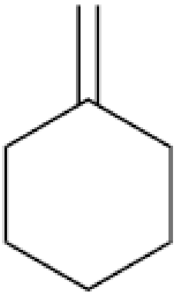
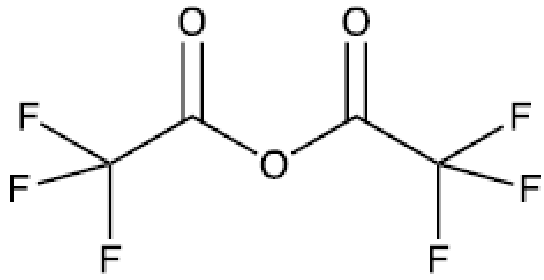
f) addition **[1]**

g)  **[1]** h)  **[1]** i)  **[1]**

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18 E

18 The answer is option **E**.

Compound P must have a C=C bond somewhere in its structure, and Q is a bromoalkane.

Alcohols are formed when bromoalkanes undergo substitution reactions with aqueous sodium hydroxide.

When completely oxidised by acidified potassium dichromate(VI), primary alcohols form carboxylic acids which do react with aqueous sodium carbonate.

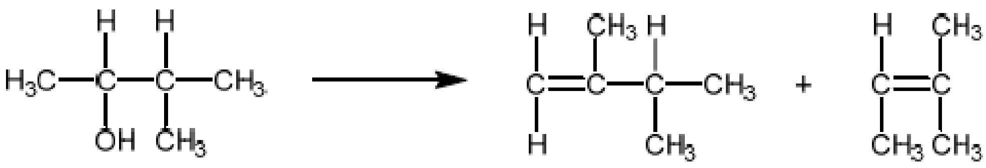
Secondary alcohols are oxidised to ketones which do not react with aqueous sodium carbonate and tertiary alcohols cannot be oxidised by acidified potassium dichromate(VI). Therefore R must be a secondary alcohol.

Pent-1-ene is incorrect as it would form 2-bromopentane as the only major product with HBr, which would then form pentan-2-ol. This would be dehydrated to form pent-2-ene as the other alkene, S. This does have stereoisomers.

Pent-2-ene is incorrect as there would be two products in significant quantity formed in the reaction with HBr: 2-bromopentane and 3-bromopentane (both formed from secondary carbocations).

The correct answer must therefore be one of the branched alkenes. If P were either 2-methylbut-1-ene or 2-methylbut-2-ene, because the double bond is adjacent to the branch in the chain, a tertiary bromoalkane would be formed as the major product. After the substitution reaction, this bromoalkane would become a tertiary alcohol, which cannot be oxidised by acidified potassium dichromate(VI).

3-methylbut-1-ene must therefore be the correct answer. This alkene would firstly form 2-bromo-3-methylbutane as the only major product with HBr and then 2-methylbutan-2-ol. This alcohol would be dehydrated to form 2-methylbut-2-ene as alkene S, which has two methyl groups attached to one end of the carbon double bond, and therefore does not have stereoisomers.



P S

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Q25	D

Q# 320/ Cambridge/2021/Section 2/ www.SmashingScience.org

Q26	B

Q# 321/ Cambridge/2021/Section 2/ www.SmashingScience.org

Q29	D

Q# 322/ Cambridge/2021/Section 2/ www.SmashingScience.org

Q36	E

Q# 323/ Cambridge/2021/Section 2/ www.SmashingScience.org

Q38	H

Q# 324/ Cambridge/2022/Section 2/ www.SmashingScience.org

Q51	C

Q# 325/ Cambridge/2020/Section 2/ www.SmashingScience.org

Q49	D

APPENDIX ESAT Syllabus mapped to CAIE A Level Chemistry

ESAT Topic	CAIE Topic	NSAA Topic Details
C1. Atomic structure	T1 Atomic structure	C1.1 Describe the structure of the atom as a central nucleus (containing protons and neutrons) surrounded by electrons moving in shells/energy levels. C1.2 Know the relative masses and charges of protons, neutrons and electrons, and recognise that most of the mass of an atom is in the nucleus. C1.3 Know and be able to use the terms *atomic number* and *mass number*, together with standard notation (e.g. $^{12}_{6}C$), and so be able to calculate the number of protons, neutrons and electrons in any atom or ion. C1.4 Use the atomic number to write the electron configurations of the first 20 elements in the Periodic Table (H to Ca) in comma-separated format (e.g. 2,8,8,1 for a potassium atom). C1.5 Know the definition of isotopes as atoms of an element with the same number of protons but different numbers of neutrons (so having different mass numbers). Use data, including that from a mass spectrometer, to identify the number and abundances of different isotopes of elements. C1.6 Know and use the concept of relative atomic mass, A_r, including calculating values from given data.
C2. The Periodic Table (IUPAC conventions, Groups are labelled as 1-18)	T9 The periodic table	C2.1 Know that Periods are horizontal rows and Groups are vertical columns. C2.2 Know that the elements are arranged in the order of increasing atomic number. C2.3 Recall the position of metals and non-metals in the Periodic Table: alkali metals (Group 1), alkaline earth metals (Group 2), common non-metals in Group 16, the halogens (Group 17), the noble gases (Group 18) and the transition metals. C2.4 Know and use the relationship between the position of an atom in the Periodic Table (Group and Period) and the electron configuration of the atom. C2.5 Understand that elements in the same Group have similar chemical properties and that down a metal Group, reactivity increases and down a non-metal Group, reactivity decreases.
C3. Chemical reactions, formulae and equations	T2 Atoms, molecules and stoichiometry T7 Equilibria	C3.1 Understand that in a chemical reaction, new substances are formed by the rearrangement of atoms and their electrons, but no nuclei are destroyed or created. C3.2 Know the chemical formulae of simple, common ionic and covalent compounds.

ESAT Topic	CAIE Topic	NSAA Topic Details
		C3.3 Know and use state symbols: solid (s), liquid (l), gas (g), aqueous solution (aq). C3.4 Be able to construct and balance a chemical equation, including ionic and half-equations. C3.5 Understand that often chemical reactions can be reversible and do not go to completion. All of the reactants do not turn fully into the products but the reaction reaches a state of equilibrium in a closed system. a. Know the factors that can affect the position of an equilibrium (concentration of reactants/products, temperature, overall pressure). b. Predict the effect of changing these factors on the position of equilibrium.
C4. Quantitative chemistry	T2 Atoms, molecules and stoichiometry	C4.1 Use A_r values to calculate the relative molar mass, M_r. C4.2 Know that Avogadro's number gives the number of particles in one mole of a substance. C4.3 Know that one mole of a substance is the A_r or M_r in grams, and perform conversions of grams to moles and *vice versa* (including working in tonnes and kilograms). Know that the amount of a substance corresponds to the number of moles of a substance. C4.4 Calculate the percentage composition by mass of a compound using given A_r values. C4.5 Know that the *empirical formula* is the simplest integer ratio of atoms in a compound. Find the empirical formula of a compound from a variety of data, such as the percentage composition by mass of the elements present or reacting masses. Find the molecular formula from the empirical formula if given the M_r value. C4.6 Use balanced chemical equations to calculate the masses of reactants and products, including if there is a limiting reactant present. C4.7 Be able to construct balanced chemical equations from reacting masses or gas volumes data. C4.8 Understand that (for an ideal gas) one mole of a gas occupies a set volume at a given temperature and pressure (for example, 24 dm^3 at room temperature and pressure (rtp)), and perform conversions of volumes to number of moles, and *vice versa*. C4.9 Solutions: a. Understand that concentration can be measured in $mol\,dm^{-3}$ or $g\,dm^{-3}$, and be able to calculate the concentration given the number of moles (or mass) of solute and the volume of solution. b. Know the term *saturated solution*, be able to calculate

ESAT Topic	CAIE Topic	NSAA Topic Details
		solubility and interpret solubility data. C4.10 Use the concentrations of solutions (or find the concentrations from given data) and the reacting ratio of reactants from the balanced equation to perform titration calculations. C4.11 Calculate the percentage yield of a reaction using the balanced chemical equation and the equation: percentage yield = actual yield (g) predicted yield (g) $\times 100$
C5. Oxidation, reduction and redox	T6 Electrochemistry	C5.1 Know that on a basic level, oxidation is the gain of oxygen and that reduction is the removal of oxygen. C5.2 Know and be able to use the concept that oxidation and reduction are the transfer of electrons, i.e. reduction is the gain of electrons and oxidation is the loss of electrons. C5.3 Determine and use the oxidation states of atoms in simple inorganic compounds. C5.4 Identify any chemical equation that involves: oxidation only, reduction only, redox (both oxidation and reduction taking place), or no oxidation/reduction. C5.5 Understand the concept of *disproportionation* and recognise reactions (or species) where this occurs. C5.6 Understand the terms *oxidising agent* and *reducing agent*, and be able to identify them in reactions.
C6. Chemical bonding, structure and properties	T3 Chemical bonding	C6.1 Define and understand the differences between elements, compounds and mixtures. C6.2 Understand that atoms often react to form compounds which have the electron configuration of a noble gas (Group 18). Understand that the type of bonding taking place depends on the atoms involved in the reaction. C6.3 Ionic bonding: a. Know that ions are formed by transfer of electrons from atoms of metals to atoms of non-metals, and that these ions (of opposite charge) attract to form ionic compounds. b. Predict the charge of the most stable ions formed from elements in Groups 1, 2, 16 and 17 and aluminium by consideration of their electron configuration. c. Know the chemical formulae of common compound ions, e.g. CO_3^{2-} and OH^-. d. Know that when an element can exist in more than one oxidation state, e.g. Cu, Fe, then Roman numerals are used

ESAT Topic	CAIE Topic	NSAA Topic Details
		to denote the one present, e.g. iron(III) chloride for $FeCl_3$. e. Determine the formulae of ionic compounds from their constituent ions. f. Understand the general physical properties of ionic compounds, such as melting point and conductivity. C6.4 Covalent bonding: a. Know that a covalent bond is formed when atoms share one (or more) pair(s) of electrons, generally between non-metals. b. Understand that covalently bonded substances can be small molecules (e.g. water, ammonia, methane) or giant structures (e.g. diamond, graphite, silicon dioxide). c. Understand the general physical properties of substances composed of small molecules or of those that exist as giant covalent structures. C6.5 Metallic bonding: a. Understand that solid metals exist as a giant structure of positively charged ions surrounded by delocalised (free) electrons. b. Understand the general physical properties of metals, such as melting point and conductivity. C6.6 Understand that intermolecular forces can exist between molecules, and that these forces must be overcome in melting and boiling. C6.7 Be able to relate structure and bonding to physical properties, such as melting point and conductivity.
C7. Group chemistry	T9 The periodic table T11 Group 17	C7.1 Know the physical and chemical properties of the alkali metals (Group 1), the halogens (Group 17) and the noble gases (Group 18). C7.2 Describe the trends in chemical reactivity and physical properties of the alkali metals (Group 1) and make predictions based on those trends. This includes knowledge of the relative positions of lithium, sodium and potassium in Group 1. C7.3 The halogens (Group 17): a. Describe the trends in chemical reactivity and physical properties of the halogens and make predictions based on those trends. This includes knowledge of the relative positions of fluorine, chlorine, bromine and iodine in Group 17. b. Explain what is meant by a displacement reaction, in terms of reactivity competition, between halogens and halide ions.
C8. Separation techniques	T37 Analytical techniques	C8.1 Know that chemical processes are required to displace constituent elements from their compounds.

ESAT Topic	CAIE Topic	NSAA Topic Details
		C8.2 Know that physical processes are required to separate mixtures, including miscible/immiscible liquids and dissolved/insoluble solids. C8.3 Know when to apply the following separation techniques: simple/fractional distillation, paper chromatography (including use of R_f values), use of a separating funnel, centrifugation, dissolving, filtration, evaporation and crystallisation. C8.4 Know how to establish the purity of a substance using chromatography.
C9. Acids, bases and salts	T7 Equilibria	C9.1 Acids: a. Define an acid as a substance that can form H^+(aq) ions or that is an H^+ donor. b. Describe reactions with metals, carbonates, metal hydroxides and metal oxides in which salts are formed. c. Understand the terms *strong*, *weak*, *dilute* and *concentrated*. d. Know that some oxides of non-metals react with water to form acidic solutions. e. Recall that pH is a measure of H^+ ion concentration, and recall that a change of 1 on the pH scale corresponds to a change by a factor of 10 in H^+ ion concentration. f. Know that one mole of some acidic substances is able to form/donate more than one mole of H^+ ions, including the use of the terms *mono-*, *di-*, *tri-*, and *polyprotic*. C9.2 Bases: a. Define a base as a substance that can form OH^-(aq) ions or that is an H^+ acceptor. b. Understand the terms *strong*, *weak*, *dilute* and *concentrated*. c. Know that some oxides and hydroxides of metals react with water to form alkaline solutions. C9.3 Know that the reaction of an acid with a base can lead to neutralisation and is often exothermic.
C10. Rates of reaction	5 Chemical energetics	C10.1 Describe the qualitative effects on a rate of reaction of concentration, temperature, particle size, a catalyst and, for gases, pressure. C10.2 Know that the rate of reaction can be found by measuring the loss of a reactant or the gain of a product, or by measurement of a physical property over time, and be able to identify which of these measurements can be used in a given situation. C10.3 Interpret data in graphical form concerning the rate of a reaction.

ESAT Topic	CAIE Topic	NSAA Topic Details
		C10.4 Use collision theory to explain changes in the rate of a reaction. C10.5 Understand that particles must have sufficient energy when they collide to react, and that this energy is called the activation energy (E_a). Identify the activation energy on an energy level diagram. C10.6 Know that catalysts: a. are not used up in a reaction. b. are chemically unchanged at the end of a reaction. c. provide an alternative route (reaction mechanism) with a lower activation energy, and interpret this effect on an energy level diagram. d. do not affect the position of an equilibrium. e. C11. Energetics C11.1 Understand the concepts of an exothermic reaction, for which ΔH is negative (negative enthalpy change), and an endothermic reaction, for which ΔH is positive (positive enthalpy change). C11.2 Know that if a reversible reaction is exothermic in one direction, it is endothermic in the other direction. C11.3 Be able to interpret energy level diagrams. C11.4 Be able to calculate energy changes from specific heat capacities and changes in temperature in calorimetry experiments. C11.5 Know that bond breaking is endothermic and bond formation is exothermic, and be able to use bond energy data to calculate energy changes.
C12. Electrolysis	T24 Electrochemistry	C12.1 Understand the terms *electrode, cathode (negative electrode), anode (positive electrode)* and *electrolyte*. C12.2 Understand why direct current (dc), and not alternating current (ac), is used in electrolysis. C12.3 Understand that in electrolysis at the cathode, the cations (positively charged ions) receive electrons (reduction) to change into atoms or molecules, and at the anode, the anions (negatively charged ions) lose electrons to form atoms or molecules (oxidation). C12.4 Understand and be able to predict the products of the electrolysis of the following: a. aqueous solutions (including those of salts), including situations where more than one ion/molecule is attracted to a single electrode b. molten binary compounds

ESAT Topic	CAIE Topic	NSAA Topic Details
		C12.5 Be able to write half-equations for the processes taking place at each electrode. C12.6 Explain how electrolysis is used to electroplate objects.
C13. Carbon/Organic chemistry	T13 An introduction to AS Level organic chemistry	C13.1 General concepts: a. Know that crude oil is the main source of hydrocarbons and that it is separated into fractions by fractional distillation (names and uses of specific fractions not expected). b. Understand the link between carbon chain length and the following trends in physical properties of hydrocarbons: boiling points, viscosity, flammability. c. Know the use of longer chain alkanes in cracking to form shorter chain alkanes and alkenes, and be able to write balanced chemical equations for these reactions. d. Understand structural isomerism and be able to recognise examples. e. Understand and be able to use the following terms: *molecular formula,* *full structural formula (displayed structure)* and *condensed structural formula*. f. Understand and be able to use the terms *complete combustion* and *incomplete combustion*, and be able to write balanced chemical equations for such reactions. g. Know the IUPAC guidelines for the systematic naming of carbon compounds, and apply the guidelines in order to be able to name all the compounds in this section of the specification. h. Know and understand the terms *homologous series* and *functional group*.
C13. Carbon/Organic chemistry	T14 Hydrocarbons	C13.2 Alkanes (saturated hydrocarbons): a. Describe alkanes as a homologous series with the general formula of C_nH_{2n+2}. b. Be able to name, or recognise from the name, the C1 to C6 straight-chain alkanes. C13.3 Alkenes (unsaturated hydrocarbons): a. Describe alkenes as a homologous series with a double bond and the general formula C_nH_{2n}. b. Be able to name, or recognise from the name, C2 to C6 straight-chain alkenes, including the position of the double bond. c. Recognise and be able to use the test for unsaturation with

