Name: Class: Date:

CAIE A Level Chemistry

Paper 5

Past Exam Questions

Organised by Question Type

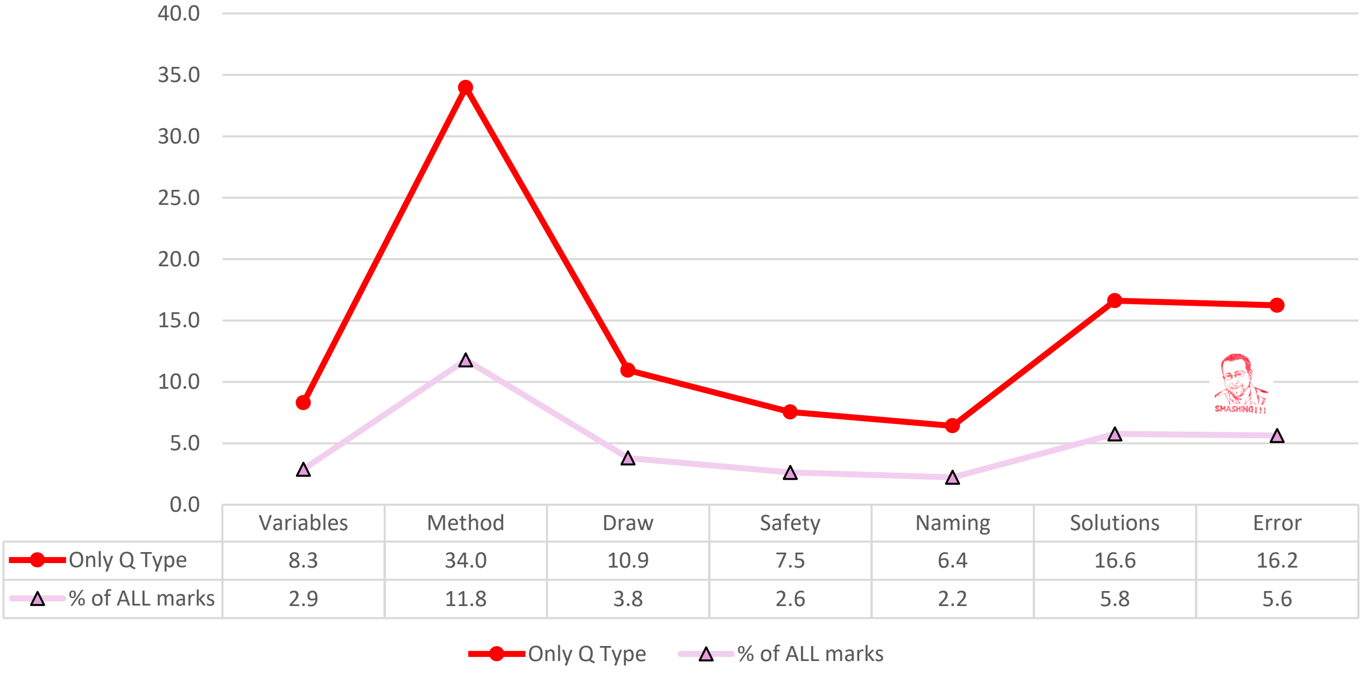
Winter 2003 to Summer 2023

Name: ______________________

Class: __________

CAIE A Level Chemistry 9701 **Paper 5**

Percentage of all marks awarded for each Exam Question Type from w2022 to s2002. Red line shows relative frequency of each question type.



	Variables	Method	Draw	Safety	Naming	Solutions	Error
Only Q Type	8.3	34.0	10.9	7.5	6.4	16.6	16.2
% of ALL marks	2.9	11.8	3.8	2.6	2.2	5.8	5.6

Note on the organisation

This workbook contains 530marks representing selected question types from a larger workbook with 1527marks which organises all of these exam papers instead by experiment type (also available on my website). The table that follows shows other kinds of questions, like those relating to graphs, that have not been included here, but should also be studied. The first two question types presented here, describing the method of an experiment and standard solutions are the most important looking at the last 7 years, the remainder are ordered alphabetically.

For and electronic version of this Work Book

Scan this code:

Contents

Name: Class: Date:

Question ID and locator	Topic #	Main experiment	# marks	Additional experimental details	Additional experimental details	Q #	Graph	Apparatus			Results table: create	Calculation: describe	Prediction	Variables	Anomaly:	Accuracy	Precision	Error	%Error	Reliability	Health & safety	Improvement
								Draw & label	Set up (Method)	Name or describe												
2002/s/tz1/ p5/Q# 1/	6	**Titration**	19			1	1															
2002/s/tz1/ p5/Q# 2/	27	**Gas volume**	9	Thermal Decomposition		2		1													1	
2002/w/tz1/ p5/Q# 1/	8	**Rate**	21			1			1													
2002/w/tz1/ p5/Q# 2/	2	**Gravimetric**	9	Mass lost		2			1		1											
2003/s/tz1/ p5/Q# 1/	6	**Titration**	20			1																
2003/s/tz1/ p5/Q# 2/	2	**Gravimetric**	10	Mass lost	Gas volume, Titration,	2					1	1										
2003/w/tz1/ p5/Q# 1/	5	**Thermometric**	25			1			1		1											
2003/w/tz1/ p5/Q# 2/	2	**States of matter**	5			2			1		1											
2004/s/tz1/ p5/Q# 1/	5	**Thermometric**	19			1	1															
2004/s/tz1/ p5/Q# 2/	2	**Gas volume**	11			2		1								1						
2004/w/tz1/ p5/Q# 1/	26	**Rate**	20			1																
2004/w/tz1/ p5/Q# 2/	4	**States of matter**	10			2	1		1		1											
2005/s/tz1/ p5/Q# 1/	2	**Gravimetric**	8	Mass lost		1																
2005/s/tz1/ p5/Q# 2/	2	**Thermometric titration**	12			2	1															
2005/s/tz1/ p5/Q# 3/	2	**Gas volume**	10	Titration		3												1	1			
2005/w/tz1/ p5/Q# 1/	4	**Titration**	20			1												1				
2005/w/tz1/ p5/Q# 2/	7	**Thermometric titration**	10			2					1											
2006/s/tz1/ p5/Q# 1/	8	**Rate**	22			1	1		1													
2006/s/tz1/ p5/Q# 2/	6	**Gravimetric**	8	Mass lost	Gas volume	2		1													1	
2006/w/tz1/ p5/Q# 1/	7	**Thermometric titration**	20			1	1															
2006/w/tz1/ p5/Q# 2/	27	**Gravimetric**	10	Mass lost		2			1													
2007/s/tz1/ p5/Q# 1/	8	**Rate**	15		Gas volume	1			1		1			1								

Question ID and locator	Topic #	Main experiment	# marks	Additional experimental details	Additional experimental details	Q #	Graph	Apparatus			Results table: create	Calculation: describe	Prediction	Variables	Anomaly:	Accuracy	Precision	Error	%Error	Reliability	Health & safety	Improvement
								Draw & label	Set up (Method)	Name or describe												
2007/s/tz1/ p5/Q# 2/	6	**Gravimetric**	15	Mass lost		2	1								1				1			
2007/w/tz1/ p5/Q# 1/	23	**Thermometric**	15			1		1	1		1		1	1				1			1	
2007/w/tz1/ p5/Q# 2/	8	**Rate**	14		Gas volume	2	1									1		1				
2008/s/tz1/ p5/Q# 1/	5	**Thermometric**	15			1			1		1	1	1	1								1
2008/s/tz1/ p5/Q# 2/	2	**Gravimetric**	15	Mass lost	Gas volume	2	1				1				1		1					1
2008/w/tz1/ p5/Q# 1/	23	**States of matter**	15			1			1		1	1		1							1	
2008/w/tz1/ p5/Q# 2/	24	**Electrolysis**	15			2	1				1				1		1					
2009/s/tz1/ p5/Q# 1/	27	**Gas volume**	15	Thermal Decomposition		1		1						1							1	
2009/s/tz1/ p5/Q# 2/	27	**States of matter**	15			2	1				1				1		1	1				
2009/w/tz1/ p5/Q# 1/	8	**Rate**	15			1			1		1			1			1					
2009/w/tz1/ p5/Q# 2/	2	**Gravimetric**	15			2					1				1			1				
2010/s/tz1/ p5/Q# 1/	5	**Thermometric titration**	15			1					1		1	1		1					1	
2010/s/tz1/ p5/Q# 2/	4	**States of matter**	9			2	1								1							
2010/s/tz1/ p5/Q# 3/	2	**Gravimetric**	6	Mass gained		3									1			1				
2010/w/tz1/ p5/Q# 1/	2	**States of matter**	16			1			1		1			1								
2010/w/tz1/ p5/Q# 2/	23	**States of matter**	14			2	1				1		1		1							
2011/s/tz1/ p5/Q# 1/	27	**Gas volume**	16	Thermal Decomposition		1		1			1			1						1		
2011/s/tz1/ p5/Q# 2/	27	**Gravimetric**	14	Mass lost	Thermal decomposition	2	1				1				1							
2011/w/tz1/ p5/Q# 1/	23	**Thermometric**	15			1			1		1											
2011/w/tz1/ p5/Q# 2/	26	**Rate**	15			2	1				1				1					1		
2012/s/tz1/ p5/Q# 1/	28	**States of matter**	15			1			1					1							1	
2012/s/tz1/ p5/Q# 2/	4	**Gas volume**	15			2	1				1				1					1		
2012/w/tz1/ p5/Q# 1/	6	**Gravimetric**	15	Mass lost		1		1		1	1	1		1							1	

Question ID and locator	Topic #	Main experiment	# marks	Additional experimental details	Additional experimental details	Q #	Graph	Apparatus			Results table: create	Calculation: describe	Prediction	Variables	Anomaly:	Accuracy	Precision	Error	%Error	Reliability	Health & safety	Improvement
								Draw & label	Set up (Method)	Name or describe												
2012/w/tz1/ p5/Q# 2/	26	**Rate**	**15**			2	1				1				1					1		
2013/s/tz1/ p5/Q# 1/	11	**Titration**	**15**			1			1				1								1	
2013/s/tz1/ p5/Q# 2/	2	**Gravimetric**	**15**	Mass lost		2	1								1					1		
2013/w/tz1/ p5/Q# 1/	23	**Thermometric**	**15**			1		1						1								
2013/w/tz1/ p5/Q# 2/	27	**States of matter**	**15**			2	1						1		1				1			
2014/s/tz1/ p5/Q# 1/	27	**Gas volume**	**15**	Thermal Decomposition		1		1									1				1	
2014/s/tz1/ p5/Q# 2/	24	**Electrolysis**	**15**			2	1								1							
2014/w/tz1/ p5/Q# 1/	9	**States of matter**	**15**			1			1								1	1				
2014/w/tz1/ p5/Q# 2/	7	**Titration**	**15**	Standard solution		2									1			1				
2015/s/tz1/ p5/Q# 1/	7	**Titration**	**15**	Standard solution		1								1								
2015/s/tz1/ p5/Q# 2/	7	**Gas volume**	**15**			2	1						1								1	
2015/w/tz1/ p5/Q# 1/	4	**Gas volume**	**15**			1		1											1		1	
2015/w/tz1/ p5/Q# 2/	7	**Thermometric titration**	**15**			2	1						1				1	1				
2016/m/tz2/ p5/Q# 1/	26	**Rate**	**20**	Titration		1			1					1								
2016/m/tz2/ p5/Q# 2/	5	**Thermometric**	**10**			2	1												1			
2016/s/tz1/ p5/Q# 1/	9	**Gas volume**	**15**	Titration		1		1													1	
2016/s/tz1/ p5/Q# 2/	26	**Rate**	**15**			2	1								1					1		
2016/w/tz1/ p5/Q# 1/	10	**Titration**	**15**	Standard solution		1			1												1	
2016/w/tz1/ p5/Q# 2/	26	**Rate**	**15**			2	1								1							
2017/m/tz2/ p5/Q# 1/	5	**Gravimetric**	**18**	Mass lost	Thermal decomposition	1	1		1				1						1			
2017/m/tz2/ p5/Q# 2/	28	**Miscellaneous**	**12**	Standard solution	Colourimetry	2	1			1											1	
2017/s/tz1/ p5/Q# 1/	5	**Thermometric**	**12**			1	1	1						1	1							
2017/s/tz1/ p5/Q# 2/	2	**Miscellaneous**	**18**	Standard solution	Optical rotation	2	1			1					1			1				

Question ID and locator	Topic #	Main experiment	# marks	Additional experimental details	Additional experimental details	Q #	Graph	Apparatus			Results table: create	Calculation: describe	Prediction	Variables	Anomaly:	Accuracy	Precision	Error	%Error	Reliability	Health & safety	Improvement
								Draw & label	Set up (Method)	Name or describe												
2017/w/tz1/ p5/Q# 1/	8	**Rate**	**14**			1				1							1		1		1	
2017/w/tz1/ p5/Q# 2/	24	**Electrolysis**	**16**			2	1											1	1			
2018/m/tz2/ p5/Q# 1/	4	**States of matter**	**16**			1	1	1							1	1	1					
2018/m/tz2/ p5/Q# 2/	6	**Titration**	**14**			2			1													
2018/s/tz1/ p5/Q# 1/	24	**Electrolysis**	**12**			1		1											1		1	
2018/s/tz1/ p5/Q# 2/	26	**Rate**	**18**		Gas volume	2	1	1														
2018/w/tz1/ p5/Q# 1/	26	**Rate**	**14**			1													1		1	
2018/w/tz1/ p5/Q# 2/	24	**Electrolysis**	**16**	Solubility product, Ksp		2	1		1	1												
2019/m/tz2/ p5/Q# 1/	26	**Rate**	**20**	Standard solution		1	1		1							1			1	1		
2019/m/tz2/ p5/Q# 2/	10	**States of matter**	**10**			2		1										1				
2019/s/tz1/ p5/Q# 1/	24	**Electrolysis**	**16**	Standard solution		1	1			1					1							
2019/s/tz1/ p5/Q# 2/	21	**States of matter**	**14**			2		1													1	
2019/w/tz1/ p5/Q# 1/	24	**Titration**	**13**	Standard solution		1				1												
2019/w/tz1/ p5/Q# 2/	4	**Rate**	**17**			2	1						1		1							
2020/m/tz2/ p5/Q# 1/	6	**Titration**	**19**			1			1							1			1			
2020/m/tz2/ p5/Q# 2/	8	**Rate**	**11**			2	1							1		1						
2020/s/tz1/ p5/Q# 1/	5	**Thermometric**	**11**			1			1				1					1			1	1
2020/s/tz1/ p5/Q# 2/	7	**Gas volume**	**19**			2	1	1		1						1						1
2020/w/tz1/ p5/Q# 1/	6	**Titration**	**13**	Standard solution		1				1									1			
2020/w/tz1/ p5/Q# 2/	14	**Gas volume**	**17**			2	1								1					1	1	1
2021/m/tz2/ p5/Q# 1/	5	**Thermometric**	**10**			1	1	1										1				
2021/m/tz2/ p5/Q# 2/	6	**Titration**	**20**	Standard solution		2				1	1											
2021/s/tz1/ p5/Q# 1/	8	**Rate**	**14**		Gas volume	1		1						1						1	1	

Question ID and locator	Topic #	Main experiment	# marks	Additional experimental details	Additional experimental details	Q #	Graph	Apparatus			Results table: create	Calculation: describe	Prediction	Variables	Anomaly:	Accuracy	Precision	Error	%Error	Reliability	Health & safety	Improvement
								Draw & label	Set up (Method)	Name or describe												
2021/s/tz1/ p5/Q# 2/	6	**Titration**	**16**			2										1		1	1			
2021/w/tz1/ p5/Q# 1/	27	**Thermometric**	**14**	Thermal Decomposition		1			1										1			1
2021/w/tz1/ p5/Q# 2/	26	**Rate**	**16**		Gas volume	2	1	1						1	1							
2022/m/tz2/ p5/Q# 1/	2	**Gravimetric**	**9**	Mass lost		1			1	1									1			
2022/m/tz2/ p5/Q# 2/	25	**Miscellaneous**	**21**	Standard solution	Conductivity	2	1								1				1	1	1	
2022/s/tz1/ p5/Q# 1/	11	**States of matter**	**14**	Standard solution		1	1			1						1			1	1		1
2022/s/tz1/ p5/Q# 2/	26	**Rate**	**16**	Titration		2	1			1				1	1						1	
2022/w/tz1/ p5/Q# 1/	11	**States of matter**	**10**			1			1										1			
2022/w/tz1/ p5/Q# 2/	4	**Gas volume**	**13**			2	1	1						1	1					1	1	
2022/w/tz1/ p5/Q# 3/	26	**Rate**	**7**	Standard solution		3				1												
2023/m/tz2/ p5/Q# 1/	7	**Titration**	**15**			1			1										1			
2023/m/tz2/ p5/Q# 2/	26	**Rate**	**15**	Standard solution		2	1		1					1	1			1	1			
2023/s/tz2/ p5/Q# 1/	25	**Titration**	**9**	Partition coefficient, Kpc		1			1				1								1	
2023/s/tz2/ p5/Q# 2/	37	**Miscellaneous**	**7**		Chromatography	2			1												1	
2023/s/tz2/ p5/Q# 3/	26	**Rate**	**14**	Standard solution	Gas volume	3	1		1						1							
Totals			**1527**				**47**	**22**	**33**	**14**	**26**	**4**	**12**	**21**	**30**	**10**	**9**	**17**	**21**	**12**	**27**	**7**

Exam Questions by Question Type

Q. Type: Describing the Method of an Experiment Topic: Chem 2 Q# 1/ ALvl Chemistry/2022/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1 A student has a sample of copper(II) sulfate crystals, $CuSO_4{\bullet}xH_2O$. The student wants to show that the value of *x* is 5.

The student uses the following method.

step 1 Weigh a clean crucible on a balance reading to two decimal places. Record the mass.

step 2 Place the sample of $CuSO_4{\bullet}xH_2O$ into the crucible. Record the mass.

step 3 Heat the crucible gently for about 1 minute then strongly for about 4 minutes.

step 4 Weigh the crucible and contents. Record the mass.

(a) Identify the instruction that is missing between **step 3** and **step 4**.

.... [1]

(b) Explain why gentle heating takes place in **step 3**.

.... [1]

(c) Name the apparatus that should be used to hold the crucible during heating.

.... [1]

(d) The method is incomplete.

State the step(s) that should be carried out to complete the method.

....

....

.... [1]

Q. Type: **Describing Method Topic: Chem 2 Q# 2/** ALvl Chemistry/2010/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 When aqueous sodium chloride, $NaCl$, is added to aqueous lead nitrate, $Pb(NO_3)_2$, a white precipitate of lead chloride, $PbCl_2$, is produced. A suggested stoichiometric equation is

$$Pb(NO_3)_2(aq) + 2NaCl(aq) \longrightarrow PbCl_2(s) + 2NaNO_3(aq)$$

In separate experiments, different volumes of 0.20 mol dm^{-3} aqueous sodium chloride are added to a fixed volume of 0.10 mol dm^{-3} aqueous lead nitrate. In each case, the precipitate is filtered, washed with distilled water and thoroughly dried. The mass of the precipitate is recorded.

> You are to plan an experiment to investigate this reaction in order to confirm or reject the stoichiometry of the equation.

(a) By considering the suggested stoichiometric equation, predict and explain how the number of moles of the precipitate, $PbCl_2$, will change as the number of moles of $NaCl$ added increases.

Prediction ....

....

....

Explanation ....

....

.... [2]

(b) State a limiting factor that must be taken into account when increasing the volume of the aqueous sodium chloride added.

.... [1]

(c) In the experiment you are about to plan, identify the following.

(i) the independent variable ....

(ii) the dependent variable ....

(iii) another variable to be controlled ....

[2]

(d) Design a laboratory experiment to test your prediction in **(a)**.

You are provided with 250 cm^3 of 0.20 $mol\,dm^{-3}$ aqueous sodium chloride.

(i) Outline how you would prepare 250 cm^3 of 0.10 $mol\,dm^{-3}$ aqueous lead nitrate.

[A_r: N, 14; O, 16; Pb, 207]

(ii) Give a step by step description of how you would carry out **one** experiment.
You should state
- the volumes of each solution to be used,
- how the volumes will be measured,
- how you would dry the precipitate.

..............................[6]

(f) How would you ensure that at the end of each experiment the precipitate was thoroughly dried?

..............................[1]

[Total: 16]

2 ASSESSMENT OF PLANNING SKILLS

The **'solubility'** of a substance in aqueous solution is defined as
the mass of anhydrous solid that will dissolve in and just saturate 100 g of water at a fixed temperature.

- 'Solubility' changes with temperature. In most cases more solid dissolves at higher temperatures.
- A solution that is saturated at a particular temperature is one in which no more solid may be dissolved.
- A saturated solution of potassium chlorate(V) can be represented by the equilibrium:

$$KClO_3(s) \rightleftharpoons KClO_3\,(aq)$$

- A saturated solution can be recognised by undissolved solid in equilibrium with aqueous solution.

DO NOT CARRY OUT YOUR PLAN

(a) You are provided with solid potassium chlorate(V), $KClO_3$, and distilled water.

You have available all the apparatus normally used in a school laboratory.
Use the information given above to plan an experiment to

(i) prepare a solution saturated with potassium chlorate at room temperature, and then

(ii) determine the 'solubility' of the potassium chlorate in that solution.

(i) Preparation of the saturated solution

....

....

....

....

....

....

....

....[3]

a	
b	
c	

(ii) Determination of the 'solubility'

....

....

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....

Create specimen results for your experiment and show how you would use these results to calculate the 'Solubility' of potassium chlorate(V) at room temperature.

....

....

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....

....

....

....

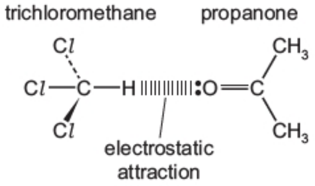
....[4]

d	
e	
f	
g	

Q. Type: **Describing Method Topic: Chem 5 Q# 4/** ALvl Chemistry/2020/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 Trichloromethane and propanone are both organic liquids. The molecules within each liquid are attracted to each other by relatively weak permanent dipole-dipole interactions.

When trichloromethane is mixed with propanone a strong electrostatic attraction forms between the two different molecules.



A student plans to perform an experiment to investigate the strength of this electrostatic attraction by finding the temperature change when equal volumes of trichloromethane and propanone are mixed together.

(a) (i) State and explain your prediction for the temperature change for this experiment.

[1]

(ii) The student is given **only** the following equipment and chemicals for the experiment.

1 × 25 cm^3 beaker
2 × thermometers
2 × 25 cm^3 measuring cylinders
50 cm^3 trichloromethane
50 cm^3 propanone

Outline the method the student should use in this one experiment to find the temperature change when trichloromethane is mixed with propanone. Give details of the volumes of liquids used and any readings taken.

volumes used

readings taken

method used

[3]

(b) The apparatus used leads to significant heat loss.

State **one** improvement the student could make to the apparatus to reduce heat loss.

[1]

(d) State **one** change, apart from reducing heat loss, that could be made to improve the accuracy of this experiment.

[1]

(f) Suggest an experiment the student could carry out to test whether the number of moles of trichloromethane affects the temperature change.

[1]

[Total: 11]

Q. Type: **Describing Method Topic: Chem 5 Q# 5/** ALvl Chemistry/2017/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1 The enthalpy change of reaction, ΔH_r, for the decomposition of sodium hydrogencarbonate, $NaHCO_3(s)$, cannot be measured directly.

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(l) + CO_2(g)$$

A student must carry out **two** separate experiments and use the results of these experiments to determine the enthalpy change of reaction for the decomposition of sodium hydrogencarbonate.

(a) Suggest why the enthalpy change of reaction, ΔH_r, for the decomposition of sodium hydrogencarbonate cannot be measured directly.

....

.... [1]

In both experiments the student used a weighing boat. A weighing boat is a small vessel used to contain solid samples when they are weighed.

Experiment 1 Reaction between sodium carbonate, $Na_2CO_3(s)$, and dilute hydrochloric acid, $HCl(aq)$

step 1 The student added approximately 3 g of $Na_2CO_3(s)$ to a weighing boat and accurately measured the combined mass of the weighing boat and $Na_2CO_3(s)$. This mass was recorded in Table 1.1.

step 2 The student used a measuring cylinder to measure 50 cm^3 of 2 mol dm^{-3} $HCl(aq)$.

step 3 The experiment was carried out and the results were recorded in Table 1.2.

step 4 The student reweighed the empty weighing boat and recorded the mass in Table 1.1.

Table 1.1 mass results from Experiment 1

mass of weighing boat and $Na_2CO_3(s)$/g	4.15
mass of empty weighing boat after addition of $Na_2CO_3(s)$ to $HCl(aq)$/g	0.97
mass of $Na_2CO_3(s)$ added/g	

Table 1.2 temperature results from Experiment 1

time/minutes	0	1	2	3		5	6	7	8	9	10
temperature of mixture/°C	20.0	19.8	19.8	19.8		24.6	24.7	24.5	24.3	24.1	23.9

(b) Outline how the student carried out **step 3** of the experiment.
You may find it helpful to write your answer as a series of smaller steps.

....

....

....

....

....

....

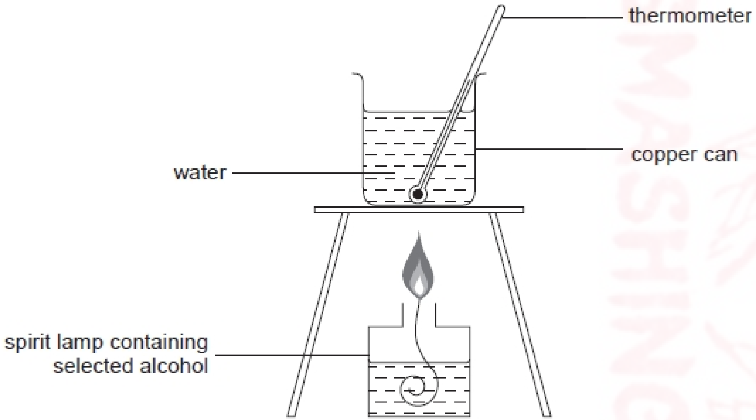
Draw a labelled diagram of the apparatus.

[3]

1 The equations for the complete combustion of the first five members of the alcohol homologous series are shown below.

methanol	$CH_3OH(l) + 1½O_2(g) \longrightarrow CO_2(g) + 2H_2O(l)$
ethanol	$CH_3CH_2OH(l) + 3O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(l)$
propan-1-ol	$CH_3CH_2CH_2OH(l) + 4½O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(l)$
butan-1-ol	$CH_3CH_2CH_2CH_2OH(l) + 6O_2(g) \longrightarrow 4CO_2(g) + 5H_2O(l)$
pentan-1-ol	$CH_3CH_2CH_2CH_2CH_2OH(l) + 7½O_2(g) \longrightarrow 5CO_2(g) + 6H_2O(l)$

You are to plan an experiment to determine the enthalpy change of combustion under laboratory conditions, ΔH_c, for each of the five alcohols using the apparatus and information below.



[4.2 J of heat energy raise the temperature of 1 cm^3 (1 g) of water by 1 °C.]

(d) You are to plan a step-by-step method to determine the enthalpy change of combustion, ΔH_c, for each of the alcohols in turn. You should use the apparatus shown in the diagram on page 2 and any other apparatus required that is normally found in a school or college laboratory.

You need only explain how the method will be used for ethanol.

Your method should cover the following points.

- the precision of the apparatus to be used
- the way in which the independent variable is varied between experiments
- measurement of the dependent variable
- appropriate quantities to be used
- the raw data to be collected
- how this data is to be processed for ethanol

[4.2 J of heat energy raise the temperature of 1 cm^3 (1 g) of water by 1 °C.]

Method

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Processing of raw data
[M_r: CH_3CH_2OH, 46]

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[6]

(f) The apparatus shown in the diagram on page 2 and used in the experiment you have described is inefficient as much of the energy released from the burning alcohol is lost to the atmosphere.
You are to plan **two simple changes** to the apparatus shown on page 2 that will reduce the loss of heat energy to the atmosphere.
Draw a diagram of your improved apparatus, indicating and explaining how these changes will reduce the loss of heat energy.

improvement 1 ....

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improvement 2 ....

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[2]

[Total: 15]

Q. Type: **Describing Method Topic: Chem 6 Q# 7/** ALvl Chemistry/2020/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1 Brass is an alloy of copper and zinc. Typical copper concentrations vary from 50% to 85%, depending upon the properties needed in the alloy. There may be small amounts of other metals present.

A student found a method to determine the percentage of copper in a sample of brass.

A known mass of brass powder is reacted with excess concentrated nitric acid. Both the copper and the zinc and any other metals present are oxidised into aqueous ions by the nitric acid. The amount of $Cu^{2+}(aq)$ ions present can be determined by a titration technique.

step 1 Use a weighing boat to accurately weigh by difference approximately 2 g of brass powder and place the brass into a small glass beaker.

step 2 In a fume cupboard add **approximately** 20 cm^3 of concentrated nitric acid to the brass in the beaker. Allow the brass to completely react to form solution **A**.

The equation for the reaction is shown.

$$Cu(s) + 4HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2NO_2(g) + 2H_2O(l)$$

step 3 Dilute **all** of solution **A** to form exactly 250.0 cm^3 of solution **B**.

step 4 Place 25.00 cm^3 of solution **B** into a conical flask.

step 5 Use a dropping pipette to add aqueous sodium carbonate, $Na_2CO_3(aq)$, to solution **B** in the conical flask until there is no more acid present.

step 6 Add approximately 20 cm^3 of aqueous potassium iodide, KI(aq), to the conical flask. A white precipitate forms as well as a brown solution of aqueous iodine, $I_2(aq)$.

step 7 Fill a burette with 0.100 mol dm^{-3} sodium thiosulfate solution, $Na_2S_2O_3(aq)$, so it is ready for the titration in **step 8**.

step 8 Carry out a titration of the aqueous iodine produced in the conical flask against the 0.100 mol dm^{-3} $Na_2S_2O_3(aq)$.

(a) Outline how the student should accurately weigh by difference in **step 1** in order that the exact mass of brass transferred into the small glass beaker is known. Include a results table, with appropriate headings, ready for the student to fill in.

....

....

[2]

(b) Suggest why it is necessary to do **step 2** in a fume cupboard.

.... [1]

(c) Outline how the student should carry out **step 3**. Include the name and capacity of the suitable piece of apparatus in which solution **B** should be prepared.

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.... [2]

(d) Name the apparatus needed to transfer solution **B** into the conical flask in **step 4**.

.... [1]

(e) State how the student would know there was no more acid present in the mixture in **step 5**.

.... [1]

(f) The student is given 200 cm^3 of 0.100 mol dm^{-3} $Na_2S_2O_3(aq)$.

Outline how the student should use this solution to fill the burette in **step 7** so it is ready for titration. Include any relevant procedures the student should follow to ensure the burette is correctly filled before any readings are taken.

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.... [2]

(i) A small percentage of silver is sometimes found in some brass alloys.

In **step 2**, when concentrated nitric acid is added, silver metal is oxidised to silver ions, $Ag^+(aq)$.

At the end of **step 6** the $Ag^+(aq)$ ions no longer remain in solution.

Explain why.

.... [1]

[Total: 19]

Q. Type: **Describing Method Topic: Chem 6 Q# 8/** ALvl Chemistry/2018/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2 'Lawn sand' is spread over the grass in gardens to reduce the growth of moss. Lawn sand is a mixture of sand and iron(II) sulfate crystals, $FeSO_4.7H_2O$.

Lawn sand usually contains 6–10% $FeSO_4.7H_2O$ by mass.

To determine the exact percentage by mass of $FeSO_4.7H_2O$ present in a sample of lawn sand, a student devises the following experiment.

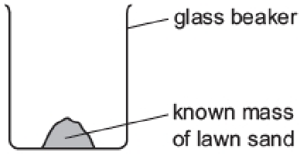
step 1 Use a known mass of lawn sand to prepare 250.0 cm³ of solution **A** containing $Fe^{2+}(aq)$ ions. Solution **A** must have dilute sulfuric acid, $H_2SO_4(aq)$, added to it **before** it is made up to 250 cm³.

step 2 To determine the concentration of $Fe^{2+}(aq)$ in solution **A**, titrate a 25.00 cm³ sample of solution **A** against 0.0200 mol dm⁻³ aqueous potassium manganate(VII), $KMnO_4(aq)$.

The reaction which takes place during the titration is shown.

$$MnO_4^-(aq) + 8H^+(aq) + 5Fe^{2+}(aq) \rightarrow Mn^{2+}(aq) + 4H_2O(l) + 5Fe^{3+}(aq)$$

(b) Describe a method to prepare 250.0 cm³ of solution **A** starting with a glass beaker which contains the known mass of lawn sand determined in **(a)(ii)** as shown.



Assume that common laboratory apparatus is available.
You may find it helpful to write your answer as a series of smaller steps.

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.... [5]

(c) State the colour change in the conical flask at the end-point of the titration.

from .... to .... [1]

(d) Aqueous potassium manganate(VII) is a powerful oxidising agent.

Suggest the effect, if any, on the end-point volume if the student acidified the mixture with dilute hydrochloric acid, $HCl(aq)$, instead of dilute sulfuric acid, $H_2SO_4(aq)$. Explain your answer.

effect, if any, on the end-point volume ....

explanation ....

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.... [2]

[Total : 14]

Q. Type: **Describing Method Topic: Chem 7 Q# 9/** ALvl Chemistry/2023/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1 Aqueous iron(II) ions, $Fe^{2+}(aq)$, are usually kept in acidic conditions to prevent them readily oxidising to aqueous iron(III) ions, $Fe^{3+}(aq)$.

$Fe^{2+}(aq)$ ions react with $Ag^{+}(aq)$ ions in a redox reaction. The following equilibrium is established.

$$Fe^{2+}(aq) + Ag^{+}(aq) \rightleftharpoons Fe^{3+}(aq) + Ag(s)$$

The concentration of $Fe^{2+}(aq)$ at equilibrium can be found by titration with a standard solution of aqueous potassium manganate(VII), $KMnO_4(aq)$. $KMnO_4(aq)$ is deep purple in colour. The equilibrium constant for the reaction can be found using the following equation.

$$K_c = \frac{[Fe^{3+}(aq)]_{eqm}}{[Fe^{2+}(aq)]_{eqm} \times [Ag^{+}(aq)]_{eqm}}$$

A student carries out the experiment using the following instructions.

step 1 Add 100.0 cm^3 of 0.200 mol dm^{-3} $AgNO_3(aq)$ to 100.0 cm^3 of 0.200 mol dm^{-3} $Fe(NO_3)_2(aq)$ in a 500 cm^3 conical flask and stopper the flask. Label the conical flask **A**.

step 2 Leave conical flask **A** for four hours, shaking intermittently. Then leave conical flask **A** untouched for one hour.

step 3 Use a pipette to transfer 25.00 cm^3 of the solution from conical flask **A** into a clean 250 cm^3 conical flask. Label this conical flask **B**.

step 4 Add 5 cm^3 of 1.00 mol dm^{-3} $NaCl(aq)$ to the solution in conical flask **B**. A white precipitate of silver chloride forms.

step 5 Use a measuring cylinder to add 20 cm^3 of 1.00 mol dm^{-3} sulfuric acid to conical flask **B**.

step 6 Rinse a burette and fill it with a standard solution of $KMnO_4(aq)$.

step 7 Add $KMnO_4(aq)$ to the mixture in conical flask **B** until an end-point is reached.

step 8 Empty conical flask **B** and rinse it with distilled water ready for the next titration.

The student repeats the titration until concordant readings are achieved.

(a) The student records their results in Table 1.1.

Table 1.1

	rough	titration 1	titration 2	titration 3
final burette reading / cm^3	10.60	20.35	30.25	9.85
initial burette reading / cm^3	0.10	10.70	20.35	0.10
titre / cm^3				

(b) State what is meant by a standard solution in **step 6**.

.... [1]

(c) **(i)** Suggest why conical flask **A** is left for four hours in **step 2**.

.... [1]

(ii) Suggest why conical flask **A** is **not** shaken during the final hour in **step 2**.

.... [1]

(d) Suggest why a measuring cylinder is the most appropriate apparatus to use for measuring sulfuric acid in **step 5**.

.... [1]

(e) State what the burette should be rinsed with in **step 6**.

.... [1]

(f) State the change of colour seen in the mixture in conical flask **B** at the end-point in **step 7**.

from .... to .... [1]

(g) The student repeats the experiment using $KMnO_4(aq)$ at a lower concentration. The student obtains a larger mean titre.

Suggest one reason why a larger titre is better than a smaller titre.