ESAT Topic	CAIE Topic	NSAA Topic Details
		bromine water. d. Know that addition reactions take place with the following substances: hydrogen, halogens, hydrogen halides and steam. Be able to write the balanced chemical equations for these reactions and recognise the formulae of the products formed. (Mechanisms and consideration of carbocation stability are **not** required.)
C13. Carbon/Organic chemistry	T20 Polymerisation T35 Polymerisation	C13.4 Polymers: a. Addition polymerisation, polyalkenes: i. Know that alkenes or other molecules with a C=C bond may react with each other to form long-chain saturated molecules called polymers by addition reactions called polymerisation, and that the unsaturated molecules are called monomers. ii. If given an unsaturated monomer molecule, be able to recognise the structure of the polymer and *vice versa*. iii. Be able to recognise the repeating unit of these polymers. b. Condensation polymerisation, polyesters and polyamides (to include amino acids forming proteins): i. If given the monomer molecules, be able to recognise the structure of the polymer and *vice versa*. ii. Be able to recognise the repeating unit of these polymers. c. Understand the terms *biodegradable* and *non-biodegradable* when applied to polymers.
C13. Carbon/Organic chemistry	T16 Hydroxy compounds	C13.5 Alcohols: a. Describe alcohols as a homologous series with the general formula $C_nH_{2n+1}OH$. b. Be able to name, or recognise from the name, C1 to C6 straight-chain alcohols, including the position of the -OH group. c. Describe the reaction of alcohols with sodium metal.
C13. Carbon/Organic chemistry	T17 Carbonyl compounds	C13.6 Carboxylic acids: a. Describe carboxylic acids as a homologous series with the general formula $C_nH_{2n+1}COOH$. b. Be able to name, or recognise from the name, C1 to C6 straight-chain carboxylic acids. c. Describe the chemical properties of carboxylic acids as those of weak acids, and so be able to predict their reactions and

ESAT Topic	CAIE Topic	NSAA Topic Details
		determine the formulae of their salts. d. Know that carboxylic acids react with alcohols in the presence of an acid catalyst to produce esters.
C14. Metals	iGCSE Topic 9 Metals A Level T28 is not a good match (nothing on extraction, too much on d orbitals)	C14.1 Understand that the reactivity of a metal is linked to its tendency to form positive ions and the ease of extraction of the metal. C14.2 Be able to use displacement reactions to establish the order of reactivity of metals and *vice versa*. C14.3 Describe how the uses of metals are related to their physical and chemical properties, e.g. Al, Fe, Cu, Ag, Au, Ti, and understand that alloys can be formed to produce materials with specific properties. C14.4 Know that most metal ores are the oxides of the metal, and that the extraction of metals always involves reduction processes. C14.5 Know that common properties of transition metals include: a. they are able to form stable ions in different oxidation states b. they often form coloured compounds c. they are often used as catalysts (as ions or atoms)
C15. Kinetic/Particle theory	T8 Reaction kinetics	C15.1 Be able to describe the packing and movement of particles in the three states of matter: solid, liquid and gas. C15.2 Understand the changes to the packing and movement of particles in the following changes of state: freezing, melting, boiling/evaporating, and condensing. Understand that the energy required for these processes is related to the bonding and structure of the substance, including a consideration of intermolecular forces.
C16. Chemical tests	iGCSE Topic 12 (no direct topic present at AS or A2, but these tests are required for Paper 3)	C16.1 Know and recognise the following tests for gases: a. hydrogen – explodes with a 'squeaky pop' when a burning splint is held at the open end of a test tube b. oxygen – relights a glowing splint c. carbon dioxide – limewater turns cloudy when shaken with the gas d. chlorine – damp blue litmus paper turns red and then is bleached (paper turns white) C16.2 Know, recognise and describe the following tests for the anions: a. carbonates – using a dilute acid b. halides – using an aqueous solution of silver nitrate in the presence of dilute nitric acid (chlorides form a white precipitate; bromides form a cream precipitate; iodides

ESAT Topic	CAIE Topic	NSAA Topic Details
		form a yellow precipitate) c. sulfates – using an aqueous solution of barium chloride in the presence of dilute hydrochloric acid C16.3 Know and recognise the test for the following metal cations using aqueous sodium hydroxide: a. Al^{3+}, Ca^{2+} and Mg^{2+} each form a white precipitate. b. Cu^{2+} forms a blue precipitate. c. Fe^{2+} forms a green precipitate. d. Fe^{3+} forms a brown precipitate. C16.4 Recall and recognise the flame test for the cations of the following metals: Li (crimson red), Na (yellow-orange), K (lilac), Ca (red-orange), Cu (green) C16.5 Know and recognise the test for the presence of water using anhydrous copper(II) sulfate (colour change from white to blue).
C17. Air and water	iGCSE Topic 10 Chemistry and the environment	C17.1 Know and be able to use the composition of dry air, and understand that fractional distillation can be used to separate the components of air. C17.2 Know the origins and describe the effects of greenhouse gases such as CO_2 and CH_4. C17.3 Know the origins and effects of gaseous pollutants such as CO, CO_2, SO_2 and NO_x. C17.4 Know the purpose of chlorine and fluoride ions in the treatment of drinking water.

April

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

May

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

June

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

July

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

August

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

September

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

October

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

November

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

December

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

January

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

February

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	

March

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

April

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

May

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

June

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

Cambridge Final Exam Timetable November 2024

Administrative zone 5

Cambridge Final Exam Timetable November 2024

Syllavus view (A–Z)

CAMBRIDGE
International Education

Cambridge International AS Level

Syllabus/Component	Code	Duration	Date	Session
A				
Accounting (Multiple Choice)	9706/12	1h	Tuesday 12 November 2024	PM
Accounting	9706/22	1h 45m	Thursday 17 October 2024	PM
Afrikaans Language	8679/02	1h 45m	Tuesday 08 October 2024	AM
Afrikaans Language	8679/03	1h 30m	Tuesday 01 October 2024	AM
B				
Biblical Studies	9484/13	1h 30m	Thursday 24 October 2024	EV
Biblical Studies	9484/23	1h 30m	Monday 28 October 2024	EV
Biology (Multiple Choice)	9700/13	1h 15m	Tuesday 12 November 2024	AM
Biology	9700/23	1h 15m	Tuesday 22 October 2024	AM
Biology (Practical - Advanced)	9700/35	2h	Tuesday 08 October 2024	AM
Biology (Practical - Advanced)	9700/36	2h	Tuesday 05 November 2024	AM
Business	9609/12	1h 15m	Monday 07 October 2024	PM
Business	9609/22	1h 30m	Thursday 10 October 2024	PM
C				
Chemistry (Multiple Choice)	9701/13	1h 15m	Thursday 14 November 2024	AM
Chemistry	9701/23	1h 15m	Friday 18 October 2024	AM
Chemistry (Practical - Advanced)	9701/35	2h	Tuesday 01 October 2024	AM
Chemistry (Practical - Advanced)	9701/36	2h	Tuesday 29 October 2024	AM
Biblical Studies	9484/43	1h 30m	Monday 11 November 2024	EV
Biology	9700/43	2h	Friday 25 October 2024	AM
Biology	9700/53	1h 15m	Tuesday 22 October 2024	AM
C				
Chemistry	9701/43	2h	Monday 04 November 2024	AM
Chemistry	9701/53	1h 15m	Friday 18 October 2024	AM

Syllabus/Component	Code	Duration	Date	Session
G				
Geography (Core)	9696/13	1h 30m	Monday 21 October 2024	AM
Geography (Core)	9696/23	1h 30m	Friday 25 October 2024	AM
German Language	8683/23	1h 45m	Monday 28 October 2024	AM
German Language	8683/33	1h 30m	Thursday 03 October 2024	AM
Global Perspectives & Research	9239/12	1h 30m	Tuesday 01 October 2024	PM
H				
History	9489/12	1h 15m	Thursday 17 October 2024	PM
History	9489/22	1h 45m	Monday 21 October 2024	PM
I				
Information Technology	9626/13	1h 45m	Friday 11 October 2024	AM
L				
Language & Literature in English	8695/13	2h	Thursday 31 October 2024	AM
Language & Literature in English	8695/23	2h	Monday 14 October 2024	AM
Law	9084/12	1h 30m	Monday 30 September 2024	PM
Law	9084/22	1h 30m	Wednesday 02 October 2024	PM
Literature in English	9695/13	2h	Monday 14 October 2024	AM
Literature in English	9695/23	2h	Friday 25 October 2024	AM
M				
M				
Marine Science	9693/33	1h 45m	Tuesday 29 October 2024	AM
Marine Science	9693/43	1h 45m	Friday 01 November 2024	AM

Planning your days **V1.0**

Period	Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
	5:00 am							
	5:30 am							
	6:00 am							
	6:30 am							
	7:00 am							
Regstn	7:25 am							
1	7:50 am							
2	8:40 am							
3	9:30 am							
4	10:20 am							
5	11:00 am							
Lunch	11:50 pm							
6	1:10 pm							
7	2:00pm							
8	2:50 pm							
9	3:40 pm							
	4:20 pm							
	5:00 pm							
	5:30 pm							
	6:00 pm							
	6:30 pm							
	7:00 pm							
	7:30 pm							
	8:00 pm							
	8:30 pm							
	9:00 pm							
	9:30 pm							
	10:00 pm							
	10:30 pm							

Planning your days – v2.0

Period	Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
	5:00 am							
	5:30 am							
	6:00 am							
	6:30 am							
	7:00 am							
Regstn	7:25 am							
1	7:50 am							
2	8:40 am							
3	9:30 am							
4	10:20 am							
5	11:00 am							
Lunch	11:50 pm							
6	1:10 pm							
7	2:00pm							
8	2:50 pm							
9	3:40 pm							
	4:20 pm							
	5:00 pm							
	5:30 pm							
	6:00 pm							
	6:30 pm							
	7:00 pm							
	7:30 pm							
	8:00 pm							
	8:30 pm							
	9:00 pm							
	9:30 pm							
	10:00 pm							
	10:30 pm							

Planning your days – v3.0

Period	Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
	5:00 am							
	5:30 am							
	6:00 am							
	6:30 am							
	7:00 am							
Regstn	7:25 am							
1	7:50 am							
2	8:40 am							
3	9:30 am							
4	10:20 am							
5	11:00 am							
Lunch	11:50 pm							
6	1:10 pm							
7	2:00pm							
8	2:50 pm							
9	3:40 pm							
	4:20 pm							
	5:00 pm							
	5:30 pm							
	6:00 pm							
	6:30 pm							
	7:00 pm							
	7:30 pm							
	8:00 pm							
	8:30 pm							
	9:00 pm							
	9:30 pm							
	10:00 pm							
	10:30 pm							

Planning your days – v4.0

Period	Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
	5:00 am							
	5:30 am							
	6:00 am							
	6:30 am							
	7:00 am							
Regstn	7:25 am							
1	7:50 am							
2	8:40 am							
3	9:30 am							
4	10:20 am							
5	11:00 am							
Lunch	11:50 pm							
6	1:10 pm							
7	2:00pm							
8	2:50 pm							
9	3:40 pm							
	4:20 pm							
	5:00 pm							
	5:30 pm							
	6:00 pm							
	6:30 pm							
	7:00 pm							
	7:30 pm							
	8:00 pm							
	8:30 pm							
	9:00 pm							
	9:30 pm							
	10:00 pm							
	10:30 pm							

Appendix - Admissions statistics for China, HK/TW & SG and all Internationals for 2019-22 entry[42]

Applications, Offers and Acceptances by Domicile – ordered by year of entry, then by college

		International (non-UK)				China				Hong Kong/Macao/Taiwan				Singapore			
Entry Year	**College**	**Apps.**	**Offers**	**Accept.**	**Success rate %**	**Apps.**	**Offers**	**Accept.**	**Success rate %**	**Apps.**	**Offers**	**Accept.**	**Success rate %**	**Apps.**	**Offers**	**Accept.**	**Success rate %**
2019	Christ's	285	60	43	**21**	38	6	4	**16**	22	1	0	**5**	27	8	6	**30**
2019	Churchill	363	49	29	**13**	70	12	5	**17**	33	5	4	**15**	21	3	<3	**14**
2019	Clare	223	31	28	**14**	29	7	7	**24**	15	1	<3	**7**	14	1	<3	**7**
2019	Corpus Christi	200	27	19	**14**	41	3	<3	**7**	13	4	<3	**31**	15	1	<3	**7**
2019	Downing	246	30	26	**12**	53	7	7	**13**	25	3	3	**12**	14	1	<3	**7**
2019	Emmanuel	202	28	23	**14**	18	4	<3	**22**	28	5	4	**18**	15	4	4	**27**
2019	Fitzwilliam	194	33	24	**17**	70	17	14	**24**	18	1	<3	**6**	17	1	<3	**6**
2019	Girton	215	35	22	**16**	42	7	5	**17**	15	3	<3	**20**	9	5	4	**56**
2019	Gonville and Caius	289	40	35	**14**	37	5	4	**14**	27	3	3	**11**	18	1	<3	**6**
2019	Homerton	297	68	54	**23**	80	15	13	**19**	33	9	9	**27**	8	0	0	**0**
2019	Hughes Hall	131	47	30	**36**	<3	5	<3		5	1	<3	**20**	22	17	13	**77**
2019	Jesus	224	18	14	**8**	27	1	<3	**4**	22	5	5	**23**	11	1	0	**9**
2019	King's	375	32	23	**9**	51	5	3	**10**	26	1	<3	**4**	22	1	<3	**5**
2019	Lucy Cavendish	83	26	23	**31**	<3	1	<3		0	1	<3		3	1	<3	**33**
2019	Magdalene	216	37	25	**17**	55	13	9	**24**	32	6	5	**19**	20	4	4	**20**
2019	Murray Edwards	193	40	27	**21**	35	11	7	**31**	7	4	3	**57**	12	5	<3	**42**
2019	Newnham	190	37	30	**19**	53	8	6	**15**	14	1	<3	**7**	14	3	3	**21**
2019	Pembroke	247	32	22	**13**	35	3	<3	**9**	20	1	<3	**5**	14	1	<3	**7**
2019	Peterhouse	208	37	27	**18**	34	10	7	**29**	18	0	0	**0**	16	4	3	**25**
2019	Queens'	264	45	36	**17**	54	10	9	**19**	12	4	<3	**33**	15	3	3	**20**
2019	Robinson	217	31	25	**14**	58	14	11	**24**	27	3	<3	**11**	12	1	<3	**8**
2019	Selwyn	159	25	19	**16**	38	7	7	**18**	15	4	3	**27**	15	1	<3	**7**
2019	Sidney Sussex	159	30	28	**19**	28	4	4	**14**	13	1	<3	**8**	4	3	3	**75**
2019	St Catharine's	281	34	29	**12**	38	3	<3	**8**	26	1	<3	**4**	19	1	<3	**5**
2019	St Edmund's	117	36	27	**31**	9	1	0	**11**	7	1	<3	**14**	17	11	10	**65**
2019	St John's	372	58	42	**16**	66	7	7	**11**	35	9	7	**26**	24	4	3	**17**
2019	Trinity	627	99	77	**16**	80	16	13	**20**	31	7	3	**23**	34	1	<3	**3**
2019	Trinity Hall	155	27	16	**17**	17	4	<3	**24**	18	6	4	**33**	15	1	<3	**7**
2019	Wolfson	111	35	29	**32**	<3	1	<3		4	0	0	**0**	20	11	9	**55**
2019	**Totals**	**6843**	**1127**	**852**	**18**	**1156**	**207**	**142**	**17**	**561**	**91**	**53**	**17**	**467**	**99**	**65**	**23**