.... [1]

Q. Type: **Describing Method Topic: Chem 8 Q# 10/** ALvl Chemistry/2009/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 One method of studying the kinetics of a reaction is by the initial rates method.
To determine the initial rate we can time how long it takes to reach an identifiable point early in the reaction.

In solution, iodide ions, I^-, are oxidised by persulfate ions, $S_2O_8^{2-}$.

$$S_2O_8^{2-}(aq) + 2I^-(aq) \longrightarrow 2SO_4^{2-}(aq) + I_2(aq)$$

If sodium thiosulfate and starch are added to the reaction mixture, the blue-black colour of an iodine-starch complex appears suddenly. This occurs when all of the thiosulfate ions, $S_2O_3^{2-}$, present in the mixture have reacted with the iodine formed in the reaction above. This is the identifiable point in the reaction.

$$2S_2O_3^{2-}(aq) + I_2(aq) \longrightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$

You are to plan an experiment to investigate how the rate of reaction between potassium persulfate and potassium iodide depends on the concentration of potassium persulfate.
A preliminary experiment, using approximate volumes of solution, indicates that the time taken for the iodine-starch complex to form doubles when the potassium persulfate is diluted with an equal amount of water.

(d) Design a laboratory experiment that you would use to investigate your prediction in **(a)**.

The following materials are to be used in your plan.

0.60 mol dm^{-3} potassium iodide
0.20 mol dm^{-3} potassium persulfate
0.01 mol dm^{-3} sodium thiosulfate
distilled water
starch indicator solution

A first experiment is carried out using the following quantities.

20 cm^3 potassium iodide
40 cm^3 potassium persulfate
20 cm^3 sodium thiosulfate
0 cm^3 distilled water
10 cm^3 starch indicator solution

Give a step-by-step description of the method you would use in further experiments. Include the following in your plan.

- the range of concentrations
- the volume of each solution to be used
- the method of measuring the volume of each solution
- how and when the solutions are to be mixed
- the way in which the dependent variable will be measured
- the control of all other variables

For Examiner's Use

i	
ii	
iii	
iv	
v	
vi	

[6]

(e) Explain why the volume of aqueous sodium thiosulfate should be measured precisely, using a burette, in each of the experiments.

[1]

Q. Type: **Describing Method Topic: Chem 8 Q# 11/** ALvl Chemistry/2007/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 Hydrochloric acid and magnesium ribbon react to produce hydrogen gas.

$$2HCl(aq) + Mg(s) \rightarrow MgCl_2(aq) + H_2(g)$$

You are to plan the details of an experiment, based on the volume of gas produced in the reaction, to investigate how the rate of reaction depends on the concentration of the hydrochloric acid.

(d) Design a laboratory experiment that you would use to investigate your prediction in **(a)(i)**.

You are provided with the following.

magnesium ribbon
2 mol dm^{-3} hydrochloric acid

Your plan should give a step-by-step description of the method, including

(i) a list of the apparatus you would use,
(ii) how you would measure the independent variable and how you would ensure that its value has been measured accurately,
(iii) how you would mix the reactants without loss of gas from the apparatus,
(iv) how you would measure the dependent variable,
(v) how you would control the other variables,
(vi) appropriate quantities (volumes, relative concentrations) to use in the experiment.

(i)	
(ii)	
(iii)	
(iv)	
(v)	
(vi)	
(vii)	

[7]

(f) Describe how you would alter the method to investigate how the rate of reaction varies with changing temperature.

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[Total: 15]

Q. Type: **Describing Method Topic: Chem 9 Q# 12/** ALvl Chemistry/2014/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 A solder is an alloy of metals which is used to join other metal pieces together.
A specialist solder that can be used to join together pieces of aluminium is made from a mixture by mass of 65% zinc, 20% aluminium and 15% copper.

You are to plan an experimental procedure to confirm the composition of a powdered sample of this solder, by adding reagents and then extracting from the mixture each of the following in sequence;

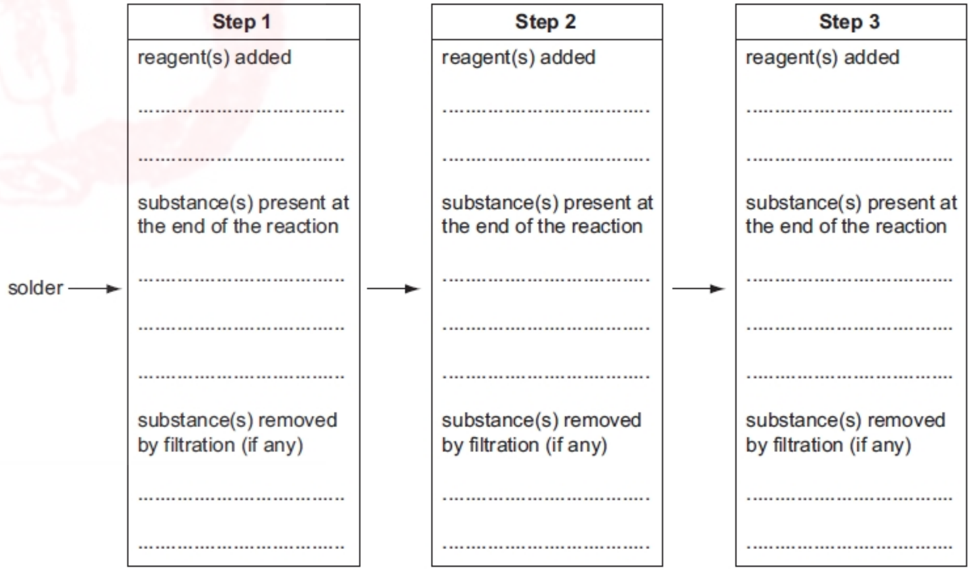
(i) the copper metal,
(ii) the aluminium as aluminium hydroxide,
(iii) the zinc as zinc hydroxide.

You are provided with

- a sample of this solder, with approximate mass 4 g,
- 1.00 mol dm^{-3} sulfuric acid,
- 1.00 mol dm^{-3} ammonia.

No other reagents should be used. Standard laboratory equipment is available including a balance, accurate to two decimal places.

(a) Complete the flowchart below to show the order in which the reagents would be added to the solder to allow you to extract and separate the components as copper metal, **(Step 1)**, aluminium hydroxide, **(Step 2)**, and zinc hydroxide, **(Step 3)**.
You are reminded that aqueous ammonia contains both the base OH$^-$ and the complex-forming molecule NH_3.



[5]

(b) For some of the steps in the procedure you would need to be careful to add an appropriate quantity of a reagent.
For each step of your procedure explain why particular quantities of reagent should be chosen.

Step 1 ....

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Step 2 ....

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Step 3 ....

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.... [4]

(c) The aluminium hydroxide and zinc hydroxide that have been extracted are difficult to dry so it is better to convert them to their oxides.
Describe how this could be done and how you would make sure that each hydroxide had been completely converted into its oxide.

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.... [2]

(d) The purpose of the experiment is to confirm the composition of the solder.
When the experiment is carried out state

- the measurements that would be taken,
- what you would do to the copper to make sure that the correct value is obtained.

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.... [2]

(f) Even if the experimental difficulties of extracting all of the copper from the mixture were overcome, it would be difficult to obtain an accurate mass of copper from this experiment.
Suggest why.

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.... [1]

Q. Type: **Describing Method Topic: Chem 10 Q# 13/** ALvl Chemistry/2016/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 When hydrated barium chloride, $BaCl_2.\mathbf{x}H_2O$, dissolves in water, $Ba^{2+}(aq)$ and $Cl^-(aq)$ ions are formed.

The concentration of chloride ions in solution can be determined by titration with aqueous silver nitrate of known concentration.

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

The indicator for the reaction is aqueous potassium chromate(VI), $K_2CrO_4(aq)$. At the endpoint of the titration, it forms a red precipitate in the presence of excess silver ions.

(a) The solubilities, in g dm^{-3}, of different ionic compounds at 20 °C are given in the table below.

	anion		
cation	Cl^-	CrO_4^{2-}	SO_4^{2-}
Ag^+	0.0019	0.022	293
Ba^{2+}	358	0.0028	0.00245

With reference to these data, where relevant, answer the following questions.

(i) Name the red precipitate and give an equation for its formation.

name: ....

equation: ....

[2]

Sulfuric acid must be added to the solution to prevent the $Ba^{2+}(aq)$ ions from interfering with the action of the potassium chromate(VI) indicator.

(ii) How would $Ba^{2+}(aq)$ ions interfere with the action of this indicator?

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.... [1]

(iii) How does the addition of sulfuric acid prevent $Ba^{2+}(aq)$ ions from interfering with the action of this indicator?

....

.... [1]

(c) You are to plan a titration experiment to determine the value of **x** in $BaCl_2.\mathbf{x}H_2O$.

You are provided with the following materials.

3.00 g of hydrated barium chloride, $BaCl_2.\mathbf{x}H_2O$
0.050 mol dm^{-3} aqueous silver nitrate
1.0 mol dm^{-3} potassium chromate(VI) solution
1.0 mol dm^{-3} sulfuric acid

(i) Name **three** pieces of volumetric apparatus you would use, with their capacities in cm^3.

1 ....

2 ....

3 ....

[2]

(iii) A known volume of barium chloride solution is transferred to a conical flask.

In what order should the other three solutions then be added to the flask?

first ....

second ....

third ....

[1]

(iv) How would you ensure that your titration result is reliable?

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.... [1]

Q. Type: **Describing Method Topic: Chem 11 Q# 14/** ALvl Chemistry/2022/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 A student attempts to determine the percentage by mass of magnesium chloride in the solid mixture containing magnesium chloride, $MgCl_2$, and anhydrous magnesium nitrate, $Mg(NO_3)_2$, using the following method.

step 1 Accurately weigh about 1.5 g of the solid mixture and record the mass.

step 2 Dissolve the solid mixture in distilled water.

step 3 Add an excess of silver nitrate solution.

step 4 Filter the solid mixture and wash the precipitate collected with distilled water.

step 5 Dry the precipitate in an oven.

step 6 Weigh the precipitate and record the mass.

In this process only the chloride ions from the magnesium chloride form a precipitate with the silver nitrate solution.

$$MgCl_2(aq) + 2AgNO_3(aq) \rightarrow Mg(NO_3)_2(aq) + 2AgCl(s)$$

One student in the class obtains the following results.

mass of solid mixture = 1.52 g

mass of $AgCl$ solid after drying = 3.63 g

(b) **(i)** Suggest what the student could do in **step 2** to ensure the solid dissolves as quickly as possible.

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.... [1]

(ii) Explain why the precipitate was washed with distilled water before it was dried.

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.... [1]

(iii) Suggest why the precipitate is dried in an oven and not by direct heating with a Bunsen burner.

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.... [1]

(iii) State what could be done in **step 5** to ensure that the precipitate was completely dried.

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.... [1]

(d) Another student in the class did not dry their silver chloride.

State how this would affect the value of the percentage by mass of magnesium chloride in the sample. Explain your answer.

....

.... [1]

[Total: 10]

Q. Type: **Describing Method Topic: Chem 11 Q# 15/** ALvl Chemistry/2013/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 Chlorine gas, Cl_2, is slightly soluble in water, approximately 5 g dm^{-3} at 25 °C. The molar enthalpy of solution of a gas is defined as the enthalpy change when one mole of the gas is dissolved in water.

(c) You are to plan an experiment to determine as accurately as possible the concentration of a saturated aqueous solution of chlorine by titration. You are reminded that the approximate solubility of chlorine is 5 g dm^{-3} at 25 °C.

The following information gives some of the hazards associated with chlorine, iodine and sodium thiosulfate.

> Saturated **chlorine water** is **low hazard** but chlorine gas escapes, which is **harmful**.
> **Iodine** is **harmful** by inhalation and in contact with skin or eyes. Solutions more concentrated than or equal to 1 mol dm^{-3} are **harmful**.
> **Sodium thiosulfate** is **non-hazardous**.

Aqueous chlorine, Cl_2, displaces iodine, I_2, from aqueous potassium iodide.

$$Cl_2(aq) + 2KI(aq) \rightarrow I_2(aq) + 2KCl(aq)$$

Therefore if a solution of chlorine is mixed with an excess of aqueous potassium iodide, iodine is displaced in a 1 : 1 molar ratio with chlorine.

The concentration of chlorine in the original solution can therefore be calculated from the concentration of the displaced iodine.

$$I_2(aq) + 2Na_2S_2O_3(aq) \rightarrow 2NaI(aq) + Na_2S_4O_6(aq)$$

You are provided with the following materials:

saturated aqueous chlorine,
solid sodium thiosulfate $Na_2S_2O_3.5H_2O$,
concentrated aqueous potassium iodide. This will be used in excess.

Give a step-by-step description of how you would carry out the experiment by including:

(i) a list of apparatus with volumes where appropriate,

(ii) a suitable indicator with relevant colours,

(iii) a calculation of the approximate concentration of saturated aqueous chlorine in mol dm^{-3} at 25 °C,
[A_r: Cl, 35.5]

(iv) a detailed description of the method for preparing a solution of aqueous sodium thiosulfate that can be used in the titration. In a titration, it is usual for the two reacting volumes to be approximately equal at the end-point. Calculate the mass of sodium thiosulfate, $Na_2S_2O_3.5H_2O$, which will produce a solution suitable for use in this titration. The relevant calculations and reasoning must be shown in full,
[A_r: H, 1.0; O, 16.0; Na, 23.0; S, 32.1]

(v) a detailed method for carrying out sufficient titrations to allow an accurate end-point to be obtained,

(vi) an outline calculation to show how the results are to be used to determine the accurate concentration of the aqueous chlorine.

[8]

Q. Type: **Describing Method Topic: Chem 23 Q# 16/** ALvl Chemistry/2011/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 When potassium nitrate dissolves in water, the temperature of the solution goes down because the enthalpy of solution is endothermic.

> You are to plan an experiment to investigate how the solubility of potassium nitrate varies with temperature. The units of solubility are grams per one hundred grams of water (g/100g water).

(c) Design a laboratory experiment to test your prediction in **(a)**.

In addition to the standard apparatus present in a laboratory you are provided with the following materials,

a boiling tube,
a looped wire stirrer,
a thermometer covering the temperature range 0 °C to 100 °C.

Describe how you would carry out the experiment. You should

- ensure a wide range of results suitable for analysis by graph,
- decide on the amounts of water and potassium nitrate to use,
- measure the amounts of the two reagents,
- heat the apparatus,
- decide at what point the temperature of the solution is to be taken.

[7]

Q. Type: **Describing Method Topic: Chem 23 Q# 17/** ALvl Chemistry/2008/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 The **solubility** of cerium(IV) sulphate, at a particular temperature, is defined as:

*the mass of cerium(IV) sulphate that will dissolve in and just **saturate** 100 g of solvent at that temperature.*

> Cerium(IV) sulphate will dissolve in water.
>
> A **saturated** solution is one in which no more solid can dissolve at a particular temperature.
> In a saturated solution in contact with undissolved solid, the following equilibrium is established.
>
> $$Ce(SO_4)_2(s) + aq \rightleftharpoons Ce^{4+}(aq) + 2SO_4^{2-}(aq)$$
>
> Cerium(IV) sulphate is unusual. Its solubility **decreases** as the temperature of the solution increases.

Cerium(IV) sulphate crystals also dissolve in dilute sulphuric acid, H_2SO_4, a corrosive aqueous solution.

> You are to plan an experiment to investigate how the **solubility** of cerium(IV) sulphate crystals in dilute sulphuric acid depends on the concentration of the acid.

(c) Design a two-part laboratory experiment to investigate your prediction in **(a)**.

Part 1 – solubility of cerium(IV) sulphate in water

In addition to the standard apparatus present in a laboratory you are provided with the following materials.

60 cm^3 distilled water
solid cerium(IV) sulphate, $Ce(SO_4)_2$

Give a step-by-step description of how you would

(i) prepare a saturated solution using all of the 60 cm^3 of distilled water,
(ii) control the variable given in **(b) (iii)**,
(iii) separate the saturated solution from undissolved solid,
(iv) obtain the mass of cerium(IV) sulphate and mass of water in the saturated solution,
(v) calculate the solubility of cerium(IV) sulphate from the experimental results.

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Part 2 – solubility of cerium(IV) sulphate in sulphuric acid

In addition to the standard apparatus present in a laboratory you are provided with the following materials.

5 mol dm^{-3} sulphuric acid
distilled water
solid cerium(IV) sulphate

Give a step-by-step description of how you would prepare a range of solutions of sulphuric acid of different concentrations. These solutions could then be used to investigate the solubility of cerium(IV) sulphate in different concentrations of sulphuric acid. See section **(e)**.

Your plan should include details of the following.

(i) the number and concentrations of the solutions to be prepared
(ii) the volumes of acid and water used to prepare the solutions
(iii) the apparatus and method you would use in their preparation

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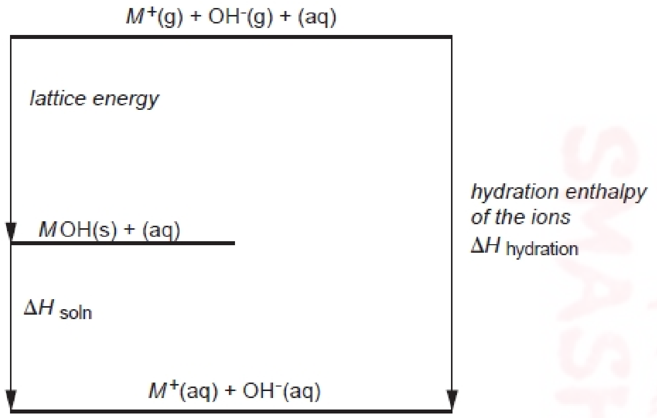
Q. Type: **Describing Method Topic: Chem 23 Q# 18/** ALvl Chemistry/2007/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 The hydroxides of Group I metals (LiOH, NaOH, KOH, RbOH, CsOH) are highly corrosive white solids which rapidly absorb water vapour on exposure to the atmosphere.
All of these solids dissolve exothermically in water.
The enthalpy change of solution, ΔH_{soln}, is the energy change associated with the following reaction. *M* represents the Group I metal.

$$MOH(s) + (aq) \rightarrow M^+(aq) + OH^-(aq)$$

The following diagram represents theoretical stages in the formation of aqueous *M*OH.



Lattice energy and hydration enthalpy are both more exothermic when ions carry a higher charge and/or ions have a smaller radius.

When comparing Group I hydroxides, changes in $\Delta H_{hydration}$ are more significant than changes in lattice energy.

(e) Describe the procedure you would carry out to find the enthalpy change of solution, ΔH_{soln}, for **one** of the Group I hydroxides.

Your plan should give a step-by-step description of the method, including

☐ ☐ ☐ ☐ how you would measure the independent variable,
☐ ☐ ☐ ☐ how you would measure the dependent variable,
☐ ☐ ☐ ☐ appropriate masses and volumes of reagents.

The following data may be of use in planning the detail of your experiment.

A_r: Li, 6.9; Na, 23.0; K, 39.1; Rb, 85.5; Cs, 133.0, O, 16.0; H, 1.0
4.3 J are required to raise the temperature of 1.0 cm^3 of any solution by 1°C.

[4]

Q. Type: **Describing Method Topic: Chem 25 Q# 19/** ALvl Chemistry/2023/s/TZ 2/ Paper 5/Q# 1/Smashing!!!

1 The partition coefficient, K_{pc}, shows the distribution of a solute between two immiscible solvents. K_{pc} is determined by measuring the concentration of the solute in each solvent.

The organic solvent ethoxyethane, $CH_3CH_2OCH_2CH_3$, and water are immiscible. A student is asked to find K_{pc} of butanedioic acid, $HOOCCH_2CH_2COOH$, between ethoxyethane and water.

The expression for K_{pc} when butanedioic acid is in equilibrium between ethoxyethane and water is shown.

$$K_{pc} = \frac{[HOOCCH_2CH_2COOH(ethoxyethane)]}{[HOOCCH_2CH_2COOH(aq)]}$$

[density: ethoxyethane, 0.71 g cm^{-3}; water, 1.00 g cm^{-3}]

The student uses the following method to find the partition coefficient. A diagram of the apparatus is shown in Fig. 1.1.

step 1 Add 30.0 cm^3 of distilled water to a separating funnel.

step 2 Weigh by difference 2.81 g of butanedioic acid into the separating funnel.

step 3 Stopper the separating funnel and shake it until the butanedioic acid has dissolved.

step 4 Remove the stopper and add 30.0 cm^3 of ethoxyethane to the separating funnel.

step 5 Replace the stopper and shake the separating funnel gently.

step 6 Place the separating funnel into a clamp. Allow the liquids to settle so that the two layers can be seen.

step 7 Remove the stopper and open the separating funnel tap to allow the lower layer to run into a beaker labelled **A**. Run the upper layer into a beaker labelled **B**.

step 8 Transfer 10.0 cm^3 of the aqueous layer into a conical flask. Titrate with 0.500 mol dm^{-3} NaOH(aq). Use thymolphthalein as the indicator.

step 9 Take 10.0 cm^3 of the ethoxyethane layer and add 10.0 cm^3 of water to it. Titrate this mixture with 0.100 mol dm^{-3} NaOH(aq). Use thymolphthalein as the indicator.

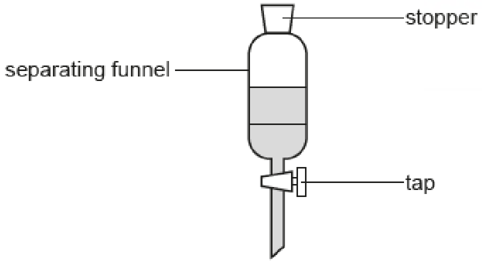


Fig. 1.1

(a) (i) State whether beaker **A** in step 7 contains the aqueous layer or the ethoxyethane layer.

Explain your answer.

Beaker **A** contains the .... layer.

explanation ....

....
[1]

(ii) Identify the piece of apparatus that should be used in step 8 to transfer 10.0 cm^3 of the aqueous layer.

.... [1]

(iii) Suggest why water is added to the ethoxyethane layer in step 9 before the titration can take place.

....

.... [1]

(b)

(iii) Explain why the student is only able to repeat the titration in step 8 once.

....

....

.... [1]

(iv) Suggest how you would modify the procedure to ensure the student can repeat the titration in step 8 more than once.

....

.... [1]

(v) A different student forgets to shake the separating funnel in step 5.

Describe the effect this would have on the calculated K_{pc} value. Explain your answer.

effect on K_{pc} ....

explanation ....

....
[1]

[Total: 9]

Q. Type: **Describing Method Topic: Chem 26 Q# 20/** ALvl Chemistry/2023/s/TZ 2/ Paper 5/Q# 3/Smashing!!!

3 A scientist is asked to find the rate of decomposition of an aromatic diazonium compound and determine the order of the reaction with respect to the aromatic diazonium compound.

(a) The scientist is given 1.02 g of an aromatic diazonium compound in a 50 cm^3 beaker.

Describe the steps the scientist should take to make a 100.0 cm^3 standard solution containing 1.02 g of this compound.

Give the name and capacity of the apparatus the scientist should use.

Write your answer using a series of numbered steps.

....

....

....

....

....

....

.... [3]

Q. Type: **Describing Method Topic: Chem 26 Q# 21/** ALvl Chemistry/2023/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2 The reaction between iodide ions, $I^-(aq)$, and aqueous hydrogen peroxide, $H_2O_2(aq)$, takes place in acidic conditions.

$$\text{reaction 1} \qquad 2I^-(aq) + H_2O_2(aq) + 2H^+(aq) \rightarrow I_2(aq) + 2H_2O(l)$$

A student carries out a series of experiments to investigate the order of reaction with respect to the concentration of $I^-(aq)$ ions. The student does this by measuring the time taken for a fixed amount of iodine to form.

A known amount of aqueous thiosulfate ions, $S_2O_3^{\ 2-}(aq)$, in the reaction mixture react with $I_2(aq)$ formed in reaction 1.

$$\text{reaction 2} \qquad I_2(aq) + 2S_2O_3^{\ 2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{\ 2-}(aq)$$

After all of the $S_2O_3^{\ 2-}(aq)$ ions have reacted in reaction 2, any further $I_2(aq)$ formed is detected using starch indicator.

The following materials are used:

- 50 cm^3 beaker containing the correct mass of solid potassium iodide crystals needed to make 250.0 cm^3 of 0.100 mol dm^{-3} KI(aq)
- 0.100 mol dm^{-3} $Na_2S_2O_3(aq)$
- 0.100 mol dm^{-3} $H_2O_2(aq)$
- 0.200 mol dm^{-3} $H_2SO_4(aq)$
- starch indicator
- distilled water.

(a) A second student looked at the equation for reaction 1 and stated the order with respect to the concentration of $I^-(aq)$ ions must be second order because the balanced equation contains $2I^-(aq)$.

Suggest why a balanced equation alone cannot be used to determine the order of a reaction.

.... [1]

(b) Describe how the student makes 250.0 cm^3 of 0.100 mol dm^{-3} KI(aq) starting from the sample of solid potassium iodide in the 50 cm^3 beaker.

Give the name and size of any key apparatus used. Describe how the student ensures the volume is exactly 250.0 cm^3.

You may wish to write your answer using a series of numbered steps.

....

....

....

....

....

.... [3]

Q. Type: **Describing Method Topic: Chem 26 Q# 22/** ALvl Chemistry/2019/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1 The reaction between hydrogen peroxide, H_2O_2(aq), and iodide ions, I^-(aq), takes place in acidic conditions.

$$H_2O_2(aq) + 2I^-(aq) + 2H^+(aq) \rightarrow I_2(aq) + 2H_2O(l) \qquad \textbf{reaction 1}$$

The rate of this reaction can be found by measuring the time taken for a given amount of iodine, I_2(aq), to form.

This is done by adding a known amount of thiosulfate ions, $S_2O_3^{2-}$(aq), and allowing the I_2(aq) formed in **reaction 1** to react with the $S_2O_3^{2-}$(aq).

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq) \qquad \textbf{reaction 2}$$

After the $S_2O_3^{2-}$(aq) ions have all reacted in **reaction 2**, any further I_2(aq) formed in **reaction 1** can be detected using an indicator.

A student carried out a series of experiments to determine the order of reaction with respect to the concentration of I^-(aq) ions in **reaction 1**.

The student prepared the following solutions.

solution **A** 0.100 mol dm^{-3} KI(aq)

solution **B** 0.0500 mol dm^{-3} $Na_2S_2O_3$(aq)

The student also had access to the following chemicals.

solution **C** 0.100 mol dm^{-3} H_2O_2(aq)
0.2 mol dm^{-3} H_2SO_4(aq)
distilled water
a suitable indicator

(a) The student prepared solution **A** in a 250 cm^3 volumetric flask.

(iii) The student dissolved the KI in the 100 cm^3 beaker in distilled water and transferred the solution formed into a 250 cm^3 volumetric flask. Distilled water was added to the volumetric flask until the volume of the solution was exactly 250 cm^3. Care was taken to avoid parallax errors.

Describe:

- how the student should transfer all the KI solution from the beaker into the 250 cm^3 volumetric flask
- how the student should fill the volumetric flask exactly up to the 250 cm^3 mark.

....

....

....

.... [2]

(b) The student rinsed a burette with solution **A** before filling it with solution **A**.

Explain why this improves the accuracy of the results.

....

.... [1]

(d) Experiment 1 was carried out using a series of steps.

step 1 The student used a measuring cylinder to measure 25 cm^3 of 0.2 mol dm^{-3} H_2SO_4(aq). This was transferred to a conical flask.

step 2 The student added 20.00 cm^3 of distilled water from a burette to the conical flask.

step 3 The student added 5.00 cm^3 of solution **A** from a burette to the conical flask.

step 4 The student added 5.00 cm^3 of solution **B** from a burette to the conical flask.

step 5 The student added 1.0 cm^3 of indicator from a teat pipette to the conical flask.

step 6 The student used a burette to add 10.00 cm^3 of solution **C** to a small beaker. The contents of the beaker were added to the conical flask and a stopclock was started immediately. The stopclock was stopped when the I_2 formed caused the indicator to change colour.

In Experiments 2–6 the student repeated **steps 1–6** but using the volumes of distilled water and solution **A** given in the table.

The student carried out two trials of each experiment.

experiment	volume of H_2SO_4(aq) / cm^3	volume of distilled water / cm^3	volume of solution **A**, *v* / cm^3	volume of solution **B** / cm^3	volume of indicator / cm^3	time for the indicator to change colour, *t* / s	
						trial 1	trial 2
1	25.0	20.00	5.00	5.00	1.0	218	220
2	25.0	15.00	10.00	5.00	1.0	112	113
3	25.0	12.50	12.50	5.00	1.0	100	
4	25.0	10.00	15.00	5.00	1.0	77	76
5	25.0	5.00	20.00	5.00	1.0	59	59
6	25.0	0.00	25.00	5.00	1.0	47	49

(i) In Experiment 3, trial 2, the indicator changed colour as soon as the student added solution **C** to the conical flask. No results were recorded for Experiment 3, trial 2.

Suggest which step the student did **not** carry out in Experiment 3, trial 2.

.... [1]

(iv) Suggest why a measuring cylinder was used to measure the volume of H_2SO_4(aq) rather than a more accurate piece of apparatus, such as a burette.

.... [1]

Q. Type: **Describing Method Topic: Chem 26 Q# 23/** ALvl Chemistry/2016/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1 Propanone, CH_3COCH_3, is an organic liquid which is soluble in water.

Aqueous propanone reacts with aqueous iodine. The reaction is catalysed by H^+(aq) ions.

$$CH_3COCH_3(aq) + I_2(aq) \rightarrow CH_3COCH_2I(aq) + HI(aq)$$

The order of reaction with respect to iodine can be determined experimentally.

An experiment is carried out using the following solutions.

- solution **A**, 25.0 cm^3 of 1.00 mol dm^{-3} CH_3COCH_3(aq)
- solution **B**, 25.0 cm^3 of 1.00 mol dm^{-3} H_2SO_4(aq)
- solution **C**, 50.0 cm^3 of 0.200 mol dm^{-3} I_2(aq)

The solutions are mixed to start the reaction. At certain time intervals, a 10.0 cm^3 portion of the mixture is withdrawn and transferred to a conical flask containing excess sodium hydrogencarbonate, $NaHCO_3$(aq). This prevents any further significant reaction taking place by removing the H^+(aq) ions. The concentration of unreacted I_2(aq) in each 10.0 cm^3 portion of the mixture can then be determined by titration with aqueous thiosulfate ions, $S_2O_3^{2-}$(aq).

(b) Solutions **A**, **B** and **C** need to be added in a specific order and the clock started as the third solution is added.

(i) Suggest the best order of adding the solutions.

1 ....

2 ....

3 ....

[1]

(ii) Explain your choice.

....

.... [1]

(c) Each 10.0 cm³ portion of mixture removed from the main reaction is added to a separate solution of sodium hydrogencarbonate, $NaHCO_3(aq)$, in a conical flask to remove $H^+(aq)$ ions.

(i) Which piece of apparatus should be used to transfer each 10.0 cm³ portion of mixture to the conical flask?

.... [1]

(ii) Suggest **two** reasons why $NaHCO_3(aq)$ is preferred to NaOH(aq) as the reagent used to remove $H^+(aq)$ ions.

reason 1 ....

....

reason 2 ....

....

[2]

(d) The unreacted iodine in each 10.0 cm³ portion of the mixture is titrated against 0.100 mol dm^{-3} aqueous thiosulfate ions, $S_2O_3^{2-}(aq)$, to determine the concentration of $I_2(aq)$ in the mixture at the time that the 10.0 cm³ portion was withdrawn.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

(ii) Suggest the name of a suitable indicator to use in the titration and state its colour change.

indicator ....

colour change ....

[2]

(h) A student suggested that the temperature at which the experiment was carried out would affect the order of reaction with respect to iodine.

State if the student was correct and explain your answer.

....

.... [1]

[Total: 20]

Q. Type: **Describing Method Topic: Chem 27 Q# 24/** ALvl Chemistry/2006/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

Use

2 ASSESSMENT OF PLANNING SKILLS

A sample of a mineral is found, on analysis, to contain the four elements, carbon, copper, hydrogen and oxygen.

The mineral is believed to be **either** azurite, $2CuCO_3.Cu(OH)_2$

or malachite, $CuCO_3.Cu(OH)_2$

Both of these minerals decompose on heating to form copper(II) oxide (CuO), carbon dioxide and water vapour.

(b) Using **only** a chemical balance, a boiling-tube and a Bunsen burner, outline **all** the steps, in the correct order, that you would take to determine if the sample was azurite or malachite.

DO NOT CARRY OUT YOUR PLAN

....[5]

a	
b	
c	
d	
e	

(d) If additional apparatus was available, what further measurement could be made during the thermal decomposition to confirm the identity of the mineral?

....[1]

Q. Type: **Describing Method Topic: Chem 28 Q# 25/** ALvl Chemistry/2012/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 When an excess of aqueous sodium hydroxide, NaOH, is added to 100 cm³ of aqueous copper(II) sulfate, $CuSO_4$, a precipitate of copper(II) hydroxide, $Cu(OH)_2$, is produced.

The stoichiometric equation for this reaction is,

$$CuSO_4\,(aq) + 2NaOH\,(aq) \longrightarrow Cu(OH)_2\,(s) + Na_2SO_4\,(aq)$$

The following information gives some of the hazards associated with these reactants.

Copper(II) sulfate (solid hydrated copper(II) sulfate $CuSO_4.5H_2O$)
Harmful. Dangerous for the environment.
Harmful if swallowed. Irritating to eyes and skin.
Solutions of concentrations equal to or greater than 1 mol dm^{-3} should be labelled HARMFUL.

Sodium hydroxide (solid NaOH)
Corrosive. Solutions of concentrations equal to or greater than 0.5 mol dm^{-3} are CORROSIVE. Solutions of concentrations equal to or greater than 0.05 mol dm^{-3} but less than 0.5 mol dm^{-3} are IRRITANT.

You are to plan an experiment to investigate the molar ratio of the equation above and confirm that it remains unchanged as the concentration of the copper(II) sulfate changes.

(a) **(i)** Predict quantitatively how the number of moles of the precipitated copper(II) hydroxide varies as the molar concentration of the copper(II) sulfate increases until saturation is reached.

....

(ii) Display your prediction in the form of a sketch graph. Remember that you are using 100 cm³ of aqueous copper(II) sulfate. Label clearly the point representing the saturated solution of copper(II) sulfate. A saturated solution at 25 °C has a concentration of 1.39 mol dm^{-3}. Give appropriate numerical scales to the two axes.

[3]

(c) Design a laboratory experiment to investigate your prediction in **(a)**.

In addition to the standard apparatus present in a laboratory you are provided with the following materials.

aqueous sodium hydroxide, NaOH (2.0 mol dm^{-3})
solid hydrated copper(II) sulfate, $CuSO_4.5H_2O$

Give a step-by-step description of how you would

(i) prepare enough solutions of copper(II) sulfate of an appropriate range of concentrations to give sufficient data to plot a graph as in **(a)(ii)**,

(ii) collect and dry the precipitated copper(II) hydroxide,

(iii) calculate the molar concentration of one of the solutions of copper(II) sulfate.
[A_r: H, 1.0; O, 16.0; S, 32.1; Cu, 63.5]

[5]

---

2 Paper chromatography can be used to separate the individual amino acids formed when tripeptides are hydrolysed.

One molecule of a tripeptide produces three amino acid molecules when hydrolysed.

A student is asked to identify the amino acids formed from the hydrolysis of three different tripeptides, **A**, **B** and **C**, using paper chromatography.

Fig. 2.1 shows the results of the student's chromatography experiment.

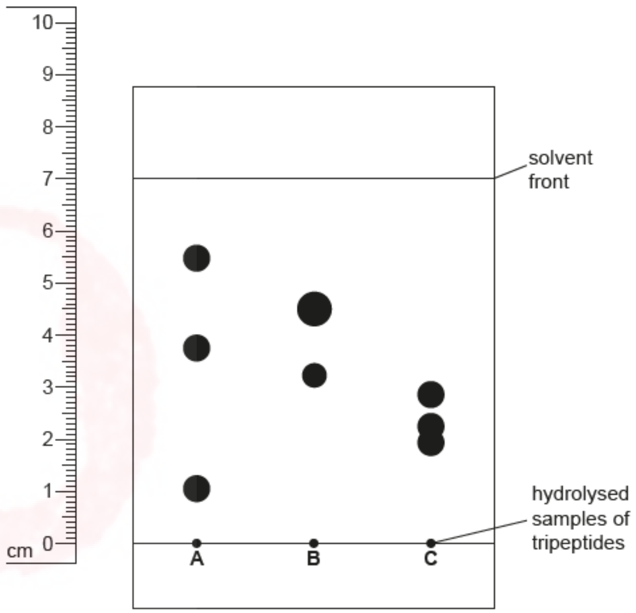


Fig. 2.1

The individual amino acids can be identified from their R_f values.

$$R_f = \frac{\text{distance travelled by the amino acid spot}}{\text{distance travelled by the solvent front}}$$

(a) Suggest why each sample is applied to the chromatography paper using a thin capillary tube rather than a dropping pipette.