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		International (non-UK)				China				Hong Kong/Macao/Taiwan				Singapore			
Entry Year	College	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %
2020	Christ's	305	61	44	**20**	61	11	7	**18**	14	4	4	**29**	22	9	5	**41**
2020	Churchill	391	65	36	**17**	78	21	11	**27**	33	4	3	**12**	31	1	<3	**3**
2020	Clare	206	31	23	**15**	39	6	6	**15**	27	1	<3	**4**	13	1	<3	**8**
2020	Corpus Christi	173	19	14	**11**	38	6	6	**16**	15	1	<3	**7**	18	1	<3	**6**
2020	Downing	237	36	30	**15**	40	6	5	**15**	47	7	5	**15**	22	5	4	**23**
2020	Emmanuel	192	27	20	**14**	25	6	5	**24**	15	1	<3	**7**	17	3	<3	**18**
2020	Fitzwilliam	216	36	26	**17**	96	21	16	**22**	22	1	<3	**5**	17	1	0	**6**
2020	Girton	254	43	32	**17**	66	8	5	**12**	25	4	4	**16**	10	1	<3	**10**
2020	Gonville and Caius	258	37	30	**14**	34	6	4	**18**	23	3	3	**13**	19	3	<3	**16**
2020	Homerton	332	62	47	**19**	113	23	18	**20**	35	4	<3	**11**	18	4	0	**22**
2020	Hughes Hall	149	46	33	**31**	10	4	3	**40**	10	4	3	**40**	22	19	15	**86**
2020	Jesus	198	20	14	**10**	33	3	<3	**9**	17	1	<3	**6**	7	1	0	**14**
2020	King's	357	47	36	**13**	34	7	4	**21**	21	6	5	**29**	26	1	<3	**4**
2020	Lucy Cavendish	69	21	18	**30**	<3	1	<3		3	0	<3	**0**	<3	1	<3	
2020	Magdalene	218	55	36	**25**	50	18	11	**36**	34	11	7	**32**	18	6	3	**33**
2020	Murray Edwards	197	26	15	**13**	49	7	6	**14**	4	3	3	**75**	15	4	<3	**27**
2020	Newnham	188	38	26	**20**	45	12	5	**27**	19	4	4	**21**	12	1	<3	**8**
2020	Pembroke	220	26	20	**12**	34	6	3	**18**	20	1	<3	**5**	10	1	0	**10**
2020	Peterhouse	191	40	34	**21**	40	9	8	**23**	20	5	5	**25**	8	1	<3	**13**
2020	Queens'	279	31	23	**11**	54	11	9	**20**	23	4	3	**17**	11	1	<3	**9**
2020	Robinson	219	32	24	**15**	77	13	9	**17**	22	1	<3	**5**	5	1	<3	**20**
2020	Selwyn	176	29	28	**16**	47	9	8	**19**	22	5	6	**23**	11	1	<3	**9**
2020	Sidney Sussex	205	27	17	**13**	53	8	7	**15**	14	1	<3	**7**	6	1	<3	**17**
2020	St Catharine's	255	33	28	**13**	47	7	5	**15**	22	4	4	**18**	25	5	5	**20**
2020	St Edmund's	107	26	20	**24**	7	4	<3	**57**	3	1	<3	**33**	11	11	9	**100**
2020	St John's	453	49	38	**11**	38	6	4	**16**	35	8	8	**23**	18	4	<3	**22**
2020	Trinity	660	97	72	**15**	85	17	14	**20**	30	9	8	**30**	44	10	5	**23**
2020	Trinity Hall	182	24	20	**13**	35	9	9	**26**	16	3	<3	**19**	12	1	3	**8**
2020	Wolfson	86	26	23	**30**	<3	1	<3		<3	0	0		14	6	6	**43**
2020	**Totals**	**6973**	**1110**	**827**	**17**	**1328**	**266**	**188**	**21**	**591**	**101**	**75**	**19**	**462**	**105**	**55**	**22**

		International (non-UK)				China				Hong Kong/Macao/Taiwan				Singapore			
Entry Year	College	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %
2021	Christ's	365	54	38	15	66	13	8	20	31	5	4	16	36	8	6	22
2021	Churchill	448	48	30	11	143	16	11	11	39	6	4	15	31	1	<3	3
2021	Clare	257	25	20	10	55	8	7	15	18	3	3	17	17	0	0	0
2021	Corpus Christi	224	23	21	10	52	9	9	17	20	3	<3	15	20	3	3	15
2021	Downing	291	27	25	9	60	9	9	15	46	5	5	11	28	3	3	11
2021	Emmanuel	195	22	15	11	54	6	4	11	17	4	3	24	11	3	3	27
2021	Fitzwilliam	295	43	34	15	131	25	20	19	24	3	3	13	28	4	4	14
2021	Girton	265	29	19	11	89	10	7	11	20	3	<3	15	11	1	0	9
2021	Gonville and Caius	284	31	24	11	70	6	6	9	25	1	<3	4	16	0	0	0
2021	Homerton	423	60	48	14	200	27	21	14	46	5	5	11	18	1	<3	6
2021	Hughes Hall	168	60	37	36	10	7	3	70	7	6	4	86	22	20	14	91
2021	Jesus	210	21	15	10	40	1	0	3	20	1	<3	5	11	1	<3	9
2021	King's	388	38	26	10	53	5	3	9	11	1	<3	9	24	1	<3	4
2021	Lucy Cavendish	167	65	46	39	43	9	8	21	14	6	5	43	<3	11	6	
2021	Magdalene	250	33	19	13	73	12	7	16	41	6	6	15	19	6	3	32
2021	Murray Edwards	219	27	20	12	76	10	9	13	8	1	<3	13	9	4	3	44
2021	Newnham	185	30	24	16	58	11	9	19	9	1	<3	11	7	1	0	14
2021	Pembroke	264	24	17	9	50	8	4	16	28	4	<3	14	16	0	0	0
2021	Peterhouse	210	38	25	18	48	6	4	13	20	5	4	25	9	1	<3	11
2021	Queens'	308	34	23	11	74	6	5	8	33	6	4	18	18	3	3	17
2021	Robinson	266	30	26	11	111	16	15	14	30	3	3	10	10	1	0	10
2021	Selwyn	204	22	16	11	75	8	6	11	18	3	3	17	12	1	0	8
2021	Sidney Sussex	194	21	18	11	67	7	6	10	18	0	0	0	9	1	<3	11
2021	St Catharine's	271	25	23	9	80	9	7	11	31	1	<3	3	20	3	<3	15
2021	St Edmund's	122	51	35	42	7	3	0	43	6	1	<3	17	13	23	17	177
2021	St John's	441	39	31	9	65	7	7	11	45	6	6	13	35	4	<3	11
2021	Trinity	718	108	77	15	94	21	15	22	31	5	5	16	53	12	10	23
2021	Trinity Hall	194	23	17	12	46	5	4	11	22	5	5	23	12	1	<3	8
2021	Wolfson	136	37	31	27	9	4	3	44	8	1	<3	13	18	11	9	61
2021	**Totals**	**7962**	**1088**	**800**	**15**	**1999**	**284**	**217**	**17**	**686**	**100**	**72**	**17**	**533**	**129**	**84**	**23**

		International (non-UK)				China				Hong Kong/Macao/Taiwan				Singapore			
Entry Year	College	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %
2022	Christ's	369	60	47	**16**	83	13	9	**16**	20	1	<3	**5**	55	11	9	**20**
2022	Churchill	428	38	32	**9**	116	9	7	**8**	35	4	4	**11**	37	6	5	**16**
2022	Clare	249	24	17	**10**	53	7	7	**13**	21	3	<3	**14**	10	1	<3	**10**
2022	Corpus Christi	209	20	15	**10**	67	6	4	**9**	17	1	<3	**6**	14	1	<3	**7**
2022	Downing	248	28	20	**11**	38	3	4	**8**	35	6	7	**17**	26	4	3	**15**
2022	Emmanuel	253	29	26	**11**	60	6	5	**10**	24	5	5	**21**	24	3	3	**13**
2022	Fitzwilliam	327	29	27	**9**	167	14	13	**8**	11	1	<3	**9**	29	3	3	**10**
2022	Girton	220	26	19	**12**	109	14	10	**13**	20	5	4	**25**	9	0	0	**0**
2022	Gonville and Caius	240	25	19	**10**	58	5	4	**9**	23	0	0	**0**	20	1	0	**5**
2022	Homerton	462	62	47	**13**	227	26	22	**11**	36	4	3	**11**	22	8	6	**36**
2022	Hughes Hall	150	59	38	**39**	7	6	4	**86**	6	4	3	**67**	22	22	18	**100**
2022	Jesus	206	17	14	**8**	34	1	<3	**3**	13	1	<3	**8**	14	0	0	**0**
2022	King's	336	26	22	**8**	54	1	<3	**2**	19	1	<3	**5**	25	5	5	**20**
2022	Lucy Cavendish	226	61	40	**27**	91	18	11	**20**	18	4	<3	**22**	4	9	8	**225**
2022	Magdalene	263	37	25	**14**	96	17	13	**18**	34	6	5	**18**	20	1	<3	**5**
2022	Murray Edwards	156	26	14	**17**	84	16	8	**19**	6	1	<3	**17**	3	3	<3	**100**
2022	Newnham	197	26	22	**13**	70	13	10	**19**	14	4	3	**29**	13	1	<3	**8**
2022	Pembroke	238	25	17	**11**	50	4	3	**8**	24	4	3	**17**	27	3	<3	**11**
2022	Peterhouse	218	37	25	**17**	48	7	6	**15**	22	1	<3	**5**	18	3	<3	**17**
2022	Queens'	343	37	28	**11**	91	12	8	**13**	24	1	<3	**4**	23	6	6	**26**
2022	Robinson	241	29	22	**12**	110	14	11	**13**	25	5	3	**20**	10	0	0	**0**
2022	Selwyn	218	33	26	**15**	84	12	8	**14**	18	4	3	**22**	15	3	<3	**20**
2022	Sidney Sussex	177	25	20	**14**	70	9	7	**13**	20	5	4	**25**	12	1	<3	**8**
2022	St Catharine's	291	24	17	**8**	81	11	10	**14**	39	1	<3	**3**	28	3	<3	**11**
2022	St Edmund's	97	38	31	**39**	10	3	<3	**30**	7	1	0	**14**	16	14	15	**88**
2022	St John's	357	46	31	**13**	65	15	11	**23**	40	8	5	**20**	27	6	3	**22**
2022	Trinity	644	107	69	**17**	82	22	19	**27**	27	5	4	**19**	59	13	7	**22**
2022	Trinity Hall	213	14	11	**7**	71	5	7	**7**	19	3	<3	**16**	10	1	<3	**10**
2022	Wolfson	103	34	30	**33**	5	5	4	**100**	0	1	<3		23	13	12	**57**
2022	Totals	7679	1042	771	**15**	2181	294	225	**19**	617	90	56	16	615	145	103	**30**

Applications, Offers and Acceptances by Domicile – ordered by success rate for non-UK students

		International (non-UK)				China				Hong Kong/Macao/Taiwan				Singapore			
Entry Year	**College**	**Apps.**	**Offers**	**Accept.**	**Success rate %**	**Apps.**	**Offers**	**Accept.**	**Success rate %**	**Apps.**	**Offers**	**Accept.**	**Success rate %**	**Apps.**	**Offers**	**Accept.**	**Success rate %**
2019	**Totals**	**6843**	**1127**	**852**	**18**	**1156**	**207**	**142**	**17**	**561**	**91**	**53**	**17**	**467**	**99**	**65**	**23**
2020	**Totals**	**6973**	**1110**	**827**	**17**	**1328**	**266**	**188**	**21**	**591**	**101**	**75**	**19**	**462**	**105**	**55**	**22**
2021	**Totals**	**7962**	**1088**	**800**	**15**	**1999**	**284**	**217**	**17**	**686**	**100**	**72**	**17**	**533**	**129**	**84**	**23**
2022	Totals	7679	1042	771	**15**	2181	294	225	**19**	617	90	56	16	615	145	103	**30**
2021	St Edmund's	122	51	35	**42**	7	3	0	**43**	6	1	<3	**17**	13	23	17	**177**
2021	Lucy Cavendish	167	65	46	**39**	43	9	8	**21**	14	6	5	**43**	<3	11	6	
2022	Hughes Hall	150	59	38	**39**	7	6	4	**86**	6	4	3	**67**	22	22	18	**100**
2022	St Edmund's	97	38	31	**39**	10	3	<3	**30**	7	1	0	**14**	16	14	15	**88**
2019	Hughes Hall	131	47	30	**36**	<3	5	<3		5	1	<3	**20**	22	17	13	**77**
2021	Hughes Hall	168	60	37	**36**	10	7	3	**70**	7	6	4	**86**	22	20	14	**91**
2022	Wolfson	103	34	30	**33**	5	5	4	**100**	0	1	<3		23	13	12	**57**
2019	Wolfson	111	35	29	**32**	<3	1	<3		4	0	0	**0**	20	11	9	**55**
2019	Lucy Cavendish	83	26	23	**31**	<3	1	<3		0	1	<3		3	1	<3	**33**
2019	St Edmund's	117	36	27	**31**	9	1	0	**11**	7	1	<3	**14**	17	11	10	**65**
2020	Hughes Hall	149	46	33	**31**	10	4	3	**40**	10	4	3	**40**	22	19	15	**86**
2020	Lucy Cavendish	69	21	18	**30**	<3	1	<3		3	0	<3	**0**	<3	1	<3	
2020	Wolfson	86	26	23	**30**	<3	1	<3		<3	0	0		14	6	6	**43**
2021	Wolfson	136	37	31	**27**	9	4	3	**44**	8	1	<3	**13**	18	11	9	**61**
2022	Lucy Cavendish	226	61	40	**27**	91	18	11	**20**	18	4	<3	**22**	4	9	8	**225**
2020	Magdalene	218	55	36	**25**	50	18	11	**36**	34	11	7	**32**	18	6	3	**33**
2020	St Edmund's	107	26	20	**24**	7	4	<3	**57**	3	1	<3	**33**	11	11	9	**100**
2019	Homerton	297	68	54	**23**	80	15	13	**19**	33	9	9	**27**	8	0	0	**0**
2019	Christ's	285	60	43	**21**	38	6	4	**16**	22	1	0	**5**	27	8	6	**30**
2019	Murray Edwards	193	40	27	**21**	35	11	7	**31**	7	4	3	**57**	12	5	<3	**42**
2020	Peterhouse	191	40	34	**21**	40	9	8	**23**	20	5	5	**25**	8	1	<3	**13**
2020	Christ's	305	61	44	**20**	61	11	7	**18**	14	4	4	**29**	22	9	5	**41**
2020	Newnham	188	38	26	**20**	45	12	5	**27**	19	4	4	**21**	12	1	<3	**8**
2019	Newnham	190	37	30	**19**	53	8	6	**15**	14	1	<3	**7**	14	3	3	**21**
2019	Sidney Sussex	159	30	28	**19**	28	4	4	**14**	13	1	<3	**8**	4	3	3	**75**

		International (non-UK)				China				Hong Kong/Macao/Taiwan				Singapore			
Entry Year	College	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %
2020	Homerton	332	62	47	**19**	113	23	18	**20**	35	4	<3	**11**	18	4	0	**22**
2019	Peterhouse	208	37	27	**18**	34	10	7	**29**	18	0	0	**0**	16	4	3	**25**
2021	Peterhouse	210	38	25	**18**	48	6	4	**13**	20	5	4	**25**	9	1	<3	**11**
2019	Fitzwilliam	194	33	24	**17**	70	17	14	**24**	18	1	<3	**6**	17	1	<3	**6**
2019	Magdalene	216	37	25	**17**	55	13	9	**24**	32	6	5	**19**	20	4	4	**20**
2019	Queens'	264	45	36	**17**	54	10	9	**19**	12	4	<3	**33**	15	3	3	**20**
2019	Trinity Hall	155	27	16	**17**	17	4	<3	**24**	18	6	4	**33**	15	1	<3	**7**
2020	Churchill	391	65	36	**17**	78	21	11	**27**	33	4	3	**12**	31	1	<3	**3**
2020	Fitzwilliam	216	36	26	**17**	96	21	16	**22**	22	1	<3	**5**	17	1	0	**6**
2020	Girton	254	43	32	**17**	66	8	5	**12**	25	4	4	**16**	10	1	<3	**10**
2022	Murray Edwards	156	26	14	**17**	84	16	8	**19**	6	1	<3	**17**	3	3	<3	**100**
2022	Peterhouse	218	37	25	**17**	48	7	6	**15**	22	1	<3	**5**	18	3	<3	**17**
2022	Trinity	644	107	69	**17**	82	22	19	**27**	27	5	4	**19**	59	13	7	**22**
2019	Girton	215	35	22	**16**	42	7	5	**17**	15	3	<3	**20**	9	5	4	**56**
2019	Selwyn	159	25	19	**16**	38	7	7	**18**	15	4	3	**27**	15	1	<3	**7**
2019	St John's	372	58	42	**16**	66	7	7	**11**	35	9	7	**26**	24	4	3	**17**
2019	Trinity	627	99	77	**16**	80	16	13	**20**	31	7	3	**23**	34	1	<3	**3**
2020	Selwyn	176	29	28	**16**	47	9	8	**19**	22	5	6	**23**	11	1	<3	**9**
2021	Newnham	185	30	24	**16**	58	11	9	**19**	9	1	<3	**11**	7	1	0	**14**
2022	Christ's	369	60	47	**16**	83	13	9	**16**	20	1	<3	**5**	55	11	9	**20**
2020	Clare	206	31	23	**15**	39	6	6	**15**	27	1	<3	**4**	13	1	<3	**8**
2020	Downing	237	36	30	**15**	40	6	5	**15**	47	7	5	**15**	22	5	4	**23**
2020	Robinson	219	32	24	**15**	77	13	9	**17**	22	1	<3	**5**	5	1	<3	**20**
2020	Trinity	660	97	72	**15**	85	17	14	**20**	30	9	8	**30**	44	10	5	**23**
2021	Christ's	365	54	38	**15**	66	13	8	**20**	31	5	4	**16**	36	8	6	**22**
2021	Fitzwilliam	295	43	34	**15**	131	25	20	**19**	24	3	3	**13**	28	4	4	**14**
2021	Trinity	718	108	77	**15**	94	21	15	**22**	31	5	5	**16**	53	12	10	**23**
2022	Selwyn	218	33	26	**15**	84	12	8	**14**	18	4	3	**22**	15	3	<3	**20**
2019	Clare	223	31	28	**14**	29	7	7	**24**	15	1	<3	**7**	14	1	<3	**7**
2019	Corpus Christi	200	27	19	**14**	41	3	<3	**7**	13	4	<3	**31**	15	1	<3	**7**
2019	Emmanuel	202	28	23	**14**	18	4	<3	**22**	28	5	4	**18**	15	4	4	**27**
2019	Gonville and Caius	289	40	35	**14**	37	5	4	**14**	27	3	3	**11**	18	1	<3	**6**