....

.... [1]

(b) Suggest why it is necessary to spray a developing agent over the chromatography paper before the chromatogram can be analysed.

....

.... [1]

(c) Table 2.1 shows R_f values for some amino acids in the solvent used in Fig. 2.1.

Table 2.1

amino acid	R_f value
lysine	0.14
glycine	0.26
serine	0.27
glutamic acid	0.30
alanine	0.38
proline	0.43
tryptophan	0.50
valine	0.60
leucine	0.73

Use the data in Table 2.1 to identify the amino acids in tripeptide **A**.

....

.... [2]

(d) Suggest why the hydrolysed sample of **B** produces only two spots.

....

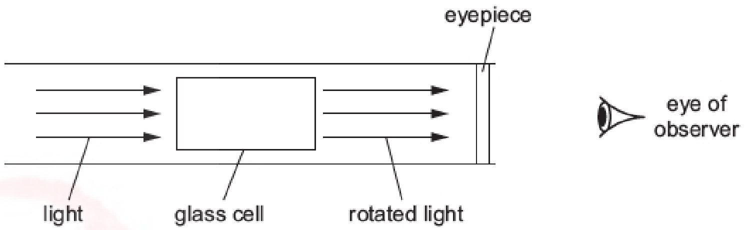
.... [1]

Q. Type: Standard Solutions Topic: Chem 2 Q# 27/ ALvl Chemistry/2017/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 Sucrose is a sugar. The concentration of a solution of sucrose can be measured by the optical rotation, α, of a sucrose solution. The more concentrated the solution, the greater the optical rotation of the solution.

A polarimeter is used to measure optical rotation. Light is passed through a sample of the sucrose solution in a glass cell, and the observed angle of rotation, α_{obs}, is measured.

A simplified diagram of a polarimeter is shown.



If a glass cell of length 10 cm is filled with a solution of sucrose of concentration 1 g cm^{-3} the measured angle of rotation is known as the specific rotation, **[α]**.

The observed angle of rotation, α_{obs}, measured by the polarimeter is related mathematically to the concentration of the sucrose solution by the equation shown.

$$\alpha_{obs} = [\alpha]c$$

α_{obs} is the observed angle of rotation using a 10 cm cell

[α] is the specific rotation of sucrose solution

c is the concentration of sucrose, in g cm^{-3}

A student wanted to determine the specific rotation of sucrose, [α]. Solutions of different concentrations of sucrose at 20 °C were placed in a polarimeter and the observed angle of rotation, α_{obs}, recorded. The '+' sign is used to show that the rotation is in a clockwise direction.

(b) You are asked to write instructions for another student to follow so they can prepare a standard solution of 250 cm^3 0.0750 g cm^{-3} sucrose. The student is provided with solid sucrose and a 250 cm^3 volumetric flask.

(i) Calculate the mass, in g, of sucrose the student would need to use.

mass of sucrose = ... g [1]

(ii) Describe how the student should accurately prepare the standard solution using a sample of sucrose of mass calculated in **(i)**.

....

....

....

....

....

.... [2]

(c) **(i)** The student used the standard solution prepared in **(b)** to prepare the solutions in the table on page 8.

Calculate the volume of standard solution of concentration 0.0750 g cm^{-3} and the volume of distilled water needed to prepare 15.00 cm^3 of sucrose solution of concentration 0.0350 g cm^{-3}.
Give your answers to **two** decimal places.

volume of standard solution = ... cm^3

volume of distilled water = ... cm^3
[1]

The volumes of the two solutions given in **(c)(i)** could be measured using the same type of apparatus.

(ii) Name a suitable piece of apparatus which could be used to measure these volumes.

.... [1]

(iii) In **(a)(ii)** you circled an anomalous point. This was caused by the student incorrectly making one of the sucrose solutions.

Suggest the error made by the student that caused this anomaly.

....

....

.... [1]

Q. Type: **Standard Solutions Topic: Chem 6 Q# 28/** ALvl Chemistry/2021/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2 Ethanedioic acid is a white crystalline solid.

If excess aqueous potassium hydroxide, KOH(aq), is added to dilute ethanedioic acid, $H_2C_2O_4$(aq), full neutralisation occurs and potassium ethanedioate, $K_2C_2O_4$(aq), forms.

$$H_2C_2O_4(aq) + 2KOH(aq) \rightarrow K_2C_2O_4(aq) + 2H_2O(l)$$

If a small amount of potassium hydroxide is added, **partial** neutralisation takes place and not all H^+ ions in the acid are replaced by K^+ ions.

Instead an acid salt forms, which crystallises to form a solid with the formula $K_aH_b(C_2O_4)_c\bullet dH_2O$.

The letters *a*, *b* and *c* represent a ratio of the numbers of species present in the compound and may not necessarily be whole numbers. The relative number of water molecules associated with one formula of the compound is represented by *d*.

A student attempted to determine the values of *a*, *b*, *c* and *d* in a sample of an acid salt, $K_aH_b(C_2O_4)_c\bullet dH_2O$.

(a) The student wants to make a 250.0 cm³ aqueous solution of $K_aH_b(C_2O_4)_c\bullet dH_2O$, solution **A**.

The student adds 1.89 g of $K_aH_b(C_2O_4)_c\bullet dH_2O$ into a 100 cm³ beaker.

Describe the next steps the student should take to make solution **A**, containing exactly 1.89 g of $K_aH_b(C_2O_4)_c\bullet dH_2O$.

Give the name and capacity of the apparatus which should be used and describe how the student should ensure the volume is exactly 250.0 cm³.

Write your answer using a series of numbered steps.

....

....

....

....

....

....

....

.... [4]

(vi) Determine the number of moles of $C_2O_4^{2-}$ ions in the 250.0 cm³ of solution **A**, $K_aH_b(C_2O_4)_c\bullet dH_2O$.

Give your answer to **three** significant figures.

moles of $C_2O_4^{2-}$ ions in 250.0 cm³ of solution **A** = ... mol [3]

Q. Type: **Standard Solutions Topic: Chem 6 Q# 29/** ALvl Chemistry/2020/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 Aqueous potassium manganate(VII) can be used to determine the amount of iron present in a sample of iron wire by redox titration. Before potassium manganate(VII) can be used, its concentration must be determined using aqueous sodium ethanedioate made from the hydrated solid $Na_2C_2O_4{\bullet}2H_2O$.

(a) **(i)** Calculate the mass of $Na_2C_2O_4{\bullet}2H_2O$ required to make 250.0 cm³ of 0.200 mol dm⁻³ sodium ethanedioate standard solution.
[A_r: Na, 23.0; C, 12.0; O, 16.0; H, 1.0]

mass of $Na_2C_2O_4{\bullet}2H_2O$ = ... g [1]

(ii) Describe how the student should accurately prepare 250.0 cm³ of 0.200 mol dm⁻³ sodium ethanedioate standard solution from the weighed sample of $Na_2C_2O_4{\bullet}2H_2O$ of mass calculated in **(a)(i)**.
In your description you should include the names and capacities of any apparatus used.

....

....

....

.... [2]

(b) Ethanedioate ions, $C_2O_4^{2-}$(aq), react with manganate(VII) ions, MnO_4^-(aq), according to the ionic equation shown.

$$2MnO_4^-(aq) + 16H^+(aq) + 5C_2O_4^{2-}(aq) \rightarrow 2Mn^{2+}(aq) + 8H_2O(l) + 10CO_2(g)$$

25.0 cm³ of 0.200 mol dm⁻³ $C_2O_4^{2-}$(aq) required 18.40 cm³ MnO_4^-(aq) for complete reaction.

Calculate the concentration of the aqueous potassium manganate(VII). Give your answer to **three significant figures**.

concentration of aqueous potassium manganate(VII) = ... mol dm⁻³ [3]

Q. Type: **Standard Solutions Topic: Chem 7 Q# 30/** ALvl Chemistry/2015/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 A saturated aqueous solution of magnesium methanoate, $Mg(HCOO)_2$, has a solubility of approximately 150 g dm⁻³ at room temperature. Its exact solubility can be determined by titrating magnesium methanoate against aqueous potassium manganate(VII).

During the titration, the methanoate ion, $HCOO^-$, is oxidised to carbon dioxide while the manganate(VII) ion, MnO_4^-, is reduced to Mn^{2+}.

You are supplied with:
a saturated aqueous solution of $Mg(HCOO)_2$
aqueous potassium manganate(VII), $KMnO_4$, of concentration 0.0200 mol dm⁻³

(a) **(i)** Write the half equations for the oxidation of $HCOO^-$(aq) to CO_2(g) and the reduction of MnO_4^-(aq) to Mn^{2+}(aq) in acid solution.

....

.... [2]

(ii) Using the approximate solubility above, calculate the concentration, in mol dm⁻³, of the saturated aqueous magnesium methanoate and the concentration of the methanoate ions present in this solution.
[A_r: H, 1.0; C, 12.0; O, 16.0; Mg, 24.3]

[2]

(iii) In order to obtain a reliable titre value, the saturated solution of magnesium methanoate needs to be diluted.

Describe how you would accurately measure a 5.0 cm³ sample of saturated magnesium methanoate solution and use it to prepare a solution fifty times more dilute than the saturated solution.

....

....

....

.... [2]

(iv) Before the titration is carried out, dilute sulfuric acid must be added to the magnesium methanoate.

Explain why this is necessary and also whether the volume of sulfuric acid chosen will affect the result of the titration.

....

....

....

.... [2]

(v) The potassium manganate(VII) is added from a burette into the magnesium methanoate in a conical flask.

Describe what you would see when you had reached the end-point of the titration.

....

.... [1]

(vi) 1 mol of acidified MnO_4^- ions reacts with 2.5 mol of $HCOO^-$ ions.

25.0 cm^3 of the diluted solution prepared in **(iii)** required 25.50 cm^3 of 0.0200 mol dm^{-3} potassium manganate(VII) solution to reach the end-point.

Use this information to calculate the concentration, in mol dm^{-3}, of $HCOO^-$ ions in the diluted solution.

.... mol dm^{-3} [1]

(vii) Use your answer to **(vi)** to calculate the concentration, in mol dm^{-3}, of the saturated solution of magnesium methanoate, $Mg(HCOO)_2$. Give your answer to **three significant figures**.

.... mol dm^{-3} [1]

(d) A student used the same titration method, this time to measure the concentration of a saturated solution of *barium* methanoate.

Explain why the acidification of the solution with dilute sulfuric acid might make the titration difficult to do.

....

.... [1]

[Total: 15]

Q. Type: **Standard Solutions Topic: Chem 7 Q# 31/** ALvl Chemistry/2014/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 The acid dissociation constant, K_a, of a weak monoprotic acid, **HA**, is to be determined from the measurement of the pH change that occurs when it is titrated with an aqueous solution of sodium hydroxide.

2.70 g of **HA** was dissolved in distilled water to make exactly 250.0 cm^3 of solution.
25.00 cm^3 of the solution was pipetted into a beaker.
The pH of the acid in the beaker was measured and recorded in the table below.

A burette was then filled with aqueous sodium hydroxide and the 25.00 cm^3 of **HA** was titrated by adding volumes of the aqueous sodium hydroxide to the beaker as indicated in the table below. After each addition the pH was measured and the value recorded.

volume of sodium hydroxide added / cm^3	pH measured
0.00	2.41
2.00	2.75
4.00	3.09
8.00	3.46
12.00	3.52
16.00	3.96
20.00	4.20
24.00	4.50
28.00	5.05
30.00	7.00
32.00	11.55
36.00	12.00

(d) 30.00 cm^3 of aqueous sodium hydroxide is required to neutralise 25.00 cm^3 of **HA** and the equation for the neutralisation is shown.

$$NaOH + HA \rightarrow NaA + H_2O$$

(i) Excluding water, state the three ions or molecules that will be present in the highest concentration when 15.00 cm^3 of aqueous sodium hydroxide has been added to 25.00 cm^3 of **HA**.

....

.... [1]

(ii) State and explain how the concentrations of these ions or molecules compare.

....

....

....

.... [2]

(g) Even if the experiment is done very carefully with very accurate apparatus, the answer obtained for the molecular mass of **HA** is likely to be subject to error. Suggest why.

....

....

....

.... [1]

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1 When hydrated barium chloride, $BaCl_2.xH_2O$, dissolves in water, $Ba^{2+}(aq)$ and $Cl^-(aq)$ ions are formed.

The concentration of chloride ions in solution can be determined by titration with aqueous silver nitrate of known concentration.

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

The indicator for the reaction is aqueous potassium chromate(VI), $K_2CrO_4(aq)$. At the endpoint of the titration, it forms a red precipitate in the presence of excess silver ions.

(a) The solubilities, in g dm^{-3}, of different ionic compounds at 20 °C are given in the table below.

	anion		
cation	Cl^-	CrO_4^{2-}	SO_4^{2-}
Ag^+	0.0019	0.022	293
Ba^{2+}	358	0.0028	0.00245

With reference to these data, where relevant, answer the following questions.

(i) Name the red precipitate and give an equation for its formation.

name: ....

equation: .... [2]

Sulfuric acid must be added to the solution to prevent the $Ba^{2+}(aq)$ ions from interfering with the action of the potassium chromate(VI) indicator.

(ii) How would $Ba^{2+}(aq)$ ions interfere with the action of this indicator?

....

.... [1]

(iii) How does the addition of sulfuric acid prevent $Ba^{2+}(aq)$ ions from interfering with the action of this indicator?

....

.... [1]

(c) You are to plan a titration experiment to determine the value of **x** in $BaCl_2.\mathbf{x}H_2O$.

You are provided with the following materials.

3.00 g of hydrated barium chloride, $BaCl_2.\mathbf{x}H_2O$
0.050 mol dm^{-3} aqueous silver nitrate
1.0 mol dm^{-3} potassium chromate(VI) solution
1.0 mol dm^{-3} sulfuric acid

(i) Name **three** pieces of volumetric apparatus you would use, with their capacities in cm^3.

1 ....

2 ....

3 ....
[2]

(ii) Describe how you would make a solution of barium chloride that is suitable for use in your titration.

....

....

....

....

....

.... [2]

(iii) A known volume of barium chloride solution is transferred to a conical flask.

In what order should the other three solutions then be added to the flask?

first ....

second ....

third ....
[1]

1 A student plans an investigation to find the molar ratio of the reaction between sodium chloride, NaCl, and a lead compound.

The student is provided with solid NaCl and 0.200 mol dm^{-3} aqueous lead compound.

The reaction between NaCl(aq) and the aqueous lead compound produces an insoluble compound as a precipitate.

(a) The student prepares 0.200 mol dm^{-3} NaCl(aq).

Calculate the mass of NaCl(s) needed to make 250.0 cm^3 of 0.200 mol dm^{-3} NaCl(aq).

mass of NaCl = ... g [1]

(b) The student weighs the mass of NaCl(s) calculated in **(a)** in a weighing boat. The solid mass is then transferred into a small beaker.

Describe how the student should accurately weigh by difference so the exact mass of NaCl transferred into the small beaker is known.

....

....

....

.... [1]

(c) The student is given a small beaker containing the mass of NaCl calculated in **(a)**.

Describe how the student should prepare 250.0 cm^3 of 0.200 mol dm^{-3} NaCl(aq).

Include the names and capacities of each piece of apparatus used in the preparation of the solution.

....

....

....

....

.... [2]

(d) The student plans the following method using the 0.200 mol dm^{-3} aqueous lead compound and the 0.200 mol dm^{-3} NaC*l*(aq) prepared in **(c)**.

Step 1 Mix the NaC*l*(aq) and the aqueous lead compound in eight separate beakers in the proportions by volume shown in Table 1.1.

Table 1.1

beaker	volume of 0.200 mol dm^{-3} NaC*l*(aq) / cm^3	volume of 0.200 mol dm^{-3} aqueous lead compound / cm^3
1	10.00	40.00
2	15.00	35.00
3	20.00	30.00
4	25.00	25.00
5	30.00	20.00
6	35.00	15.00
7	40.00	10.00
8	45.00	5.00

Step 2 Filter the contents of each beaker to collect the precipitate.

Step 3 Dry the precipitate for 3 minutes in an oven and allow to cool.

Step 4 Weigh and record the mass of precipitate produced in each beaker.

(i) State **one** extra step that would improve this method. Explain why this step is necessary.

extra step:

....

....

explanation:

....

....

.... [2]

Q. Type: **Standard Solutions Topic: Chem 24 Q# 34/** ALvl Chemistry/2019/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 Yttrium barium copper oxide, $YBa_2Cu_3O_7$, is a crystalline compound.

You are to design an experiment in which $YBa_2Cu_3O_7$ is first synthesised and then analysed by titration.

(a) $YBa_2Cu_3O_7$ can be synthesised by reacting Y_2O_3, $BaCO_3$ and CuO using the following method.

- Place solid Y_2O_3, $BaCO_3$ and CuO together in a mortar and grind the mixture well with a pestle.
- Transfer the mixture to a porcelain crucible and place this in an oven set at 920 °C.
- Heat the mixture for 12 hours, then allow the crucible and its contents to cool slowly in the oven to below 100 °C before removing it.

The equation for the reaction is given.

$$Y_2O_3 + 4BaCO_3 + 6CuO + \tfrac{1}{2}O_2 \rightarrow 2YBa_2Cu_3O_7 + 4CO_2$$

$YBa_2Cu_3O_7$ contains some copper ions in the unusual +3 oxidation state.

The proportion of Cu^{3+} in $YBa_2Cu_3O_7$ can be determined by titration.

- **Step 1**
  A sample of $YBa_2Cu_3O_7$ is reacted with an excess of concentrated aqueous HBr. Cu^{3+} ions are reduced to Cu^{2+} ions and Br_3^- ions are formed.

  $$2Cu^{3+}(s) + 3Br^-(aq) \rightarrow 2Cu^{2+}(aq) + Br_3^-(aq)$$

- **Step 2**
  A solution of 1.0 mol dm^{-3} sodium citrate is added to the mixture from **Step 1**. The resulting mixture is then neutralised with a minimum volume of concentrated $NH_3(aq)$.

- **Step 3**
  Excess I^- is added which reacts with Br_3^- to form I_2.

  $$Br_3^-(aq) + 2I^-(aq) \rightarrow 3Br^-(aq) + I_2(aq)$$

- **Step 4**
  The I_2 is titrated with a standard solution of $S_2O_3^{2-}$ and starch solution as an indicator.

  $$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$

The concentration of $I_2(aq)$ can therefore be determined and hence the concentration of $Br_3^-(aq)$. From this the amount of $Cu^{3+}(s)$ can be determined.

(b) The table gives some electrochemical data.

reduction process	E°/V
$I_2 + 2e^- \rightleftharpoons 2I^-$	+0.54
$Cu^{2+} + I^- + e^- \rightleftharpoons CuI$	+0.86
$O_2 + 4H^+ + 4e^- \rightleftharpoons 2H_2O$	+1.23

Use these data and the information given above to answer the following questions.

(i) The citrate anion forms an insoluble complex with Cu^{2+} and so removes Cu^{2+} from solution.

Explain why this is necessary.

....

....

.... [1]

(ii) Explain why it is necessary to neutralise the mixture in **Step 2**.

....

.... [1]

(iii) When starch indicator is added in **Step 4**, the mixture turns blue-black due to the presence of $I_2(aq)$. The end-point of the titration with $S_2O_3^{2-}(aq)$ is a colourless solution.

The number of moles of $S_2O_3^{2-}(aq)$ needed for complete reaction with $I_2(aq)$ can be calculated from the mean titre value. Hence the moles of $I_2(aq)$ can be determined.

State the expression for the moles of Cu^{3+} in the sample of $YBa_2Cu_3O_7$. Use A to represent the number of moles of $I_2(aq)$ in **Step 4**.

moles Cu^{3+} = ... mol [1]

(c) **(i)** Calculate the mass of hydrated sodium citrate, $Na_3C_6H_5O_7$•$2H_2O$, that would be required for the preparation of 250.0 cm^3 of a solution of 1.0 mol dm^{-3} citrate ions, $C_6H_5O_7^{3-}$.

[M_r: $Na_3C_6H_5O_7$•$2H_2O$, 294.0]

mass of $Na_3C_6H_5O_7$•$2H_2O$ = ... g [1]

(ii) A student places the mass of $Na_3C_6H_5O_7$•$2H_2O$ calculated in **(c)(i)** into a beaker.

Describe how the student can prepare exactly 250.0 cm^3 of a solution of 1.0 mol dm^{-3} citrate ions from the sample in the beaker.

Give the name and capacity, in cm^3, of any apparatus used.

....

....

....

....

.... [3]

(d) A different student records the following titration data in **Step 4**.

experiment	rough	1	2
final reading / cm^3	21.20	24.60	47.75
initial reading / cm^3	0.00	3.10	25.30
titre / cm^3	21.20	21.50	22.45

Identify the problem with the student's titration method **and** suggest how it could be improved.

....

....

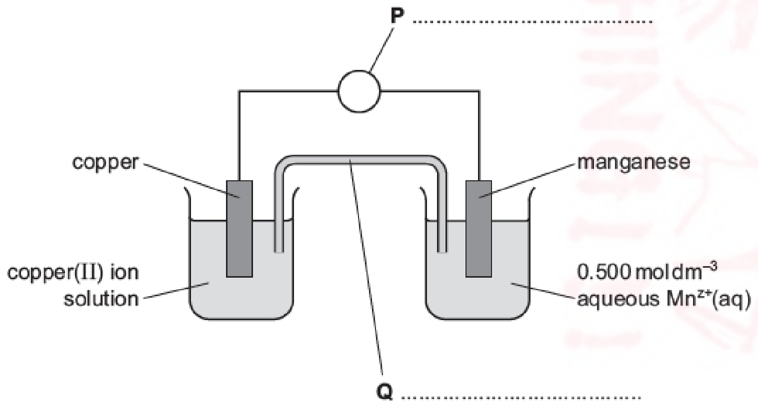
....

.... [2]

Q. Type: **Standard Solutions Topic: Chem 24 Q# 35/** ALvl Chemistry/2019/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 A student investigates the charge (z+) carried by aqueous manganese ions, $Mn^{z+}(aq)$. The electrochemical cell shown is set up for this investigation with the following two half-cells:

- a standard copper(II) ion / copper half-cell ($E^{\ominus} = +0.340\,V$)
- a half-cell made from manganese and $0.500\,mol\,dm^{-3}$ $Mn^{z+}(aq)$.



(b) During the investigation the student plans to use solutions of $Mn^{z+}(aq)$ of lower concentration than $0.500\,mol\,dm^{-3}$.

(i) Calculate the volume of $0.500\,mol\,dm^{-3}$ $Mn^{z+}(aq)$ needed to prepare $100.0\,cm^3$ of $0.200\,mol\,dm^{-3}$ $Mn^{z+}(aq)$.

volume = ... cm^3 [1]

(ii) Describe how, using a $100\,cm^3$ volumetric flask, the student should prepare exactly $100.0\,cm^3$ of $0.200\,mol\,dm^{-3}$ $Mn^{z+}(aq)$ using the volume of $0.500\,mol\,dm^{-3}$ $Mn^{z+}(aq)$ calculated in **(b)(i)** and standard school or college apparatus.

....

....

....

....

.... [2]

Q. Type: **Standard Solutions Topic: Chem 25 Q# 36/** ALvl Chemistry/2022/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2 The conductivity of an ionic solution can be determined by passing an electric current through the solution and measuring the conductivity using a conductivity meter.

(a) A student carries out an experiment to measure the conductivity of different solutions of ethanoic acid, CH_3COOH, which is a weak acid.

The acid dissociation constant, K_a, can be determined from this experiment.

The student makes standard solution **A**, 250.0 cm^3 of 2.00 mol dm^{-3} $CH_3COOH(aq)$.

(i) State what is meant by a standard solution.

....

.... [1]

(ii) Describe how the student should make standard solution **A** from pure ethanoic acid.

The concentration of standard solution **A** should be 2.00 mol dm^{-3} to the nearest **three** significant figures.

Your answer should state the name and capacity of any apparatus that the student should use. A balance is not available.

Pure ethanoic acid is a liquid with a density of 1.05 g cm^{-3} at room temperature.

You may wish to write your answer using a series of numbered steps.

[M_r: CH_3COOH, 60.0]

....

....

....

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.... [4]

Q. Type: **Standard Solutions Topic: Chem 26 Q# 37/** ALvl Chemistry/2023/s/TZ 2/ Paper 5/Q# 3/Smashing!!!

3 A scientist is asked to find the rate of decomposition of an aromatic diazonium compound and determine the order of the reaction with respect to the aromatic diazonium compound.

(a) The scientist is given 1.02 g of an aromatic diazonium compound in a 50 cm^3 beaker.

Describe the steps the scientist should take to make a 100.0 cm^3 standard solution containing 1.02 g of this compound.

Give the name and capacity of the apparatus the scientist should use.

Write your answer using a series of numbered steps.

....

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....

....

....

....

.... [3]

Q. Type: **Standard Solutions Topic: Chem 26 Q# 38/** ALvl Chemistry/2023/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2 The reaction between iodide ions, $I^-(aq)$, and aqueous hydrogen peroxide, $H_2O_2(aq)$, takes place in acidic conditions.

reaction 1 $\quad 2I^-(aq) + H_2O_2(aq) + 2H^+(aq) \rightarrow I_2(aq) + 2H_2O(l)$

A student carries out a series of experiments to investigate the order of reaction with respect to the concentration of $I^-(aq)$ ions. The student does this by measuring the time taken for a fixed amount of iodine to form.

A known amount of aqueous thiosulfate ions, $S_2O_3^{2-}(aq)$, in the reaction mixture react with $I_2(aq)$ formed in reaction 1.

reaction 2 $\quad I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$

After all of the $S_2O_3^{2-}(aq)$ ions have reacted in reaction 2, any further $I_2(aq)$ formed is detected using starch indicator.

The following materials are used:

- 50 cm^3 beaker containing the correct mass of solid potassium iodide crystals needed to make 250.0 cm^3 of 0.100 mol dm^{-3} $KI(aq)$
- 0.100 mol dm^{-3} $Na_2S_2O_3(aq)$
- 0.100 mol dm^{-3} $H_2O_2(aq)$
- 0.200 mol dm^{-3} $H_2SO_4(aq)$
- starch indicator
- distilled water.

(b) Describe how the student makes 250.0 cm^3 of 0.100 mol dm^{-3} KI(aq) starting from the sample of solid potassium iodide in the 50 cm^3 beaker.

Give the name and size of any key apparatus used. Describe how the student ensures the volume is exactly 250.0 cm^3.

You may wish to write your answer using a series of numbered steps.

....

....

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....

.... [3]

Q. Type: **Standard Solutions Topic: Chem 26 Q# 39/** ALvl Chemistry/2022/w/TZ 1/ Paper 5/Q# 3/Smashing!!!

3 Potassium bromate(V) reacts with potassium bromide and sulfuric acid to form potassium sulfate, bromine and water according to the following equation.

$$KBrO_3(aq) + 5KBr(aq) + 3H_2SO_4(aq) \rightarrow 3K_2SO_4(aq) + 3Br_2(aq) + 3H_2O(l)$$

A student is investigating how the rate of this reaction is affected by changing the concentration of the reactants in turn. This is done by keeping the total volume of mixture constant and adding different, small volumes of each reagent.

The reaction produces bromine which is orange in colour. The student times the reaction and then determines the rate as $\frac{1}{\text{time}}$.

The rate equation for the reaction is of the form:

$$\text{rate} = k[KBrO_3]^x[KBr]^y[H_2SO_4]^z$$

k is the rate constant for the reaction and *x*, *y* and *z* are the respective orders of the reaction for each reagent.

The student carried out the experiment and obtained the following data.

Table 3.1

mixture	[$KBrO_3$] / mol dm^{-3}	[KBr] / mol dm^{-3}	[H_2SO_4] / mol dm^{-3}	rate of reaction / s^{-1}
A	0.025	0.125	0.075	0.059
B	0.050	0.125	0.075	0.117
C	0.025	0.250	0.075	0.118
D	0.025	0.125	0.150	0.235
E	0.050	0.250	0.150	0.941

(b) The student carried out each reaction using a boiling tube (capacity 50 cm^3) and varied the concentration by adding different volumes of each reagent. For example, in mixture A, 5.0 cm^3 of $KBrO_3$(aq) is required.

Name a suitable piece of apparatus which could be used to measure this volume.

.... [1]

(c) Suggest why the reagents are heated to the same temperature before mixing.

.... [1]

(d) The solution of sulfuric acid used in each mixture was of concentration 0.150 mol dm^{-3}. This acid was prepared from a solution of concentration 1 mol dm^{-3}.

Briefly describe how to make the more dilute solution, stating the capacity of any apparatus used.

....

....

....

.... [2]

Q. Type: **Standard Solutions Topic: Chem 26 Q# 40/** ALvl Chemistry/2019/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1 The reaction between hydrogen peroxide, H_2O_2(aq), and iodide ions, I^-(aq), takes place in acidic conditions.

$H_2O_2(aq) + 2I^-(aq) + 2H^+(aq) \rightarrow I_2(aq) + 2H_2O(l)$ **reaction 1**

The rate of this reaction can be found by measuring the time taken for a given amount of iodine, I_2(aq), to form.

This is done by adding a known amount of thiosulfate ions, $S_2O_3^{2-}$(aq), and allowing the I_2(aq) formed in **reaction 1** to react with the $S_2O_3^{2-}$(aq).

$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$ **reaction 2**

After the $S_2O_3^{2-}$(aq) ions have all reacted in **reaction 2**, any further I_2(aq) formed in **reaction 1** can be detected using an indicator.

A student carried out a series of experiments to determine the order of reaction with respect to the concentration of I^-(aq) ions in **reaction 1**.

The student prepared the following solutions.

solution **A**	0.100 mol dm^{-3} KI(aq)
solution **B**	0.0500 mol dm^{-3} $Na_2S_2O_3$(aq)

The student also had access to the following chemicals.

solution **C** 0.100 mol dm^{-3} H_2O_2(aq)
0.2 mol dm^{-3} H_2SO_4(aq)
distilled water
a suitable indicator

(a) The student prepared solution **A** in a 250 cm^3 volumetric flask.

(i) The student used a balance accurate to two decimal places and a weighing boat. A weighing boat is a small container used to hold solid samples when they are weighed.

Determine the mass, in g, of KI needed to prepare 250.0 cm^3 of solution **A**.
[A_r: K, 39.1; I, 126.9]

mass = ... g [2]

(ii) The student weighed the empty weighing boat. The student then added solid KI to the weighing boat until the mass of KI calculated in **(i)** was reached. The student transferred all of the KI from the weighing boat into a 100 cm^3 beaker.

Describe how the student could check that the mass of KI transferred into the 100 cm^3 beaker was exactly the same as the mass calculated in **(i)**.

....

.... [1]

(iii) The student dissolved the KI in the 100 cm^3 beaker in distilled water and transferred the solution formed into a 250 cm^3 volumetric flask. Distilled water was added to the volumetric flask until the volume of the solution was exactly 250 cm^3. Care was taken to avoid parallax errors.

Describe:

- how the student should transfer all the KI solution from the beaker into the 250 cm^3 volumetric flask
- how the student should fill the volumetric flask exactly up to the 250 cm^3 mark.

....

....

....

.... [2]

(b) The student rinsed a burette with solution **A** before filling it with solution **A**.

Explain why this improves the accuracy of the results.

....

.... [1]

(c) The student was given a solution of 0.400 mol dm^{-3} $Na_2S_2O_3$(aq).

Determine the volume, in cm^3, of this solution that should be added to a 100 cm^3 volumetric flask to prepare 100.0 cm^3 of solution **B**. Give your answer to **two** decimal places.

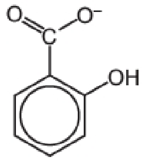
volume = ... cm^3 [1]

Q. Type: **Standard Solutions Topic: Chem 28 Q# 41/** ALvl Chemistry/2017/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2 Transition metal complex ions are coloured. The formula of a complex ion can be determined using colorimetry.

In colorimetry, light of a certain wavelength is passed through a complex ion solution. The absorbance of the light is proportional to the intensity of the colour of the solution. The more concentrated the complex ion solution, the more intense its colour and so the higher the absorbance.

A student carried out an experiment to determine the formula of the complex ion formed between aqueous iron(III) ions, $Fe^{3+}(aq)$, and aqueous 2-hydroxybenzoate ions, $C_6H_4(OH)CO_2^-$, which have the structure shown.



(a) In the first step of the experiment the student prepared 100.0 cm^3 of 0.0500 mol dm^{-3} aqueous iron(III) nitrate.

(i) Determine the mass, in g, of solid hydrated iron(III) nitrate, $Fe(NO_3)_3.9H_2O$, needed to prepare 100.0 cm^3 of a 0.0500 mol dm^{-3} solution.
[A_r: Fe, 55.8; N, 14.0; O, 16.0; H, 1.0]

mass of $Fe(NO_3)_3.9H_2O$ = ... g [2]

(ii) Describe how, after weighing the mass determined in **(i)**, the student should prepare 100.0 cm^3 of 0.0500 mol dm^{-3} aqueous iron(III) nitrate.

In your answer you must give the name and capacity, in cm^3, of any apparatus used.

....

....

....

....

.... [2]

Q. Type: Drawing Apparatus Topic: Chem 2x Q# 42/ ALvl Chemistry/2004/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 ASSESSMENT OF PLANNING SKILLS

Lithium is an alkali metal – one of a group of very reactive metals which are stored under oil to prevent contact with air and water vapour.

The reaction of lithium with water can be represented by the equation below.

$$2Li(s) + 2H_2O(l) \longrightarrow 2LiOH(aq) + H_2(g)$$

(a) In the space below, draw a diagram that clearly shows the apparatus you could use to:

- react a weighed amount of lithium metal with water,
- collect the hydrogen gas produced,
- measure the volume of gas produced.

[2]

2 Charles' law states that for a fixed mass of gas at constant pressure, its volume is proportional to its absolute temperature. Most gases are non-ideal and do not obey this law, but at lower pressures and high temperatures some gases are close to ideal behaviour. One gas that behaves like this is oxygen.

Oxygen can be prepared by decomposing hydrogen peroxide with the catalyst manganese(IV) oxide, MnO_2.

The equation for the decomposition of hydrogen peroxide is shown.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

Safety hazard: hydrogen peroxide is corrosive to skin and can cause serious eye damage.

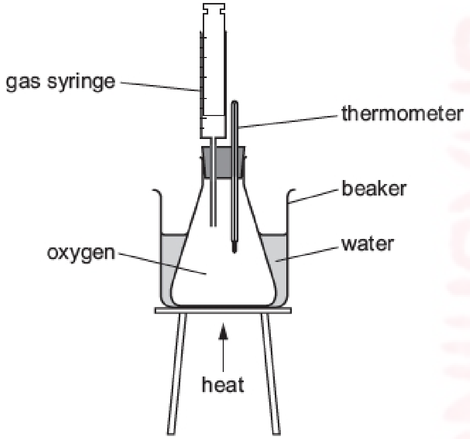


Fig. 2.1

Once the apparatus is assembled the volume of oxygen in the gas syringe is 2 cm^3. There are 80 cm^3 of oxygen remaining in the flask. The total volume of oxygen is 82 cm^3.

Charles' law is investigated by the following method.

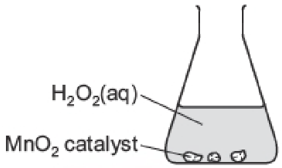
step 1 Once assembled allow the apparatus to reach room temperature.

step 2 Record this temperature and the total volume of oxygen reading on the syringe.

step 3 Gently heat the apparatus until the temperature reaches 30 °C and record the total volume of oxygen.

step 4 Repeat at intervals of 5 °C until the temperature reaches 70 °C.

(b) (i) Complete the following diagram to show how the student can obtain oxygen by gas collection over water for use in the experiment shown in Fig. 2.1.



[2]

(ii) Suggest how the student could ensure they collect pure oxygen gas in the conical flask.

....