		International (non-UK)				China				Hong Kong/Macao/Taiwan				Singapore			
Entry Year	College	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %
2019	Robinson	217	31	25	**14**	58	14	11	**24**	27	3	<3	**11**	12	1	<3	**8**
2020	Emmanuel	192	27	20	**14**	25	6	5	**24**	15	1	<3	**7**	17	3	<3	**18**
2020	Gonville and Caius	258	37	30	**14**	34	6	4	**18**	23	3	3	**13**	19	3	<3	**16**
2021	Homerton	423	60	48	**14**	200	27	21	**14**	46	5	5	**11**	18	1	<3	**6**
2022	Magdalene	263	37	25	**14**	96	17	13	**18**	34	6	5	**18**	20	1	<3	**5**
2022	Sidney Sussex	177	25	20	**14**	70	9	7	**13**	20	5	4	**25**	12	1	<3	**8**
2019	Churchill	363	49	29	**13**	70	12	5	**17**	33	5	4	**15**	21	3	<3	**14**
2019	Pembroke	247	32	22	**13**	35	3	<3	**9**	20	1	<3	**5**	14	1	<3	**7**
2020	King's	357	47	36	**13**	34	7	4	**21**	21	6	5	**29**	26	1	<3	**4**
2020	Murray Edwards	197	26	15	**13**	49	7	6	**14**	4	3	3	**75**	15	4	<3	**27**
2020	Sidney Sussex	205	27	17	**13**	53	8	7	**15**	14	1	<3	**7**	6	1	<3	**17**
2020	St Catharine's	255	33	28	**13**	47	7	5	**15**	22	4	4	**18**	25	5	5	**20**
2020	Trinity Hall	182	24	20	**13**	35	9	9	**26**	16	3	<3	**19**	12	1	3	**8**
2021	Magdalene	250	33	19	**13**	73	12	7	**16**	41	6	6	**15**	19	6	3	**32**
2022	Homerton	462	62	47	**13**	227	26	22	**11**	36	4	3	**11**	22	8	6	**36**
2022	Newnham	197	26	22	**13**	70	13	10	**19**	14	4	3	**29**	13	1	<3	**8**
2022	St John's	357	46	31	**13**	65	15	11	**23**	40	8	5	**20**	27	6	3	**22**
2019	Downing	246	30	26	**12**	53	7	7	**13**	25	3	3	**12**	14	1	<3	**7**
2019	St Catharine's	281	34	29	**12**	38	3	<3	**8**	26	1	<3	**4**	19	1	<3	**5**
2020	Pembroke	220	26	20	**12**	34	6	3	**18**	20	1	<3	**5**	10	1	0	**10**
2021	Murray Edwards	219	27	20	**12**	76	10	9	**13**	8	1	<3	**13**	9	4	3	**44**
2021	Trinity Hall	194	23	17	**12**	46	5	4	**11**	22	5	5	**23**	12	1	<3	**8**
2022	Girton	220	26	19	**12**	109	14	10	**13**	20	5	4	**25**	9	0	0	**0**
2022	Robinson	241	29	22	**12**	110	14	11	**13**	25	5	3	**20**	10	0	0	**0**
2020	Corpus Christi	173	19	14	**11**	38	6	6	**16**	15	1	<3	**7**	18	1	<3	**6**
2020	Queens'	279	31	23	**11**	54	11	9	**20**	23	4	3	**17**	11	1	<3	**9**
2020	St John's	453	49	38	**11**	38	6	4	**16**	35	8	8	**23**	18	4	<3	**22**
2021	Churchill	448	48	30	**11**	143	16	11	**11**	39	6	4	**15**	31	1	<3	**3**
2021	Emmanuel	195	22	15	**11**	54	6	4	**11**	17	4	3	**24**	11	3	3	**27**
2021	Girton	265	29	19	**11**	89	10	7	**11**	20	3	<3	**15**	11	1	0	**9**
2021	Gonville and Caius	284	31	24	**11**	70	6	6	**9**	25	1	<3	**4**	16	0	0	**0**

		International (non-UK)				China				Hong Kong/Macao/Taiwan				Singapore			
Entry Year	College	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %	Apps.	Offers	Accept.	Success rate %
2021	Queens'	308	34	23	**11**	74	6	5	**8**	33	6	4	**18**	18	3	3	**17**
2021	Robinson	266	30	26	**11**	111	16	15	**14**	30	3	3	**10**	10	1	0	**10**
2021	Selwyn	204	22	16	**11**	75	8	6	**11**	18	3	3	**17**	12	1	0	**8**
2021	Sidney Sussex	194	21	18	**11**	67	7	6	**10**	18	0	0	**0**	9	1	<3	**11**
2022	Downing	248	28	20	**11**	38	3	4	**8**	35	6	7	**17**	26	4	3	**15**
2022	Emmanuel	253	29	26	**11**	60	6	5	**10**	24	5	5	**21**	24	3	3	**13**
2022	Pembroke	238	25	17	**11**	50	4	3	**8**	24	4	3	**17**	27	3	<3	**11**
2022	Queens'	343	37	28	**11**	91	12	8	**13**	24	1	<3	**4**	23	6	6	**26**
2020	Jesus	198	20	14	**10**	33	3	<3	**9**	17	1	<3	**6**	7	1	0	**14**
2021	Clare	257	25	20	**10**	55	8	7	**15**	18	3	3	**17**	17	0	0	**0**
2021	Corpus Christi	224	23	21	**10**	52	9	9	**17**	20	3	<3	**15**	20	3	3	**15**
2021	Jesus	210	21	15	**10**	40	1	0	**3**	20	1	<3	**5**	11	1	<3	**9**
2021	King's	388	38	26	**10**	53	5	3	**9**	11	1	<3	**9**	24	1	<3	**4**
2022	Clare	249	24	17	**10**	53	7	7	**13**	21	3	<3	**14**	10	1	<3	**10**
2022	Corpus Christi	209	20	15	**10**	67	6	4	**9**	17	1	<3	**6**	14	1	<3	**7**
2022	Gonville and Caius	240	25	19	**10**	58	5	4	**9**	23	0	0	**0**	20	1	0	**5**
2019	King's	375	32	23	**9**	51	5	3	**10**	26	1	<3	**4**	22	1	<3	**5**
2021	Downing	291	27	25	**9**	60	9	9	**15**	46	5	5	**11**	28	3	3	**11**
2021	Pembroke	264	24	17	**9**	50	8	4	**16**	28	4	<3	**14**	16	0	0	**0**
2021	St Catharine's	271	25	23	**9**	80	9	7	**11**	31	1	<3	**3**	20	3	<3	**15**
2021	St John's	441	39	31	**9**	65	7	7	**11**	45	6	6	**13**	35	4	<3	**11**
2022	Churchill	428	38	32	**9**	116	9	7	**8**	35	4	4	**11**	37	6	5	**16**
2022	Fitzwilliam	327	29	27	**9**	167	14	13	**8**	11	1	<3	**9**	29	3	3	**10**
2019	Jesus	224	18	14	**8**	27	1	<3	**4**	22	5	5	**23**	11	1	0	**9**
2022	Jesus	206	17	14	**8**	34	1	<3	**3**	13	1	<3	**8**	14	0	0	**0**
2022	King's	336	26	22	**8**	54	1	<3	**2**	19	1	<3	**5**	25	5	5	**20**
2022	St Catharine's	291	24	17	**8**	81	11	10	**14**	39	1	<3	**3**	28	3	<3	**11**
2022	Trinity Hall	213	14	11	**7**	71	5	7	**7**	19	3	<3	**16**	10	1	<3	**10**

Appendix – Changes to the Natural Sciences Entrance Requirements webpage through time

Comparing 2016 with 2020 versions of the website:

https://web.archive.org/web/20200811000352/https://www.undergraduate.study.cam.ac.uk/courses/natural-sciences

“Changes to the assessment format

Please be aware that Section 2 Biology was updated in 2022. Section 2 Biology now tests knowledge of advanced topics, bringing it in line with Section 2 Physics and Chemistry. You should take this into consideration when looking at past papers.(2023)”[43]

“A specimen paper has been produced to allow you to sample the written assessment format and practice under timed conditions. It is not expected that you will answer every question correctly; the written assessment is designed to be challenging. Even some strong candidates may not complete the paper in the time allowed; it is designed to distinguish across our field of high-calibre applicants.

Experience with similar assessments and from trials indicates that, on average, typical applicants to the most highly selective undergraduate courses (who are by definition academically very able) will gain approximately half of the available marks. The best applicants will score more highly, but only relatively few are expected to gain more than 80% of the available marks.

Written assessments help admissions tutors to assess whether candidates have the skills, aptitudes and any required subject knowledge and understanding required to study the relevant course at Cambridge. They are only one of the elements used in the admissions process. Others include a candidate’s academic record and forecast grades in school-leaving examinations; UCAS application form; examples of recent written work submitted to the College to which they are applying; and performance at interview, if invited to attend.”[44]

Comparing two versions of the Entrance Requirements from 03/08/2016[45] (differences highlighted green) and 21/03/2021[46] (differences highlighted in red)

https://web.archive.org/web/20210323162554/https://www.undergraduate.study.cam.ac.uk/courses/natural-sciences

For further information about studying Natural Sciences at the University of Cambridge see the Natural Sciences Tripos website.
Typical offers and requirementsrequire
A Level: A*A*A
IB: 40-42 40-41 points, with 776 at Higher Level
Other qualifications: See For other qualifications, see our main Entrance requirements and International qualifications.
'Science/mathematics pages.
Course requirements
Please note that in the following 'science/mathematics subjects' refers to Biology, Chemistry, Physics, Mathematics and Further Mathematics. It does not include Psychology.
Required by all Colleges: A Colleges:A Levels/IB Higher Levels in at least two science/mathematics, see also the Part IA paper descriptions for specific subject requirements for the Year 1 options
Required by some Colleges: AS or A Level/IB Standard or Higher Level in a third science/mathematics subject and/or particular subjects

[43] From: https://www.undergraduate.study.cam.ac.uk/apply/how/natural-sciences-admission-test (accessed September 2023)

[44] https://web.archive.org/web/20160828130710/https://www.undergraduate.study.cam.ac.uk/courses/natural-sciences#entry-requirements

[45] https://web.archive.org/web/20160803045320/http://www.undergraduate.study.cam.ac.uk/courses/natural-sciences

[46] https://web.archive.org/web/20210323162554/https://www.undergraduate.study.cam.ac.uk/courses/natural-sciences

Other examination systems
We expect applicants taking other recognised qualifications to have a level of understanding in science and mathematics roughly equivalent to those applying with A Levels.
Refer to our main Entrance requirements pages and consult a College Admissions Tutor for further advice.
Admission assessment
For 2022 entry, all All applicants for Natural Sciences (including applicants to mature Colleges) are required to take a the pre-interview written assessment in early November 2021, for Natural Sciences at an authorised centre local to them (for a lot of applicants, this will be their school/college).
Please see the Cambridge Admissions Testing website for information about registration deadlines, and check admission assessments for further details.
Assessment format
The format for the 2021 assessment will be as follows:
Section 1: Multiple choice questions in mathematics plus one science (Biology, Chemistry or Physics) (60 1 content
Maths and Science MCQs (80 minutes)
Section 2: Extended multiple choice 2 content
Science-specific longer questions in Biology, Chemistry or Physics (60 (40 minutes)
PDF icon Natural Sciences Admissions Assessment Specification 2021Specification
You must be registered in advance (separately to your UCAS application) to take the assessment – the registration deadline is 15 October 2016. Your assessment centre must register you for the pre-interview assessment; you're not able to register yourself. See the written assessments page for information about assessment centres and registration.
The pre-interview written assessment for Natural Sciences will be taken on 2 November 2016. Please check the Admissions Testing Service website for scheduled start times.
Please note that your performance in the pre-interview assessment will not be considered in isolation, but will be taken into account alongside the other elements of your application.
In addition to the pre-interview assessment, applicants who are invited to the following Colleges interview are required to take a College-set written assessment at interview at the following Colleges (see individual College websites for details):
Magdalene
St John's
Trinity
Mature students (aged 21 or over) applying to one of the mature Colleges should refer to the relevant information about pre-interview assessments on the written assessments page.
Specimen and past papers
A specimen paper has been produced to allow you to sample the written assessment format and practice under timed conditions. It is not expected that you will answer every question correctly; the written assessment is designed to be challenging. Even some strong candidates may not complete the paper in the time allowed; it is designed to distinguish across our field of high-calibre applicants.
Experience with similar assessments and from trials indicates that, on average, typical applicants to the most highly selective undergraduate courses (who are by definition academically very able) will gain approximately half of the available marks. The best applicants will score more highly, but only relatively few are expected to gain more than 80 per cent 80% of the available marks.

Comparing 21/03/2021[47] (red highlighted) with 02/06/22[48] (green highlighted)

Required: a laptop - cost if purchased new will depend on choice, but existing laptops if less than four years old are likely to be completely adequate for the course needs.
Optional: textbooks (available in libraries), specialist equipment (can be borrowed)
Optional – for Part IA Evolution and Behaviour: field course - Estimated cost £65 £50 + travel
Years 2, 3 and 4
Required and optional additional costs are dependent on the options taken
Information about additional costs is available on the Natural Sciences website. Refer to the individual Departments' websites for further details.
Changing course
In the first year, a number of students take Mathematics with Physics and then change to Natural Sciences to continue with Physics from their second year.
In contrast, some students take Part IA Natural Sciences and change to the Computer Science course or Chemical Engineering in their second year. It's also possible

Entry Requirements
This page details the standard entry requirements for this course. However, variations may exist between Colleges and you should check the documents below for details:
PDF icon Natural Sciences (Biological) entry requirements by College for 2023 entry (these are subject to change and will be finalised by early July 2022).
PDF icon Natural Sciences (Physical) entry requirements by College for 2023 entry (these are subject to change and will be finalised by early July 2022).
Typical offers and requirementsrequire
A Level: A*A*A
IB: 40-42 points, with 776 at Higher Level

[47] https://web.archive.org/web/20210323162554/https://www.undergraduate.study.cam.ac.uk/courses/natural-sciences
[48] https://web.archive.org/web/20220602102835/https://www.undergraduate.study.cam.ac.uk/courses/natural-sciences

Admission assessment
For 2022 entry, all All applicants for Natural Sciences (including applicants to mature Colleges) are required to take a pre-interview written assessment in early November 2021, the Natural Sciences Admissions Assessment (NSAA) at an authorised assessment centre local to them (for a lot of applicants, this will (usually your school or college), for which you must be their school/college).
registered in advance.
Please see the Cambridge Admissions Testing website for information about dates and registration deadlines, and check admission assessments for further details.
Assessment format
The NSAA Section 2 Biology component is being updated for 2022. From November 2022, Section 2 Biology will assume knowledge of advanced topics. This brings it in line with Section 2 Physics and Chemistry, which already assume knowledge of advanced topics. The topics to be included will be detailed in an updated test specification, to be published here in May 2022 together with a revised specimen question paper and explained answers.
The NSAA format for the 2021 assessment will be as follows:
Section 1: Multiple choice questions in mathematics plus one science (Biology, Chemistry or Physics) (60 minutes)
Section 2: Extended multiple choice questions in Biology, Chemistry or Physics (60 minutes)
PDF icon Natural Sciences Admissions Assessment Specification 2021
Please note that your performance in the pre-interview assessment will not be considered in isolation, but will be taken into account alongside the other elements of your application.

In addition to the pre-interview assessment, addition, applicants to the following some Colleges are may be required to take a College-set written assessment at interview (see individual College websites for details):
Magdalene
Trinitydetails).
Specimen and past papers
A specimen paper has been produced to allow you to sample the written assessment format and practice under timed conditions. It is not expected that you will answer every question correctly; the written assessment is designed to be challenging. Even some strong candidates may not complete the paper in the time allowed; it is designed to distinguish across our field of high-calibre applicants.
Experience with similar assessments and from trials indicates that, on average, typical applicants to the most highly selective undergraduate courses (who are by definition academically very able) will gain approximately half of the available marks. The best applicants will score more highly, but only relatively few are expected to gain more than 80 per cent of the available marks.
Written assessments help admissions tutors to assess whether candidates have the skills, aptitudes and any required subject knowledge and understanding required to study the relevant course at Cambridge. They are only one of the elements used in the admissions process. Others include a candidate's academic record and forecast grades in school-leaving examinations; UCAS application form; examples of recent written work submitted to the College to which they are applying; and performance at interview, if invited to attend.

Comparing 30/04/23[49] (green highlights) with 02/06/22[50] (red highlighted)

Subject requirements
'Science/mathematics subjects' refers to Biology, Chemistry, Physics, Mathematics and Further Mathematics. It does not include Psychology.
Required by all Colleges: All Colleges require: A Level/IB Higher Level Mathematics and A Levels/IB Higher Levels in at least two science/mathematics, other science subjects, see also subject requirements for Year 1 options
Required by some Colleges: AS or A Level/IB Standard or Higher Level in a third Further guidance: In exceptional circumstances, applicants with only two science/mathematics subject and/or particular subjects
PDF icon Natural subjects and Biological Sciences (Biological): Subject Requirements and Typical Offer by College
PDF icon Natural Sciences (Physical): Subject Requirements and Typical Offer by College
All undergraduate admissions decisions are the responsibility of the Cambridge Colleges. Please contact the relevant College admissions office if you have any queries about College-specific requirements.applicants without Mathematics may be considered.
See Entrance requirements and PDF icon The Subject Matters Choosing your post-16 subjects for additional advice about general requirements for entry, qualifications guidance and offers.conditions of entry.
A Levels
Most students have Your subject choices at least three science/mathematics A Levels. The minimum requirement is two, but this will Level may restrict your choice of Part IA options. In these circumstances, you'll normally be expected to achieve A* in both of the science/mathematics subjects and encouraged to take an additional science/mathematics AS Level. subject choice. The more useful subject combinations are:
A Level Biology, A Level Chemistry, and AS Level Mathematics or Physics
A Level Chemistry, A Level Mathematics, Mathematics and AS A Level Biology or Physics
A Level Physics, A Level Mathematics and AS A Level Further Mathematics
If you don't have A Level Mathematics, you're required to complete some preparatory work before the start of the course Biology, A Level Chemistry and must take Mathematical Biology as your mathematics subject in Year 1.A Level Mathematics
International Baccalaureate
The advice above about A Level subject combinations also applies to the IB. For these purposes:
Standard Level subjects will satisfy AS Level subject requirementsIB.
Higher Level subjects will satisfy A Level subject requirements
IB For Natural Sciences (Physical), if taking Higher Level Mathematics, applicants are expected to take IB Higher Level 'Analysis Analysis and Approaches' for any course where Mathematics is a requirement.Approaches. If this option is not available at your school, please contact the College that you wish to apply to directly for further advice and guidance.
For Natural Sciences (Biological), if taking Higher Level Mathematics, we recommend Analysis and Approaches for the most competitive application, however Applications and Interpretations will also be considered.

[49] https://web.archive.org/web/20230430054945/https://www.undergraduate.study.cam.ac.uk/courses/natural-sciences
[50] https://web.archive.org/web/20220602102835/https://www.undergraduate.study.cam.ac.uk/courses/natural-sciences

Admission assessment
For 2022 entry, all All applicants for Natural Sciences (including applicants to mature Colleges) are required to take a pre-interview written assessment in early November 2021, the Natural Sciences Admissions Assessment (NSAA) at an authorised assessment centre local to them (for a lot of applicants, this will (usually your school or college), for which you must be their school/college).
registered in advance.
Please see the Cambridge Admissions Testing website for information about dates and registration deadlines, and check admission assessments for further details.
Assessment format
The format NSAA Section 2 Biology component is being updated for the 2021 assessment 2022. From November 2022, Section 2 Biology will be as follows:assume knowledge of advanced topics, bringing it in line with Section 2 Physics and Chemistry, which already assume knowledge of advanced topics. See the updated specification document and specimen papers below for details.
PDF icon Natural Sciences Admissions Assessment Specification 2022
Section 1: Multiple choice questions in mathematics plus one science (Biology, Chemistry or Physics) (60 minutes)
Section 2: Extended multiple choice questions in Biology, Chemistry or Physics (60 minutes)
PDF icon Natural Sciences Admissions Assessment Specification 2021
Please note that your performance in the pre-interview assessment will not be considered in isolation, but will be taken into account alongside the other elements of your application.
In addition to the pre-interview assessment, applicants to the following Colleges are required to take a College-set written assessment at interview (see individual College websites for details):
Magdalene
Trinity
Specimen and past papers
A specimen paper has been produced to allow you to sample the written assessment format and practice under timed conditions. It is not expected that you will answer every question correctly; the written assessment is designed to be challenging. Even some strong candidates may not complete the paper in the time allowed; it is designed to distinguish across our field of high-calibre applicants.
Experience with similar assessments and from trials indicates that, on average, typical applicants to the most highly selective undergraduate courses (who are by definition academically very able) will gain approximately half of the available marks. The best applicants will score more highly, but only relatively few are expected to gain more than 80 per cent of the available marks.
Written assessments help admissions tutors to assess whether candidates have the skills, aptitudes and any required subject knowledge and understanding required to study the relevant course at Cambridge. They are only one of the elements used in the admissions process. Others include a candidate's academic record and forecast grades in school-leaving examinations; UCAS application form; examples of recent written work submitted to the College to which they are applying; and performance at interview, if invited to attend.
When using the specimen Specimen papers and past papers below, please for the Natural Sciences Admission Assessment are available below. Before you attempt the papers, make sure you read the related specimen papers information and guidance.
Please note that the following changes to the Natural Sciences admissions assessment Admissions Assessment (NSAA) were introduced in 2020:
Natural Sciences Admission AssessmentNSAA

Appendix: Performance in standardised tests of English language proficiency such as IELTS

If you are a learner where English is not your first language than you are likely to need to sit a standardised tests of English language proficiency such as IELTS.

A good and effective command of English will help drive success in these kinds of exams. For a variety of reading lists and activities to help improve your English language skills in a non-specific but still important way, especially for top universities, go here: https://www.smashingscience.org/expanding-your-mind

Regardless of which English language speaking university you eventually attend[51], and even if it not English is not a national language[52], scoring higher in your English language standardised test has deep and powerful value to your success at university. It will not only improve the easier-to-measure things like academic success, but also have a potentially more valuable impact on your ability to interact positively and productively with other students, academics and professionals while you are at an English language university.

For specific strategies for the various kinds of standardised test, talking to your English teacher should be your starting point. As with any kind of skilful action, like making a great UCAS application, you should **start preparing early**, and map out when the deadlines are going to land in your weeks, months and years so you can properly plan around them and for them.

One thing that sometimes surprises students is how inflexible some universities are about the English language requirements. But your time at university ought to be a transformative experience, and in a good way; an eye opening and amazing time of growth. This change becomes less and less likely when the language barriers get higher and higher.

Appendix: Individual contextual factors

This includes this form, which allows you to describe and explain how the pandemic impacted your education:

Additional Applicant Information Form (AAIF) – 2024 entry[53]

It looks like a fairly straightforward form.

Appendix: Contextual data

"The University of Cambridge is committed to ensuring that we offer admission to students of the highest academic potential, irrespective of social, racial, religious and financial considerations."

There are only a small number of points that a student will have an input for this part of the Cambridge selection process. In the "My Cambridge Application"you can include if "you have been eligible for Free School Meals", one way that economic disadvantage is measured and tracked in the UK, and if "they have spent time in local authority care"[54], a measure of educational disadvantage.

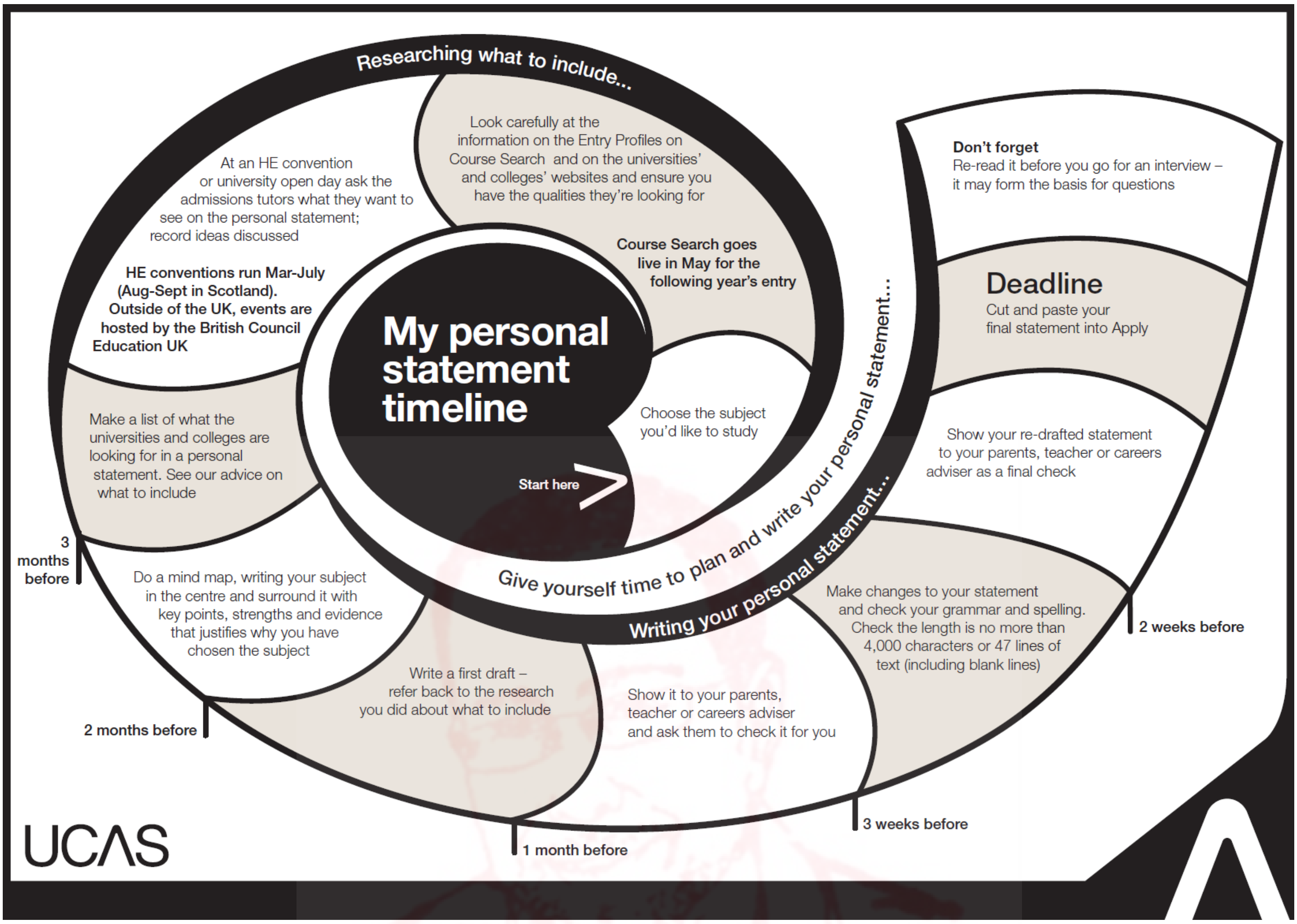
"However, academic achievement remains central to all admissions decisions - 'flagged' applicants won't necessarily be invited to attend an interview, be made an offer or be made a conditional offer at lower grades."

It is possible therefore that some of the small number of offers and acceptances with non-A*A*A* profiles (see *A Level grade profiles for 2022*, at the start of this book) may come from a cohort identified here. **If you have succeeded despite these challenges and your grades are not quite there, then this program is designed to give you credit for overcoming the kinds of challenges that most Oxbridge applicants have not, and you ought to apply**.

[51] https://www.tandfonline.com/doi/full/10.1080/13803611.2024.2314533#abstract
[52] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10404714/
[53] https://www.undergraduate.study.cam.ac.uk/files/aaif_guide.pdf
[54] https://www.undergraduate.study.cam.ac.uk/apply/after/contextual-data

Appendix: Personal Statement advice and information

From UCAS a possible timeline for a good top 50 university application, but especially helpful with the writing aspect of it, which is the least important part:



The best personal statements are the not result of great writing, but magnificent living.

For a good Oxbridge application, the work needs to be started much, much earlier than your AS year of study.

It is essentially a highlight list of interesting, difficult to achieve and important things you have done outside of the classroom that explains how passionate, curious and hardworking you are about the subject you are applying for.

Some experiences, for instance 3 years of being the most active member of an evidently successful and obviously active extracurricular Chemistry Society are difficult to achieve, and normally only the most organised and goal oriented Oxbridge applicants. But a much, much larger proportion of those who are offered a place will be offering those kinds of things.

It can be helpful to think about it as blocks of time. You need to start thinking about whichever subject you are thinking of applying to study at university normally when you chose your GCSEs, and you should have good idea of what you could do when you chose your A Levels in your final year of GCSEs.

Organising your years to create the life experiences that the best personal statements contain

You will begin gaining important life experiences years before your UCAS application year, but a magnificent amount of growth will come through your failures, some of which take months or even years to appreciate. For instance, how do you learn when is too late to apply for a summer program? If it is something really awe-inspiring, rare and worthwhile, learning that the application deadline was last week will give you the most long lasting and powerful lesson in the value of proactive time management. If this happens in a GCSE year it can help you with your all-important summer going into your A2 year.

Cambridge has suggestions of things you could do that they would value, though they don't explain how they would rank two otherwise identical applications with two different kinds of experiences here:

https://www.undergraduate.study.cam.ac.uk/files/publications/super-curricular_suggestions.pdf

A general rule that can help is if the activity is easy to do, fun and/or impossible to verify, like watching a video, then it is less likely to be helpful in a personal statement. Some summer camps run by private companies for instance, but even ones that are held in the University buildings, and especially the ones where the main way of selecting their participants is centred around paying a usually large fee, are less useful, perhaps even useless. Chasing squirrels in a park or watching a nice movie would both be considerably cheaper activities, and probably deliver as much, if not more, positive value to your Oxbridge application than these kinds of expensive, challenge-free holiday-like experiences.

The kinds of activities that are more valuable, when done well, will have overlapping and reinforcing effects on your learning. Talking to your teachers about their subjects, and the harder parts of the syllabus, for instance, won't only help improve your eventual UCAS reference. And learning about academic competitions and working towards their deadlines to prepare for their tests, will also help you with your academic exams, especially the value and power of starting early to deliver your strongest performance. And learning about working to deliver a positive, productive and successful performance within predictable but sometimes challenging deadlines is the single best thing the best applicants will get out of their Oxbridge application, regardless if they get an offer or not.

Block of time	Main events	What you can do
The year before GCSEs start	Decide optional GCSE subjects What are you best at	**Start learning about careers** (how much they pay, how long do you need to train, what are the typical working hours, are you interested in the work?)
First year of GCSE	Start a more serious qualification. Learn about the power of past exam questions in delivering academic success.	**Learn about careers –** Are you still interested in that kind of work? What degrees help achieve that career? **Start learning about extracurricular activities**, participate in school, learn about what can be done outside of school. Find out how they work well, and when they don't work, or are not productive (**zombie societies** and clubs that exist but achieve nothing). How could you show later on that you made an active and successful contribution? **Learn about deadlines for academic competitions**, some have junior or intermediate versions that are suitable for GCSE students
Summer going into final GCSE year	**Learning about summer activities**	**Discover summer activities** - what can be done, and when you need to apply. Discover how hard it is to do worthwhile things in the summer that are difficult to achieve (need very early applications, few opportunities, difficult to organise into your life). Think about how different these hard to get selected for and hard to organise activities are from the kinds of activities where the only qualification is paying the usually large fee.
Second year of GCSEs	**Learn about effective time management to deliver success** in your: • months • weeks • days **Start reading one news article a week** in your favourite subjects	**Participate in academic competitions**, learn how to organise your time to compete as well as succeed in all of your GCSE subjects **Learn about the most impressive academic clubs** and societies in your school, what can you do to have a senior position next year. If the perfect society for you doesn't exist, create it in this year. **Think about which teachers could be your UCAS reference** and start talking to them about your subject inside and outside of lesson time, ideally about harder parts of the course and occasionally about new scientific advances. Often teachers are busy, so take the care to ask them if they are busy, or if they can talk about something you find interesting at that moment.
Summer going into AS year	Do something useful, interesting and valuable with your summer	Use your experiences trying to organise something interesting and worthwhile in your previous summer to apply better for this summer: 1. be early (start in September) 2. learn about realistic opportunities 3. know requirements (e.g. references, essays etc) 4. know the deadlines

Block of time	Main events	What you can do
		5. learn about opportunities only available to students a year older (so you can get a head start this next year) This could be a good sentence or two in your personal statement, but hopefully the experiences closer to the application would be too valuable to give this experience the space. A really great personal statement will leave out many excellent achievements.
First year of AS	**Academic competitions** **Extracurricular societies**, clubs and activities **Read academic books** recommended by Oxbridge	**These experiences, especially building on previous years will deliver a complete and strong paragraph in your personal statement.** **Read 3 to 6 books** about your subject that are (not textbooks) about recent advances that you enjoy (and take notes on them): https://www.ox.ac.uk/admissions/undergraduate/courses/suggested-subject-resources **This can deliver a strong sentence**, or add to another paragraph in your personal statement.
Summer going into AS year	Most important summer for activities and accomplishments	Participate and complete something amazing, fascinating and really hard to achieve this summer. **This will be a solid paragraph in your personal statement.**
A2 year	Apply for UCAS	Nothing much for an Oxbridge personal statement can be done in this year. Your personal statement should be essentially finished in early September, with the last 3 to 4 weeks used to fit within the 4000 character, 47 line limit with enough feedback so that it still makes sense, and hopefully also has a pleasing flow to it (less important, but a nice touch).