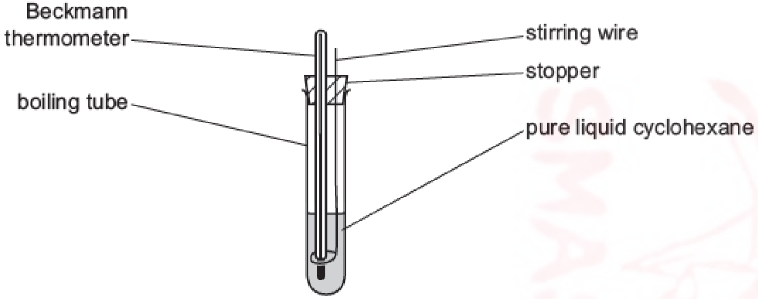
.... [1]

Q. Type: **Drawing Apparatus Topic: Chem 4 Q# 44/** ALvl Chemistry/2018/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1 When a solute is added to a solvent the freezing point of the solution is lower than that of the pure solvent.

The lowering of freezing point is very small. A chemist called Beckmann invented a thermometer capable of measuring these small temperature changes accurately. The Beckmann thermometer must be calibrated at the start of the experiment.

An incomplete diagram of the Beckmann apparatus is shown containing pure liquid cyclohexane, an organic solvent with a freezing point of about 6.5 °C. The diagram does not show how the cyclohexane could be frozen.



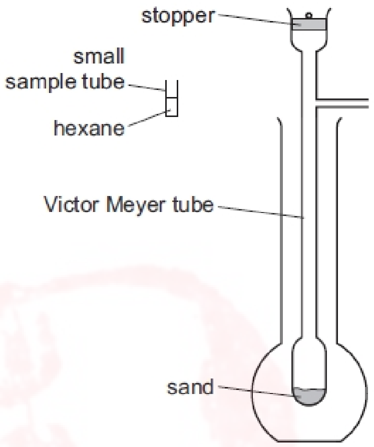
(a) Complete the diagram to show how the pure liquid cyclohexane could be frozen using simple laboratory apparatus. [1]

Q. Type: **Drawing Apparatus Topic: Chem 4 Q# 45/** ALvl Chemistry/2015/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 It is possible to determine the relative molecular mass, M_r, of a small sample of a volatile liquid by measuring its mass and then heating to vaporise it to obtain its volume as a gas.

In an experiment to determine the relative molecular mass of hexane, boiling point 69 °C, a specialist piece of apparatus called a Victor Meyer tube can be used. This consists of a long tube with a bulb at the base in which a sample can be vaporised. The tube has a side arm to allow the escape of gas from within the tube. The tube is surrounded by another which can be used to heat the contents of the first tube.

A diagram of the apparatus is shown below.



A small sample tube containing the hexane is inserted at the top of the Victor Meyer tube. The sample tube is small enough to fit inside the Victor Meyer tube and falls freely onto the hot sand below. The sand will cushion its fall so that the sample tube does not break. The stopper is then quickly replaced at the top of the Victor Meyer tube. The hot sand causes the hexane to vaporise and expel air contained in the Victor Meyer tube.

(c) Complete the diagram above to show:

- how the apparatus should be heated,
- a connection to further apparatus which would allow the air expelled from the Victor Meyer tube when the sample of hexane is vaporised to be collected and measured.

[2]

Q. Type: **Drawing Apparatus Topic: Chem 5 Q# 46/** ALvl Chemistry/2021/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1 Zinc metal reacts with aqueous copper(II) sulfate.

$$Zn(s) + CuSO_4(aq) \rightarrow Cu(s) + ZnSO_4(aq)$$

The enthalpy change of this reaction, ΔH, can be determined by adding excess zinc powder to a measured volume of 0.500 mol dm^{-3} aqueous copper(II) sulfate.

The temperature of 25.0 cm^3 of 0.500 mol dm^{-3} aqueous copper(II) sulfate is recorded for three minutes. At four minutes 3 g, an excess, of zinc powder is added and the mixture is continuously stirred. The temperature is recorded at times shown in the table.

time / min	0	1	2	3		$4\frac{1}{2}$	5	$5\frac{1}{2}$	6	$6\frac{1}{2}$	7	8	9	10
temperature / °C	18	19.5	19.5	19.5		32.5	38	36	34	33	32.5	31.5	31	31

(a) Use the results table to deduce the graduations on the thermometer that is used to record these temperature readings.

.... [1]

(b) Draw a labelled diagram of the apparatus set up at one minute.

[2]

Q. Type: **Drawing Apparatus Topic: Chem 5 Q# 47/** ALvl Chemistry/2017/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 The pain of muscle strains and swellings can be eased by using heat packs. As a source of heat, some heat packs use the energy released when anhydrous calcium chloride dissolves in water.

$$CaCl_2(s) \xrightarrow{\text{water}} Ca^{2+}(aq) + 2Cl^-(aq)$$

A heat pack consists of a bag of water, inside which a smaller bag contains anhydrous calcium chloride. When pressure is applied to the heat pack, the smaller bag bursts releasing the anhydrous calcium chloride into the water. The heat pack is shaken to speed up dissolving. Energy is released which warms the heat pack.

A student carried out an experiment to determine the enthalpy change when anhydrous calcium chloride dissolves in distilled water. The results the student obtained are plotted on the graph on page 4.

(a) By considering the graph of results, draw a labelled diagram of the experimental set-up that the student could have used to produce the graph shown.
Label the apparatus and chemicals required to measure the **two** variables.

[2]

Q. Type: **Drawing Apparatus Topic: Chem 6 Q# 48/** ALvl Chemistry/2012/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 There are three oxides of lead, PbO, PbO_2 and Pb_3O_4, all of which can be reduced to metallic lead by hydrogen.

The following information gives some of the hazards associated with these compounds.

Lead oxides
Lead(II) oxide (PbO) **Lead(IV) oxide** (PbO_2) **Dilead(II) lead(IV) oxide** (Pb_3O_4)
Toxic Dangerous for the environment
Harmful by inhalation and if swallowed. Danger of cumulative effects.

Hydrogen Extremely flammable. Readily forms an explosive mixture with air. Mixtures between 4 and 74 % by volume are explosive.

An unknown sample of an oxide of lead can be identified by investigating the molar ratio of oxygen atoms to lead atoms.

You are to plan an experiment to investigate the molar ratio of oxygen atoms to lead atoms in the oxide sample. Your plan should result in a correct identification of the oxide.

(d) Draw a diagram of the apparatus and experimental set up you would use to determine the chemical formula of the oxide. Your apparatus should use only standard items found in a school or college laboratory and should show clearly

(i) how the hydrogen gas needed for the reduction is prepared, naming the chemicals (reagents) to be used,

(ii) how the oxide of lead will be heated,

(iii) how any excess hydrogen is dealt with safely.

Label each piece of apparatus used.

[3]

Q. Type: **Drawing Apparatus Topic: Chem 6 Q# 49/** ALvl Chemistry/2006/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 ASSESSMENT OF PLANNING SKILLS

Copper has two oxides, CuO and Cu_2O.
Each oxide can be reduced to copper metal by heating it in a stream of hydrogen gas.
The oxide turns to copper metal powder in an exothermic reaction in which the powder may be seen to glow red hot.

$$CuO(s) + H_2(g) \rightarrow Cu(s) + H_2O(g)$$

$$Cu_2O(s) + H_2(g) \rightarrow 2Cu(s) + H_2O(g)$$

(a) Draw a diagram to show the assembled apparatus you could use in a school laboratory to carry out the reduction of one of the oxides. The apparatus should enable you to:

(i) weigh the oxide before heating and the metallic copper after heating,

(ii) condense, collect and weigh the steam/water produced,

(iii) burn any excess hydrogen after it has passed through the apparatus.

You may assume that a supply of hydrogen gas is available – you do not have to prepare the gas. You need not draw a balance.

[3]

Q. Type: **Drawing Apparatus Topic: Chem 7 Q# 50/** ALvl Chemistry/2020/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 Nitrogen dioxide can be prepared by strongly heating anhydrous lead nitrate, $Pb(NO_3)_2(s)$. The thermal decomposition occurs according to the equation shown.

$$2Pb(NO_3)_2(s) \rightarrow 2PbO(s) + 4NO_2(g) + O_2(g)$$

The nitrogen dioxide, NO_2, can be separated from the oxygen by cooling the gas mixture produced until the NO_2 condenses and the oxygen does not.

	melting point/K	boiling point/K
nitrogen dioxide	262	294
oxygen	54	90

(a) Draw a labelled diagram of the laboratory apparatus (assembled) that could be used to prepare **liquid** nitrogen dioxide from the thermal decomposition of anhydrous lead nitrate.

[2]

Q. Type: **Drawing Apparatus Topic: Chem 8 Q# 51/** ALvl Chemistry/2021/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 Hydrogen peroxide decomposes slowly at room temperature to give water and oxygen.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

The **initial** rate of this reaction can be increased by the addition of a metal oxide catalyst.

A student is asked to investigate which metal oxide catalyst is best at increasing the **initial** rate of this reaction by using a method which involves the collection of oxygen.

The student is provided with the following metal oxides: copper(II) oxide, iron(III) oxide, manganese(IV) oxide, nickel(II) oxide and titanium(IV) oxide.

The student is also provided with an excess volume, of a known concentration, of aqueous hydrogen peroxide and any laboratory equipment needed.

(c) Draw a labelled diagram of the assembled apparatus that could be used to carry out these experiments. The apparatus should allow the accurate recording of the oxygen produced.

[3]

Q. Type: **Drawing Apparatus Topic: Chem 9 Q# 52/** ALvl Chemistry/2016/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 Lithium is a soft alkali metal which may be cut with a knife. It is usually stored under oil because it reacts rapidly with moisture and oxygen in the air.

> **Lithium** is **corrosive** and may cause burns.
>
> **Lithium** is **highly flammable** and in large amounts reacts violently with water.

$$2Li(s) + 2H_2O(l) \rightarrow 2LiOH(aq) + H_2(g)$$

This reaction can be used to determine the relative atomic mass of lithium by measuring the volume of hydrogen produced from a small amount of lithium.

(a) Draw the apparatus you could use to measure the volume of hydrogen produced, using standard laboratory equipment.

Label the chemicals in your diagram and show how the reactants can be kept apart until the reaction is started.

[3]

Q. Type: **Drawing Apparatus Topic: Chem 10 Q# 53/** ALvl Chemistry/2019/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2 A student was given a sample of an unknown Group 2 chloride. The student dissolved 3.172 g of the unknown Group 2 chloride in distilled water in a beaker and added an excess of aqueous silver nitrate, $AgNO_3$(aq), to the beaker.

A white precipitate of silver chloride formed.

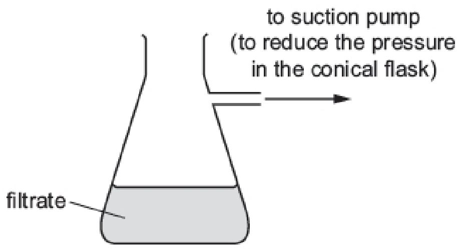
(a) Write the ionic equation, including state symbols, for the reaction occurring.

.... [1]

(b) To separate the filtrate from the residue, filtration can be carried out using gravity or by using reduced pressure.

The student decided to filter the mixture under reduced pressure.

(i) Complete the labelled diagram to suggest how the student could filter the mixture under reduced pressure.



[2]

(ii) Suggest **one** major advantage of filtering the mixture under reduced pressure compared with filtering using gravity.

.... [1]

Q. Type: **Drawing Apparatus Topic: Chem 21 Q# 54/** ALvl Chemistry/2019/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 A student plans to prepare propanone from propan-2-ol and test the product. Reagents provided to the student and some of their hazards are shown in the table.

reagent	hazard
propan-2-ol	flammable
concentrated sulfuric acid	corrosive
potassium dichromate(VI)	oxidising
distilled water	non-hazardous

(a) **(i)** The full equation for the reaction between propan-2-ol and acidified potassium dichromate(VI) is shown.

$$3CH_3CH(OH)CH_3 + K_2Cr_2O_7 + 4H_2SO_4 \rightarrow 3(CH_3)_2CO + K_2SO_4 + Cr_2(SO_4)_3 + 7H_2O$$

(ii) The student is provided with a set of instructions to prepare the propanone.

step 1 Add concentrated sulfuric acid to 5.0 g of propan-2-ol in a round-bottomed flask, a few drops at a time.

step 2 Dissolve the mass of potassium dichromate(VI) calculated in **(a)(i)** in a few cm^3 of distilled water.

step 3 Add this aqueous potassium dichromate(VI) slowly to the mixture in the round-bottomed flask.

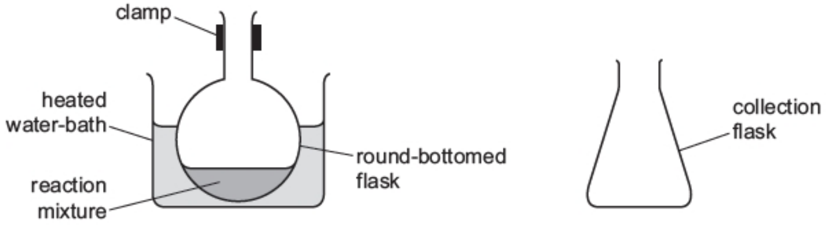
step 4 Heat the mixture under reflux.

step 5 Separate the propanone from the reaction mixture using distillation.

The student is also provided with the boiling points of propan-2-ol and propanone.

compound	boiling point / °C
propan-2-ol	82.5
propanone	56.5

Complete the diagram to show how the propanone is separated from the reaction mixture in step 5.
Label your diagram fully including the location of propan-2-ol and propanone after distillation has taken place. There is no need to include clamps.



[3]

(iii) The reaction mixture needs heating for reflux to take place.

Explain why a water-bath is used to heat the mixture.

....

....

.... [1]

Q. Type: **Drawing Apparatus Topic: Chem 23 Q# 55/** ALvl Chemistry/2013/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 Ammonium nitrate, NH_4NO_3, is soluble in water (approximately 2.5 mol / 100 g at 25 °C). The molar enthalpy of solution of a solid is defined as the enthalpy change when one mole of the solid is dissolved in water.

$$NH_4NO_3(s) \rightleftharpoons NH_4^+(aq) + NO_3^-(aq) \qquad \Delta H_{soln} = +26.5\,kJ\,mol^{-1}$$

(c) You are to plan an experiment to determine as accurately as possible how the temperature change varies when different solutions are made, each with different concentrations of ammonium nitrate. You are reminded that the approximate solubility of ammonium nitrate is 2.5 mol / 100 g at 25 °C.

The following information gives some of the hazards associated with ammonium nitrate.

> **Ammonium nitrate** NH_4NO_3. Contact with combustible material may cause fire. Explosive when mixed with combustible material.
> **Do not allow the salt to become contaminated with organic matter and do not grind it.**
> Solutions should be diluted to less than 0.5 mol dm^{-3} for disposal.

You should use only standard apparatus found in a school or college laboratory. Draw a diagram of the apparatus and experimental set up you would use showing clearly the following:

(i) the apparatus used, such as the reaction vessel, and how the thermometer will be positioned in order to measure the temperature of the solution as accurately as possible,

(ii) how the apparatus will be insulated.

Label each piece of apparatus used, indicating its size or capacity and both the temperature range and the precision of the thermometer.

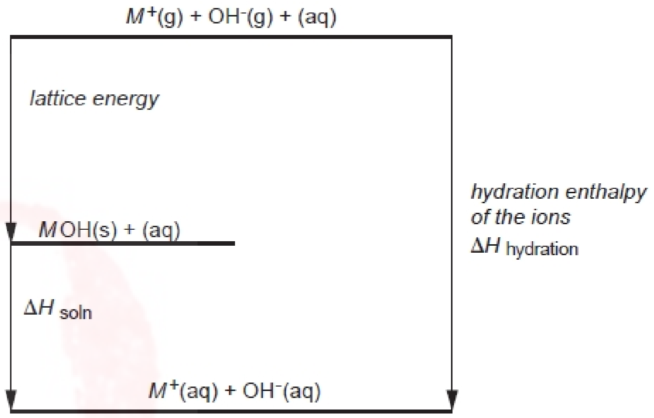
[3]

Q. Type: **Drawing Apparatus Topic: Chem 23 Q# 56/** ALvl Chemistry/2007/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 The hydroxides of Group I metals (LiOH, NaOH, KOH, RbOH, CsOH) are highly corrosive white solids which rapidly absorb water vapour on exposure to the atmosphere.
All of these solids dissolve exothermically in water.
The enthalpy change of solution, ΔH_{soln}, is the energy change associated with the following reaction. *M* represents the Group I metal.

$$MOH(s) + (aq) \longrightarrow M^+(aq) + OH^-(aq)$$

The following diagram represents theoretical stages in the formation of aqueous *M*OH.



Lattice energy and hydration enthalpy are both more exothermic when ions carry a higher charge and/or ions have a smaller radius.

When comparing Group I hydroxides, changes in $\Delta H_{hydration}$ are more significant than changes in lattice energy.

(c) Draw a labelled diagram to show the apparatus you would use to obtain data from which ΔH_{soln} could be determined.

From the information given on page 2 and the apparatus you plan to use, identify **two** possible sources of error in the experiment and state how you would minimise the effect of each.

error 1 ....

....

error 2 ....

....

[3]

Q. Type: **Drawing Apparatus Topic: Chem 24 Q# 57/** ALvl Chemistry/2018/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 The Faraday constant is the charge in coulombs, C, carried by 1 mole of electrons.

(a) A student plans an electrolysis experiment to determine the Faraday constant.

The student was supplied with the following.

- 1.0 mol dm^{-3} copper(II) sulfate
- clean, dry copper foil electrodes, labelled ‘anode’ and ‘cathode’
- balance
- stop-clock
- ammeter
- other equipment suitable for carrying out electrolysis

Draw a labelled diagram of the apparatus and chemicals the student should use in their electrolysis experiment. Include in your diagram the circuit connecting the anode and cathode.

[2]

Q. Type: **Drawing Apparatus Topic: Chem 26 Q# 58/** ALvl Chemistry/2021/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 The rate of reaction between calcium carbonate, $CaCO_3$, and hydrochloric acid, HCl, can be followed by collecting and measuring the volume of carbon dioxide produced at 30-second intervals.

The equation for the reaction is:

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

(a) A student plans to collect the carbon dioxide by displacement of water.

Draw a labelled diagram of the apparatus that could be used to carry out this experiment.

The apparatus should allow the accurate recording of the volume of carbon dioxide produced.

[3]

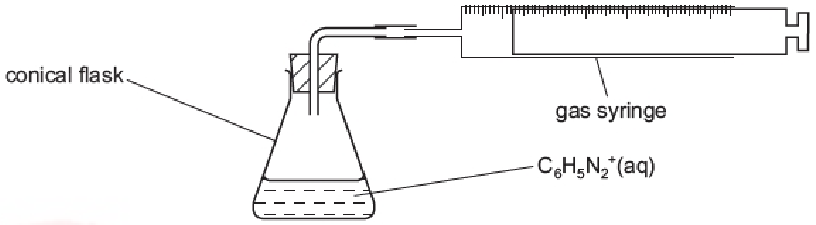
Q. Type: **Drawing Apparatus Topic: Chem 26 Q# 59/** ALvl Chemistry/2018/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 At temperatures above 5 °C, the benzenediazonium ion, $C_6H_5N_2^+$, reacts with water as shown.

$$C_6H_5N_2^+(aq) + H_2O(l) \rightarrow C_6H_5OH(aq) + N_2(g) + H^+(aq)$$

A student investigates this reaction by measuring the volume of nitrogen gas produced at regular time intervals.

The diagram shows the experimental set-up used to investigate this reaction.



(a) The student finds that the reaction is very slow, so decides to investigate the reaction at 30 °C.

Complete the diagram to show how the student could investigate this reaction at a constant 30 °C. [2]

Q. Type: **Drawing Apparatus Topic: Chem 27 Q# 60/** ALvl Chemistry/2014/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 When magnesium nitrate(V) is heated, it decomposes to form magnesium oxide, nitrogen(IV) oxide and oxygen.
Nitrogen(IV) oxide is an acidic gas that reacts readily and completely with alkalis.

You are to plan a **single** experiment to confirm that the molar quantities of magnesium oxide, nitrogen(IV) oxide and oxygen produced agree with the equation for the thermal decomposition of magnesium nitrate(V).

The following information gives some of the hazards associated with nitrogen(IV) oxide.

> **Nitrogen(IV) oxide** must not be inhaled. A large dose can be fatal and smaller quantities can have severe effects on breathing, particularly for people who suffer from asthma.

You are provided with anhydrous magnesium nitrate(V) and have access to the usual laboratory equipment and reagents.

(b) **(i)** Draw and label a diagram of the apparatus and experimental set-up you would use. The set-up needs to be capable of absorbing the nitrogen(IV) oxide and collecting the oxygen separately and in sequence.

[4]

Q. Type: **Drawing Apparatus Topic: Chem 27 Q# 61/** ALvl Chemistry/2011/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 The carbonates of group II in the periodic table decompose on heating forming an oxide and carbon dioxide.
X is any group II cation (e.g. Mg^{2+})

$$XCO_3 \rightarrow XO + CO_2$$

This decomposition occurs because the positively charged cations polarise (distort) the C—O bond in the carbonate ion causing the ion to break up. The charge density of the group II cations decreases down the group. This affects the decomposition rate.

You are to plan an experiment to investigate how the rate of decomposition of a group II carbonate varies as the group is descended. The rate can be conveniently measured by finding the time taken to produce the same volume of carbon dioxide from each carbonate.

(c) Draw a diagram of the apparatus and experimental set up you would use to carry out this experiment. Your apparatus should use only standard items found in a school or college laboratory and show clearly the following.

(i) the apparatus used to heat the carbonate

(ii) how the carbon dioxide will be collected

Label each piece of apparatus used, indicating its size or capacity.

[2]

Q. Type: **Drawing Apparatus Topic: Chem 27 Q# 62/** ALvl Chemistry/2009/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 You are to plan an investigation into the thermal decomposition of caesium nitrate, $CsNO_3$.

You may make use of some or all of the following data when planning your investigation.

Group I element	cation	ionic radius / nm
lithium	Li^+	0.060
sodium	Na^+	0.095
potassium	K^+	0.133
rubidium	Rb^+	0.148
caesium	Cs^+	0.176

Equations for the thermal decomposition of lithium nitrate and sodium nitrate are given below.

$$4LiNO_3(s) \rightarrow 2Li_2O(s) + 4NO_2(g) + O_2(g)$$
$$2NaNO_3(s) \rightarrow 2NaNO_2(s) + O_2(g)$$

nitrogen dioxide gas	oxygen gas
NO_2	O_2
brown in colour	colourless
soluble in water	almost insoluble in water
poisonous	powerful oxidant

1 mol of any gas occupies a volume of approximately 24 dm^3 at room temperature and atmospheric pressure.

A_r: Cs, 133; N, 14.0; O, 16.0

(c) Draw a diagram of the apparatus you would use in this experiment.
Your apparatus should use only standard items found in a school or college laboratory.
Show clearly how the solid will be heated, the gas collected and its volume measured.
Label each piece of apparatus used, indicating its size or capacity, e.g. *250 cm^3 beaker*.

Assuming that either equation in **(a)** might be correct, which gas or gases would you expect to collect in your apparatus. Explain your answer.

....

.... [3]

Q. Type: **Drawing Apparatus Topic: Chem 27 Q# 63/** ALvl Chemistry/2002/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 ASSESSMENT OF PLANNING SKILLS

DO NOT CARRY OUT YOUR PLAN

Caesium nitrate, $CsNO_3$, decomposes on heating.

The decomposition is represented by one of the following equations.

$$4CsNO_3(s) \rightarrow 2Cs_2O(s) + 4NO_2(g) + O_2(g)$$

$$2CsNO_3(s) \rightarrow 2CsNO_2(s) + O_2(g)$$

You are to devise a method of heating the solid nitrate, collecting the gas given off and measuring its volume.
From the experimental results you are to determine which is the correct equation for the decomposition.

Information that may be used in the question.

The molar volume of gas, V_m, is 24.0 dm^3 mol^{-1} under room conditions.

Nitrogen dioxide, NO_2, a toxic gas, is soluble in water.
Oxygen, O_2, is not soluble in water.

[A_r; Cs, 133.0; N, 14.0; O, 16.0.]

(a) Draw and label the apparatus you would use to heat the caesium nitrate, to collect the gas and to measure its volume.

When labelling your diagram include the volume of apparatus used (e.g. 250 cm^3 beaker) where appropriate. [2]

Q. Type: Error Topic: Chem .2 Q# 64/ ALvl Chemistry/2005/s/TZ 1/ Paper 5/Q# 3/Smashing!!!

[Most valuable question dealing with Error in the 20-year sample]

3 ANALYSIS AND EVALUATION

(a) Indicate the size of the error you would expect in making measurements with the thermometer in question 2.

....

....

....[1]

(b) Why is it **not** necessary to consider the errors in the measuring cylinder used in question 1?

....

....

....[1]

ASSESSMENT OF PLANNING SKILLS

The relative atomic mass of **X** can also be determined by an experiment in which carbon dioxide is evolved in the reaction between a weighed sample of the carbonate of **X** and excess hydrochloric acid. The sample is added to the acid and the bung quickly re-inserted in the flask. The gas displaced from the apparatus is collected and its volume measured using the apparatus below.

The acid is placed in a 250 cm^3 conical flask and the gas collected by displacing water from an inverted 100 cm^3 measuring cylinder.

(c) In both Question 1 and the experiment above, the accuracy of the measured mass or volume can be improved by dissolving a small quantity of sodium carbonate in the acid before the start of the experiment.

Suggest the reason behind this.

....

....

....

....

....

....[2]

(d) For the experiment shown in the photograph, suggest **two other major** sources of error (not including that mentioned in part **(c)**) in the spaces provided on page 10.

For each source of error describe a method of reducing this error, explaining the reasoning for your method.

The data below may be relevant.

Data

Solubility of carbon dioxide gas at different temperatures

temperature /°C	solubility /g CO_2 per 100 g of water
0	0.348
25	0.145
40	0.097
60	0.058

The general gas equation $pV = nRT$

The specific heat capacity of water $= 4.18\ J\ g^{-1}\ K^{-1}$

Vapour pressure of water at different temperatures

temperature /°C	Vapour pressure /Pa
20	2388
25	3167
30	4243
35	5623
40	7376

Technical data for X_2CO_3

Minimum assay	99%
Substances insoluble in water	0.0025%
Water	0.35%
Arsenic	0.0001%
Lead	0.003%
Sulphate	0.02%
Iron	0.001%

(i) first major source of error

....

method for reducing this error

....

....

explanation

....

....[3]

(ii) second major source of error

....

....

method for reducing this error

....

....

explanation

....

....[3]

[Total : 10]

Q. Type: **Error Topic: Chem 2 Q# 65/** ALvl Chemistry/2022/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1 A student has a sample of copper(II) sulfate crystals, $CuSO_4•xH_2O$. The student wants to show that the value of *x* is 5.

The student uses the following method.

step 1 Weigh a clean crucible on a balance reading to two decimal places. Record the mass.

step 2 Place the sample of $CuSO_4•xH_2O$ into the crucible. Record the mass.

step 3 Heat the crucible gently for about 1 minute then strongly for about 4 minutes.

step 4 Weigh the crucible and contents. Record the mass.

(e) The student records their results in Table 1.1.

Table 1.1

	mass / g
mass of crucible	13.60
mass of crucible + contents before heating	21.09
mass of crucible + contents at the end of experiment	17.94

(ii) Suggest why the experimental value of *x* varies from the expected value of 5.

If you were unable to obtain an answer to **(e)(i)**, use the experimental value *x* = 6.9. This is **not** the correct answer.

....

.... [1]

(f) The empty crucible weighs 13.60 g.

Calculate the percentage error in this measurement.

Show your working.

percentage error = ... [1]

[Total: 9]

Q. Type: **Error Topic: Chem 2 Q# 66/** ALvl Chemistry/2010/s/TZ 1/ Paper 5/Q# 3/Smashing!!!

3 A group of students perform an experiment to confirm that the formula of magnesium oxide is MgO. Each student is provided with a different length of magnesium ribbon which is coiled and heated in a crucible fitted with a lid. The magnesium reacts with oxygen to form magnesium oxide.

The instructions for the experiment are as follows.

- Weigh the empty crucible and lid.
- Coil the length of magnesium ribbon and place it in the bottom of the crucible.
- Reweigh the crucible and lid with the magnesium.
- Heat the crucible with a Bunsen burner.
- Periodically lift the crucible lid for a very short period of time. This allows air to enter the crucible.
- Each time the lid is lifted, take care to minimise the loss of any white smoke which is some of the powder formed.
- When the reaction appears to have stopped, remove the crucible lid and heat the crucible and its contents strongly for 2 minutes.
- Cool and reweigh the crucible, lid and the contents.

The results of the experiment are given below.

student	mass of crucible and lid / g	mass of crucible and lid + magnesium / g	mass of crucible and lid + magnesium oxide / g	mass of magnesium / g	mass of magnesium oxide / g
1	25.37	26.62	27.50		
2	25.18	27.01	28.19	1.83	3.01
3	25.44	27.73	29.19	2.29	3.75
4	25.26	27.71	24.96	2.45	
5	25.39	28.11	29.84	2.72	4.45
6	25.04	27.89	28.54	2.85	3.50
7	25.13	28.08	29.93		

(e) The result for student 4 could not be plotted on the graph. Suggest an error in carrying out the experiment that could have led to this result.

....

....

....[1]

(f) Student 1 added a few drops of water to the cooled residue in the crucible.
The residue and water reacted to produce ammonia gas, NH_3.
Explain why this observation reduces confidence in this experiment as a method for determining the formula of magnesium oxide.

....

....

....[1]

Q. Type: **Error Topic: Chem 5 Q# 67/** ALvl Chemistry/2021/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1 Zinc metal reacts with aqueous copper(II) sulfate.

$$Zn(s) + CuSO_4(aq) \rightarrow Cu(s) + ZnSO_4(aq)$$

The enthalpy change of this reaction, Δ*H*, can be determined by adding excess zinc powder to a measured volume of 0.500 mol dm^{-3} aqueous copper(II) sulfate.

The temperature of 25.0 cm^3 of 0.500 mol dm^{-3} aqueous copper(II) sulfate is recorded for three minutes. At four minutes 3 g, an excess, of zinc powder is added and the mixture is continuously stirred. The temperature is recorded at times shown in the table.

time / min	0	1	2	3		$4\frac{1}{2}$	5	$5\frac{1}{2}$	6	$6\frac{1}{2}$	7	8	9	10
temperature / °C	18	19.5	19.5	19.5		32.5	38	36	34	33	32.5	31.5	31	31

(e) Heat loss is a major source of error in the results of this experiment.

Suggest how the following changes would affect the amount of heat loss, if at all.

Explain your answer in each case.

(i) The mass of zinc is doubled.

effect on heat loss ....

explanation ....

.... [1]

(ii) The concentration of 25.0 cm^3 of aqueous copper(II) sulfate is doubled. The amount of zinc used is still an excess.

effect on heat loss ....

explanation ....

.... [1]

(iii) The volume of 0.500 mol dm^{-3} aqueous copper(II) sulfate is doubled. The amount of zinc used is still an excess.

effect on heat loss ....

explanation ....

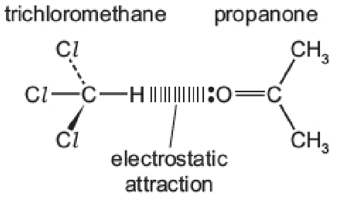
.... [1]

[Total: 10]

Q. Type: **Error Topic: Chem 5 Q# 68/** ALvl Chemistry/2020/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 Trichloromethane and propanone are both organic liquids. The molecules within each liquid are attracted to each other by relatively weak permanent dipole-dipole interactions.

When trichloromethane is mixed with propanone a strong electrostatic attraction forms between the two different molecules.



A student plans to perform an experiment to investigate the strength of this electrostatic attraction by finding the temperature change when equal volumes of trichloromethane and propanone are mixed together.

(b) The apparatus used leads to significant heat loss.

State **one** improvement the student could make to the apparatus to reduce heat loss.

....

.... [1]

(c) Trichloromethane and propanone are both volatile and flammable.

State **one** relevant precaution that should be taken when carrying out this experiment.

....

.... [1]

(d) State **one** change, apart from reducing heat loss, that could be made to improve the accuracy of this experiment.

....

.... [1]

Q. Type: **Error Topic: Chem 5 Q# 69/** ALvl Chemistry/2017/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1 The enthalpy change of reaction, ΔH_r, for the decomposition of sodium hydrogencarbonate, $NaHCO_3(s)$, cannot be measured directly.

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(l) + CO_2(g)$$

A student must carry out **two** separate experiments and use the results of these experiments to determine the enthalpy change of reaction for the decomposition of sodium hydrogencarbonate.

In both experiments the student used a weighing boat. A weighing boat is a small vessel used to contain solid samples when they are weighed.

Experiment 1 Reaction between sodium carbonate, Na_2CO_3(s), and dilute hydrochloric acid, HC*l*(aq)

step 1 The student added approximately 3 g of Na_2CO_3(s) to a weighing boat and accurately measured the combined mass of the weighing boat and Na_2CO_3(s). This mass was recorded in Table 1.1.

step 2 The student used a measuring cylinder to measure 50 cm^3 of 2 mol dm^{-3} HC*l*(aq).

step 3 The experiment was carried out and the results were recorded in Table 1.2.

step 4 The student reweighed the empty weighing boat and recorded the mass in Table 1.1.

Table 1.1 mass results from Experiment 1

mass of weighing boat and Na_2CO_3(s) / g	4.15
mass of empty weighing boat after addition of Na_2CO_3(s) to HC*l*(aq) / g	0.97
mass of Na_2CO_3(s) added / g	

Table 1.2 temperature results from Experiment 1

time / minutes	0	1	2	3		5	6	7	8	9	10
temperature of mixture / °C	20.0	19.8	19.8	19.8		24.6	24.7	24.5	24.3	24.1	23.9

Experiment 2 Reaction between sodium hydrogencarbonate, $NaHCO_3$(s), and dilute hydrochloric acid, HC*l*(aq)

step 1 The student weighed an empty weighing boat and recorded the mass in Table 1.3.

step 2 The student added exactly 4.20 g of $NaHCO_3$(s) to the weighing boat and recorded the mass in Table 1.3.

step 3 The student carried out the same experimental procedure as in **steps 2** and **3** of Experiment 1.

Table 1.3 mass results from Experiment 2

mass of empty weighing boat / g	0.95
mass of weighing boat and $NaHCO_3$(s) / g	5.15
mass of $NaHCO_3$(s) added / g	

(f) Explain why the method of determining the mass of solid added in Experiment 2 is less accurate than the method of determining the mass of solid added in Experiment 1.

....

.... [1]

(g) **(i)** In Experiment 2 a 50 cm^3 measuring cylinder was used to measure the 50 cm^3 of HC*l*(aq). The 50 cm^3 measuring cylinder had 1 cm^3 graduations.

Calculate the maximum percentage error in measuring 50 cm^3 of HC*l*(aq) with this 50 cm^3 measuring cylinder.

maximum percentage error = ... % [1]

(ii) Explain why measuring the concentration of the 2 mol dm^{-3} HC*l* more precisely would **not** affect the result of the experiment.

....

.... [1]

(iii) Suggest what the student should change to reduce the percentage error associated with the temperature readings **without** changing the apparatus.

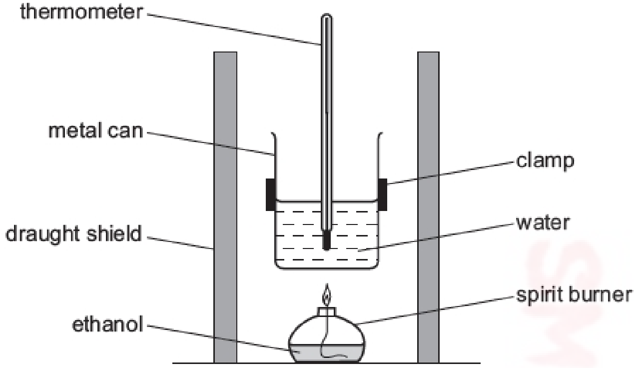
....

.... [1]

Q. Type: **Error Topic: Chem 5 Q# 70/** ALvl Chemistry/2016/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2 A student carried out a series of experiments to determine the enthalpy change of combustion of ethanol, C_2H_5OH.

A diagram of the apparatus is shown below.



The ethanol in the spirit burner was burned to heat a measured mass of water in the metal can. The student recorded the initial and final mass of ethanol and the initial and final temperature of the water for each experiment.

(f) **(i)** Calculate the maximum percentage error in the measurement of each mass used in experiment 1.

mass measured	maximum error in a single reading	maximum percentage error / %
0.391 g of ethanol burned	0.0005 g	
40.0 g of water	0.05 g	

[1]

(ii) Another student repeated the experiments using the method described under the same conditions. The value obtained for the enthalpy change of combustion of ethanol was –612 kJ mol^{-1}.