Appendix: Oxbridge Reading Lists for Chemistry and Biology

For a digital version of this scan this QR code for clickable links (in e.g. MS Word app):

Chemistry in the news – Where to learn about recent important events.

Try to read **3 interesting** and **2 useful** articles every week of A2 (or 1 of each type every week at AS):

UK – Royal Society of Chemistry Magazine (recommended by Oxford Uni): https://www.chemistryworld.com/news

US – American Chemical Society Magazine: https://www.acs.org/education/resources/highschool/chemmatters.html

Science news websites

International News – Associated Press (less focused on the science of "chemistry"): https://apnews.com/hub/chemistry

https://www.sciencenews.org/topic/chemistry

Requires subscription (possibly worth it in A2):

https://www.newscientist.com/article-topic/chemistry/

Especially good if also interested in business and finance: https://www.economist.com/science-and-technology

Oxford research in chemistry (recommended by Oxford Uni):

- Turning orange into grapefruit
- Fuel cells inspired by nature video
- Chemistry in the garden video

Science Podcasts

NPR: Short Wave - Short (10min) episodes on a single science news topic. Very good.

NYT: Hard Fork – Weekly technology with a focus on Silicon Valley news. Outstanding.

Economist: Babbage – Weekly science podcast (subscription may be necessary) focusing on a single topic. 40minutes. Excellent

Universe Today: Fraser Crain – A focus on astronomy, cosmology, and space news. Reliably Excellent, often outstanding.

BBC: In our Time with Melvyn Bragg – Sometimes covers science, always outstanding.

New Scientist: Podcast – Science news. It can be good.

Freakonomics M.D. – Investigating the intersection of economics and medicine. Excellent.

BBC: The Infinities Monkey Cage – Panel talk show on big science topics. Often very good.

Stephen Fry's Great Leap Years – History of science and technology. Outstanding.

BBC Discovery – "An in-depth look at the most significant ideas, discoveries and trends in science". Often good.

BBC: History Extra Podcast – Sometimes covers the history of science or scientists, always excellent, often outstanding.

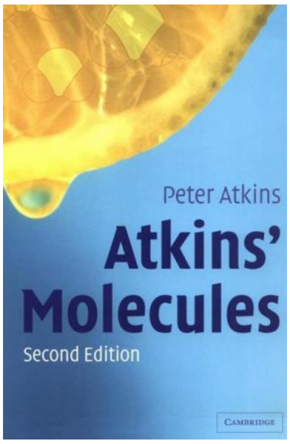
Nature Podcast – Outstanding science packaged into a relentlessly mediocre podcast.

General and Popular Chemistry Books

Thise books are all from this site:

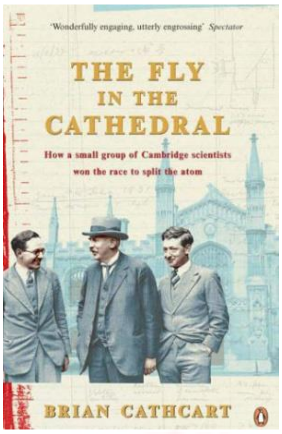
https://www.univ.ox.ac.uk/applying-to-univ/reading-bank/?category=maths-physical-life-sciences&subcategory=chemistry

If you click are each you can get a review by the Oxford student (their degree subject is in brackets)



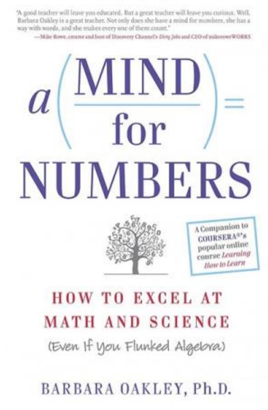
Atkins' Molecules

By Peter Atkins



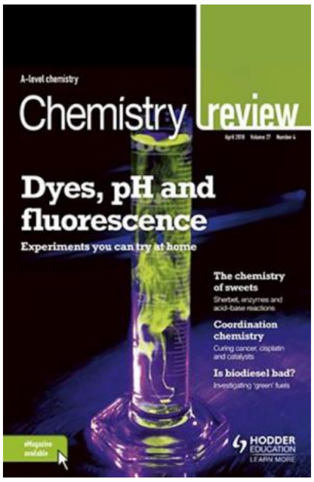
The Fly in the Cathedral

By Brian Cathcart



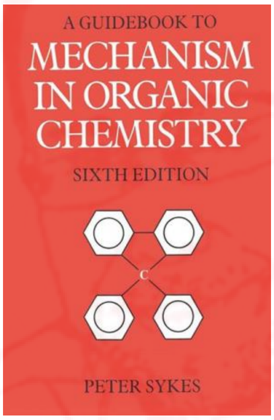
A Mind for Numbers

By Barbara Oakley



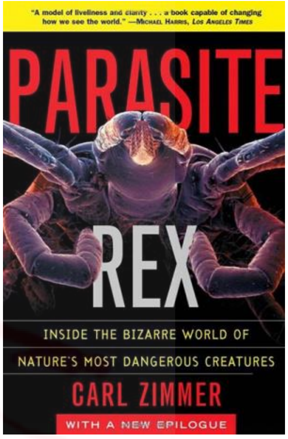
Chemistry Review

By Hodder Education



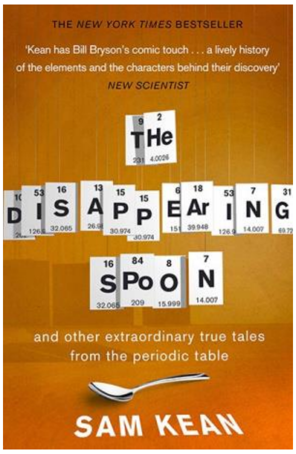
Guidebook to Mechanism in Organic Chemistry

By Peter Sykes



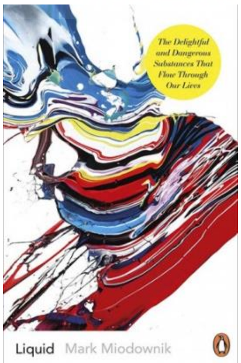
Parasite Rex

By Carl Zimmer



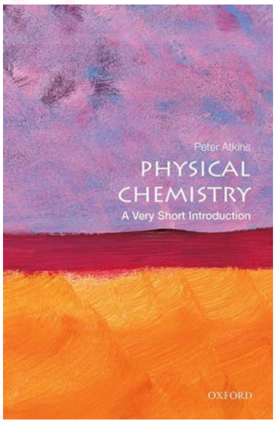
The Disappearing Spoon

By Sam Kean



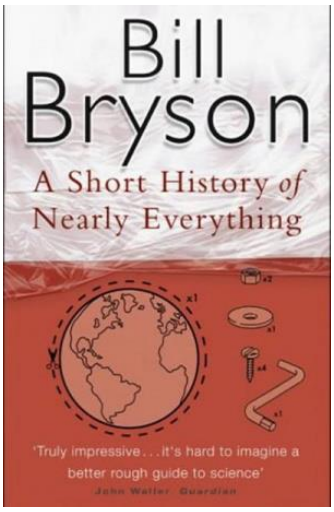
Liquid

By Mark Miodownik



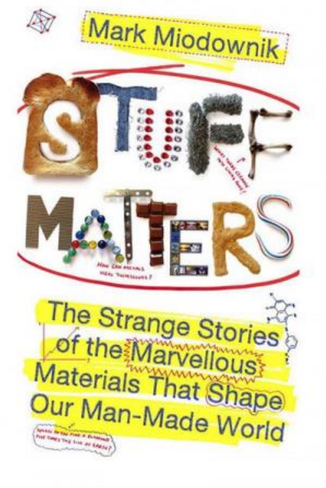
Physical Chemistry: A Very Short Introduction

By Peter Atkins



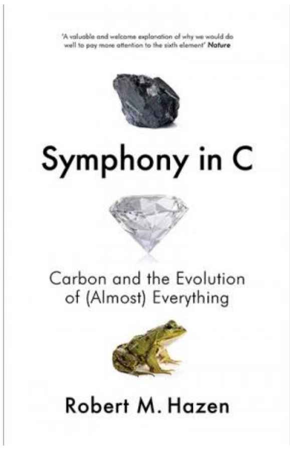
[A Short History of Nearly Everything](#)

By Bill Bryson



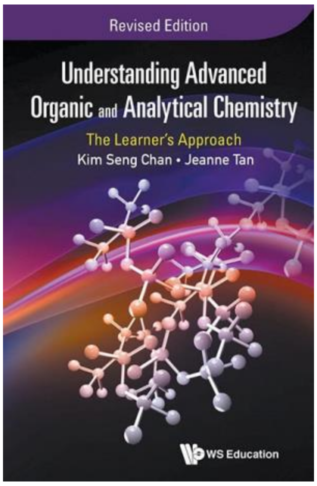
[Stuff Matters](#)

By Mark Miodownik



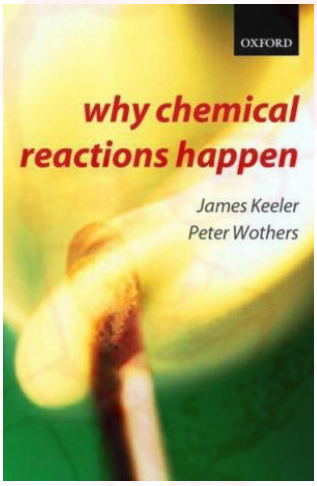
[Symphony in C: Carbon and the Evolution of (Almost) Everything](#)

By Robert M Hazen



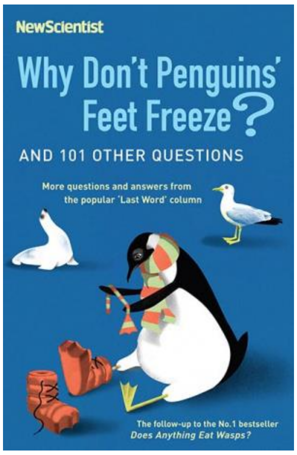
[Understanding Advanced Organic and Analytic Chemistry](#)

By Kim Seng Chan and Jeanne Tan



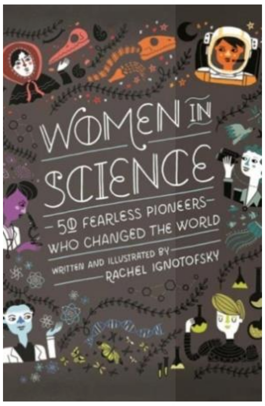
[Why Chemical Reactions Happen](#)

By James Keeler and Peter Wothers



[Why Don't Penguins' Feet Freeze?](#)

By New Scientist



[Women in Science](#)

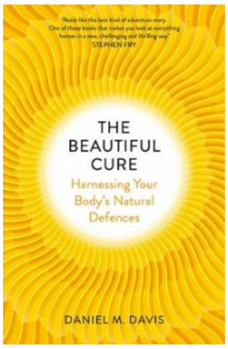
By Rachel Ignotofsky

Name: Class: Date:

General and Popular Biology Books

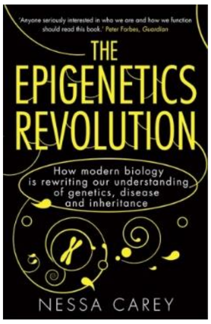
Thise books are all from this site: https://www.univ.ox.ac.uk/applying-to-univ/reading-bank/?category=maths-physical-life-sciences&subcategory=biology

If you click are each you can get a review by the Oxford student (their degree subject is in brackets)



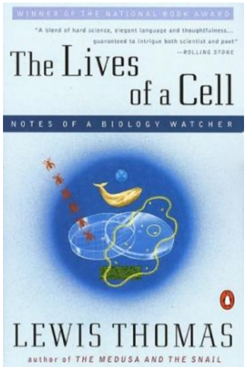
The Beautiful Cure

By Daniel M Davis



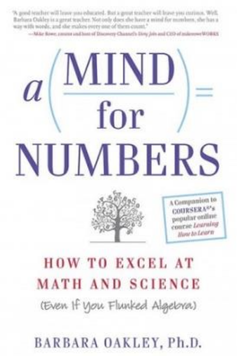
The Epigenetics Revolution

By Nessa Carey
Reviews by Katie H



The Lives of a Cell

By Lewis Thomas



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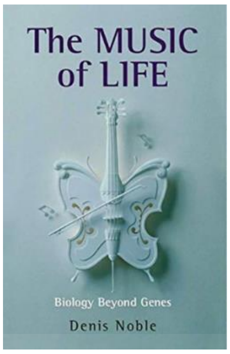
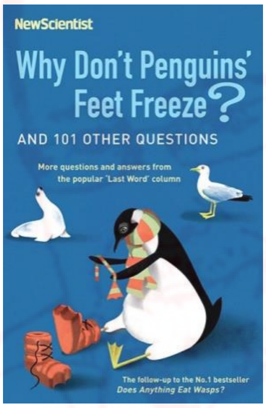


The Music of Life – Biology Beyond Genes

By Denis Noble



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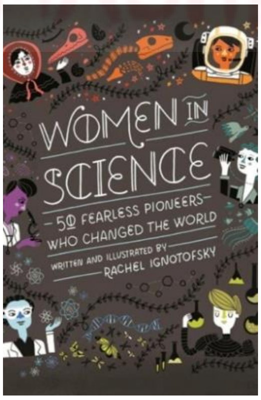

Women in Science

By Rachel Ignotofsky

Chemistry Textbooks

These books can be of help to further pursue ideas you find fascinating at A2, but you should probably try these online textbooks:

For A level chemistry: https://www.chemguide.co.uk/

For some A level and mainly undergraduate chemistry (also has online textbooks about other subjects): https://chem.libretexts.org/

For the Wikipedia Portal for everything chemistry: https://en.wikipedia.org/wiki/Portal:Chemistry

From Oxford University (accessed 29th Aug 2023):

https://www.ox.ac.uk/admissions/undergraduate/courses/suggested-subject-resources

Introductory reading for Chemistry.

*Physical Chemistry, P W Atkins, Oxford University Press (8th edn.) 2006, [7th edn. 2001]

* Inorganic Chemistry, Shriver and Atkins, Oxford University Press (4th edn) 2006, (previous edn., 1999]

Chemistry of the Elements, Greenwood & Earnshaw, Pergamon (2nd edn.), 1997 [1st edn. 1985]

Foundations of Organic Chemistry, Hornby & Peach, Oxford Chemistry Primer, OUP, 1996

* A Guide to Mechanism in Organic Chemistry, Sykes, Pearson (6th edn.),1986

Organic Chemistry, Maitland, Jones, Norton, (3rd edn.) 2004

* Mathematical Methods for Science Students, G. Stephenson, Pearson (2nd edn.) 1978, rep. 1984

Organic Chemistry, Clayden, Greeves, Warren and Wothers, OUP

*especially useful

Appendix: Degree subjects which require interviews

If done before you submit your UCAS application this worksheet can help you learn which universities and courses interview prospective students and what that means.

Like any exam or assessment, to excel you need to understand what is being measured or investigated in order to deliver your best performance. Filling out this completed form not only will help you prepare better, you will also feel more prepared, so less stressed. But this work you do learning about this process also can help others who are helping you succeed, like parents, guardians and teachers be better informed.

For the courses that you intend to study, complete this table for the degrees and universities you are most interested in to find out if they interview. Normally effective would be a Google search with: “[university name] interview undergraduate”.

For completed versions of these tables accurate as of November 2023 see the same table filled in for some universities further along here.