Suggest a reason why the errors calculated in **(i)** do not fully account for the difference between the student's value and the accepted value for enthalpy change of combustion, –1370 kJ mol^{-1}.

....

.... [1]

[Total: 10]

Q. Type: **Error Topic: Chem 6 Q# 71/** ALvl Chemistry/2021/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 A student is given 250.0 cm^3 of solution containing a mixture of Fe^{2+} and Fe^{3+} ions. The student is asked to find the total mass of iron ions and the percentage by mass of Fe^{3+} in the solution by performing titrations with aqueous potassium manganate(VII), $KMnO_4$.

The student is told that the Fe^{3+}(aq) ions can be reduced to Fe^{2+}(aq) ions by reaction with zinc.

The student is given the following instructions.

- Calculate the mass of $KMnO_4$ needed to make 500.0 cm^3 of 0.0200 mol dm^{-3} $KMnO_4$(aq).
- Record the mass of an empty plastic weighing boat (a small container used to hold solid samples).
- Add the calculated mass of $KMnO_4$ to the weighing boat.
- Transfer the $KMnO_4$ from the weighing boat into a 100 cm^3 beaker.
- Add 50 cm^3 of distilled water to the beaker.
- Transfer the mixture from the beaker into a 500.0 cm^3 volumetric flask.
- Make up to the graduation mark, dropwise, with distilled water.

(ii) The student used a balance accurate to two decimal places.

Calculate the percentage error in weighing the mass of the $KMnO_4$ by difference.

If you were unable to calculate a value for **2(a)(i)** use the mass 1.75 g. This is **not** the correct answer to **2(a)(i)**. Show your working.

percentage error = ... % [1]

(iii) The student noticed that some crystals of $KMnO_4$ were stuck to the weighing boat after adding the $KMnO_4$ solid to the beaker.

State how the student should modify the instructions to ensure that the measured mass of $KMnO_4$ was accurate.

....

....

.... [1]

(iv) Give two additional instructions that should be given to the student to ensure that the solution is prepared as accurately as possible.

1 ....

....

2 ....

.... [2]

(b) When the $KMnO_4$(aq) is ready for use, the student is given additional instructions.

step 1 Fill a burette with 0.0200 mol dm^{-3} $KMnO_4$(aq).

step 2 Using a measuring cylinder, transfer 25.00 cm^3 of Fe^{2+}(aq)/Fe^{3+}(aq) solution into a conical flask.

step 3 Add 10 cm^3 of 1.0 mol dm^{-3} sulfuric acid to the conical flask.

step 4 Titrate this acidified solution of Fe^{2+}(aq)/Fe^{3+}(aq) with 0.0200 mol dm^{-3} $KMnO_4$(aq) until the end-point.

step 5 Repeat titrations until the titres are concordant.
This set of results is **set A**.

step 6 Using a measuring cylinder, add 100 cm^3 of the Fe^{2+}(aq)/Fe^{3+}(aq) solution into a beaker then add excess zinc. Allow time for reduction to Fe^{2+}(aq) to take place.

step 7 Filter the mixture into a beaker.

step 8 Transfer 25.00 cm^3 of the filtrate into a conical flask and add 10 cm^3 of 1.0 mol dm^{-3} sulfuric acid.

step 9 Titrate this acidified solution of the filtrate with 0.0200 mol dm^{-3} $KMnO_4$(aq) until the end-point.

step 10 Repeat **steps 8** and **9** twice.
This set of results is **set B**.

(i) How should the burette be prepared for use before it is filled in **step 1**?

....

.... [1]

(ii) What must be done to ensure as accurate an end-point as possible?

....

.... [1]

(c) **(i)** Identify an experimental weakness in **step 2**. Explain how this would affect the results.

....

....

.... [1]

(ii) How could this weakness be overcome?

.... [1]

Q. Type: **Error Topic: Chem 6 Q# 72/** ALvl Chemistry/2020/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1 Brass is an alloy of copper and zinc. Typical copper concentrations vary from 50% to 85%, depending upon the properties needed in the alloy. There may be small amounts of other metals present.

A student found a method to determine the percentage of copper in a sample of brass.

A known mass of brass powder is reacted with excess concentrated nitric acid. Both the copper and the zinc and any other metals present are oxidised into aqueous ions by the nitric acid. The amount of Cu^{2+}(aq) ions present can be determined by a titration technique.

step 1 Use a weighing boat to accurately weigh by difference approximately 2 g of brass powder and place the brass into a small glass beaker.

step 2 In a fume cupboard add **approximately** 20 cm^3 of concentrated nitric acid to the brass in the beaker. Allow the brass to completely react to form solution **A**.

The equation for the reaction is shown.

$$Cu(s) + 4HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2NO_2(g) + 2H_2O(l)$$

step 3 Dilute **all** of solution **A** to form exactly 250.0 cm^3 of solution **B**.

step 4 Place 25.00 cm^3 of solution **B** into a conical flask.

step 5 Use a dropping pipette to add aqueous sodium carbonate, Na_2CO_3(aq), to solution **B** in the conical flask until there is no more acid present.

step 6 Add approximately 20 cm^3 of aqueous potassium iodide, KI(aq), to the conical flask. A white precipitate forms as well as a brown solution of aqueous iodine, I_2(aq).

step 7 Fill a burette with 0.100 mol dm^{-3} sodium thiosulfate solution, $Na_2S_2O_3$(aq), so it is ready for the titration in **step 8**.

step 8 Carry out a titration of the aqueous iodine produced in the conical flask against the 0.100 mol dm^{-3} $Na_2S_2O_3$(aq).

(g) The titration table the student used is shown.

titration number	rough	1	2	3	
final burette reading / cm^3	20.50	40.25	19.90	39.65	
initial burette reading / cm^3	0.00	20.60	0.00	19.90	
titre / cm^3					

(ii) The burette used by the student has graduations of 0.10 cm^3.

Determine the percentage error in the titre measured in titration number 2.

Show your working.

percentage error = ... [1]

(iii) Other than a change in apparatus, suggest one change to the experiment which would lead to a reduction in the percentage error in a measured titre.

....

.... [1]

Q. Type: **Error Topic: Chem 7 Q# 73/** ALvl Chemistry/2015/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 In an experiment, various masses of solid barium hydroxide are added to 60.0 cm^3 of a solution of hydrochloric acid contained in a polystyrene cup.

In each experiment a fresh sample of the acid is taken and its initial temperature is measured. After the barium hydroxide has been added, the acid is stirred and the maximum temperature reached is noted.

(e) **(i)** When the experiment is done in the way described, the results are not very accurate.

Apart from limitations due to the accuracy of the measuring equipment, suggest why:

- all the temperature rises measured are less than theoretically should be expected,

....

....

- the temperature rises are more inaccurate as they approach their maximum value.

....

....

[2]

(ii) What improvement would you make to achieve greater accuracy?

....

....

....

.... [1]

Q. Type: **Error Topic: Chem 7 Q# 74/** ALvl Chemistry/2014/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 The acid dissociation constant, K_a, of a weak monoprotic acid, **HA**, is to be determined from the measurement of the pH change that occurs when it is titrated with an aqueous solution of sodium hydroxide.

2.70 g of **HA** was dissolved in distilled water to make exactly 250.0 cm^3 of solution.
25.00 cm^3 of the solution was pipetted into a beaker.
The pH of the acid in the beaker was measured and recorded in the table below.

A burette was then filled with aqueous sodium hydroxide and the 25.00 cm^3 of **HA** was titrated by adding volumes of the aqueous sodium hydroxide to the beaker as indicated in the table below. After each addition the pH was measured and the value recorded.

(g) Even if the experiment is done very carefully with very accurate apparatus, the answer obtained for the molecular mass of **HA** is likely to be subject to error. Suggest why.

....

....

....

.... [1]

Q. Type: **Error Topic: Chem 8 Q# 75/** ALvl Chemistry/2017/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 Iodide ions, I⁻, and persulfate ions, $S_2O_8^{2-}$, react according to the following equation.

$$2I^-(aq) + S_2O_8^{2-}(aq) \rightarrow I_2(aq) + 2SO_4^{2-}(aq)$$

The rate of reaction between these ions can be determined from the time it takes for a certain amount of iodine, I_2(aq), to be produced.

- A mixture of solutions is prepared, containing known volumes of
  - ○ aqueous ammonium persulfate, $(NH_4)_2S_2O_8$(aq),
  - ○ aqueous sodium thiosulfate, $Na_2S_2O_3$(aq),
  - ○ starch indicator.
- A known volume of aqueous potassium iodide, KI(aq), is added to this mixture and a timer is started.
- After the reactants are mixed, they react slowly to produce iodine, I_2(aq).
- Any iodine initially produced is removed by a reaction with thiosulfate ions.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

- Iodine, I_2(aq), is continuously removed until all of the thiosulfate ions have been used up.
- After that time any I_2(aq) that is produced turns the starch indicator blue.
- The time of the first appearance of the blue colour is recorded.
- This procedure is repeated with different volumes of reactants, keeping the total volume of the reaction mixture constant by adding the required volume of distilled water.

You are to plan a series of experiments to determine the effect of changing the concentration of iodide ions on the rate of reaction.

You are provided with the following materials.

solid ammonium persulfate, $(NH_4)_2S_2O_8$(s)
0.20 mol dm⁻³ aqueous KI, a source of I⁻(aq)
0.0050 mol dm⁻³ aqueous $Na_2S_2O_3$, a source of $S_2O_3^{2-}$(aq)
starch indicator

(c) In a different experiment, a student mixed the following solutions and measured the time taken for the reaction.

- 10.0 cm³ of 1.00 mol dm⁻³ $(NH_4)_2S_2O_8$(aq)
- 5.0 cm³ of 0.0050 mol dm⁻³ $Na_2S_2O_3$(aq)
- 5.0 cm³ of 0.20 mol dm⁻³ KI(aq)
- 1.0 cm³ of starch indicator

(i) The time taken for the blue colour to appear was 134 seconds (to the nearest second).

(ii) What should the student have done to make sure that the results were reliable?

....

.... [1]

(iii) The 5.0 cm³ of 0.0050 mol dm⁻³ $Na_2S_2O_3$(aq) was measured using a 50 cm³ burette which had graduations every 0.1 cm³.

Calculate the maximum percentage error in the measured volume of this solution.

percentage error = ... % [1]

(d) A second student tried to perform the same experiment but found that the reaction mixture turned blue immediately after KI(aq) was added.

State what error the student had made.

....

.... [1]

Q. Type: **Error Topic: Chem 8 Q# 76/** ALvl Chemistry/2007/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

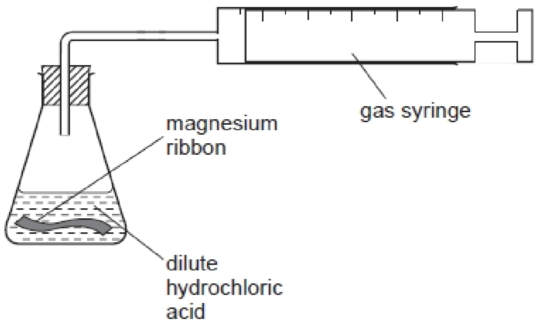
2 Students were asked to investigate how the rate of reaction between magnesium ribbon and hydrochloric acid varied with change in concentration of the acid.

$$2HCl(aq) + Mg(s) \longrightarrow MgCl_2(aq) + H_2(g)$$

Student 1, looking at the equation, suggested the following.

rate of production of hydrogen gas = $k[HCl]^2$

This student used the following apparatus to investigate the rate of production of hydrogen gas, H_2.



The student used a 500 cm^3 measuring cylinder to measure 100 cm^3 of dilute acid into a conical flask.
A 1 cm length (0.01 g) of magnesium ribbon was dropped into the acid in the flask and the stopper quickly replaced in the flask.
The stop-clock was started and the volume of gas collected was measured at 0.5 minute intervals. The results of the experiment were recorded as shown in the table below.

time / min	volume of H_2 / cm^3	time / min	volume of H_2 / cm^3
0.5	15.5	5.5	80.0
1.0	25.0	6.0	82.5
1.5	34.0	6.5	85.0
2.0	43.0	7.0	87.0
2.5	51.0	7.5	87.5
3.0	59.0	8.0	91.0
3.5	65.0	8.5	92.5
4.0	69.5	9.0	93.5
4.5	74.0	9.5	94.5
5.0	75.0	10.0	95.0

(e) Identify a further source of error in the method described and suggest a change to the method to reduce this error.

....

....

.... [1]

Q. Type: **Error Topic: Chem 9 Q# 77/** ALvl Chemistry/2014/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 A solder is an alloy of metals which is used to join other metal pieces together.
A specialist solder that can be used to join together pieces of aluminium is made from a mixture by mass of 65% zinc, 20% aluminium and 15% copper.

You are to plan an experimental procedure to confirm the composition of a powdered sample of this solder, by adding reagents and then extracting from the mixture each of the following in sequence;

(i) the copper metal,
(ii) the aluminium as aluminium hydroxide,
(iii) the zinc as zinc hydroxide.

You are provided with

- a sample of this solder, with approximate mass 4 g,
- 1.00 mol dm^{-3} sulfuric acid,
- 1.00 mol dm^{-3} ammonia.

No other reagents should be used. Standard laboratory equipment is available including a balance, accurate to two decimal places.

(c) The aluminium hydroxide and zinc hydroxide that have been extracted are difficult to dry so it is better to convert them to their oxides.
Describe how this could be done and how you would make sure that each hydroxide had been completely converted into its oxide.

....

....

....

.... [2]

(f) Even if the experimental difficulties of extracting all of the copper from the mixture were overcome, it would be difficult to obtain an accurate mass of copper from this experiment.
Suggest why.

....

....

....

.... [1]

Q. Type: **Error Topic: Chem 10 Q# 78/** ALvl Chemistry/2019/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2 A student was given a sample of an unknown Group 2 chloride. The student dissolved 3.172 g of the unknown Group 2 chloride in distilled water in a beaker and added an excess of aqueous silver nitrate, $AgNO_3(aq)$, to the beaker.

A white precipitate of silver chloride formed.

(c) The student rinsed the residue, transferred it to a crucible and placed it in a warm oven to dry it.

(i) What should the student do to ensure that the drying process is complete?

.... [1]

(iv) State and explain how the number of moles of silver chloride formed in **(ii)** would change if the student used tap water instead of distilled water to dissolve the Group 2 chloride.

....

.... [1]

Q. Type: **Error Topic: Chem 11 Q# 79/** ALvl Chemistry/2022/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 A student attempts to determine the percentage by mass of magnesium chloride in the solid mixture containing magnesium chloride, $MgCl_2$, and anhydrous magnesium nitrate, $Mg(NO_3)_2$, using the following method.

step 1 Accurately weigh about 1.5 g of the solid mixture and record the mass.

step 2 Dissolve the solid mixture in distilled water.

step 3 Add an excess of silver nitrate solution.

step 4 Filter the solid mixture and wash the precipitate collected with distilled water.

step 5 Dry the precipitate in an oven.

step 6 Weigh the precipitate and record the mass.

In this process only the chloride ions from the magnesium chloride form a precipitate with the silver nitrate solution.

$$MgCl_2(aq) + 2AgNO_3(aq) \rightarrow Mg(NO_3)_2(aq) + 2AgCl(s)$$

One student in the class obtains the following results.

mass of solid mixture = 1.52 g

mass of $AgCl$ solid after drying = 3.63 g

(b) **(i)** Suggest what the student could do in **step 2** to ensure the solid dissolves as quickly as possible.

....

....

.... [1]

(ii) Explain why the precipitate was washed with distilled water before it was dried.

....

....

.... [1]

(iii) Suggest why the precipitate is dried in an oven and not by direct heating with a Bunsen burner.

....

....

.... [1]

(c) **(i)** In **step 1**, a small beaker was weighed, using a balance accurate to two decimal places, and its mass recorded. The sample was placed in the beaker and the mass of the beaker increased by 1.52 g.

Calculate the percentage error in measuring the mass of this sample.

Show your working.

percentage error = ... [1]

(ii) Other than by changing the balance, state how this percentage error could be reduced.

.... [1]

(iii) State what could be done in **step 5** to ensure that the precipitate was completely dried.

....

.... [1]

(d) Another student in the class did not dry their silver chloride.

State how this would affect the value of the percentage by mass of magnesium chloride in the sample. Explain your answer.

....

.... [1]

[Total: 10]

Q. Type: **Error Topic: Chem 11 Q# 80/** ALvl Chemistry/2022/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 A student plans an investigation to find the molar ratio of the reaction between sodium chloride, NaC*l*, and a lead compound.

The student is provided with solid NaC*l* and 0.200 mol dm^{-3} aqueous lead compound.

The reaction between NaC*l*(aq) and the aqueous lead compound produces an insoluble compound as a precipitate.

(d) The student plans the following method using the 0.200 mol dm^{-3} aqueous lead compound and the 0.200 mol dm^{-3} NaC*l*(aq) prepared in **(c)**.

Step 1 Mix the NaC*l*(aq) and the aqueous lead compound in eight separate beakers in the proportions by volume shown in Table 1.1.

Table 1.1

beaker	volume of 0.200 mol dm^{-3} NaC*l*(aq) / cm^3	volume of 0.200 mol dm^{-3} aqueous lead compound / cm^3
1	10.00	40.00
2	15.00	35.00
3	20.00	30.00
4	25.00	25.00
5	30.00	20.00
6	35.00	15.00
7	40.00	10.00
8	45.00	5.00

Step 2 Filter the contents of each beaker to collect the precipitate.

Step 3 Dry the precipitate for 3 minutes in an oven and allow to cool.

Step 4 Weigh and record the mass of precipitate produced in each beaker.

(i) State **one** extra step that would improve this method. Explain why this step is necessary.

extra step:

....

....

explanation:

....

....

.... [2]

(ii) The volumes of solutions are measured using a burette.

Calculate the percentage error when measuring 10.00 cm^3 of solution.
Show your working.

percentage error = ... [1]

(iii) Explain how you would ensure that the results of the investigation are reliable.

....

....

.... [1]

(g) A student suggests that a simpler method can be used to find the molar ratio.

Different volumes of 0.200 mol dm^{-3} NaCl(aq) and 0.200 mol dm^{-3} aqueous lead compound are mixed in test-tubes. The resulting precipitates are allowed to settle. The height of each precipitate is then measured.

A further two investigations are carried out. The volumes used and the results of the two investigations are shown.

Investigation 1

Precipitate heights are measured after 1 minute.

Table 1.2

volume 0.200 mol dm^{-3} NaCl(aq) / cm^3	1	2	3	4	5	6	7	8	9
volume 0.200 mol dm^{-3} aqueous lead compound / cm^3	9	8	7	6	5	4	3	2	1

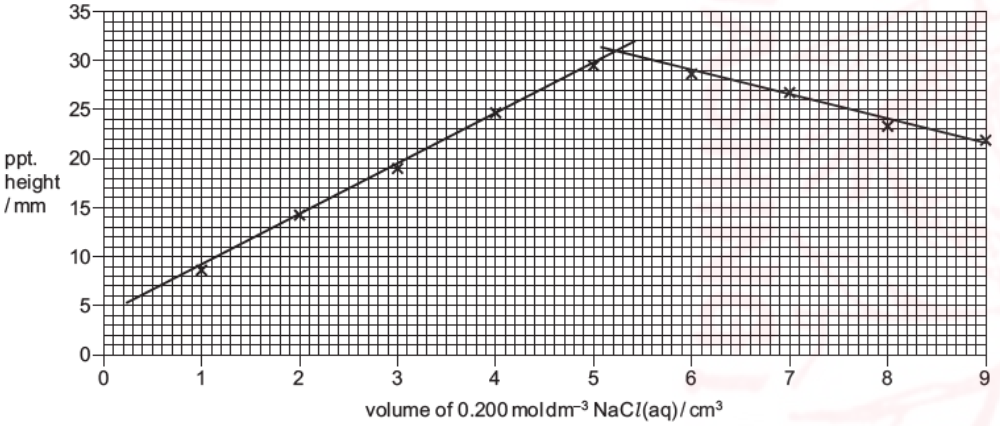


Fig. 1.2

Investigation 2

Precipitate heights are measured after 5 minutes.

Table 1.3

volume 0.200 mol dm^{-3} NaCl(aq) / cm^3	1	2	3	4	5	6	7	8	9
volume 0.200 mol dm^{-3} aqueous lead compound / cm^3	5	5	5	5	5	5	5	5	5

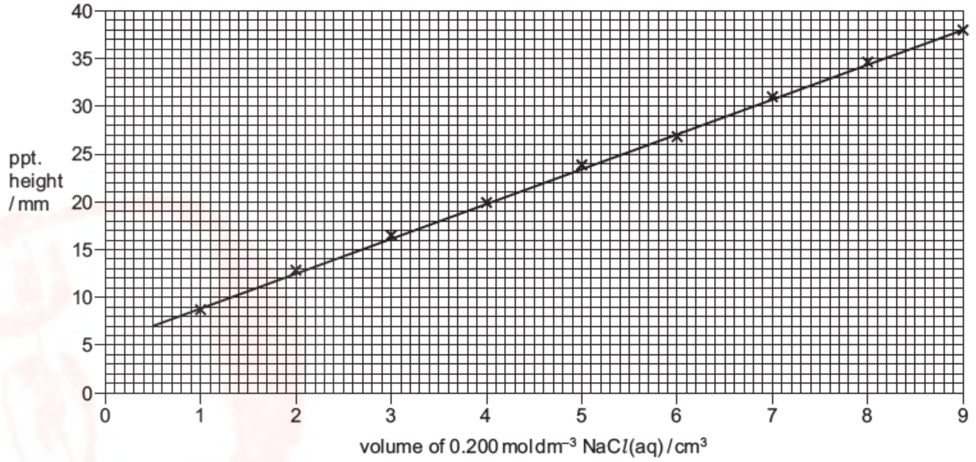


Fig. 1.3

Neither investigation produced the expected results. Both investigations, 1 and 2, contain weaknesses in the experimental procedure.

State how you would modify the experimental procedure in each case so that the expected results are obtained.

modification for investigation 1:

....

....

modification for investigation 2:

....

.... [2]

[Total: 14]

Q. Type: **Error Topic: Chem 24 Q# 81/** ALvl Chemistry/2018/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 The Faraday constant is the charge in coulombs, C, carried by 1 mole of electrons.

(a) A student plans an electrolysis experiment to determine the Faraday constant.

The student was supplied with the following.

- 1.0 mol dm^{-3} copper(II) sulfate
- clean, dry copper foil electrodes, labelled 'anode' and 'cathode'
- balance
- stop-clock
- ammeter
- other equipment suitable for carrying out electrolysis

(h) A possible source of error is not drying the anode at the start of the experiment.

Explain the effect, if any, on the calculated value of the Faraday constant if the anode is wet at the beginning of the experiment but dry at the end.

effect ....

explanation ....

.... [1]

(i) The student wanted to ensure that the anode was completely dry at the end of the experiment and decided to evaporate off the propanone using a blue Bunsen flame. The student noticed some blackening of the surface of the copper.

Suggest what caused this blackening.

....

.... [1]

(j) The student calculated the mass change of the anode and the cathode after the experiment was complete.

mass change of anode = –0.282 g   mass change of cathode = +0.217 g

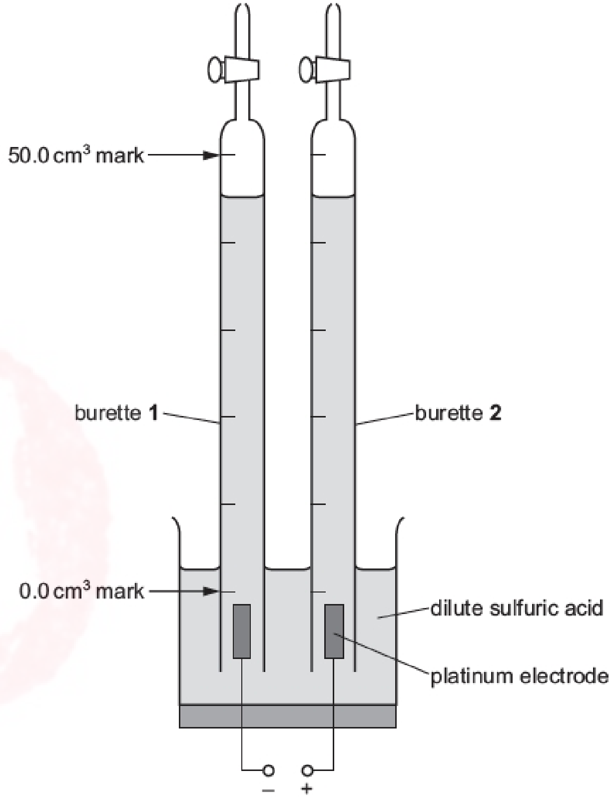
Suggest **one** reason why the mass gained at the cathode is **not** the same as the mass lost at the anode. Assume the student has recorded the mass changes correctly.

....

.... [1]

Q. Type: **Error Topic: Chem 24 Q# 82/** ALvl Chemistry/2017/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 Dilute sulfuric acid, H_2SO_4(aq), can be electrolysed using platinum electrodes and a direct current. Hydrogen gas is produced at the cathode and oxygen gas is produced at the anode. The two gases are collected separately in burettes filled with dilute sulfuric acid placed over each electrode.



reaction at electrode in burette **1**: $2H^+(aq) + 2e^- \rightarrow H_2(g)$
reaction at electrode in burette **2**: $H_2O(l) \rightarrow \frac{1}{2}O_2(g) + 2H^+(aq) + 2e^-$

The production of hydrogen gas over time can be measured, and the data used to determine the charge of one mole of electrons, known as the Faraday constant, *F*.

(a) The volumes of hydrogen gas produced during the electrolysis process are recorded in the table.

Process the results to calculate the volume of hydrogen gas produced, in cm^3, and the charge passed, in coulombs, C.

charge (C) = current (A) × time (s)

The current was kept constant at 0.80 A.

(g) A student's teacher suggested it would be cheaper to use copper rather than platinum electrodes in the electrolysis of dilute sulfuric acid.

half-equation	$E^\ominus$/V
$2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$	0.00
$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$	+0.34
$\frac{1}{2}O_2(g) + 2H^+(aq) + 2e^- \rightleftharpoons H_2O(l)$	+1.23

Using the information in the table, suggest what effect, if any, the use of copper electrodes would have on the volume of gas produced at **each** electrode. Explain your answer.

cathode ....

....

....

anode ....

....

.... [3]

[Total: 16]

Q. Type: **Error Topic: Chem 26 Q# 83/** ALvl Chemistry/2023/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2 The reaction between iodide ions, $I^-(aq)$, and aqueous hydrogen peroxide, $H_2O_2(aq)$, takes place in acidic conditions.

reaction 1 $2I^-(aq) + H_2O_2(aq) + 2H^+(aq) \rightarrow I_2(aq) + 2H_2O(l)$

A student carries out a series of experiments to investigate the order of reaction with respect to the concentration of $I^-(aq)$ ions. The student does this by measuring the time taken for a fixed amount of iodine to form.

A known amount of aqueous thiosulfate ions, $S_2O_3^{2-}(aq)$, in the reaction mixture react with $I_2(aq)$ formed in reaction 1.

reaction 2 $I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$

After all of the $S_2O_3^{2-}(aq)$ ions have reacted in reaction 2, any further $I_2(aq)$ formed is detected using starch indicator.

The following materials are used:

- $50\,cm^3$ beaker containing the correct mass of solid potassium iodide crystals needed to make $250.0\,cm^3$ of $0.100\,mol\,dm^{-3}$ KI(aq)
- $0.100\,mol\,dm^{-3}$ $Na_2S_2O_3(aq)$
- $0.100\,mol\,dm^{-3}$ $H_2O_2(aq)$
- $0.200\,mol\,dm^{-3}$ $H_2SO_4(aq)$
- starch indicator
- distilled water.

(c) The student carries out Experiment 1 using the following steps.

step 1 Add 25 cm^3 of 0.200 mol dm^{-3} H_2SO_4(aq) to a conical flask.

step 2 Add 20.00 cm^3 of distilled water to the conical flask from a burette.

step 3 Add 5.00 cm^3 of 0.100 mol dm^{-3} KI(aq) to the conical flask from a burette.

step 4 Add 5.00 cm^3 of 0.100 mol dm^{-3} $Na_2S_2O_3$(aq) to the conical flask from a burette.

step 5 Add 2 cm^3 of starch indicator to the conical flask.

step 6 Use a burette to add 10.00 cm^3 of 0.100 mol dm^{-3} H_2O_2(aq) to a small beaker.

step 7 Add the contents of the beaker to the conical flask and start a timer immediately. Stop the timer when the starch indicates the presence of I_2(aq).

The student carries out a further six experiments by repeating **steps 1** to **7**, using the volumes shown in Table 2.1.

Table 2.1

experiment	volume of H_2SO_4(aq) /cm^3	volume of distilled water /cm^3	volume of KI(aq), V /cm^3	volume of $Na_2S_2O_3$(aq) /cm^3	volume of indicator /cm^3	time taken for colour change, t /s
1	25	20.00	5.00	5.00	2	257
2	25	17.50	7.50	5.00	2	120
3	25	15.00	10.00	5.00	2	112
4	25	12.50	12.50	5.00	2	76
5	25	10.00	15.00	5.00	2	1
6	25	5.00	20.00	5.00	2	59
7	25	0.00	25.00	5.00	2	44

(i) State how the student could improve the reliability of the experiment.

.... [1]

(d) The rate equation is represented as rate = $k[I^-]^n$.

- $[I^-]$ is proportional to the volume of KI(aq)
- n is the order of reaction with respect to I^-
- rate is proportional to $1/t$
- $\log(\text{rate}) = \log k + n\log[I^-]$

(i) Use the results from the student's experiments in **(c)** to complete Table 2.2.

V is the volume of KI(aq) and t is the time taken for the colour to change.

Give all values to **three** significant figures.

The results for Experiment 5 should **not** be used.

Table 2.2

experiment	V/cm^3	t/s	log V	log (1/t)
1	5.00	257		
2	10.00	120		
3	12.50	112		
4	15.00	76		
5	17.50	1	X	X
6	20.00	56		
7	25.00	44		

The gradient mentioned in the question part that follows for (d)(iv) The experimental determined order of reaction is 1.10

(v) The total percentage error from measurements is determined to be 5.25%.

The true order of reaction is 1. Use this and your gradient from **(d)(iv)** to determine whether the error in the experiment could be accounted for by error from measurements or is caused by other factors.

Show any working.

....

.... [1]

[Total: 15]

Q. Type: **Error Topic: Chem 26 Q# 84/** ALvl Chemistry/2019/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1 The reaction between hydrogen peroxide, H_2O_2(aq), and iodide ions, I^-(aq), takes place in acidic conditions.

$$H_2O_2(aq) + 2I^-(aq) + 2H^+(aq) \rightarrow I_2(aq) + 2H_2O(l) \qquad \textbf{reaction 1}$$

The rate of this reaction can be found by measuring the time taken for a given amount of iodine, I_2(aq), to form.

This is done by adding a known amount of thiosulfate ions, $S_2O_3^{2-}$(aq), and allowing the I_2(aq) formed in **reaction 1** to react with the $S_2O_3^{2-}$(aq).

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq) \qquad \textbf{reaction 2}$$

After the $S_2O_3^{2-}$(aq) ions have all reacted in **reaction 2**, any further I_2(aq) formed in **reaction 1** can be detected using an indicator.

A student carried out a series of experiments to determine the order of reaction with respect to the concentration of I^-(aq) ions in **reaction 1**.

The student prepared the following solutions.

solution **A** 0.100 mol dm^{-3} KI(aq)

solution **B** 0.0500 mol dm^{-3} $Na_2S_2O_3$(aq)

The student also had access to the following chemicals.

solution **C** 0.100 mol dm^{-3} H_2O_2(aq)
0.2 mol dm^{-3} H_2SO_4(aq)
distilled water
a suitable indicator

(b) The student rinsed a burette with solution **A** before filling it with solution **A**.

Explain why this improves the accuracy of the results.

....

.... [1]

(d) Experiment 1 was carried out using a series of steps.

step 1 The student used a measuring cylinder to measure 25 cm^3 of 0.2 mol dm^{-3} H_2SO_4(aq). This was transferred to a conical flask.

step 2 The student added 20.00 cm^3 of distilled water from a burette to the conical flask.

step 3 The student added 5.00 cm^3 of solution **A** from a burette to the conical flask.

step 4 The student added 5.00 cm^3 of solution **B** from a burette to the conical flask.

step 5 The student added 1.0 cm^3 of indicator from a teat pipette to the conical flask.

step 6 The student used a burette to add 10.00 cm^3 of solution **C** to a small beaker. The contents of the beaker were added to the conical flask and a stopclock was started immediately. The stopclock was stopped when the I_2 formed caused the indicator to change colour.

In Experiments 2–6 the student repeated **steps 1–6** but using the volumes of distilled water and solution **A** given in the table.

The student carried out two trials of each experiment.

experiment	volume of H_2SO_4(aq) / cm^3	volume of distilled water / cm^3	volume of solution **A**, *v* / cm^3	volume of solution **B** / cm^3	volume of indicator / cm^3	time for the indicator to change colour, *t* / s	
						trial 1	trial 2
1	25.0	20.00	5.00	5.00	1.0	218	220
2	25.0	15.00	10.00	5.00	1.0	112	113
3	25.0	12.50	12.50	5.00	1.0	100	▨
4	25.0	10.00	15.00	5.00	1.0	77	76
5	25.0	5.00	20.00	5.00	1.0	59	59
6	25.0	0.00	25.00	5.00	1.0	47	49

(i) In Experiment 3, trial 2, the indicator changed colour as soon as the student added solution **C** to the conical flask. No results were recorded for Experiment 3, trial 2.

Suggest which step the student did **not** carry out in Experiment 3, trial 2.

.... [1]

(ii) Suggest why the results shown in the table could be considered reliable.

....

.... [1]

(iii) What was the percentage error in the burette reading for measuring the volume of solution **A** in Experiment 5?

percentage error = ... % [1]

(iv) Suggest why a measuring cylinder was used to measure the volume of H_2SO_4(aq) rather than a more accurate piece of apparatus, such as a burette.

.... [1]

Q. Type: **Error Topic: Chem 26 Q# 85/** ALvl Chemistry/2018/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 The Finkelstein reaction is a nucleophilic substitution reaction in which a halogen atom in a halogenoalkane is replaced by another halogen atom. The reaction is carried out using dry propanone as a solvent.

One example of the Finkelstein reaction is given.

$$CH_3CH_2CH_2Br + NaI \rightleftharpoons CH_3CH_2CH_2I + NaBr$$

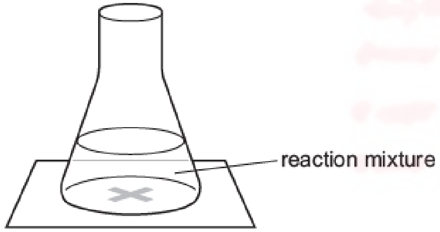
(c) A student plans an experiment to show that the rate of the reaction is proportional to the concentration of NaI.

Propanone is used as the solvent in this reaction.

$$CH_3CH_2CH_2Br(pr) + NaI(pr) \rightarrow CH_3CH_2CH_2I(pr) + NaBr(s)$$

(pr) = substance is dissolved in propanone

The student plans to record the time it takes for the solid formed to obscure a cross on a piece of paper below the conical flask, as shown.



To carry out this experiment, the following materials are available.

- $CH_3CH_2CH_2Br(l)$
- NaI(s)
- dry propanone, $CH_3COCH_3(l)$
- usual laboratory apparatus

(v) Identify the major source of inaccuracy of measurement in this reaction.

Suggest an improvement to the experiment to make it more accurate.

inaccuracy ....

....

improvement ....

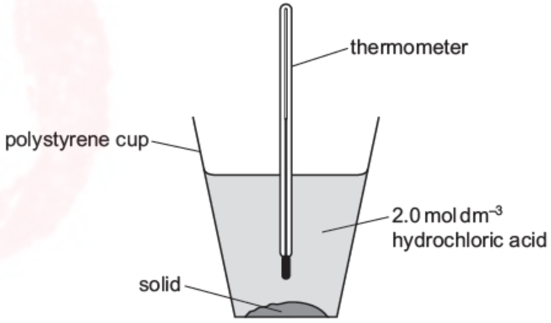
.... [2]

Q. Type: **Error Topic: Chem 27 Q# 86/** ALvl Chemistry/2021/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 Potassium hydrogencarbonate, $KHCO_3$, decomposes when strongly heated to form potassium carbonate, K_2CO_3.

$$2KHCO_3(s) \rightarrow K_2CO_3(s) + CO_2(g) + H_2O(l)$$

A student plans to determine the value for the enthalpy change for this reaction, ΔH_r, which cannot be determined directly. The student carries out two separate experiments using the following apparatus.



Experiment 1 uses solid $KHCO_3$.

Experiment 2 uses solid K_2CO_3.

The following method is used for both experiments:

- Transfer 50.00 cm³, an excess, of 2 mol dm⁻³ hydrochloric acid into a cup.
- After 2 minutes, record the temperature of the acid.
- Weigh approximately 0.0250 moles of solid.
- Add the solid to the acid, stir the mixture using a thermometer and record the temperature throughout the reaction.

Hazard information: 2 mol dm⁻³ hydrochloric acid is irritant, solid potassium hydrogencarbonate and solid potassium carbonate may cause irritation to the skin and eyes.

The equations for the two reactions are:

reaction 1 $KHCO_3(s) + HCl(aq) \rightarrow KCl(aq) + CO_2(g) + H_2O(l)$

reaction 2 $K_2CO_3(s) + 2HCl(aq) \rightarrow 2KCl(aq) + CO_2(g) + H_2O(l)$

(b) **(i)** Calculate the mass of 0.0250 moles of each solid. Give your answers to **three** decimal places.

[A_r: K, 39.1; H, 1.0; C, 12.0; O, 16.0]

mass of $KHCO_3$ = ... g

mass of K_2CO_3 = ... g
[1]

(ii) The masses of solid are measured using a three decimal place balance.

Calculate the percentage error in the measurement of the mass of $KHCO_3$.

Show your working.

percentage error = ... [1]

(e) A textbook states the value of the enthalpy change for the decomposition of potassium hydrogencarbonate as +76.0 kJ mol^{-1}.

Suggest **two** reasons why the experimental value is different to the actual value.

1 ....

2 ....
[2]

(f) Suggest **one** improvement to the apparatus which would reduce the difference between the experimental value and the actual value.

.... [1]

(g) Name a suitable piece of apparatus which should be used to measure the volume of acid used in **experiment 1**.

.... [1]

Q. Type: **Error Topic: Chem 27 Q# 87/** ALvl Chemistry/2013/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 The solubility of hydrated sodium sulfate, $Na_2SO_4.10H_2O$, in water increases with temperature. At a temperature between 25 °C and 70 °C there is a transition and the solubility becomes that of Na_2SO_4. The units of solubility are grams per one hundred grams of water, g / 100 g water.

An experiment was carried out to investigate this solubility and determine the transition temperature between the two forms of sodium sulfate.

- An empty boiling tube was weighed and the mass recorded.
- Some distilled water was added to the boiling tube and the new mass recorded.
- A small sample of hydrated sodium sulfate was added and this new mass recorded.
- The boiling tube was carefully heated with stirring until all the solid had dissolved.
- The apparatus was cooled slowly while constantly stirring and the temperature recorded when the first crystals appeared in the tube.

(a) The results of several of these experiments are recorded below.

Process the results in the table to calculate the solubility, in g / 100 g water, of the sodium sulfate for each of the temperatures listed.

Record these values to **two decimal places** in the additional columns of the table. You may use some or all of the columns.

Label the columns you use.

For each column you use include units where appropriate and an expression to show how your values are calculated.

Use the column headings **A** to **H** for these expressions (e.g. **A**–**B**).

A	B	C	D	E	F	G	H
experiment number	mass of boiling tube /g	mass of boiling tube + water /g	mass of boiling tube + water + solid /g	crystallising temperature °C			
1	10.20	35.20	36.45	0.0			
2	10.35	30.35	31.60	10.0			
3	10.10	35.10	40.10	20.0			
4	9.80	29.20	36.96	30.0			
5	9.95	32.95	44.06	40.0			
6	9.90	34.90	46.65	50.0			
7	9.70	30.70	40.32	60.0			
8	10.45	30.45	39.55	70.0			
9	10.05	35.05	46.30	80.0			
10	10.10	40.10	53.45	90.0			

[3]

(e) It was found that all the mass recordings in columns **C** and **D** had been made with a balance that had been zeroed incorrectly and they should all have been 0.3 g smaller. The masses recorded in column **B** can be considered to be accurate. Using the corrected masses from experiment 6 calculate the new value of the solubility. By comparing this with the original solubility value for experiment 6 calculate the percentage error difference.

[2]

Q. Type: Naming Apparatus Topic: Chem 2 Q# 88/ ALvl Chemistry/2022/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1 A student has a sample of copper(II) sulfate crystals, $CuSO_4 \cdot xH_2O$. The student wants to show that the value of *x* is 5.

The student uses the following method.

step 1 Weigh a clean crucible on a balance reading to two decimal places. Record the mass.

step 2 Place the sample of $CuSO_4 \cdot xH_2O$ into the crucible. Record the mass.

step 3 Heat the crucible gently for about 1 minute then strongly for about 4 minutes.

step 4 Weigh the crucible and contents. Record the mass.

(a) Identify the instruction that is missing between **step 3** and **step 4**.

.... [1]

(b) Explain why gentle heating takes place in **step 3**.

.... [1]

(c) Name the apparatus that should be used to hold the crucible during heating.

.... [1]

(d) The method is incomplete.

State the step(s) that should be carried out to complete the method.

....

....

.... [1]

Q. Type: **Naming Apparatus Topic: Chem 6 Q# 89/** ALvl Chemistry/2021/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2 Ethanedioic acid is a white crystalline solid.

If excess aqueous potassium hydroxide, KOH(aq), is added to dilute ethanedioic acid, $H_2C_2O_4$(aq), full neutralisation occurs and potassium ethanedioate, $K_2C_2O_4$(aq), forms.

$$H_2C_2O_4(aq) + 2KOH(aq) \rightarrow K_2C_2O_4(aq) + 2H_2O(l)$$

If a small amount of potassium hydroxide is added, **partial** neutralisation takes place and not all H^+ ions in the acid are replaced by K^+ ions.

Instead an acid salt forms, which crystallises to form a solid with the formula $K_aH_b(C_2O_4)_c{\bullet}dH_2O$.

The letters *a*, *b* and *c* represent a ratio of the numbers of species present in the compound and may not necessarily be whole numbers. The relative number of water molecules associated with one formula of the compound is represented by *d*.

A student attempted to determine the values of *a*, *b*, *c* and *d* in a sample of an acid salt, $K_aH_b(C_2O_4)_c{\bullet}dH_2O$.

(b) Determining the number of moles of $C_2O_4^{2-}$ present

Ethanedioate ions, $C_2O_4^{2-}$(aq), react with manganate(VII) ions, MnO_4^-(aq), in acidified conditions, as shown.

$$5C_2O_4^{2-}(aq) + 16H^+(aq) + 2MnO_4^-(aq) \rightarrow 2Mn^{2+}(aq) + 8H_2O(l) + 10CO_2(g)$$

MnO_4^-(aq) ions are a very deep purple in colour. All other species appear colourless.

The reaction takes place above a temperature of 70 °C.

The student carries out a redox titration using the following steps.

step 1 The student rinses and fills a burette with 0.0200 mol dm^{-3} MnO_4^-(aq).

step 2 The student uses a pipette to transfer 25.0 cm^3 of solution **A** into a conical flask.

step 3 The student adds 20 cm^3, an excess, of 0.5 mol dm^{-3} H_2SO_4(aq) to the conical flask.

step 4 The conical flask is heated until a temperature of about 80 °C is reached.

step 5 The student adds MnO_4^-(aq) from the burette until an end-point is reached.

The student repeats the titration until concordant readings are achieved.

	rough	titration 1	titration 2	titration 3
final burette reading / cm^3	25.05	24.50	26.60	24.50
initial burette reading / cm^3	0.10	0.10	0.10	0.10
titre / cm^3	25.05	24.40	26.50	24.40

The student determines the average titre to be 24.40 cm^3.

(i) When emptying the pipette in **step 2**, the student touches the surface of the solution in the flask with the tip of the pipette.

Suggest why the student does this.

....

.... [1]

(ii) Suggest the most appropriate piece of apparatus to measure H_2SO_4(aq) in **step 3**.

.... [1]

(iii) Suggest why the student starts each titration with an initial burette reading of 0.10 cm^3 rather than the usual 0.00 cm^3.

.... [1]

(iv) What is meant by the term *concordant readings*?

.... [1]

(v) State the change of colour seen in the mixture in the conical flask at the end-point.

from .... to .... [1]

Q. Type: **Naming Apparatus Topic: Chem 6 Q# 90/** ALvl Chemistry/2020/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 Aqueous potassium manganate(VII) can be used to determine the amount of iron present in a sample of iron wire by redox titration. Before potassium manganate(VII) can be used, its concentration must be determined using aqueous sodium ethanedioate made from the hydrated solid $Na_2C_2O_4$•$2H_2O$.

(c) In another experiment, a student uses 0.0200 mol dm^{-3} MnO_4^-(aq) to analyse the percentage of iron in a sample of iron wire using the following method.

step 1 The mass of the iron wire is recorded.

step 2 The iron wire is dissolved in 20 cm^3, an excess, of sulfuric acid and made up to a volume of 250.0 cm^3 with distilled water. The iron reacts and dissolves in sulfuric acid to form Fe^{2+}(aq) ions.

step 3 A 25.0 cm^3 sample of this Fe^{2+} containing solution is titrated with 0.0200 mol dm^{-3} MnO_4^-(aq).

The ionic equation for the reaction between MnO_4^-(aq) and Fe^{2+}(aq) is shown.

$$MnO_4^-(aq) + 8H^+(aq) + 5Fe^{2+}(aq) \rightarrow Mn^{2+}(aq) + 5Fe^{3+}(aq) + 4H_2O(l)$$

The student's results are shown in the table.

[A_r: Fe, 55.8]

(v) In **step 2**, the sulfuric acid is used to dissolve the iron in the iron wire.

Suggest the other function of the sulfuric acid in this experiment.

....

.... [1]

(d) Name an appropriate piece of apparatus to measure the volume of sulfuric acid in **step 2**. Give a reason for your answer.

....

.... [1]

Q. Type: **Naming Apparatus Topic: Chem 7 Q# 91/** ALvl Chemistry/2020/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 Nitrogen dioxide can be prepared by strongly heating anhydrous lead nitrate, $Pb(NO_3)_2(s)$. The thermal decomposition occurs according to the equation shown.

$$2Pb(NO_3)_2(s) \rightarrow 2PbO(s) + 4NO_2(g) + O_2(g)$$

The nitrogen dioxide, NO_2, can be separated from the oxygen by cooling the gas mixture produced until the NO_2 condenses and the oxygen does not.

	melting point / K	boiling point / K
nitrogen dioxide	262	294
oxygen	54	90

A student plans to investigate the variation of K_p with temperature.

(c) (i) A sample of the mixture of nitrogen oxides is introduced into a gas syringe at 295 K and the gas syringe is sealed so that it is both airtight and watertight. The volume occupied by the mixture is measured at different temperatures. The K_p value is calculated at each temperature.

Name the apparatus you would use to heat the gas syringe at different temperatures between 295 K and 370 K so that a volume reading of the gas syringe could be easily taken.

.... [1]

Q. Type: **Naming Apparatus Topic: Chem 11 Q# 92/** ALvl Chemistry/2022/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 A student plans an investigation to find the molar ratio of the reaction between sodium chloride, Na*Cl*, and a lead compound.

The student is provided with solid Na*Cl* and 0.200 mol dm^{-3} aqueous lead compound.

The reaction between Na*Cl*(aq) and the aqueous lead compound produces an insoluble compound as a precipitate.

(b) The student weighs the mass of Na*Cl*(s) calculated in **(a)** in a weighing boat. The solid mass is then transferred into a small beaker.

Describe how the student should accurately weigh by difference so the exact mass of Na*Cl* transferred into the small beaker is known.

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Q. Type: **Naming Apparatus Topic: Chem 24 Q# 93/** ALvl Chemistry/2019/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 Yttrium barium copper oxide, $YBa_2Cu_3O_7$, is a crystalline compound.

You are to design an experiment in which $YBa_2Cu_3O_7$ is first synthesised and then analysed by titration.

(a) $YBa_2Cu_3O_7$ can be synthesised by reacting Y_2O_3, $BaCO_3$ and CuO using the following method.

- Place solid Y_2O_3, $BaCO_3$ and CuO together in a mortar and grind the mixture well with a pestle.
- Transfer the mixture to a porcelain crucible and place this in an oven set at 920 °C.
- Heat the mixture for 12 hours, then allow the crucible and its contents to cool slowly in the oven to below 100 °C before removing it.

The equation for the reaction is given.

$$Y_2O_3 + 4BaCO_3 + 6CuO + \tfrac{1}{2}O_2 \rightarrow 2YBa_2Cu_3O_7 + 4CO_2$$

(ii) State what should be done once the solid product has cooled to ensure that the highest possible yield of $YBa_2Cu_3O_7$ has been produced.

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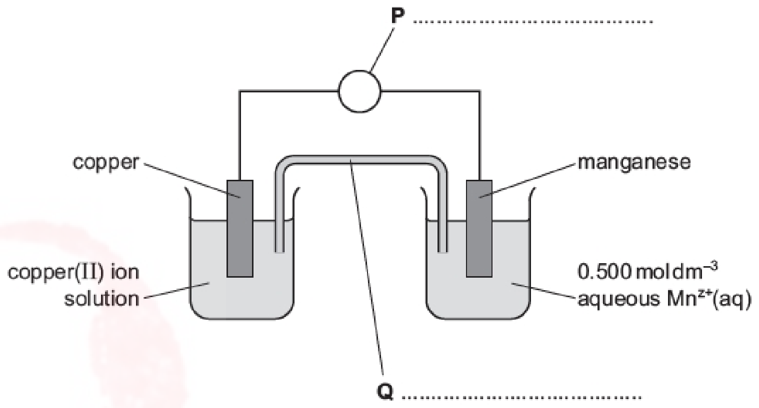
Q. Type: **Naming Apparatus Topic: Chem 24 Q# 94/** ALvl Chemistry/2019/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 A student investigates the charge (z+) carried by aqueous manganese ions, $Mn^{z+}(aq)$. The electrochemical cell shown is set up for this investigation with the following two half-cells:

- a standard copper(II) ion / copper half-cell ($E^\circ = +0.340\,V$)
- a half-cell made from manganese and $0.500\,mol\,dm^{-3}$ $Mn^{z+}(aq)$.

(a) Label the items **P** and **Q** and state the concentration of the copper(II) ion solution in the copper half-cell.



concentration of the copper(II) ion solution in the copper half-cell = ... [1]

(g) Lowering $[Mn^{z+}]$ causes the value of the electrode potential of the manganese half-cell to become more negative.

Suggest why this happens.

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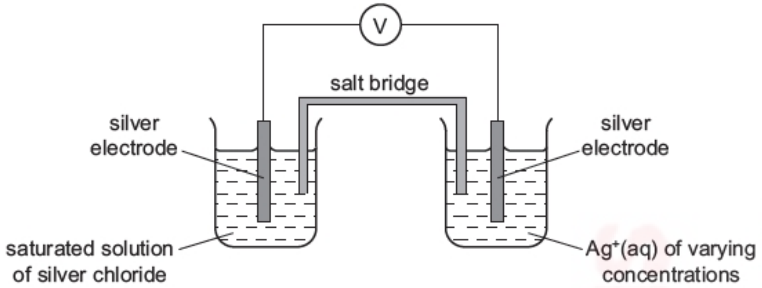
.... [1]

[Total: 16]

Q. Type: **Naming Apparatus Topic: Chem 24 Q# 95/** ALvl Chemistry/2018/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 The solubility product, K_{sp}, of a sparingly soluble salt can be determined by measuring the cell potential of a cell known as a *concentration cell*. One of the half-cells uses a saturated solution of the salt as the electrolyte.

The K_{sp} of silver chloride, AgC*l*, can be measured using the apparatus shown.



The silver electrodes of the two half-cells were connected via a voltmeter, reading to three decimal places. This measured the cell potential of the concentration cell.

The half-cells were kept at a temperature of 40 °C. Under these conditions, the relationship between cell potential, E_{cell}, and $[Ag^+(aq)]$ is

$$16.1E_{cell} = \log C_{sat} - \log [Ag^+(aq)]$$

C_{sat} is the concentration of the saturated solution of silver chloride

(a) **(i)** The solutions in the half-cells need to be kept at 40 °C.

Explain how you would do this.

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.... [1]

(ii) If the temperature was maintained at 40 °C, over time the reading on the voltmeter would change.

Suggest **one** reason why.

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.... [1]

(d) To carry out these experiments, $Ag^+(aq)$ of concentration 2.0 mol dm^{-3} was prepared.

(ii) Name a suitable piece of apparatus which could be used to measure the volume calculated in **(i)**.

....[1]

(f) The salt bridge in a concentration cell commonly contains a solution of one of the following compounds.

potassium chloride potassium nitrate sodium chloride

Identify which, if any, of these compounds would **not** be suitable for use in the salt bridge in this experiment.

Explain your answer.

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.... [2]

[Total: 16]

Q. Type: **Naming Apparatus Topic: Chem 26 Q# 96/** ALvl Chemistry/2022/w/TZ 1/ Paper 5/Q# 3/Smashing!!!

3 Potassium bromate(V) reacts with potassium bromide and sulfuric acid to form potassium sulfate, bromine and water according to the following equation.

$$KBrO_3(aq) + 5KBr(aq) + 3H_2SO_4(aq) \rightarrow 3K_2SO_4(aq) + 3Br_2(aq) + 3H_2O(l)$$

A student is investigating how the rate of this reaction is affected by changing the concentration of the reactants in turn. This is done by keeping the total volume of mixture constant and adding different, small volumes of each reagent.

The reaction produces bromine which is orange in colour. The student times the reaction and then determines the rate as $\frac{1}{\text{time}}$.

The rate equation for the reaction is of the form:

$$\text{rate} = k[KBrO_3]^x[KBr]^y[H_2SO_4]^z$$

k is the rate constant for the reaction and *x*, *y* and *z* are the respective orders of the reaction for each reagent.

The student carried out the experiment and obtained the following data.

Table 3.1

mixture	$[KBrO_3]$ / mol dm^{-3}	[KBr] / mol dm^{-3}	$[H_2SO_4]$ / mol dm^{-3}	rate of reaction / s^{-1}
A	0.025	0.125	0.075	0.059
B	0.050	0.125	0.075	0.117
C	0.025	0.250	0.075	0.118
D	0.025	0.125	0.150	0.235
E	0.050	0.250	0.150	0.941

(a) (i) Suggest how the student might time the reaction and judge the end point of the reaction for each mixture.

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.... [1]

(b) The student carried out each reaction using a boiling tube (capacity 50 cm^3) and varied the concentration by adding different volumes of each reagent. For example, in mixture A, 5.0 cm^3 of $KBrO_3(aq)$ is required.

Name a suitable piece of apparatus which could be used to measure this volume.

.... [1]

(c) Suggest why the reagents are heated to the same temperature before mixing.

.... [1]

(d) The solution of sulfuric acid used in each mixture was of concentration 0.150 mol dm^{-3}. This acid was prepared from a solution of concentration 1 mol dm^{-3}.

Briefly describe how to make the more dilute solution, stating the capacity of any apparatus used.

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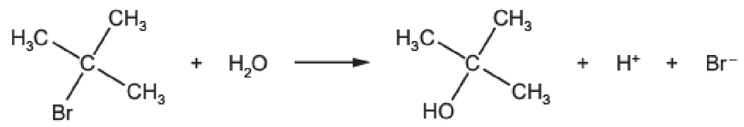
.... [2]

[Total: 7]

Q. Type: **Naming Apparatus Topic: Chem 26 Q# 97/** ALvl Chemistry/2022/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 A student plans to study the rate of hydrolysis of 2-bromo-2-methylpropane.



As the concentration of 2-bromo-2-methylpropane decreases during the reaction, the concentration of hydrogen ions increases.

The student plans the following method.

Step 1 Place 100 cm^3 of a mixture of propanone and water into a conical flask.

Step 2 Heat the mixture to 35 °C and maintain this temperature.

Step 3 Add 1.00 cm^3 of 2-bromo-2-methylpropane to the mixture and start timing.

Step 4 After 1 minute, transfer a 10.00 cm^3 sample of the reaction mixture into a conical flask containing ice and 4 drops of methyl orange indicator.

Step 5 Immediately titrate the 10.00 cm^3 of the reaction mixture with 0.0200 mol dm^{-3} sodium hydroxide.

Step 6 Repeat sampling and titrating at regular time intervals over a total time of 45 minutes.

Step 7 Heat the reaction mixture to 50 °C, remove the final sample, and titrate this.

(a) **(i)** State the apparatus you would use to maintain the temperature of the reaction mixture.

.... [1]

(ii) Suggest why the experiment is carried out away from naked flames.

....

.... [1]

(b) State the pieces of equipment and their capacities that you would use to:

(i) measure 1.00 cm^3 of 2-bromo-2-methylpropane in step 3

.... [1]

(ii) transfer a 10.00 cm^3 sample of the mixture in step 4.

.... [1]

(c) Explain why the reaction mixture is transferred into a conical flask containing ice.

....

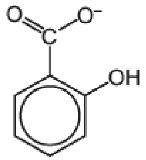
.... [1]

Q. Type: **Naming Apparatus Topic: Chem 28 Q# 98/** ALvl Chemistry/2017/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2 Transition metal complex ions are coloured. The formula of a complex ion can be determined using colorimetry.

In colorimetry, light of a certain wavelength is passed through a complex ion solution. The absorbance of the light is proportional to the intensity of the colour of the solution. The more concentrated the complex ion solution, the more intense its colour and so the higher the absorbance.

A student carried out an experiment to determine the formula of the complex ion formed between aqueous iron(III) ions, Fe^{3+}(aq), and aqueous 2-hydroxybenzoate ions, $C_6H_4(OH)CO_2^-$, which have the structure shown.



(a) In the first step of the experiment the student prepared 100.0 cm^3 of 0.0500 mol dm^{-3} aqueous iron(III) nitrate.

(ii) Describe how, after weighing the mass determined in **(i)**, the student should prepare 100.0 cm^3 of 0.0500 mol dm^{-3} aqueous iron(III) nitrate.

In your answer you must give the name and capacity, in cm^3, of any apparatus used.

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.... [2]

(b) The student prepared solutions containing various combinations of 0.0500 mol dm^{-3} Fe^{3+}(aq) and 0.0500 mol dm^{-3} aqueous 2-hydroxybenzoate, as shown in the table.

The student placed a small sample of each solution into a colorimeter and measured the absorbance. The student made a mistake in test number **9** and did **not** measure the result.

test number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
volume of Fe^{3+}(aq) / cm^3	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0		9.0	10.0
volume of aqueous 2-hydroxybenzoate / cm^3	10.0	9.0	8.0	7.0	6.0	5.0	4.0	3.0		1.0	0.0
absorbance	0	23	46	69	70	58	47	35		13	0

(v) Name the apparatus that should be used to measure the volumes of the solutions given in the table accurately.

.... [1]

Q. Type: Hazards and Safety Topic: Chem 4 Q# 99/ ALvl Chemistry/2022/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 Charles' law states that for a fixed mass of gas at constant pressure, its volume is proportional to its absolute temperature. Most gases are non-ideal and do not obey this law, but at lower pressures and high temperatures some gases are close to ideal behaviour. One gas that behaves like this is oxygen.

Oxygen can be prepared by decomposing hydrogen peroxide with the catalyst manganese(IV) oxide, MnO_2.

The equation for the decomposition of hydrogen peroxide is shown.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

Safety hazard: hydrogen peroxide is corrosive to skin and can cause serious eye damage.

(a) Other than the wearing of safety goggles, give a safety precaution that the student must take during the preparation of oxygen.

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.... [1]

Q. Type: **Hazards and Safety Topic: Chem 4 Q# 100/** ALvl Chemistry/2015/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 It is possible to determine the relative molecular mass, M_r, of a small sample of a volatile liquid by measuring its mass and then heating to vaporise it to obtain its volume as a gas.

(d) Suggest **one** hazard associated with the use of hexane.

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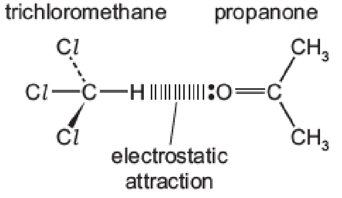
.... [1]

Q. Type: **Hazards and Safety Topic: Chem 5 Q# 101/** ALvl Chemistry/2020/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 Trichloromethane and propanone are both organic liquids. The molecules within each liquid are attracted to each other by relatively weak permanent dipole-dipole interactions.

When trichloromethane is mixed with propanone a strong electrostatic attraction forms between the two different molecules.



A student plans to perform an experiment to investigate the strength of this electrostatic attraction by finding the temperature change when equal volumes of trichloromethane and propanone are mixed together.

(c) Trichloromethane and propanone are both volatile and flammable.

State **one** relevant precaution that should be taken when carrying out this experiment.

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.... [1]

Q. Type: **Hazards and Safety Topic: Chem 5 Q# 102/** ALvl Chemistry/2010/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 The neutralisation of an acid by a base is exothermic.

In this experiment the following solutions are available.

2 mol dm^{-3} sulfuric acid, H_2SO_4
3 mol dm^{-3} sodium hydroxide, NaOH

The equation for the reaction is:

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

(a) 2 mol dm^{-3} H_2SO_4 is gradually added to a fixed volume of 3 mol dm^{-3} NaOH in a 150 cm^3 plastic cup, while stirring continuously. The temperature of the solution, measured with a thermometer, increases until the alkali is just neutralised. On further addition of the cold acid the temperature of the solution slowly falls.

(e) Identify and assess

(i) a risk associated with the plastic cup used in this experiment,

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(ii) a risk associated with the 3 mol dm^{-3} NaOH.

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.... [1]

(f) Describe how the risks in **(e)** can be kept to a minimum for

(i) the plastic cup,

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(ii) the 3 mol dm^{-3} NaOH.

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.... [1]

Q. Type: **Hazards and Safety Topic: Chem 6 Q# 103/** ALvl Chemistry/2012/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 There are three oxides of lead, PbO, PbO_2 and Pb_3O_4, all of which can be reduced to metallic lead by hydrogen.

The following information gives some of the hazards associated with these compounds.

Lead oxides
Lead(II) oxide (PbO) **Lead(IV) oxide** (PbO_2) **Dilead(II) lead(IV) oxide** (Pb_3O_4)
Toxic Dangerous for the environment
Harmful by inhalation and if swallowed. Danger of cumulative effects.

Hydrogen Extremely flammable. Readily forms an explosive mixture with air. Mixtures between 4 and 74 % by volume are explosive.

An unknown sample of an oxide of lead can be identified by investigating the molar ratio of oxygen atoms to lead atoms.

You are to plan an experiment to investigate the molar ratio of oxygen atoms to lead atoms in the oxide sample. Your plan should result in a correct identification of the oxide.

(d) Draw a diagram of the apparatus and experimental set up you would use to determine the chemical formula of the oxide. Your apparatus should use only standard items found in a school or college laboratory and should show clearly

(i) how the hydrogen gas needed for the reduction is prepared, naming the chemicals (reagents) to be used,

(ii) how the oxide of lead will be heated,

(iii) how any excess hydrogen is dealt with safely.

Label each piece of apparatus used.

[3]

(f) State one hazard that must be considered when planning the experiment and describe a precaution that should be taken to minimise the risk from this hazard.

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.... [1]

Q. Type: **Hazards and Safety Topic: Chem 6 Q# 104/** ALvl Chemistry/2006/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 ASSESSMENT OF PLANNING SKILLS

Copper has two oxides, CuO and Cu_2O.
Each oxide can be reduced to copper metal by heating it in a stream of hydrogen gas.
The oxide turns to copper metal powder in an exothermic reaction in which the powder may be seen to glow red hot.

$$CuO(s) + H_2(g) \rightarrow Cu(s) + H_2O(g)$$

$$Cu_2O(s) + H_2(g) \rightarrow 2Cu(s) + H_2O(g)$$

(a) Draw a diagram to show the assembled apparatus you could use in a school laboratory to carry out the reduction of one of the oxides. The apparatus should enable you to:

(i) weigh the oxide before heating and the metallic copper after heating,

(ii) condense, collect and weigh the steam/water produced,

(iii) burn any excess hydrogen after it has passed through the apparatus.

You may assume that a supply of hydrogen gas is available – you do not have to prepare the gas. You need not draw a balance.

[3]

(b) At the start of the experiment the apparatus is full of air. Hydrogen and air mixtures are explosive.

What precaution could you take to prevent explosion when igniting the excess hydrogen leaving the apparatus?

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.... [1]

Q. Type: **Hazards and Safety Topic: Chem 7 Q# 105/** ALvl Chemistry/2015/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 At high temperatures a mixture of iodine and hydrogen gases reacts to form an equilibrium with gaseous hydrogen iodide.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

(b) The expression for the equilibrium constant from **(a)(ii)** can be re-written as shown below.

$$y = \frac{\mathbf{a}\sqrt{K_c}}{2 + \sqrt{K_c}}$$

In an experiment, air was removed from a 1 dm³ flask and amounts of hydrogen and iodine gases were mixed together such that their initial concentrations were both **a** mol dm^{-3}. This mixture was allowed to come to equilibrium at 760 K in the flask. The equilibrium concentration of iodine, (**a** – **y**) mol dm^{-3}, was then measured.

The experiment was repeated for various initial concentrations, **a** mol dm^{-3}, and the results were recorded in the table below.

(d) Explain why, for safety reasons, it is necessary to remove air from the 1 dm³ flask.

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.... [1]

Q. Type: **Hazards and Safety Topic: Chem 8 Q# 106/** ALvl Chemistry/2021/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 Hydrogen peroxide decomposes slowly at room temperature to give water and oxygen.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

The **initial** rate of this reaction can be increased by the addition of a metal oxide catalyst.

A student is asked to investigate which metal oxide catalyst is best at increasing the **initial** rate of this reaction by using a method which involves the collection of oxygen.

The student is provided with the following metal oxides: copper(II) oxide, iron(III) oxide, manganese(IV) oxide, nickel(II) oxide and titanium(IV) oxide.

The student is also provided with an excess volume, of a known concentration, of aqueous hydrogen peroxide and any laboratory equipment needed.

(h) When aqueous hydrogen peroxide is stored there is a small hole in the lid of the bottle.

Suggest why this is necessary.

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.... [1]

Q. Type: **Hazards and Safety Topic: Chem 8 Q# 107/** ALvl Chemistry/2017/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 Iodide ions, I⁻, and persulfate ions, $S_2O_8^{2-}$, react according to the following equation.

$$2I^-(aq) + S_2O_8^{2-}(aq) \rightarrow I_2(aq) + 2SO_4^{2-}(aq)$$

The rate of reaction between these ions can be determined from the time it takes for a certain amount of iodine, I_2(aq), to be produced.

(e) The following information gives some of the hazards associated with the chemicals used in the procedure.

Ammonium persulfate	Solid is **oxidising** and **hazardous to the environment**. Contact with combustible material may cause fire. It is classified as **health hazard**, is harmful if swallowed and is irritating to eyes, respiratory system and skin. Solutions equal to or more concentrated than 0.2 mol dm^{-3} should be labelled **health hazard** and **hazardous to the environment**. Solutions equal to or more concentrated than 0.05 mol dm^{-3} but less concentrated than 0.2 mol dm^{-3} should be labelled **health hazard**.
Potassium iodide	All solutions are low hazard.
Sodium thiosulfate	All solutions are low hazard.

Describe **one** relevant precaution, other than eye protection and a lab coat, that should be taken to keep the risk associated with the chemicals used to a minimum. Explain your answer.

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.... [1]

Q. Type: **Hazards and Safety Topic: Chem 9 Q# 108/** ALvl Chemistry/2016/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 Lithium is a soft alkali metal which may be cut with a knife. It is usually stored under oil because it reacts rapidly with moisture and oxygen in the air.

Lithium is **corrosive** and may cause burns.

Lithium is **highly flammable** and in large amounts reacts violently with water.

$$2Li(s) + 2H_2O(l) \rightarrow 2LiOH(aq) + H_2(g)$$

This reaction can be used to determine the relative atomic mass of lithium by measuring the volume of hydrogen produced from a small amount of lithium.

(b) To successfully carry out this experiment a correct procedure must be followed. The lithium you will use is stored as large pieces under oil.

(iii) Other than eye protection, state two precautions you would take to make sure that the experiment proceeds safely.

1. ....

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2. ....

.... [2]

Q. Type: **Hazards and Safety Topic: Chem 10 Q# 109/** ALvl Chemistry/2016/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 When hydrated barium chloride, $BaCl_2.xH_2O$, dissolves in water, $Ba^{2+}(aq)$ and $Cl^-(aq)$ ions are formed.

The concentration of chloride ions in solution can be determined by titration with aqueous silver nitrate of known concentration.

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

The indicator for the reaction is aqueous potassium chromate(VI), $K_2CrO_4(aq)$. At the endpoint of the titration, it forms a red precipitate in the presence of excess silver ions.

(a) The solubilities, in g dm^{-3}, of different ionic compounds at 20 °C are given in the table below.

	anion		
cation	Cl^-	CrO_4^{2-}	SO_4^{2-}
Ag^+	0.0019	0.022	293
Ba^{2+}	358	0.0028	0.00245

With reference to these data, where relevant, answer the following questions.

(d) The following information gives some of the hazards associated with the chemicals used in the procedure.

Barium chloride	Solid barium chloride is classified as **toxic**. Solutions equal to or more concentrated than 0.4 mol dm^{-3} are classified as **moderate hazard** and are harmful if swallowed. Solutions less concentrated than 0.4 mol dm^{-3} are classified as non-hazardous.
Potassium chromate(VI)	All solutions more concentrated than 0.9 mol dm^{-3} are classified as **health hazard**. They may cause skin, eye and respiratory irritation.
Silver nitrate	Solutions equal to or more concentrated than 0.18 mol dm^{-3} are classified as **corrosive**. Solutions equal to or more concentrated than 0.06 mol dm^{-3} but less than 0.18 mol dm^{-3} are classified as **moderate hazard** and cause skin and eye irritation. Solutions less concentrated than 0.06 mol dm^{-3} are classified as non-hazardous.

Identify **one** hazard that must be considered when planning the experiment and describe a precaution, other than eye protection, that should be taken to keep risks from this hazard to a minimum.

hazard: ....

precaution: ....

.... [1]

Q. Type: **Hazards and Safety Topic: Chem 11 Q# 110/** ALvl Chemistry/2013/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 Chlorine gas, Cl_2, is slightly soluble in water, approximately 5 g dm^{-3} at 25 °C. The molar enthalpy of solution of a gas is defined as the enthalpy change when one mole of the gas is dissolved in water.

(c) You are to plan an experiment to determine as accurately as possible the concentration of a saturated aqueous solution of chlorine by titration. You are reminded that the approximate solubility of chlorine is 5 g dm^{-3} at 25 °C.

The following information gives some of the hazards associated with chlorine, iodine and sodium thiosulfate.

Saturated **chlorine water** is **low hazard** but chlorine gas escapes, which is **harmful**.
Iodine is **harmful** by inhalation and in contact with skin or eyes. Solutions more concentrated than or equal to 1 mol dm^{-3} are **harmful**.
Sodium thiosulfate is **non-hazardous**.

(d) State one hazard that must be considered when planning the experiment and describe a precaution that should be taken to keep risks from this hazard to a minimum. You should use the information in **(c)**.

....

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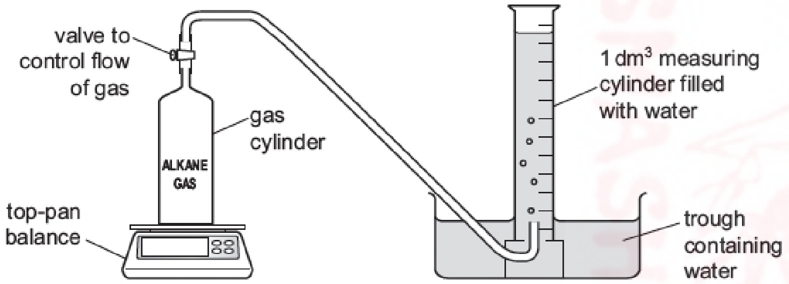
.... [2]

Q. Type: **Hazards and Safety Topic: Chem 14 Q# 111/** ALvl Chemistry/2020/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 A student uses the apparatus shown to calculate the relative molecular mass, M_r, of a gaseous alkane. The experiment took place at 298 K and 101 kPa.



The alkane is flammable.

The student opens the tap and allows a small amount of the alkane gas into the measuring cylinder, displacing water. The gas in the measuring cylinder is allowed to reach room temperature and the volume recorded. This process is repeated and the measurements of mass of gas cylinder and total volume of gas collected are recorded in the table.