University	Course name	UCAS code	Department undergraduate website	Do they interview?
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				

Now read through each webpage above for those that interview, then close your web browser and write out the key details from memory in the space below. Then go back to the website and fill in, with a different colour, the information you missed. A completed version for some course as of November 2023 follows on

University & course	Online?	Key interview details

University & course	Online?	Key interview details

Learning more about your chosen course and the best universities that offer it

Using Admission report to better understand your potential university choices

https://www.admissionreport.com/schools

University & course	Admissions report information		UCAS information	
	Offer rate	Year data comes from	Required A Level Grades	GCSE requirements
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				

Completed versions for both previous tables, accurate as of November 2023

University	Course name	UCAS code	Department undergraduate website	Do they interview?
Birmingham	Most subjects		https://www.birmingham.ac.uk/students/ug-admissions/solution?answered=4171&nodeid=4171	No
Bristol	Chemistry		https://www.bristol.ac.uk/study/undergraduate/after-you-apply/interviews/chemistry/	Yes, & all non-standard applications
Bristol	Biology		https://www.bristol.ac.uk/study/undergraduate/after-you-apply/interviews/	No
Cambridge	Natural Science	BCF0	https://www.undergraduate.study.cam.ac.uk/courses/natural-sciences	Yes
Durham	All courses (except Primary education)		https://www.durham.ac.uk/study/undergraduate/how-to-apply/what-happens-to-your-application/interviews-and-selection-days/	No
Imperial College	Chemistry	F100	https://www.imperial.ac.uk/study/courses/undergraduate/chemistry-bsc/	Yes
Imperial College	Biochemistry	C700	https://www.imperial.ac.uk/study/courses/undergraduate/biochemistry-bsc/ - "Generally, the department does not hold interviews."	No
Imperial College	Biology	C100	https://www.imperial.ac.uk/study/courses/undergraduate/biological-sciences/ - "Generally, the department does not hold interviews."	No
Imperial College	Material science & engineering, MEng	JFM2	https://www.imperial.ac.uk/study/courses/undergraduate/materials-science-engineering-meng/	Yes
Imperial College	Chemical engineering, MEng	H801	https://www.imperial.ac.uk/study/courses/undergraduate/chemical-engineering/	Maybe
Manchester	Biology	C100	https://www.manchester.ac.uk/study/undergraduate/courses/2024/00524/bsc-biology/application-and-selection/#course-profile "How your application is considered Applications are considered on the basis of the UCAS form. Some candidates may be interviewed online or by telephone, or asked to complete an alternative admissions statement."	Probably not
Oxford	Chemistry, MChem	F100	https://www.chem.ox.ac.uk/admissions	Yes
UCL	Chemistry	F100	https://www.ucl.ac.uk/chemistry/study-here/undergraduate	No
UCL	Pharmacy		https://www.ucl.ac.uk/prospective-students/undergraduate/how-apply/how-we-assess-your-application	Yes
Warrick	Most subjects		https://warwick.ac.uk/study/international/admissions/help/do_all_applications_include_an_interview/	No

University & course	Online?	Key interview details
IC Chem, F100	Probably, (can't say, previously always was for international students)	**Time:** Morning and Afternoon (to cater to different time zones) **Date:** Ongoing it seems, but given offers only made after all interviews are complete at the end of March, has to be before then. **Purpose**: Assess motivation for studying chemistry and potential for the future. Also how they think and how they reason through a problem **Format:** Individual interview with an academic **Additional information:** Pre-recorded talk by the admissions department **Add info:** Online Q and A sessions **Add info:** Virtual tour of department: https://virtual-tour.imperial.ac.uk/explore/chemistry/wider-department-2?study_level=undergraduate&subject_area=chemistry **Content assessed:** Personal statement initially, then could be about "unfamiliar topics" **Offers:** only made after all interviews are complete, by email, end of March
IC Material science and engineering, JFM2	Probably, (can't say, previously always was for international students)	Time: 10:30 to 15:30 Date: Between November and March Format: Happens in a single whole "Applicant Day", which includes talks by Director of Undergraduate Studies then the Admissions Tutor **Content 1 to 1 interview:** with a lecturer for 30minute. "We aim for the interview to be more of a conversation.", so perhaps about the personal statement? **Content group task:** a 45minute engineering based problem solving challenge working in a team. [**Not on the website** but previous years students have given a topic, like "What is the material of the future?" 24hours in advance and then required to deliver a 90second introduction to a material you have researched, with the group time also used to explore your research and understanding of your chosen material]. **Content Q&A:** With current student ambassadors for 60minutes. Most international students, including Chinese nationals, need to get an ATAS certificate to get student visa
UCL Chem, F100		Not on this list (therefore does not use interviews for this course): https://www.ucl.ac.uk/prospective-students/undergraduate/how-apply/how-we-assess-your-application Use "gathered field" approach to assess UCAS applications: "All applications submitted by 6pm UK time on 25 January 2023 are given equal consideration." They then say: "Gathered fields - A gathered field allows us to assess all applications in the same fair and consistent manner, whether they are received in October or January (by the UCAS deadline). This means we will need to wait until we have enough comparable applications to make a final decision." What is logically possible from these statement: 1. They clearly want it known that they believe equal consideration is given to any applicant delivered at any time before the UCAS deadline. 2. The final decision will be delivered after they have "enough comparable applications", **which can be before the UCAS deadline**.
IC, Chem Eng, MEng H801	Probably	This was accessed on 31st October 2023: "Interview days The Department plans to hold interview days as part of the selection process. Check back soon for more information."
Oxford	Probably, did in 2023, but may have changed since	[Like Cambridge,] use interviews to see if students are suited to the **small class tutorial** structure of their undergraduate course [no other university uses it]. Shortlisting: At least 2 interviews at their first-assigned college (could also be interviewed by their second-assigned college, or other colleges). **Best 10,000 applicants** are invited for interview **for 3,300 places** (total 22,000 applicants; most do not get an interview) • Middle November to early December interview notices emailed • Early to mi-December interviews carried out • Candidates interviewed by a different college finish in mid-December, soon after initial interviews (none of Cambridge's perplexing "Winter Pool" business)

		Shortlisting: At least 2 interviews at their first-assigned college (could also be interviewed by their second-assigned college, or other colleges) **Content of interview** • First, about personal statement or why you chose that course • Subject specific, including about a text, graph, object [e.g. image] • Can also include content about your current A Levels • Can also include what you have read around the subject and your interests beyond syllabus **If you don't know the answer**: • Exploring your thought process [by speaking your thoughts] will interest them [but they may not only be interested in ways you succeeded at interview] • Apply logic and reason to the question • Tell them if you have not covered it yet, but remain enthusiastic about wanting to find the answer [don't use that stamen "I've not covered that yet" as the solution, or the reason you don't have to be interested in the idea; if it is not from A Level, then they may be assessing your general interest in the subject] • Evidence of your ability to think about an idea differently could be what the examiner is trying to uncover. So, eagerness, intellectual flexibility and a capacity to bear being stretched while solving a problem allows them to assess your potential • Finally "just be yourself", advice that will be interpreted wildly differently by different demographics. If everyone in your life has a competitive, professional highly educated background, than this could mean "display your best self, and avoid highlighting your faults". It highlights the profound tension that exists in everything that they write about this selection process, they are likely aiming for it to come across as a merit based, fair, rigidly logical process that is highly successful at selecting the very best students, regardless of their background. Saying you should "just be yourself" is like saying "be honest" which is an ideal that we all should aspire towards, but it is a striking thread they are pulling on. https://www.ox.ac.uk/admissions/undergraduate/applying-to-oxford/guide/interviews
Cambridge	Probably, did in 2023, but may have changed since	• Invitations for interview in November. • Interviews in December. • Potential additional interview in early January (Winter Pool). All students with an offer have an interview. 35-50minutes total interview time Most applicants offered an interview, number of interviews (usually 1 or 2) not connected with chances of offer. Normally get at least one subject specific interview, essentially an exam in spoken form. Some questions you are not expected to know the answer to, but to use the information provided to work it out in the moment. **Content assessed**: • Personal statement • Using existing knowledge to solve unknown problems • News in your subject **General academic interview content** assessed: • Personal statement • Why Cambridge, why [your subject] • Other academic interests or work • Your plans after your degree https://www.undergraduate.study.cam.ac.uk/apply/after/cambridge-interviews

Appendix: Science subjects that require an entrance exam

Imperial College[55] Science Subjects Entrance Exams

Unlike Oxford or Cambridge, there is an opportunity to take the test at the start of January

Test format -

The ESAT is a computer-based assessment. It is made up of individual multiple-choice modules lasting 40 minutes each. You will sit these back-to-back on the day of the test.

Mathematics 1 is compulsory for all candidates.

The remaining modules will depend on the Imperial course you are applying to.

In most cases, you will complete two additional multiple-choice modules, making the test 120 minutes in total. For the Dyson School of Design Engineering you will only be required to complete one additional module, which is Mathematics 2. Details of which modules to select for each Imperial department can be found in the table below:

Department	Test	Module 1	Module 2	Module 3
Aeronautics	ESAT	Mathematics 1	Physics	Mathematics 2
Chemical Engineering	ESAT	Mathematics 1	Chemistry	Mathematics 2
Civil and Environmental Engineering	ESAT	Mathematics 1	Physics	Mathematics 2
Dyson School of Design Engineering	ESAT	Mathematics 1	Mathematics 2	N/A
Electrical and Electronic Engineering	ESAT	Mathematics 1	Physics	Mathematics 2
Mechanical Engineering	ESAT	Mathematics 1	Physics	Mathematics 2
Physics	ESAT	Mathematics 1	Physics	Mathematics 2

There is no pass or fail for ESAT. You should aim to do the best you can.

Your final scores are based on the number of correct answers you give. You do not lose marks for wrong answers, so it's worth attempting all questions.

Test dates -

You must register and book a time slot in advance of the test taking place.

You can choose whether you sit the test in October or January.

- **Test sitting 1:** 15 and 16 October 2024; or
- **Test sitting 2:** 7 and 8 January 2025.

We will only accept the results from your first test sitting per admissions cycle (even if you sit the test twice), so you should aim to do the best you can.

There is no advantage to sitting the test in the first or second sitting. However, we strongly encourage you to register for test sitting 1, where possible, to have access to the widest choice of time slots in your chosen location.

University of Cambridge[56] Science Subjects Entrance Exams

Natural Sciences (Physical Sciences) and the Natural Sciences (Biological Sciences): require the ESAT.

For Chemical Engineering and Biotechnology, BA (Hons) and Meng: require the ESAT.

[55] https://www.imperial.ac.uk/study/apply/undergraduate/process/admissions-tests/esat/
[56] https://www.undergraduate.study.cam.ac.uk/courses/natural-sciences-ba-hons-msci

Psychological and Behavioural Sciences, BA (Hons): "There is an admission assessment at some Colleges for this course. You do not need to register in advance. Check the College admission assessments page for more information. …Applicants to some Colleges are required to submit written work prior to interview."[57]

Medicine, MB and Bchir[58]: "You will need to take the University Clinical Aptitude Test."

University of Oxford[59] Science Subjects Entrance Exams

Which course are you applying for?

Biology

Test(s) required

There is no admissions test for your chosen course.

Which course are you applying for?

Biomedical Sciences

Test(s) required

Biomedical Sciences Admissions Test

Which course are you applying for?

Chemistry

Test(s) required

There is no admissions test for your chosen course.

Which course are you applying for?

Computer Science

Test(s) required

MAT (Mathematics Admissions Test)

Which course are you applying for?

Engineering Science

Test(s) required

PAT (Physics Admissions Test)

Which course are you applying for?

Materials Science

Test(s) required

PAT (Physics Admissions Test)

Which course are you applying for?

Medicine

Test(s) required

UCAT (University Clinical Aptitude Test)

Which course are you applying for?

Medicine (graduate entry)

Test(s) required

UCAT (University Clinical Aptitude Test

Which course are you applying for?

Physics

Test(s) required

PAT (Physics Admissions Test)

Which course are you applying for?

Physics and Philosophy

Test(s) required

PAT (Physics Admissions Test)

Which course are you applying for?

Psychology (Experimental)

Test(s) required

TSA (Thinking Skills Assessment)

Which course are you applying for?

Psychology, Philosophy and Linguistics

Test(s) required

TSA (Thinking Skills Assessment)

57 https://www.undergraduate.study.cam.ac.uk/courses/psychological-behavioural-sciences-ba-hons
58 https://www.undergraduate.study.cam.ac.uk/courses/medicine-mb-bchir
59 https://www.ox.ac.uk/admissions/undergraduate/applying-to-oxford/guide/admissions-tests

Appendix: Goal setting and introducing yourself at A2

Please complete this brief introduction to yourself and your background and what you hope to study later on and why.

Name, English and Chinese (in pinyin): ______________________________ **Class:**__________

Intending to apply to (circle): Cambridge/Oxford Yes/No

Intending to apply for medicine? Yes/No

Have you finished your Personal Statement? Yes/No

Are you interested in tutoring AS students (chem OR biology)? Yes/No

Email address: ______________________________

Subject	iGCSE Grade	AS Grade	AS %	A2 Target grade

What do you want to do after high school?

- What kinds of subjects might you be interested in studying at university?
- Which universities are you hoping to go to?
- What type of career, or profession, are you hoping to do after that university degree?

Rank possible subjects you might study and include what kind of career you might hope it could lead to, as well as the universities you are interested in (1 = 1st choice, your favourite, 5 = 5th choice, least favourite):

Number	Degree subject	Country	University	Career
1		UK		
2		UK		
3		UK		
4		UK		
5		UK		

Achievements, goals and interests

What are your interests outside of the classroom?

Which competitions/awards have you got (e.g. International Chemistry/Maths/Physics Olympiad etc)

Which competitions/awards do you intend to do, and date you will get the result

Which activities (at school or outside of school, like music or sport) have you done before?

What career would you like (if you are not sure yet, what careers might you be interested in?)

What are your targets (what do you hope to achieve or find out about) for the first few weeks of term?

Academic Targets for this term (and what you will do to achieve them):

What are the last 3 good books you have read?

Can you think of anything that has happened in science recently in the news that you thought was amazing?

Appendix: Organising your interview preparation

Goals for this kind of preparation for your interview

1. Be able to speak better about what you know and how you solve problems (including stronger grasp and easier use of technical language).
2. Learn more facts about your subject.
3. To understand how different parts of the subject relate to each other (understand and analyse what you know).
4. Grow your confidence thinking and speaking at the highest level in your subject at your age.
5. Learn to use your notetaking skills to learn about things that are not directly related to a lesson.

There are three main sources for finding out about your interview: the university website, the academic department website and the college you are applying to website.

Your university website:

https://www.ox.ac.uk/admissions/undergraduate/applying-to-**oxford**/guide/interviews

https://www.undergraduate.study.cam.ac.uk/apply/after/**cambridge**-interviews

Describe the additional information given here:

Your notes:

Describe and explain how you could use this extra information to better lead your interview preparation:

Your notes:

Your department website

Cambridge Natural Science – No information I can find for the interview process (searched 9/11/23), so you could use the Oxford Chemistry Department

https://www.chem.ox.ac.uk/admissions

Describe the additional information given here:

Your notes:

Describe and explain how you could use this extra information to better lead your interview preparation:

Your notes:

Your college website

URL:

Describe the additional information given here:

Your notes:

Describe and explain how you could use this extra information to better lead your interview preparation:

Your notes:

Organising your preparations and research for your interview

Add here your notes to yourself about the things that your chosen university has stated that you think are important to improving your performance in the interview process. You can start this process by answering these questions.

Time (when is it?):

Important dates:

1. When are you notified you have one:
   Your answer:
2. When is it likely to be:
   Your answer:
3. When do you get the result:
   Your answer:

Their stated purposes for interviewing (how do they explain this?):

Your answer:

Their actual purposes for interviewing (if different):

Your answer:

Your purposes for this process:

Your answer:

Format of interview:

Your answer:

Additional information:

Your answer:

Content assessed in the interview process:

Your answer:

What questions to they say you need to be prepared for?

Your answer:

Describe and explain what you know about "winter pool", (what is it, why does it exist, how could it help you etc.):

Your answer:

Add info: Online Q and A sessions with current student ambassadors (ask at least 3!):

Your Questions	Their answers
1. E.g. What helped you most when you were preparing for your interview?	
2.	
3.	
4.	
5.	
6.	

Things you have gained and learned by taking the virtual tours (if available) of:

1. Department:

Your notes: ____

____

2. College:

Your notes: ____

____

3. University:

Your notes: ____

____

Organising your research about the college you are applying for

College you are applying for:

Does selecting your college through "open applications" affect their expectations about how much they think you should prepare?

Your answer: ____

What are the reasons for choosing a college (see here)?

https://www.undergraduate.study.cam.ac.uk/choosing-your-college

https://www.ox.ac.uk/admissions/undergraduate/colleges/do-you-choose-a-college

Your answer: ____

What reasons should not use when choosing a college?

Your answer: ____

How do they describe themselves?

Your answer: ____

How do they describe their strengths?

Your answer: ____

How do they see themselves as different to other colleges?

Your answer: ____

How are they the same as others?