(ii) Apart from wearing eye protection or a lab coat, state **one** safety precaution which the student must take when carrying out this experiment.

.... [1]

Q. Type: **Hazards and Safety Topic: Chem 21 Q# 112/** ALvl Chemistry/2019/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 A student plans to prepare propanone from propan-2-ol and test the product. Reagents provided to the student and some of their hazards are shown in the table.

reagent	hazard
propan-2-ol	flammable
concentrated sulfuric acid	corrosive
potassium dichromate(VI)	oxidising
distilled water	non-hazardous

(iii) The reaction mixture needs heating for reflux to take place.

Explain why a water-bath is used to heat the mixture.

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.... [1]

Q. Type: **Hazards and Safety Topic: Chem 23 Q# 113/** ALvl Chemistry/2008/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 The **solubility** of cerium(IV) sulphate, at a particular temperature, is defined as:

the mass of cerium(IV) sulphate that will dissolve in and just ***saturate*** *100 g of solvent at that temperature.*

> Cerium(IV) sulphate will dissolve in water.
>
> A **saturated** solution is one in which no more solid can dissolve at a particular temperature.
> In a saturated solution in contact with undissolved solid, the following equilibrium is established.
>
> $$Ce(SO_4)_2(s) + aq \rightleftharpoons Ce^{4+}(aq) + 2SO_4^{2-}(aq)$$
>
> Cerium(IV) sulphate is unusual. Its solubility **decreases** as the temperature of the solution increases.

Cerium(IV) sulphate crystals also dissolve in dilute sulphuric acid, H_2SO_4, a corrosive aqueous solution.

> You are to plan an experiment to investigate how the **solubility** of cerium(IV) sulphate crystals in dilute sulphuric acid depends on the concentration of the acid.

(d) State a risk that must be taken into consideration when planning the experiment.

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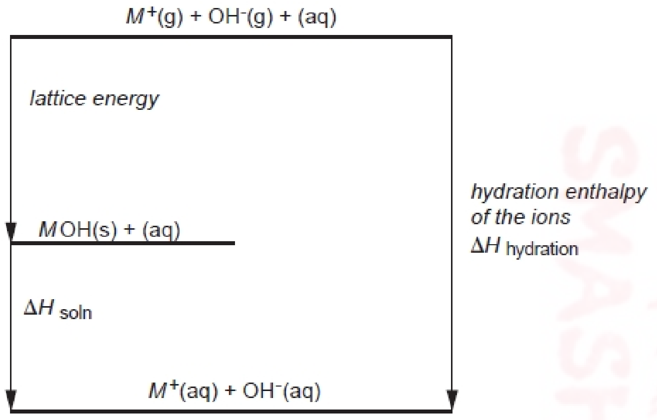
.... [1]

Q. Type: **Hazards and Safety Topic: Chem 23 Q# 114/** ALvl Chemistry/2007/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 The hydroxides of Group I metals (LiOH, NaOH, KOH, RbOH, CsOH) are highly corrosive white solids which rapidly absorb water vapour on exposure to the atmosphere.
All of these solids dissolve exothermically in water.
The enthalpy change of solution, ΔH_{soln}, is the energy change associated with the following reaction. *M* represents the Group I metal.

$$MOH(s) + (aq) \longrightarrow M^+(aq) + OH^-(aq)$$

The following diagram represents theoretical stages in the formation of aqueous *M*OH.



Lattice energy and hydration enthalpy are both more exothermic when ions carry a higher charge and/or ions have a smaller radius.

When comparing Group I hydroxides, changes in $\Delta H_{hydration}$ are more significant than changes in lattice energy.

(d) Identify a health and safety risk in the experiment and explain how you would minimise it when carrying out the experiment.

....

....

.... [2]

Q. Type: **Hazards and Safety Topic: Chem 24 Q# 115/** ALvl Chemistry/2018/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 The Faraday constant is the charge in coulombs, C, carried by 1 mole of electrons.

(a) A student plans an electrolysis experiment to determine the Faraday constant.

The student was supplied with the following.

- 1.0 mol dm^{-3} copper(II) sulfate
- clean, dry copper foil electrodes, labelled 'anode' and 'cathode'
- balance
- stop-clock
- ammeter
- other equipment suitable for carrying out electrolysis

(b) Two of the hazards of using copper(II) sulfate solution are given below.

For each hazard, state a precaution, other than eye protection and a lab coat, that the student should take when carrying out the experiment.

hazard: copper(II) sulfate solution causes skin irritation

precaution ....

....

hazard: copper(II) sulfate solution is toxic to aquatic life

precaution ....

....

[2]

Q. Type: **Hazards and Safety Topic: Chem 25 Q# 116/** ALvl Chemistry/2022/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2 The conductivity of an ionic solution can be determined by passing an electric current through the solution and measuring the conductivity using a conductivity meter.

(a) A student carries out an experiment to measure the conductivity of different solutions of ethanoic acid, CH_3COOH, which is a weak acid.

The acid dissociation constant, K_a, can be determined from this experiment.

The student makes standard solution **A**, 250.0 cm^3 of 2.00 mol dm^{-3} $CH_3COOH(aq)$.

Pure ethanoic acid is a liquid with a density of 1.05 g cm^{-3} at room temperature.

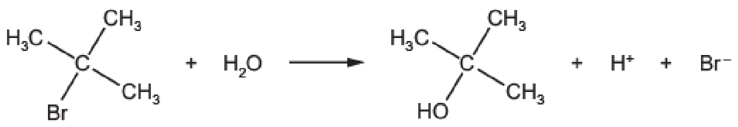
(b) The student wears chemically resistant gloves throughout this procedure.

Suggest why.

.... [1]

Q. Type: **Hazards and Safety Topic: Chem 26 Q# 117/** ALvl Chemistry/2022/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 A student plans to study the rate of hydrolysis of 2-bromo-2-methylpropane.



As the concentration of 2-bromo-2-methylpropane decreases during the reaction, the concentration of hydrogen ions increases.

The student plans the following method.

Step 1 Place 100 cm^3 of a mixture of propanone and water into a conical flask.

Step 2 Heat the mixture to 35 °C and maintain this temperature.

Step 3 Add 1.00 cm^3 of 2-bromo-2-methylpropane to the mixture and start timing.

Step 4 After 1 minute, transfer a 10.00 cm^3 sample of the reaction mixture into a conical flask containing ice and 4 drops of methyl orange indicator.

Step 5 Immediately titrate the 10.00 cm^3 of the reaction mixture with 0.0200 mol dm^{-3} sodium hydroxide.

Step 6 Repeat sampling and titrating at regular time intervals over a total time of 45 minutes.

Step 7 Heat the reaction mixture to 50 °C, remove the final sample, and titrate this.

(a) (i) State the apparatus you would use to maintain the temperature of the reaction mixture.

.... [1]

(ii) Suggest why the experiment is carried out away from naked flames.

....

.... [1]

Q. Type: **Hazards and Safety Topic: Chem 26 Q# 118/** ALvl Chemistry/2018/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 The Finkelstein reaction is a nucleophilic substitution reaction in which a halogen atom in a halogenoalkane is replaced by another halogen atom. The reaction is carried out using dry propanone as a solvent.

One example of the Finkelstein reaction is given.

$$CH_3CH_2CH_2Br + NaI \rightleftharpoons CH_3CH_2CH_2I + NaBr$$

(b) Some safety information for the organic compounds used in this reaction is shown.

- 1-bromopropane is **highly flammable** and **moderate health hazard**. It is irritating to eyes, the respiratory system and skin.
- 1-iodopropane is **flammable** and **moderate health hazard**. It is irritating to eyes, the respiratory system and skin.
- Propanone is **highly flammable** and **moderate health hazard**. It is irritating to eyes, and may cause dizziness and drowsiness.

Identify **two** different precautions, other than using protective equipment such as gloves, a lab coat or eye protection, that should be taken when carrying out this experiment. Explain each answer.

1 precaution ....

....

explanation ....

....

2 precaution ....

....

explanation ....

....

[2]

Q. Type: **Hazards and Safety Topic: Chem 27 Q# 119/** ALvl Chemistry/2014/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 When magnesium nitrate(V) is heated, it decomposes to form magnesium oxide, nitrogen(IV) oxide and oxygen.
Nitrogen(IV) oxide is an acidic gas that reacts readily and completely with alkalis.

You are to plan a **single** experiment to confirm that the molar quantities of magnesium oxide, nitrogen(IV) oxide and oxygen produced agree with the equation for the thermal decomposition of magnesium nitrate(V).

The following information gives some of the hazards associated with nitrogen(IV) oxide.

> **Nitrogen(IV) oxide** must not be inhaled. A large dose can be fatal and smaller quantities can have severe effects on breathing, particularly for people who suffer from asthma.

You are provided with anhydrous magnesium nitrate(V) and have access to the usual laboratory equipment and reagents.

(f) What precautions would you take to make sure that the experiment could be performed safely?

....

....

....

.... [1]

Q. Type: **Hazards and Safety Topic: Chem 27 Q# 120/** ALvl Chemistry/2009/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 You are to plan an investigation into the thermal decomposition of caesium nitrate, $CsNO_3$.

You may make use of some or all of the following data when planning your investigation.

Group I element	cation	ionic radius / nm
lithium	Li^+	0.060
sodium	Na^+	0.095
potassium	K^+	0.133
rubidium	Rb^+	0.148
caesium	Cs^+	0.176

Equations for the thermal decomposition of lithium nitrate and sodium nitrate are given below.

$$4LiNO_3(s) \longrightarrow 2Li_2O(s) + 4NO_2(g) + O_2(g)$$
$$2NaNO_3(s) \longrightarrow 2NaNO_2(s) + O_2(g)$$

nitrogen dioxide gas	oxygen gas
NO_2	O_2
brown in colour	colourless
soluble in water	almost insoluble in water
poisonous	powerful oxidant

1 mol of any gas occupies a volume of approximately 24 dm^3 at room temperature and atmospheric pressure.

A_r: Cs, 133; N, 14.0; O, 16.0

(h) Identify a risk present in the method you have described.

....

....

....

Describe how you would minimise this risk.

....

....

....

[2]

[Total: 15]

Q. Type: **Hazards and Safety Topic: Chem 27 Q# 121/** ALvl Chemistry/2002/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 ASSESSMENT OF PLANNING SKILLS

DO NOT CARRY OUT YOUR PLAN

Caesium nitrate, $CsNO_3$, decomposes on heating.

The decomposition is represented by one of the following equations.

$$4CsNO_3(s) \rightarrow 2Cs_2O(s) + 4NO_2(g) + O_2(g)$$

$$2CsNO_3(s) \rightarrow 2CsNO_2(s) + O_2(g)$$

You are to devise a method of heating the solid nitrate, collecting the gas given off and measuring its volume.
From the experimental results you are to determine which is the correct equation for the decomposition.

(e) Suggest one safety precaution that should be undertaken during this experiment and the reason for it.

....

....

....[1]

[Total 9]

Q. Type: **Hazards and Safety Topic: Chem 28 Q# 122/** ALvl Chemistry/2012/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 When an excess of aqueous sodium hydroxide, NaOH, is added to 100 cm^3 of aqueous copper(II) sulfate, $CuSO_4$, a precipitate of copper(II) hydroxide, $Cu(OH)_2$, is produced.

The stoichiometric equation for this reaction is,

$$CuSO_4\,(aq) + 2NaOH\,(aq) \longrightarrow Cu(OH)_2\,(s) + Na_2SO_4\,(aq)$$

The following information gives some of the hazards associated with these reactants.

Copper(II) sulfate (solid hydrated copper(II) sulfate $CuSO_4.5H_2O$)
Harmful. Dangerous for the environment.
Harmful if swallowed. Irritating to eyes and skin.
Solutions of concentrations equal to or greater than 1 mol dm^{-3} should be labelled HARMFUL.

Sodium hydroxide (solid NaOH)
Corrosive. Solutions of concentrations equal to or greater than 0.5 mol dm^{-3} are CORROSIVE. Solutions of concentrations equal to or greater than 0.05 mol dm^{-3} but less than 0.5 mol dm^{-3} are IRRITANT.

You are to plan an experiment to investigate the molar ratio of the equation above and confirm that it remains unchanged as the concentration of the copper(II) sulfate changes.

(d) **(i)** State two hazards that must be considered when planning the experiment.

....

....

....

(ii) State a precaution that should be taken to minimise the risk of one of these hazards.

....

....

....[3]

Q. Type: Dependent, Independent and Controlled Variables Topic: Chem 2 Q# 123/ ALvl Chemistry/2010/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 When aqueous sodium chloride, $NaCl$, is added to aqueous lead nitrate, $Pb(NO_3)_2$, a white precipitate of lead chloride, $PbCl_2$, is produced. A suggested stoichiometric equation is

$$Pb(NO_3)_2(aq) \;+\; 2NaCl(aq) \;\longrightarrow\; PbCl_2(s) \;+\; 2NaNO_3(aq)$$

In separate experiments, different volumes of 0.20 mol dm^{-3} aqueous sodium chloride are added to a fixed volume of 0.10 mol dm^{-3} aqueous lead nitrate. In each case, the precipitate is filtered, washed with distilled water and thoroughly dried. The mass of the precipitate is recorded.

You are to plan an experiment to investigate this reaction in order to confirm or reject the stoichiometry of the equation.

(c) In the experiment you are about to plan, identify the following.

(i) the independent variable ....

(ii) the dependent variable ....

(iii) another variable to be controlled ....
[2]

2 Charles' law states that for a fixed mass of gas at constant pressure, its volume is proportional to its absolute temperature. Most gases are non-ideal and do not obey this law, but at lower pressures and high temperatures some gases are close to ideal behaviour. One gas that behaves like this is oxygen.

Oxygen can be prepared by decomposing hydrogen peroxide with the catalyst manganese(IV) oxide, MnO_2.

The equation for the decomposition of hydrogen peroxide is shown.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

Safety hazard: hydrogen peroxide is corrosive to skin and can cause serious eye damage.

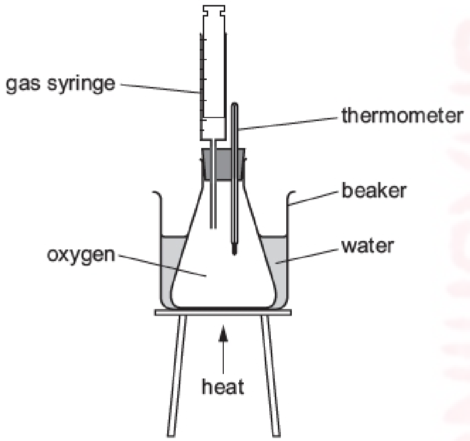


Fig. 2.1

Once the apparatus is assembled the volume of oxygen in the gas syringe is 2 cm^3. There are 80 cm^3 of oxygen remaining in the flask. The total volume of oxygen is 82 cm^3.

Charles' law is investigated by the following method.

step 1 Once assembled allow the apparatus to reach room temperature.

step 2 Record this temperature and the total volume of oxygen reading on the syringe.

step 3 Gently heat the apparatus until the temperature reaches 30 °C and record the total volume of oxygen.

step 4 Repeat at intervals of 5 °C until the temperature reaches 70 °C.

(e) **(i)** Identify the independent variable.

.... [1]

---

1 The pain of muscle strains and swellings can be eased by using heat packs. As a source of heat, some heat packs use the energy released when anhydrous calcium chloride dissolves in water.

$$CaCl_2(s) \xrightarrow{\text{water}} Ca^{2+}(aq) + 2Cl^-(aq)$$

A heat pack consists of a bag of water, inside which a smaller bag contains anhydrous calcium chloride. When pressure is applied to the heat pack, the smaller bag bursts releasing the anhydrous calcium chloride into the water. The heat pack is shaken to speed up dissolving. Energy is released which warms the heat pack.

A student carried out an experiment to determine the enthalpy change when anhydrous calcium chloride dissolves in distilled water. The results the student obtained are plotted on the graph on page 4.

(a) By considering the graph of results, draw a labelled diagram of the experimental set-up that the student could have used to produce the graph shown.
Label the apparatus and chemicals required to measure the **two** variables.

[2]

Q. Type: **Variables Topic: Chem 5 Q# 126/** ALvl Chemistry/2010/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 The neutralisation of an acid by a base is exothermic.

In this experiment the following solutions are available.

2 mol dm^{-3} sulfuric acid, H_2SO_4
3 mol dm^{-3} sodium hydroxide, NaOH

The equation for the reaction is:

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

(b) This experiment can be used to determine the enthalpy change of neutralisation for the reaction. To ensure reliable results the experiment should be repeated a number of times.

When sulfuric acid is added to the fixed volume of aqueous sodium hydroxide in this experiment

(i) the independent variable is .... ,

(ii) the dependent variable is .... ,

(iii) the other variables that need to be controlled are ....

....

[3]

(c) In carrying out the experiment, what apparatus would you use to accurately measure the independent variable?

....[1]

(d) Explain how you would use this apparatus to control the independent variable.

....

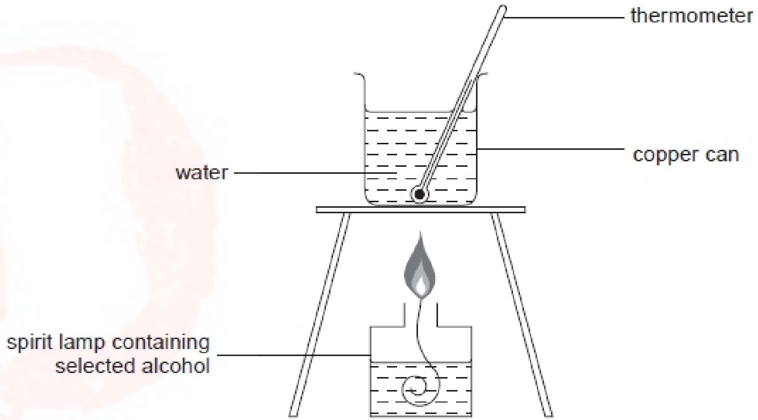
....[1]

Q. Type: **Variables Topic: Chem 5 Q# 127/** ALvl Chemistry/2008/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 The equations for the complete combustion of the first five members of the alcohol homologous series are shown below.

methanol	$CH_3OH(l) + 1½O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$
ethanol	$CH_3CH_2OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$
propan-1-ol	$CH_3CH_2CH_2OH(l) + 4½O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$
butan-1-ol	$CH_3CH_2CH_2CH_2OH(l) + 6O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$
pentan-1-ol	$CH_3CH_2CH_2CH_2CH_2OH(l) + 7½O_2(g) \rightarrow 5CO_2(g) + 6H_2O(l)$

You are to plan an experiment to determine the enthalpy change of combustion under laboratory conditions, ΔH_c, for each of the five alcohols using the apparatus and information below.



[4.2 J of heat energy raise the temperature of 1 cm^3 (1 g) of water by 1 °C.]

(c) Identify each of the following variables in the experiment to determine the enthalpy change of combustion of an alcohol using the apparatus in the diagram.

The independent variable is ....

The dependent variable is ....

Two variables to be controlled in this experiment are

1 ....

2 ....

[3]

Q. Type: **Variables Topic: Chem 6 Q# 128/** ALvl Chemistry/2012/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 There are three oxides of lead, PbO, PbO_2 and Pb_3O_4, all of which can be reduced to metallic lead by hydrogen.

The following information gives some of the hazards associated with these compounds.

Lead oxides
Lead(II) oxide (PbO) **Lead(IV) oxide** (PbO_2) **Dilead(II) lead(IV) oxide** (Pb_3O_4)
Toxic Dangerous for the environment
Harmful by inhalation and if swallowed. Danger of cumulative effects.

Hydrogen Extremely flammable. Readily forms an explosive mixture with air. Mixtures between 4 and 74 % by volume are explosive.

An unknown sample of an oxide of lead can be identified by investigating the molar ratio of oxygen atoms to lead atoms.

You are to plan an experiment to investigate the molar ratio of oxygen atoms to lead atoms in the oxide sample. Your plan should result in a correct identification of the oxide.

(c) In the experiment you are about to plan, identify the following.

(i) the independent variable ....

(ii) the dependent variable ....
[1]

Q. Type: **Variables Topic: Chem 7 Q# 129/** ALvl Chemistry/2015/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 A saturated aqueous solution of magnesium methanoate, $Mg(HCOO)_2$, has a solubility of approximately 150 g dm^{-3} at room temperature. Its exact solubility can be determined by titrating magnesium methanoate against aqueous potassium manganate(VII).

During the titration, the methanoate ion, $HCOO^-$, is oxidised to carbon dioxide while the manganate(VII) ion, MnO_4^-, is reduced to Mn^{2+}.

You are supplied with:
a saturated aqueous solution of $Mg(HCOO)_2$
aqueous potassium manganate(VII), $KMnO_4$, of concentration 0.0200 mol dm^{-3}

(b) The solubility of magnesium methanoate can be determined at higher temperatures using the same titration.

In an experiment to determine how the concentration of saturated magnesium methanoate varies with temperature, name the independent variable and the dependent variable.

independent variable ....

dependent variable ....
[1]

Q. Type: **Variables Topic: Chem 8 Q# 130/** ALvl Chemistry/2021/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 Hydrogen peroxide decomposes slowly at room temperature to give water and oxygen.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

The **initial** rate of this reaction can be increased by the addition of a metal oxide catalyst.

A student is asked to investigate which metal oxide catalyst is best at increasing the **initial** rate of this reaction by using a method which involves the collection of oxygen.

The student is provided with the following metal oxides: copper(II) oxide, iron(III) oxide, manganese(IV) oxide, nickel(II) oxide and titanium(IV) oxide.

The student is also provided with an excess volume, of a known concentration, of aqueous hydrogen peroxide and any laboratory equipment needed.

(a) **(i)** State the independent variable.

.... [1]

(ii) State the dependent variable.

.... [1]

(b) State two variables that would need to be controlled.

1 ....

2 ....
[2]

Q. Type: **Variables Topic: Chem 8 Q# 131/** ALvl Chemistry/2020/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2 The activation energy, E_a, of the reaction between aqueous manganate(VII) ions, $MnO_4^-(aq)$, and aqueous ethanedioate ions, $C_2O_4^{2-}(aq)$, can be determined as follows.

step 1 Use a pipette to transfer 10.00 cm^3 of 0.0200 mol dm^{-3} $MnO_4^-(aq)$ into a boiling tube.

step 2 Use a second pipette to transfer 10.00 cm^3 of 0.0500 mol dm^{-3} $C_2O_4^{2-}(aq)$ into a second boiling tube.

step 3 Place both boiling tubes into a water-bath at approximately 50 °C and allow the temperature of both solutions to become equal and constant.

step 4 Record this constant temperature.

step 5 Pour the $C_2O_4^{2-}(aq)$ solution into the boiling tube containing the $MnO_4^-(aq)$ solution and immediately start the timer. Continue to stir the mixture during the reaction.

step 6 When the reaction finishes, stop the timer and record the time.

step 7 Repeat the experiment at different temperatures and record the results.

(d) Identify the dependent variable.

.... [1]

Q. Type: **Variables Topic: Chem 8 Q# 132/** ALvl Chemistry/2009/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 One method of studying the kinetics of a reaction is by the initial rates method.
To determine the initial rate we can time how long it takes to reach an identifiable point early in the reaction.

In solution, iodide ions, I^-, are oxidised by persulfate ions, $S_2O_8^{2-}$.

$$S_2O_8^{2-}(aq) + 2I^-(aq) \longrightarrow 2SO_4^{2-}(aq) + I_2(aq)$$

If sodium thiosulfate and starch are added to the reaction mixture, the blue-black colour of an iodine-starch complex appears suddenly. This occurs when all of the thiosulfate ions, $S_2O_3^{2-}$, present in the mixture have reacted with the iodine formed in the reaction above. This is the identifiable point in the reaction.

$$2S_2O_3^{2-}(aq) + I_2(aq) \longrightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$

You are to plan an experiment to investigate how the rate of reaction between potassium persulfate and potassium iodide depends on the concentration of potassium persulfate.
A preliminary experiment, using approximate volumes of solution, indicates that the time taken for the iodine-starch complex to form doubles when the potassium persulfate is diluted with an equal amount of water.

(b) (i) Identify the independent variable in the investigation.

....

(ii) Identify the dependent variable in the investigation.

....[2]

(c) Explain why it is important that the iodine formed by oxidation reacts with the sodium thiosulfate and is converted back to iodide ions.

....

....

....[1]

Q. Type: **Variables Topic: Chem 8 Q# 133/** ALvl Chemistry/2007/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 Hydrochloric acid and magnesium ribbon react to produce hydrogen gas.

$$2HCl(aq) + Mg(s) \rightarrow MgCl_2(aq) + H_2(g)$$

You are to plan the details of an experiment, based on the volume of gas produced in the reaction, to investigate how the rate of reaction depends on the concentration of the hydrochloric acid.

(b) In an experiment to determine the rate of reaction with respect to HC*l* identify the independent variable.

....[1]

(c) Identify **one** variable, other than temperature, that must be controlled in the experiment.

....

....[1]

Q. Type: **Variables Topic: Chem 23 Q# 134/** ALvl Chemistry/2013/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 Ammonium nitrate, NH_4NO_3, is soluble in water (approximately 2.5 mol / 100 g at 25 °C). The molar enthalpy of solution of a solid is defined as the enthalpy change when one mole of the solid is dissolved in water.

$$NH_4NO_3(s) \rightleftharpoons NH_4^+(aq) + NO_3^-(aq) \qquad \Delta H_{soln} = +26.5\,kJ\,mol^{-1}$$

(b) If you were to carry out an experiment to investigate how the **temperature change** of the solution varies as the **concentration changes** name,

(i) the independent variable, ...

(ii) the dependent variable. ....
[1]

Q. Type: **Variables Topic: Chem 23 Q# 135/** ALvl Chemistry/2008/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 The **solubility** of cerium(IV) sulphate, at a particular temperature, is defined as:
the mass of cerium(IV) sulphate that will dissolve in and just ***saturate*** *100 g of solvent at that temperature.*

Cerium(IV) sulphate will dissolve in water.

A **saturated** solution is one in which no more solid can dissolve at a particular temperature.
In a saturated solution in contact with undissolved solid, the following equilibrium is established.

$$Ce(SO_4)_2(s) + aq \rightleftharpoons Ce^{4+}(aq) + 2SO_4^{2-}(aq)$$

Cerium(IV) sulphate is unusual. Its solubility **decreases** as the temperature of the solution increases.

Cerium(IV) sulphate crystals also dissolve in dilute sulphuric acid, H_2SO_4, a corrosive aqueous solution.

You are to plan an experiment to investigate how the **solubility** of cerium(IV) sulphate crystals in dilute sulphuric acid depends on the concentration of the acid.

(b) In the experiment you are about to plan, identify the following.

(i) the independent variable ....

(ii) the dependent variable ....

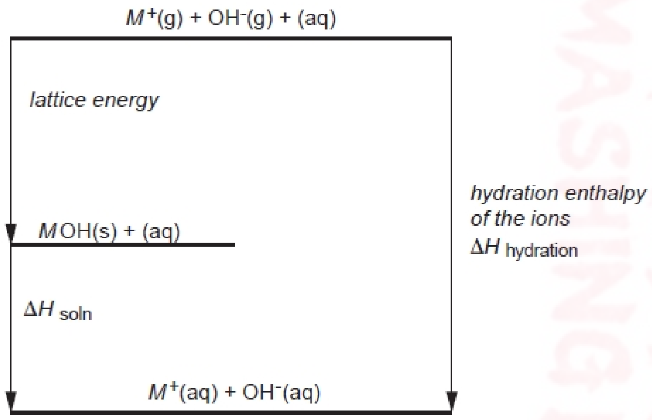
(iii) another variable to be controlled .... [3]

Q. Type: **Variables Topic: Chem 23 Q# 136/** ALvl Chemistry/2007/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 The hydroxides of Group I metals (LiOH, NaOH, KOH, RbOH, CsOH) are highly corrosive white solids which rapidly absorb water vapour on exposure to the atmosphere.
All of these solids dissolve exothermically in water.
The enthalpy change of solution, ΔH_{soln}, is the energy change associated with the following reaction. *M* represents the Group I metal.

$$MOH(s) + (aq) \rightarrow M^+(aq) + OH^-(aq)$$

The following diagram represents theoretical stages in the formation of aqueous *M*OH.



Lattice energy and hydration enthalpy are both more exothermic when ions carry a higher charge and/or ions have a smaller radius.

When comparing Group I hydroxides, changes in $\Delta H_{hydration}$ are more significant than changes in lattice energy.

(b) The enthalpy change of solution, ΔH_{soln}, for any Group I hydroxide can be measured experimentally in the laboratory.

In experiments to compare ΔH_{soln} for LiOH, NaOH, KOH, RbOH, CsOH state

the independent variable .... ,

the dependent variable .... ,

the other variable to be controlled ....

....

[3]

Q. Type: **Variables Topic: Chem 26 Q# 137/** ALvl Chemistry/2023/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2 The reaction between iodide ions, $I^-(aq)$, and aqueous hydrogen peroxide, $H_2O_2(aq)$, takes place in acidic conditions.

$$\text{reaction 1} \quad 2I^-(aq) + H_2O_2(aq) + 2H^+(aq) \rightarrow I_2(aq) + 2H_2O(l)$$

A student carries out a series of experiments to investigate the order of reaction with respect to the concentration of $I^-(aq)$ ions. The student does this by measuring the time taken for a fixed amount of iodine to form.

A known amount of aqueous thiosulfate ions, $S_2O_3^{2-}(aq)$, in the reaction mixture react with $I_2(aq)$ formed in reaction 1.

$$\text{reaction 2} \quad I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

After all of the $S_2O_3^{2-}(aq)$ ions have reacted in reaction 2, any further $I_2(aq)$ formed is detected using starch indicator.

The following materials are used:

- $50\,cm^3$ beaker containing the correct mass of solid potassium iodide crystals needed to make $250.0\,cm^3$ of $0.100\,mol\,dm^{-3}$ KI(aq)
- $0.100\,mol\,dm^{-3}$ $Na_2S_2O_3(aq)$
- $0.100\,mol\,dm^{-3}$ $H_2O_2(aq)$
- $0.200\,mol\,dm^{-3}$ $H_2SO_4(aq)$
- starch indicator
- distilled water.

(c) The student carries out Experiment 1 using the following steps.

step 1 Add 25 cm^3 of 0.200 mol dm^{-3} H_2SO_4(aq) to a conical flask.

step 2 Add 20.00 cm^3 of distilled water to the conical flask from a burette.

step 3 Add 5.00 cm^3 of 0.100 mol dm^{-3} KI(aq) to the conical flask from a burette.

step 4 Add 5.00 cm^3 of 0.100 mol dm^{-3} $Na_2S_2O_3$(aq) to the conical flask from a burette.

step 5 Add 2 cm^3 of starch indicator to the conical flask.

step 6 Use a burette to add 10.00 cm^3 of 0.100 mol dm^{-3} H_2O_2(aq) to a small beaker.

step 7 Add the contents of the beaker to the conical flask and start a timer immediately. Stop the timer when the starch indicates the presence of I_2(aq).

The student carries out a further six experiments by repeating **steps 1** to **7**, using the volumes shown in Table 2.1.

Table 2.1

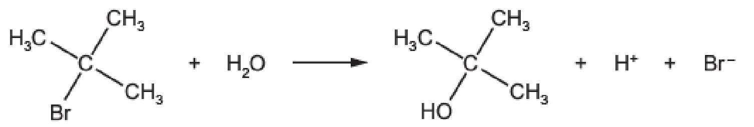
experiment	volume of H_2SO_4(aq) / cm^3	volume of distilled water / cm^3	volume of KI(aq), *V* / cm^3	volume of $Na_2S_2O_3$(aq) / cm^3	volume of indicator / cm^3	time taken for colour change, *t* / s
1	25	20.00	5.00	5.00	2	257
2	25	17.50	7.50	5.00	2	120
3	25	15.00	10.00	5.00	2	112
4	25	12.50	12.50	5.00	2	76
5	25	10.00	15.00	5.00	2	1
6	25	5.00	20.00	5.00	2	59
7	25	0.00	25.00	5.00	2	44

(ii) State the independent variable in Experiments 1 to 7.

.... [1]

Q. Type: **Variables Topic: Chem 26 Q# 138/** ALvl Chemistry/2022/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 A student plans to study the rate of hydrolysis of 2-bromo-2-methylpropane.



As the concentration of 2-bromo-2-methylpropane decreases during the reaction, the concentration of hydrogen ions increases.

The student plans the following method.

Step 1 Place 100 cm^3 of a mixture of propanone and water into a conical flask.

Step 2 Heat the mixture to 35 °C and maintain this temperature.

Step 3 Add 1.00 cm^3 of 2-bromo-2-methylpropane to the mixture and start timing.

Step 4 After 1 minute, transfer a 10.00 cm^3 sample of the reaction mixture into a conical flask containing ice and 4 drops of methyl orange indicator.

Step 5 Immediately titrate the 10.00 cm^3 of the reaction mixture with 0.0200 mol dm^{-3} sodium hydroxide.

Step 6 Repeat sampling and titrating at regular time intervals over a total time of 45 minutes.

Step 7 Heat the reaction mixture to 50 °C, remove the final sample, and titrate this.

(d) State the measured dependent variable for this experiment.

.... [1]

Q. Type: **Variables Topic: Chem 26 Q# 139/** ALvl Chemistry/2021/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 The rate of reaction between calcium carbonate, $CaCO_3$, and hydrochloric acid, HC*l*, can be followed by collecting and measuring the volume of carbon dioxide produced at 30-second intervals.

The equation for the reaction is:

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

(d) Calcium carbonate is a component of antacid tablets.

An alternative method of studying the rate of reaction between calcium carbonate and hydrochloric acid is:

- Place one antacid tablet into a beaker.
- Add 50 cm^3, **an excess**, of 2.0 mol dm^{-3} hydrochloric acid and start the stop-clock immediately.
- Record the time taken for the fizzing to stop.

(ii) Identify the dependent variable in this investigation.

.... [1]

Q. Type: **Variables Topic: Chem 26 Q# 140/** ALvl Chemistry/2016/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1 Propanone, CH_3COCH_3, is an organic liquid which is soluble in water.

Aqueous propanone reacts with aqueous iodine. The reaction is catalysed by H^+(aq) ions.

$$CH_3COCH_3(aq) + I_2(aq) \rightarrow CH_3COCH_2I(aq) + HI(aq)$$

The order of reaction with respect to iodine can be determined experimentally.

An experiment is carried out using the following solutions.

- solution **A**, 25.0 cm^3 of 1.00 mol dm^{-3} CH_3COCH_3(aq)
- solution **B**, 25.0 cm^3 of 1.00 mol dm^{-3} H_2SO_4(aq)
- solution **C**, 50.0 cm^3 of 0.200 mol dm^{-3} I_2(aq)

The solutions are mixed to start the reaction. At certain time intervals, a 10.0 cm^3 portion of the mixture is withdrawn and transferred to a conical flask containing excess sodium hydrogencarbonate, $NaHCO_3$(aq). This prevents any further significant reaction taking place by removing the H^+(aq) ions. The concentration of unreacted I_2(aq) in each 10.0 cm^3 portion of the mixture can then be determined by titration with aqueous thiosulfate ions, $S_2O_3^{2-}$(aq).

(e) State **two** variables which must be recorded in this experiment.

For each variable, state the units.

variable 1 .... units ....

variable 2 .... units ....

[2]

(f) State **one** other variable which must be controlled in this experiment.

.... [1]

Q. Type: **Variables Topic: Chem 27 Q# 141/** ALvl Chemistry/2011/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 The carbonates of group II in the periodic table decompose on heating forming an oxide and carbon dioxide.
X is any group II cation (e.g. Mg^{2+})

$$XCO_3 \rightarrow XO + CO_2$$

This decomposition occurs because the positively charged cations polarise (distort) the C—O bond in the carbonate ion causing the ion to break up. The charge density of the group II cations decreases down the group. This affects the decomposition rate.

You are to plan an experiment to investigate how the rate of decomposition of a group II carbonate varies as the group is descended. The rate can be conveniently measured by finding the time taken to produce the same volume of carbon dioxide from each carbonate.

(b) In the experiment you are about to plan, identify the following.

(i) the independent variable ....

(ii) the dependent variable .... [2]

Q. Type: **Variables Topic: Chem 27 Q# 142/** ALvl Chemistry/2009/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 You are to plan an investigation into the thermal decomposition of caesium nitrate, $CsNO_3$.

(b) You are to plan an experiment in which

- caesium nitrate is heated,
- gas is collected,
- the volume of gas collected is measured,
- the experimental results are used in a calculation to confirm or reject your prediction.

(i) Identify the independent variable in the experiment.

....

(ii) Identify the dependent variable in the experiment.