Your answer: ____

Now with all of this research try to answer these questions as fully as you can:

What skills, attributes and attitudes do you think they are more interested in seeing in their successful applicants?

Your answer: ____

____

What skills, attributes and attitudes will they be selecting against?

Your answer: ____

____

Organising your revision and learning program for your interview

In addition to general revision of ALL AS Level material, you should also be learning about A2 and slightly beyond material in the subject you are applying for.

Try to select a more junior academic from your college's staff directory, they might be more likely to be involved in the interviewing process. If you are splendidly lucky, you will have researched their work before you find out that they are interviewing you. If not, you have developed and expanded on your research skills which will allow you to more effectively and efficiently research whoever becomes your interviewer.

You are not aiming to be able to answer their hardest questions, rather you are using this interview experience to expand your science learning to A2 level and even beyond. You will also be growing your confidence levels in science.

It may be possible in some circumstances to do this process in conjunction with the teachers and or university advisor who are helping you with your UCAS application, so talk to them and ask them if they think it would be a good fit for how they prefer to coach students.

This will allow you to practice speaking what you know, as well as to help embed and consolidate your learning so that you understand it in a deeper way and are more likely to remember it for longer. This, in fact, is very much what the Oxbridge small group tutoring approach to university education is about. A major reason for the interview itself is to assess how well you would learn in a system like this, so while you are improving your ability to demonstrate your passion and understanding for your subject, you are also developing essential tutorial skills that the interviewers are strongly selecting for.

Longer term, this structured and highly organised approach to revision, learning and preparation will help you make the most competitive applications in your future, for instance, for your dream job one day.

If you find you have more time, it is better to go more deeply into one of these research projects, so learn more and better about a single topic, than to simply copy and past words into the table. You will be asked questions about this, after all, so successful work here should be measured in how well you talk about this science and answer questions, rather than how much text you pour into these tables.

Try to write in pen, or in electronic pen, it leaves a deeper impression on the brain and you can show yourself, and possibly your teacher how seriously and how hard you are working.

Name of college fellow	
Position	
Their college webpage	
Their lab's website	
Your notes about their work (3 most accessible areas)	
Most suitable area to learn more about, both at A2 and slightly beyond	
A2 CAIE Syllabus Topic name and number	

A2 Summary notes on the hardest parts of this in the syllabus (2-3 paragraphs of your own writing)	
Notes on research, e.g. from LibreText and Wikipedia website going a little beyond the A2 syllabus (2-3 paragraphs of describing and explaining with your own words)	

Name of college fellow	
Position	
Their college webpage	
Their lab's website	
Your notes about their work (3 most accessible areas)	
Most suitable area to learn more about, both at A2 and slightly beyond	
A2 CAIE Syllabus Topic name and number	
A2 Summary notes on the hardest parts of this in the syllabus (2-3 paragraphs of your own writing)	
Notes on research, e.g. from LibreText and Wikipedia website going a little beyond the A2 syllabus (2-3 paragraphs of describing and explaining with your own words)	

Name of college fellow	
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Their college webpage	
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Your notes about their work (3 most accessible areas)	
Most suitable area to learn more about, both at A2 and slightly beyond	
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Notes on research, e.g. from LibreText and Wikipedia website going a little beyond the A2 syllabus (2-3 paragraphs of describing and explaining with your own words)	

Name of college fellow	
Position	
Their college webpage	
Their lab's website	
Your notes about their work (3 most accessible areas)	
Most suitable area to learn more about, both at A2 and slightly beyond	
A2 CAIE Syllabus Topic name and number	

A2 Summary notes on the hardest parts of this in the syllabus (2-3 paragraphs of your own writing)	
Notes on research, e.g. from LibreText and Wikipedia website going a little beyond the A2 syllabus (2-3 paragraphs of describing and explaining with your own words)	

Name of college fellow	
Position	
Their college webpage	
Their lab's website	
Your notes about their work (3 most accessible areas)	
Most suitable area to learn more about, both at A2 and slightly beyond	
A2 CAIE Syllabus Topic name and number	
A2 Summary notes on the hardest parts of this in the syllabus (2-3 paragraphs of your own writing)	
Notes on research, e.g. from [LibreText]() and Wikipedia website going a little beyond the A2 syllabus (2-3 paragraphs of describing and explaining with your own words)	

Appendix Mock Interview Feedback Form

This is one example of a kind of feedback form that you might get after a mock interview. It can help you by highlighting areas where you can improve, and what you could do to become better at this skill. Ticks in the *Interview skill/ability* box indicate a proven example of that skill in that interview, if the Yes is circled in the *Do you need to improve?* box you can think about the things suggested in the *What you can do to improve this skill*.

General interview kinds of skills are in italics and highlighted in grey (address the most predictable questions), **academic abilities are in bold** (usually more commonly tested in interviews). If the **skill can be tested by both types of interviews question it is both grey and bold**.

Student name: Type of interview: Academic/General

Universities interested in: Course:

Areas to improve:

Interview skill/ability	What you can do to improve this skill	Do you need to improve?
Understanding of course structure	*Find out essential details about your course from the university website.*	Yes
Ability to explain well why you applied to Oxford/Cambridge/Imperial	*Make sure your answers to predictable questions often asked are filled with details of things you have learnt; these will demonstrate that you are an enthusiastic student that wants to find answers because of your curiosity. You are interested in finding out how and why things work.*	Yes
Ability to explain why you chose your college	*Find out details about a science researcher and learn about how that relates.*	Yes
Ability to explain why you chose your subject at university	*This is an excellent opportunity to explain through the details you provide that you are curious about the subject and knowledgeable. A strong personal answer could even deliver a demonstration of your excitement about your subject.*	Yes
Ability to display outside reading	**Some questions, like why Cambridge/Chemistry are easier to show this than others.**	Yes
Curiosity in science	**Questions where you do not know the answer are straightforward to display your curiosity, but it is a really difficult skill to show, especially if it isn't really there. But you can build your curiosity through hard work and commitment, but it takes time and a great deal of passion for excellence to grow, but perhaps the most valuable skill to have at university.**	Yes
Ability to answer the question asked, and not talk about not relevant	**Think carefully before you answer, and never pretend you have misunderstood the question. At best, you are wasting your own interview time, at worst you are demonstrating an ability to be dishonest.**	Yes
Ability to demonstrate a quick honesty when you don't know the answer	**Think about the question and if you discover you don't have the answer, you next thing you need to help deliver the answer is to ask for help. If you waste time thinking about something with almost no chance of success you are demonstrating an inability to work effectively with ideas you are unfamiliar with. This is at the core of what these interviews are trying to find out about you.**	Yes

Interview skill/ability	What you can do to improve this skill	Do you need to improve?
Confidence	Strong, consistent success at A level can help, but so too will talking to others effectively. Confidence is all about knowing your limits and working within them. Arrogance is the opposite, not knowing your limits and working beyond them. Being good at AS level compared to others in your school is very different from being a strong Oxbridge candidate.	Yes
Strong English listening skills	Talk to your teachers in English about their subject, often and regularly. Talk to your friends and classmates in English about your favourite subjects, often and regularly.	Yes
Strong English-speaking skills	Talk to your teachers in English about their subject, often and regularly. Talk to your friends and classmates in English about your favourite subjects, often and regularly.	Yes
Waiting before you start to talk to think through the structure of your answer	Record yourself speaking your answer to a 3- or 4-mark exam question (either Paper 2 or even Paper 4), ideally without writing down anything. You can start with easier 1-mark questions. If it is a calculations question, you should also write out our answer.	Yes
Speaking out loud what you are thinking when you start answering a question	Mock interview practice is especially useful for this.	Yes
Ability to ask for help early and interact effectively with hints	Asking for help allows you to demonstrate a quickness and clarity of thought, and asking well for hints shows you can learn in the tutorial system which Oxbridge uses to teach undergraduates.	Yes
Ability to display strong command of subject syllabus knowledge	Sit your A2 exams in November (or at least plan and prepare to) and do the work necessary to get a strong A* at least in the subject you are applying to university for.	Yes
Ability to talk about larger and more complex science ideas effectively and in English	Talk to your teachers in English about their subject, often and regularly. Talk to your friends and classmates in English about your favourite subjects, often and regularly.	Yes
Understanding of the scientific method	Papes 3 and 5 (any science A Level) can help.	Yes
Ease and accuracy of use of technical terms	When you are talking with your teachers and friends, try to introduce 2 or 3 new technical terms into a conversation. Plan this before your conversation.	Yes
Ability to learn new information in the interview	This is a skill connected to learning, confidence and experience. A large amount of experience talking with knowledgeable people about things you are less knowledgeable can help. A wide and deep outside interest (curiosity) in your subject, for instance always and often watching excellent documentaries your whole life.	Yes

Appendix: Organising your best reference

Your reference will be about you and should include the best things you have done. It is vital that you help whoever is writing your reference write the best possible one they can.

In addition to giving them your personal statement answers to some or all of these questions will help!

Some of these questions you can also ask yourself at the start of your AS year, **and before you write your personal statement**, if you struggle to answer them well, then **<u>GET ACTIVE</u>** and do the things needed to allow you to answer them well!

Try to answer these questions as well as you can, with as much detail as possible. This form will help make all of the extra things you have done inside and outside of school help make your university application even better!

Name, English and Chinese (in pinyin): ______________________________ **Class:**__________

Email address: ______________________________

Which subject is writing your references (usually the subject you are applying for at degree level): __________

Which teacher is writing it?__________________________ Have you spoken to them about this? Yes/No

Getting to know your Choices.

1. **<u>Where</u>** do you want to study?
   Answer:

2. **<u>What:</u>** first choice subject?
   Answer:

3. Second and third choice subjects (if any)?
   Answer:

4. What do you **like** most about that subject?
   Answer:

5. What has happened that you find interesting in this field? (What's been in the news?)
   Answer:

6. Top 3 ideas for a career?
   Answer:

7. Why do you want to pursue your top career choices?
   Answer:

Getting to know your Interests

8. What have you done, seen, experienced that makes you more interested in this subject choice?
   Answer:

9. What do you **like most** about studying this subject at A Level?
   Answer:

10. What do you find most **interesting** about this subject and why?
    Answer:

11. What was the **last interesting** conversation you had with your teacher in your subject of interest?
    Answer:

12. What was the **most interesting** conversation you had with you teacher in your subject of interest?
    Answer:

13. How often do you talk about this subject with your friends?
    Answer:

14. What are the top 3 **biggest ideas** you have encountered?
    Answer:

15. What are the **3 most important** ideas to you that you have ever thought about?
    Answer:

16. What are your 3 favourite books you have read?
    Answer:

17. What are the 3 most important books to your development of your mind, that have had the biggest impact on how you think that you have read?
    Answer:

Getting to know your Achievements

18. What achievements do you have within the school? (e.g. helping out with school events, promoting the school, mentoring students, participating in events like maths day etc.).
    Answer:

19. Are you a member of any societies?
    Answer:

20. Have you lead any societies? How?
    Answer:

21. Have you achieved anything important with any society that you worked really hard at and are really proud of?
    Answer:

22. What after school events, like plays or sports competitions have you participated in? What did you learn from those experiences?
    Answer:

23. What are the top 3 reasons for going to or experiences you want to get out of your time at university?
    Answer:

24. When you imagine yourself after succeeding at university, how are you different? How are you the same?
    Answer:

25. What are the 3 things you are most proud about yourself?
    Answer:

Name: Class: Date:

Achievements

Include anything like academics/school Involvements, school productions, music performances, extracurricular activities: summer school, research project, school clubs, internship, community service, sports, skills, hobbies. Rank them according to how important you think they are (1=most important, 5 least important).

Your Rank	Grade	Hour/ week	Week /year	Activity Type	Year/ Break	Organization Name	Position	Activity Description
1	11	21	4	Academic	Summer break	Summer school with topic ****	Participant	Took lessons in *** taught by ***. Made 2 projects: *** & ***, which I presented to a group of 30 students and teachers at the end of the course. Achievements/what you took away from it： Worked as a team to learn about a topic beyond the syllabus for 3 weeks at a university in a city that I do not live in. Learnt the importance of effective and timely communication when working towards a deadline in a group setting with highly competitive people.

Your Rank	Grade	Hour/ week	Week /year	Activity Type	Year/ Break	Organization Name	Position	Activity Description

Competitions and Awards

Rank	Grade Level	Year	Honor Title	Awards	Level(s) of recognition	Additional notes
1	10	2020	UKMT Senior Mathematical Challenge	Merit	National	

Name: Class: Date:

Getting to know what you think about yourself

Be sure to give concrete examples to back up more general statements. Specificity is very important in a letter of recommendation.

And be as positive about yourself as possible!

Intellectual ability

Think about: overall intelligence, analytical skills, creativity, academic record, retention of information.

Answer:

Performance in class

Think about depth and breadth of knowledge, grade results, ability to analyze and apply what you have learnt

Answer:

Communication skills

Writing skills (what did you write?), spoken skills, e.g. in presentations given

Answer:

Self-discipline

To what extent are you persistent, efficient and motivated? Are you able to work independently?

Answer:

Personal qualities

Industry, self-discipline, motivation, maturity, initiative, flexibility, leadership qualities, team working skills, perseverance, energy, competitiveness, etc.

Answer:

Most important strengths and weaknesses

What do you expect to achieve at university. What things are you excited about doing whilst there?

Answer:

Any other things that make you stand out

Anything that is unique, important and good

Answer:

Getting to know your education history:

When did you come to High School?

Answer:

What's your primary and secondary school? Are they international schools or domestic schools?

Answer:

When did you decide to study abroad?

Answer:

Final opportunity

Further information you would like your reference to know **about you**, **your interests** and how all of this relates to **things you have done** that demonstrates **your subject passion**:

Getting to know what is on your UCAS form:

Intended degree subjects:

Number	Degree subject	Country	University
1		UK	
2		UK	
3		UK	
4		UK	
5		UK	

Grades

For the final column "Confirmed?", write yes if you have spoken to the teacher who is responsible for making that prediction and they are 100% sure they will give you that prediction.

Subject	iGCSE Grade	AS Grade	AS %	A2 Target grade	Predicted A Level grade	100% Confirmed?

If any of your predictions have not been 100% confirmed, add any additional details here that you would like your reference to know about:

Discussions with your referee

Ways to make talking with your teachers more positive and more productive:

- Talking with people in your life like teachers is a skill, if you find it difficult, don't worry, you just need to build this skill through careful practice!
- Be respectful, you are asking someone for something, their time, that they usually have very little of!
- Choose your time to ask them for their time carefully. Ask them "are you are free to talk now?", if they are usually busy, **ask them when they prefer to talk.**
- Write out what you would like to ask them, using the table that follows. This can help you feel less nervous. It will also mean that you are thinking much harder about your subject (active learning) which will improve your academic performance.
- Prepare your questions, based on what was taught last lesson, or recently. Try to pick a subtopic your teacher is obviously interested.
- Try to make your questions open ended, giving them the freedom to talk about their passion. Avoid questions like how many atoms are in the amino acid tryptophan, instead pick up on something they said in class "you said that tryptophan is an essential amino acid, what makes it essential?"
- The easiest kinds of questions are connected to what they like most about what they are teaching now, or what they teach in general.
- You should not be trying to catch them out, or get them onto parts of a subject they are less comfortable with. You want at the end of this for them to have the evidence to suggest that they think you would fit in well in any future academic setting. If you are going out of your way to make their work life more difficult than you are making it harder for them to write you a good reference, the opposite of a good idea.
- Start early, ideally at the start of your AS year! If you do, just one question a week per teacher will deliver a whole year's worth of outstanding engagement in all subjects form you
- As you get more experience talking to a teacher, try to talk to your other teachers. You might discover that they are quite different people when you take the care to get to know them! Showing an interest in your studies can also really help build positive and productive relationships that can prevent all kinds of problems that come from misunderstandings. You will also be building your skills in forming and maintaining professional relationships, a key life skill.
- Getting good at asking interesting questions is the essence of a thoughtful intellectual, and will help you stand out, even in the most intellectually competitive environments, like university and beyond.

Record of your conversations with your teacher in this table

Date	Day	Time	Topic discussed	Questions you asked, and the answers you got
26th Aug	Monday	Afterschool, 4:45pm	T23: Chemical energetics	You mentioned last lesson that this is your favourite topic in the syllabus. Last lesson you mentioned that the conservation of mass and the conservation of energy are fundamentally bound together, and to chemistry, what did you mean? Why are only the electron affinities of group 16 and 17 looked into on this course? How does charge density affect lattice enthalpy? If entropy can be thought of as time's arrow, why do we learn it along with advanced theories on energy?

Ideally this form should be typed out, but it could also easily just be used written out by hand.

To download an electronic version of the activities in MS Word format scan this:

File name: *Oxford, Cambridge and Top 20 University UCAS* ***Activities ONLY***

Or go here: https://www.smashingscience.org/uni-guidance