.... [2]

Q. Type: **Variables Topic: Chem 28 Q# 143/** ALvl Chemistry/2012/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 When an excess of aqueous sodium hydroxide, NaOH, is added to 100 cm^3 of aqueous copper(II) sulfate, $CuSO_4$, a precipitate of copper(II) hydroxide, $Cu(OH)_2$, is produced.

The stoichiometric equation for this reaction is,

$$CuSO_4 (aq) + 2NaOH (aq) \rightarrow Cu(OH)_2 (s) + Na_2SO_4 (aq)$$

The following information gives some of the hazards associated with these reactants.

Copper(II) sulfate (solid hydrated copper(II) sulfate $CuSO_4.5H_2O$)
Harmful. Dangerous for the environment.
Harmful if swallowed. Irritating to eyes and skin.
Solutions of concentrations equal to or greater than 1 mol dm^{-3} should be labelled HARMFUL.

Sodium hydroxide (solid NaOH)
Corrosive. Solutions of concentrations equal to or greater than 0.5 mol dm^{-3} are CORROSIVE.
Solutions of concentrations equal to or greater than 0.05 mol dm^{-3} but less than 0.5 mol dm^{-3} are IRRITANT.

You are to plan an experiment to investigate the molar ratio of the equation above and confirm that it remains unchanged as the concentration of the copper(II) sulfate changes.

(b) In the experiment you are about to plan, identify the following.

(i) the independent variable ....

(ii) the dependent variable ....

(iii) one other variable to be controlled ....[2]

Mark Scheme

Q# 1/ Describing Method **ALvl** Chemistry/2022/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1(a)	allow (crucible / contents) to cool	1
1(b)	to prevent spitting of crystals	1
1(c)	pipe-clay triangle	1
1(d)	heat to constant mass	1

Q# 2/ Describing Method ALvl Chemistry/2010/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 (a)	PLAN Problem	Predicts a direct proportionality. Accept statements such as 'no. of moles of the precipitate/$PbCl_2$ will increase (as the number of moles of NaCl increases'). Equation shows a 1 to 2 molar ratio or wtte. (If a 'plateau' graph is described for the first mark allow a correctly explanation for the second mark i.e. all the lead nitrate has been used up)	[1] [1]
(b)	PLAN Method & Problem & ACE	All the lead nitrate was used up; moles or concentration of lead nitrate; **total** volume of lead nitrate. **NOT** amount A diagonal straight-line going through the origin. The line will abruptly change to a horizontal line Possible alternatives: • Diagonal line only, with +ve slope from the origin – 1 mark • Diagonal line not starting at the origin with a horizontal line – 1 mark • Curve from the origin with decreasing gradient and horizontal straight-line – 1 mark • Curve not from the origin with decreasing gradient and horizontal straight-line – 0 marks • Any lines showing an increase in gradient – 0 marks	[1] [1] [1]
(c)	PLAN Problem	Independent variable – volume/mass/moles of NaCl Dependent variable – moles/mass of $PbCl_2$ / ppt Other variables – temperature. **NOT** amount and **NOT** concentration of the NaCl Three points correct – 2 marks Two points correct – 1 mark Any incorrect suggestions cancel correct suggestions	[2]
(d) (i) (ii)	PLAN Method	Calculating an appropriate mass of lead nitrate; this should be 8.275(8.3)g Dissolving the solid in water (or stirring) in a beaker or other appropriate vessel (<u>volumetric/graduated/dilution</u> flask) using less than 250 cm^3 Adding to the <u>volumetric/graduated/dilution</u> flask and adding water to the 250 cm^3 mark (if 250 cm^3 of water are added directly to a <u>volumetric/ graduated/dilution</u> flask (containing the solid of course) allow 1 mark) Any dilution from a 'given' solution of lead nitrate gets 0 marks out of 3. Synthesis of the lead nitrate from lead and nitric acid scores zero. A student who uses 33.1 grams of lead nitrate to make up correctly 1 dm^3 of solution can gain the first two marks, but to gain the third mark a measured 250 cm^3 needs to be taken using an appropriate measuring vessel. Apparatus for volume measurement (burette/pipette/measuring cylinder)(not a syringe) used to measure 50 cm^3 or less of lead nitrate and 100 cm^3 or less of sodium chloride (mention of only one measuring vessel is enough for this mark) Method for drying the precipitate (adding propanone and allowing to evaporate/pressing with filter paper/warm oven/sun leaving out to dry. **NOT** heat or the use of a Bunsen or microwave.	[1] [1] [1] [1] [1]
(f)	PLAN Method	The drying process should be repeated to constant mass Allow heat/reheat to constant mass/weight.	[1]
	Total		**[16]**

Q# 3/ Describing Method ALvl Chemistry/2004/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 Three basic plan methods have been identified.

METHOD A - Preparing a solution by dissolving solid in hot water and cooling to saturate

METHOD B - Preparing a solution at room temperature

METHOD C - Preparing a solution from weighed solid and weighed/measured water

and

Three additional methods for determining the solubility

METHOD D - Titration method

METHOD E - Cooling curve

METHOD F - Filtrate method when a fixed mass of water is used in the experiment

IN EACH METHOD:

Record the letter of the marking point in the script at the point where it is given and place a tick in the grid in the margin.

Each point scores one mark — count the ticks and record the total below the grid.

Candidates employing different methods for making the saturated solution and for determining the solubility will be seen frequently. Mark each using the appropriate section of the mark scheme.

In all calculation sections, allow answers that are in g/100g water, g/g water, g/100 cm^3 water or g/cm^3 of water.

If the preparation of the saturated solution can be marked using different methods, award the marks for the method that benefits the candidate.

Many of the methods of determining solubility contain small errors that are not penalised (e.g. water that is lost in filter papers or on wet, filtered solid)

METHOD A

(a) PREPARATION OF THE SATURATED SOLUTION

Marking point

(a) Heating water above room temperature

(b) Dissolving (enough) solid (so that)

(c) Solid forms on cooling **3**

DETERMINATION OF THE 'SOLUBILITY'

(d) Weighing a sample of the saturated solution

(e) Evaporating all of the water

(f) Weighing the solid remaining

(g) Using specimen results (numerical or algebraic) to calculate the solubility **4**

METHOD B

(a) PREPARATION OF THE SATURATED SOLUTION

Marking point

(a) Add solid to water (until)

(b) Solid remains undissolved/no more dissolves (Implied by filtering)

(c) Allow to stand/leave for a long time (to establish equilibrium) **3**

DETERMINATION OF THE ‘SOLUBILITY’

	METHOD B1	METHOD B2 (for a known mass of water when making saturated solution)
(d)	Weighing a sample of the saturated solution	*Weighing an empty container (and adding the filtrate)*
(e)	Evaporating all of the water	Evaporating all of the water
(f)	Weighing the solid remaining	Weighing the solid remaining
(g)	Using specimen results (numerical or algebraic) to calculate the solubility	Using specimen results (numerical or algebraic) to calculate the solubility

4

METHOD C

(b) PREPARATION OF THE SATURATED SOLUTION

Marking point

(a) Weigh or state mass of solid **and** measure or state mass/volume of water

(b) Dissolve solid until undissolved solid remains (Implied by filtering) *(If heated during preparation, solid forms on cooling)*

(c) Allow to stand/leave for a long time (to establish equilibrium) 3

DETERMINATION OF THE ‘SOLUBILITY’

	METHOD C1	METHOD C2 (where solid is added in small weighed quantities)
(d)	Filter the solution/separate solid from solution (e.g. decant)	The mass of each small sample has been measured
(e)	Dry the residue	Number of samples dissolved is recorded
(f)	Weigh the residual solid	Weighs solid from the final sample that is not added to the solution (as solution becomes saturated)
(g)	Using specimen results (numerical or algebraic) to calculate the solubility.	Using specimen results (numerical or algebraic) to calculate the solubility.

4

METHOD D - TITRATION METHOD FOR DETERMINATION OF THE ‘SOLUBILITY’

Only (d) may be awarded for a straight titration of $KClO_3$ with HCl

(d) Accurately measure a volume (pipette/burette) of **and** weigh the measured volume of the saturated solution

(e) (i) React with (excess) KI and acid

or

(ii) *(React with (excess) hydrochloric acid)*

(f) (i) Titrate iodine formed with thiosulphate

or

(ii) *(Titrate excess acid with sodium hydroxide)*

(g) Using specimen results (numerical or algebraic) to calculate the solubility. 4

METHOD E - COOLING CURVE METHOD FOR DETERMINATION OF SOLUBILITY

(d) (i) weighing samples of solid with a different mass for each experiment

or

(ii) *(Maintaining a fixed mass of solid in each experiment)*

(e) (i) Having a fixed mass/volume of water in each experiment

or

(ii) *(Varying the mass/volume of water in each experiment)*

(f) Noting the temperature at which crystals form from hot solution for at least 5 variables

(g) Showing an appropriate calculation to obtain solubility data for one of the experiments,

and

Indicating that a solubility temperature graph would be drawn,

and

The solubility at room temperature to be read from the graph 4

METHOD F - METHOD FOR DETERMINATION OF SOLUBILITY WHERE CANDIDATES START WITH A KNOWN MASS OF WATER

(d) Weigh container, e.g. a beaker

(e) Filter the saturated solution into the weighed beaker

(f) Weigh the beaker + saturated solution

(g) Calculate the mass of solute in the known mass of water and hence determine the solubility **4**

(b) Variation of sodium bromide 'Solubility' with temperature

Give **one mark** if both axes have linear numerical scales **and** points are plotted in at least 5 "large" squares in either direction.

Give **one mark** if two appropriate lines (straight lines or curves - but no s shaped curves) have been drawn through the plotted points.

The two lines do not have to intersect.

Do **not** give this mark if there is an obvious error in the plotting of any point **or** there is a "rounding" of any line to connect the two or to force a fit to the plotted point at 50°C

Give **one mark** for an appropriate transition temperature, read from the graph to within ½ small square.

This mark is independent of the previous mark.

To award this mark there must be an intersection of two lines and not a rounded point of inflexion.

Do **not** give this mark if additional graph lines have been drawn.

[The published transition temperature is 50.7°C]

Total for Question 2 = 10

Total for Paper = 30

Q# 4/ Describing Method ALvl Chemistry/2020/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

Defining the Problem

P1	Identify the apparatus suitable for carrying out each step of the procedure.
P2	Express the aim in terms of a prediction.

Methods

M1	Describe precautions that should be taken to keep risks to a minimum.
M2	Describe the method to be used when carrying out the experiment.
M3	Describe how the data might be used to reach a conclusion
M4	Describe the arrangement of the apparatus
M5	Measuring instruments should be chosen to measure the correct quantity to a suitable precision.

Dealing with data

D1	Use calculations to enable simplification or explanation of data
D2	Use a table or graph to draw attention to the key points in quantitative data.

Evaluation

E1	Identify the extent to which provided readings have been replicated
E2	Suggest and explain the effect that a change in the conditions used for the experiment might have on the results obtained.
E3	Identify and explain the weaknesses of the experimental procedure used.

Conclusion

C1	Draw conclusion from an investigation
C2	Suggest improvements

1(a)(i)	Prediction: Temperature increases **AND** Electrostatic attraction between the different molecules is stronger electrostatic attractions within each type of molecule.	1
1(a)(ii)	Two equal volumes and a total volume < 25 cm³	1
	Measure initial temperature of liquids (in measuring cylinders) – leave to equilibrate	1
	Mix two liquids in the beaker, monitor temperature every minute until temp starts to fall / read the maximum temperature	1
1(b)	one of: • Use a polystyrene cup instead of the glass beaker / insulate the glass beaker / use a dewar flask • Cover the beaker with a lid • Insulate the glass beaker	1
1(c)	The experiment must not be performed near any naked flames OR Use an electric heater	1
1(d)	Use a burette / graduated pipette instead of a measuring cylinder OR Use larger volumes of liquids OR Use a more accurate thermometer	1
1(e)(i)	37.50 / 119.5 = 0.314 **AND** 19.75 / 58 = 0.341	1
1(e)(ii)	**M1** Use of limiting factor (0.314) for number of moles **M2** $\Delta H = -1.67/0.314 = -5.32$ kJmol⁻¹	2
1(f)	keep volume of trichloromethane same and vary volume of propanone and record temperature change	1

Q# 5/ Describing Method ALvl Chemistry/2017/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1(b)	**M1** diagram indicating a labelled insulated container and a labelled thermometer in the liquid	1
	M2 temperature of mixture / HCl measured every minute	1
	M3 reactants mixed at 4 minutes	1

Q# 6/ Describing Method ALvl Chemistry/2008/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 (d) **Part 1**	PLAN Methods	M6	1	Uses thermometer capable of reading to 1 °C or better **or** balance capable of reading to 0.1 g or better.	1
		M1	2	Burns stated or measured mass or moles of ethanol completely, **or** burns ethanol to get a particular temperature rise, **or** burns ethanol for a particular length of time.	1
		M2	3	Measures initial and final temperature, **or** measures initial and final masses of ethanol.	1
		M6	4	Shows how the mass of ethanol is converted to moles. (Items 3 & 4 can be taken from the table or the calculation.) *(46 must be shown in an expression – not the symbol M_r)*	1
		M5	5	Uses mc∆T to calculate heat absorbed by the water in the can. We need to look for either suggested numbers or algebraic symbols (not just mc∆T. Accept ∆T but not theta unless defined.	1
		M5	6	Scales heat absorbed for 1 mol of ethanol (correct units are needed here)	1

1 (f)	PLAN Methods	M5	One improvement to reduce heat loss given in diagram and by explanation. From: (i) insulation on sides but not bottom of can (ii) lid on can (iii) draught shield fitted (iv) lower tripod **or** raise burner (v) replacement of tripod with insulated support Each suggestion should be supported by an appropriate reason and for such items as 'move the flame closer to the can' we need to know how this is to be done. Heat lost to the surroundings or atmosphere etc., generates no mark. Heat loss could be through the top of the cup (convection) or through the sides of the can (conduction)	1
		M5	Second improvement from same list *Give **one of these two marks** for two listed improvements without explanation.*	1
Qn 1	**Total**			**15**

Q# 7/ Describing Method ALvl Chemistry/2020/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1(a)	**M1** Order of weighing • boat + brass is weighed • (brass transferred) • empty boat reweighed **M2** table + units | | / g | | Mass of boat + brass before transfer | | | Mass of boat after transfer | | | Mass of brass transferred | |	2
1(b)	toxic / poisonous gas given off	1
1(c)	**M1** transfer of solution A into a 250 cm³ volumetric flask and rinsing of beaker **M2** top up to mark of (250 cm³) volumetric flask using distilled water	2
1(d)	(25 cm³) pipette	1
1(e)	no more effervescence is seen	1
1(f)	**M1** rinse burette with $Na_2S_2O_3$ **M2** (idea of) run some $Na_2S_2O_3$ through the tap / remove air from below tap	2

1(i)	(Ag^+) react with I^- / iodide (ions) to form a precipitate / solid	1

Q# 8/ Describing Method ALvl Chemistry/2018/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2(a)(i)	0.0200 □ 5 = 0.1(00) mol dm^{-3}	1
2(a)(ii)	M1 = 277.9 (seen anywhere) M2 = M1 □ 0.1(00) □ 250 / 1000 = 6.9475 M3 = M2 □ 100 / 8 = 86.84 g	3
2(a)(iii)	M1 = total moles of H^+ = (0.100 □ 8 / 5 □ 250 / 1000) = 0.04(00) mol M2 = volume of 2 mol dm^{-3} sulfuric acid = (M1 / 2) □ (1000 / 2) = 10 cm^3	2
2(b)	M1 Dissolve the iron(II) sulfate crystals (in the beaker) using (distilled) water M2 Filter M3 Rinse the residue If no M2 (filtration), M3 can be applied to mixture in M1 as part of transfer in M5. M4 Add H_2SO_4 M5 Transfer / add to a 250 cm^3 volumetric flask and make up to mark with (distilled) water	5
2(c)	Colourless to pink / pale purple	1
2(d)	M1 Higher M2 Some of the MnO_4^- (aq) would be used oxidising Cl^-(aq) ions	2

Q# 9/ Describing Method ALvl Chemistry/2023/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1(a)(i)	All titres to nearest 0.05 cm^3 (10.50, 9.65, 9.90, 9.75)	1
1(a)(ii)	(9.65 + 9.75) ÷ 2 = 9.70 (cm^3)	1
1(b)	A solution of known concentration	1
1(c)(i)	To allow to reach equilibrium	1
1(c)(ii)	To allow solid to settle	1
1(d)	Acid is in excess	1
1(e)	aqueous potassium manganate(VII)	1
1(f)	From colourless to pale pink	1
1(g)	Lower percentage error	1

Q# 10/ Describing Method ALvl Chemistry/2009/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

(d)	PLAN Methods	(i) Has at least 3 more appropriate experiments of lower concentration. (inappropriate experiments negate this mark) (ii) At least one of the diluted (varying water or persulphate) solutions half or less of original <u>correct</u> concentration / uses 20 cm^3 or less of persulphate at least once. (if concentration is used alone it must be correct but if used in conjunction with volumes regard the concentration as neutral). (iii) Total volume, volumes of potassium iodide, thiosulfate and starch all constant. **(allow drops of starch) (use of the exemplar experiment is not mandatory)** If all volumes stated, then the same procedure (with different persulfate concentrations) repeated could suffice. (iv) Burette or measuring cylinder used to measure volumes of persulfate <u>and</u> distilled water. (v) 'Minimum' is persulfate and iodide kept apart until reaction stated as started. (vi) Clock stopped when blue colour appears / elapsed time to blue colour is noted / measure time to the appearance of the blue colour. Not in a (timed) titration procedure. <u>Also look at the table in (f) for possible answers to the first three marks</u>.	[1] [1] [1] [1] [1] [1]
(e)	PLAN Methods	<u>Explains</u> that the volume / amount of thiosulfate defines the extent of the reaction ("finishing line") to enable comparison – or equivalent statement. Relate the constant volume of thiosulphate to the end / finishing point. Any reference to 'accuracy' should be regarded as neutral'.	[1]

Q# 11/ Describing Method ALvl Chemistry/2007/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

(d)(i)	**PLAN Methods**	Lists apparatus for the reaction of Mg/acid, collection <u>and measurement</u> of gas and timing gas collection *Connecting tube does not need to be <u>listed</u>* *gas could be measured by full test-tube etc.* *A diagram is acceptable if a timing device is mentioned in the text*	[1]	
(ii)		Dilutes a range of volumes of HC*l* sufficient for the experiment *A minimum of 5 different concentration solutions is required* *Total volume does not have to be constant*	[1]	
(iii)		Prepares diluted solutions using measuring cylinder, pipette or burette	[1]	
(iv)		Describes how collection of a stated volume of H_2 will be timed in each experiment, **or** Volume of H_2 collected in a stated time is described, **or** Volume of H_2 collected recorded at fixed intervals to enable graph to be plotted	[1]	
(v)		Reference to the way in which total volume being kept constant, **or** temperature kept constant, **or** way in which other variable from **(c)** is controlled	[1]	
(vi)		Candidate selects a range of suitable volumes of acid or states a range of concentrations to be used *Volume of acid should cover the range from starting volume (concentration) to at least half the starting volume (concentration)* *Total volume must be constant <u>unless</u> a correct (relative) concentration has been given* *Ignore starting with a concentration of <u>less</u> than 2 mol dm^{-3} hydrochloric acid.*	[1]	
(vii)		*Do <u>not</u> accept concentrations greater than 2 mol dm^{-3}* The plan is presented logically with an effective way of preventing loss of gas *The use of dropping funnels or thistle funnels is permitted for addition of acid without loss of gas*	[1]	[7]
(f)	**PLAN Methods**	Candidate repeats the experiment keeping HC*l* constant and varying the temperature Description of how the temperature will be <u>controlled</u> is required	[1]	[1]

Q# 12/ Describing Method ALvl Chemistry/2014/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 (a)

reagent added	reagent added	reagent added
sulfuric acid	**(excess, aqueous) ammonia**	**sulfuric acid**
substances present at the end of the reaction	substances present at the end of the reaction	substances present at the end of the reaction
zinc sulfate AND aluminium sulfate(copper)	**zinc (tetra) ammine (ions) (aluminium hydroxide)**	**ammonium sulfate (zinc hydroxide)**
substances removed by filtration	substances removed by filtration	substances removed by filtration
copper	**aluminium hydroxide**	**zinc hydroxide**

Allow: Correct formulae or ions instead of names. [5]

(b)	**Step 1**: Sufficient/ enough /excess sulfuric acid (to dissolve the zinc and aluminium)	1	
	Step 2: Sufficient/ enough/ excess aqueous ammonia (to precipitate aluminium hydroxide and to completely dissolve the zinc hydroxide)	1	
	Step 3: Sufficient/ enough/ sulfuric acid to: neutralise/ react with ammonia (re-) precipitate the zinc hydroxide but not so much that the zinc hydroxide reacts/ dissolves	1 1	[4]
(c)	Heat (the hydroxides)	1	
	To constant mass	1	[2]
(d)	Measure mass of any three of solder, copper, zinc oxide /hydroxide and aluminium oxide /hydroxide or residues / precipitates	1	
	The copper should be washed (with water /propanone or any other suitable organic solvent) and dried	1	[2]
(f)	The mass/amount/ percentage of copper is small	1	[1]

Q# 13/ Describing Method ALvl Chemistry/2016/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(a)(i)	silver chromate(VI) / silver chromate $2Ag^+ + CrO_4^{2-} \rightarrow Ag_2CrO_4$ OR $2Ag^+ + K_2CrO_4 \rightarrow Ag_2CrO_4 + 2K^+$ OR $2AgNO_3 + K_2CrO_4 \rightarrow Ag_2CrO_4 + 2KNO_3$	1 1	2
1(a)(ii)	insoluble / solid barium chromate(VI) / barium chromate would form	1	1
1(a)(iii)	insoluble / solid barium sulfate is formed	1	1
1(c)(i)	Volumetric/graduated flask 250 cm^3 pipette (graduated) 25 cm^3 burette 50 cm^3		2
1(c)(iii)	first = sulfuric acid second = potassium chromate(VI) third = silver nitrate	1	1
1(c)(iv)	experiment / titration is repeated to get concordant titre	1	1

Q# 14/ Describing Method ALvl Chemistry/2022/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(b)(i)	stir (when solid is mixed with water) OR increase temperature (of water) OR increase state of division of the (solid) mixture	1
1(b)(ii)	to remove magnesium nitrate / (excess) silver nitrate (from the precipitate before drying)	1
1(b)(iii)	(It is dried in an oven) to avoid (thermal) decomposition (of silver chloride / precipitate / solid)	1
1(d)	the (measured) mass / amount (of '$AgCl$' / solid / precipitate) would be greater (than the true value) **AND** the % by mass (of $MgCl_2$ in the sample) would be greater (than the true value)	1

Q# 15/ Describing Method ALvl Chemistry/2013/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

(c)	1	Pipette (5,10, 20, 25, 50 cm^3), burette (25, 50 or 100 cm^3) both required for mark.	1
	2	Starch indicator **AND** blue/blue-black **AND** colourless/opaque.	1
	3	Concentration of Cl_2 = 0.0704 mol dm^{-3} .	1
	4	Calculates M_r of $Na_2S_2O_3.5H_2O$ as 248.2 **AND** calculates mass with unit required for a solution of stated concentration and volume. (Allow any concentration)	1
	5	Mass and volume used must produce a solution twice as concentrated as the chlorine solution (ecf from Cl_2).	1
	6	Describes making of solution in <u>volumetric flask</u> which must include: <u>dissolving</u>, making up <u>to mark</u>.	1
	7	Titration is repeated to achieve concordant titration results/average titre, 'concordant' not required if meaning clear.	1
	8	Calculates moles Cl_2 in titration from 0.5 × moles thiosulfate in titre and therefore concentration **AND** concentration of Cl_2 in mol dm^{-3} in aqueous chlorine. Allow any explanation which covers these points, calculations involving concentrations or moles to mass and concentration in g dm^{-3}, or any formula that would produce a correct answer e.g. mv / n = mv / n	1

Q# 16/ Describing Method ALvl Chemistry/2011/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

(c)	PLAN Methods	There are four different approaches, all of which share the first five marking points.	
		Use 7 number labelled ticks and crosses for these points.	
		(i) At least 5 experiments.	[1]
		(ii) Uses a range of at least 40°C.	[1]
		(iii) Pilot run to choose relative amounts of materials.	[1]
		(iv) Mass by balance. Water by measuring cylinder/pipette/ burette or mass of water by balance.	[1]
		(v) stirs	[1]
		Alternate 1	
		(vi) Heat mixture to dissolve all the solute.	[1]
		(vii) Cool and measure the temperature at which first crystals appear.	[1]
		OR Alternate 2	
		(vi) Heats mixture to a particular temperature.	
		(vii) Filters the solution (not cooled or decanted) and weighs the residue.	
		OR Alternate 3	
		(vi) Heats mixture to a particular temperature.	
		(vii) filters the solution (not cooled or decanted) and evaporates the filtrate and weighs solid.	
		OR Alternate 4	
		(vi) Heats mixture to dissolve the solute.	
		(vii) Records temperature at which the solute dissolves.	

Q# 17/ Describing Method ALvl Chemistry/2008/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

(c) Part 1	PLAN Methods	M5	A. Describes a sequential method for preparing the saturated solution using <u>all of the 60 cm^3 of distilled water</u>, and filtering off <u>**excess**</u> (stated or by implication) solid. (To ensure saturation mention should be made of stirring/leaving the solution for some time/heating and cooling back to the controlled temperature).	[1]
		M3	B. Describes a practical method of controlling temperature e.g. use of a water bath.	[1]
		M5	C. There are several methods of dealing with this experiment. This could involve (i) weighing a sample of solution, an appropriate method for evaporating the water, and weighing the residual solid; (ii) weighing the water/solution (60 cm^3) with excess solid, filtering and then weighing the residue.	[1]
			(Ignore as not relevant any suggestion of water /moisture on the residue or filter paper.)	
		M5	D. Shows how the mass of solid and water are converted to solubility. $\frac{\text{mass of solid (or figures)}}{\text{60/mass of water/eqn which gives mass}} \times 100$	[1]

Part 2	PLAN Methods	M1	E. An appropriate method for diluting the sulphuric acid described. (Measurement by any means of each volume – acid and water [any volumes are acceptable].)	[1]
		M5	F. Burettes (and graduated flasks) or other suitable precision apparatus used to measure volumes.	[1]
		M6	G. Four or more solutions with different concentrations prepared (the range should cover at least a fourfold increase in concentration e.g. 1M to 4M and at least one should be greater than 2.5M. 5M could be one of these). (This mark can be accessed from the table in **(e)**.)	[1]
		M6	H. Concentrations of the solutions specified <u>(minimum of three concentrations needed)</u> or relative volumes given (provided a minimum of 60 cm^3 of acid/solution is available).	[1]

Q# 18/ Describing Method ALvl Chemistry/2007/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 (e)	PLAN Methods	1. weighs a stated mass of named hydroxide. mass to be between 0.05 mol and 0.25 mol (See appendix) and candidate describes the weighing of the solid *(two possible methods)* (i) empty bottle/empty (plastic) cup; and bottle + solid/(plastic) cup + solid (ii) bottle + solid and bottle + residual solid	1
		2. measures between 50 cm^3 and 200 cm^3 of water and describes the measurement of the volume (measuring cylinder, burette, pipette) *(apparatus for measuring the water and the volume used may be shown in the diagram)* *(A larger or smaller volume of water can be accepted if it is related to a specified capacity container.* *e.g. 400 cm^3 water in 500 cm^3 beaker* *30 cm^3 water in 50 cm^3 beaker)*	1
		3. Initial and highest temperatures recorded	1
		4. Step by step procedure described **Minimum** steps required: Weigh solid, specified/measured volume of water and measured temperature rise	1

Q# 19/ Describing Method ALvl Chemistry/2023/s/TZ 2/ Paper 5/Q# 1/Smashing!!!

1(a)(i)	aqueous AND water has greater density (than ethoxyethane so it forms the lower layer)	1
1(a)(ii)	(10 cm^3) (volumetric) pipette	1
1(a)(iii)	the acid transfers / dissolves into the water (before titration / reaction with sodium hydroxide)	1
1(b)(iii)	it is not possible to pipette all (30 cm^3) of the aqueous layer from the beaker (as some will always be left behind)	1
1(b)(iv)	use a larger volume (>30cm^3) of water (in step 1)	1
1(b)(v)	K_{pc} value would be smaller / decrease AND because (equilibrium had not been attained and) more butanedioic acid remains in aqueous layer	1

Q# 20/ Describing Method ALvl Chemistry/2023/s/TZ 2/ Paper 5/Q# 3/Smashing!!!

3(a)	**M1** add (a small volume of) distilled water (to the 50 cm^3 beaker) **AND** dissolve the (aromatic diazonium) compound / solid **M2** transfer the solution and washings (using a funnel) **AND** into a 100 cm^3 volumetric flask **M3** make up to the (calibration) mark / line with (distilled) water **AND** then mix the solution (by inverting the flask)	3

Q# 21/ Describing Method ALvl Chemistry/2023/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2(a)	(not all) reactants may feature in the rate determining step OR order can only be determined experimentally	1
2(b)	M1 Dissolve the solid / potassium iodide (in the beaker) (using a small volume of) (distilled) water M2 Transfer / add to a (250 cm^3 volumetric) flask **AND** Rinse (with distilled water) M3 Top the 250 cm^3 volumetric flask up to mark (with distilled water)	3

Q# 22/ Describing Method ALvl Chemistry/2019/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1(a)(iii)	**M1** (pour using a funnel and) rinse the beaker with (distilled) water **M2** add (distilled) water dropwise near the mark	2
1(b)	the solution in the burette is at the expected concentration	1
1(c)	12.50 (cm^3)	1
1(d)(i)	step 4	1
1(d)(ii)	the recorded times are repeatable / the recorded times can be duplicated / the repeated times are close to one another	1
1(d)(iii)	0.5(00)%	1
1(d)(iv)	acid is in excess	1
1(d)(v)	**M1** independent: (relative) concentration of KI / (relative) concentration of I^- **M2** dependent: time (taken)	2

Q# 23/ Describing Method ALvl Chemistry/2016/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

(b)	(i)	**B** must be added before first or second reactant	[1]
	(ii)	the reactants are **A** and **C** so one of these must be mixed last; **or** the reaction must not start before all three substances are present;	[1]
(c)	(i)	(10 cm^3) pipette	[1]
	(ii)	**M1** $NaHCO_3$ will effervesce so when effervescence finishes it shows that all H^+ ions have been removed; **M2** NaOH will react with I_2 / CH_3COCH_3 / reactants;	[2]

(d)	(i)	**M1**
		mol $I_2 = (10/100) \times 0.200 \times (50/1000) = 1.(00) \times 10^{-3}$ mol;
		M2
		mol $S_2O_3^{2-} = 2 \times 1.00 \times 10^{-3} = 2.(00) \times 10^{-3}$ mol;
		M3
		volume 0.100 mol dm^{-3} $S_2O_3^{2-} = (1000 \times 2.00 \times 10^{-3}) / 0.100 = 20(.0) cm^3$;
			[3]

	(ii)	indicator = starch; colour change = blue-black to colourless;	[2]

(h)	(incorrect and) half-life will still be constant; **or** temperature has no effect upon order (of reaction);	[1]

Q# 24/ Describing Method ALvl Chemistry/2006/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

(b) Reward the following points (which are shown in the correct order):

a	Weigh the empty <u>tube</u> but **not** for taring the tube *Do not give this mark if for example an evaporating basin has been weighed and used for heating the sample*
b	Weigh the (tube) + mineral **or** Tared (tube) + mineral weighed **or** Known amount of mineral taken
c	Heat the mineral *Do not allow heating using a water-bath*
d	Cool and reweigh
e	(Continue heating and weighing) to constant mass (Reheating/reweighing twice can be accepted as heating to constant mass)

***Deduct one mark** from these potential five marks (no negative marks) for **any** of the following:*

- *(i) the points are not awarded in a correct practical sequence* ***or***
- *(ii) an unnecessary step (e.g. making a solution) has been introduced* ***or***
- *(iii) apparatus has been used at this stage to collect/measure/test the gas(es) given off.*

[5]

(d) Give **one mark** for any of the following:
- **(i)** measuring the volume of <u>carbon dioxide</u> evolved
- **(ii)** measuring mass of carbon dioxide and water vapour absorbed by soda-lime
- **(iii)** measuring mass of water absorbed by anhydrous calcium chloride, concentrated sulphuric acid or silica gel
- **(iv)** condensing water vapour and weighing the water collected

[1]

[Total for Question 2 10]

Q# 25/ Describing Method ALvl Chemistry/2012/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 (a) (i)	PLAN Problem	States that the moles of copper(II) hydroxide increase as the molar concentration of copper(II) sulfate increases and sketches a line from the origin with an initial positive gradient. Ignore any subsequent plateau or maximum on this line.	[1]
(ii)		A straight line terminating at the point of saturation with marked co-ordinates: award 2 marks.	[1]
		A straight line clearly terminating within the grid but without marked co-ordinates: award 1 mark.	[1]
		A line (not necessarily straight) which does not terminate at the saturation point but with the co-ordinates marked: award 1 mark. This line can plateau after the saturation point.	

(c)	PLAN Method	Indicates at least five experiments. These may be shown in the table in 1(e). Five blank rows in the table are acceptable.	[1]
		A range of concentrations over at least 0.8 mol dm^{-3}, which must cover 1.0 mol dm^{-3}, up to a maximum of 1.39. Accept a range of mass of copper(II) sulfate (with solution volume) that has been calculated satisfying the same concentration criteria.	[1]
		Filtering/centrifuging	[1]
		Method of drying and weighing the precipitate. Include washing with water (and propanone), (air) drying and weighing (to constant mass). Do not accept direct heating, blotting or a statement that the precipitate is simply left to dry.	[1]
		A suitable calculation of a molarity, even if greater than 1.39 (M_r of the copper(II) sulfate must be used). Check that the solution is made up to the appropriate volume and not that a mass is added to a fixed volume of water.	[1]

Q# 26/ Describing Method ALvl Chemistry/2023/s/TZ 2/ Paper 5/Q# 2/Smashing!!!

2(a)	the application of the hydrolysed samples (to the paper) is more controlled	1
2(b)	to make the amino acids / spots visible	1
2(c)	lysine, tryptophan and leucine two correct for one mark, three correct for two marks	2
2(d)	two (of the three) amino acids (that compose the tripeptide) are the same	1

Q# 27/ Standard Solutions ALvl Chemistry/2017/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2(b)(i)	0.0750×250 = **18.75** (g)	1
2(b)(ii)	dissolve the sucrose / mass of sucrose given in **2(b)(i)** / weighed mass in a stated volume of (distilled) water, less than 250 cm^3, or if not stated but then later made up to 250 cm^3 / up to the mark	1
	transfer solution to (a 250 cm^3) volumetric flask AND Make up the solution to the mark / flask volume with (distilled) water	1

2(c)(i)	$\left(\frac{0.0350}{0.0750} \times 15.00 = 7.00\,\text{cm}^3\right)$ Volume of standard solution = **7.00** (cm^3) Volume of distilled water = **8.00** (cm^3)	1
2(c)(ii)	burette / graduated pipette	1
2(c)(iii)	solution was more dilute than expected	1

Q# 28/ Standard Solutions ALvl Chemistry/2021/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2(a)	**M1:** (250 cm^3) volumetric flask **M2:** dissolve the solid / acid salt (1.89 g) (in the beaker) (using distilled) water **M3:** transfer / add to a (250 cm^3 volumetric) flask AND rinse (with distilled water) **M4:** top up to mark (with distilled water)	4

2(b)(vi)	**M1:** mol MnO_4^-(aq) = 0.0200 × 24.40 / 1000 = 4.88 × 10^{-4} (mol) **M2:** mol of $C_2O_4^{2-}$(aq) (in 25.0 cm^3) = M1 × 5 / 2 = 1.22 × 10^{-3} (mol) **M3:** mol of $C_2O_4^{2-}$(aq) (in solution A) = M2 × 250 / 25 = 1.22 × 10^{-2} (mol)	3

Q# 29/ **Standard Solutions** ALvl Chemistry/2020/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(a)(i)	= 0.200 × 250 / 1000 × 170.0 = 8.5 g	1
1(a)(ii)	**M1:** dissolve a known mass / mass in (a)(i)) / solid in (distilled water), less than 250 cm³ (if stated), (in a suitable container) **M2:** transfer / add the solution to a 250 cm³ volumetric / graduated flask (with washings) **AND** make up to the mark with (distilled) water.	2
1(b)	**M1:** number of moles $C_2O_4^{2-}$(aq) = 25 / 1000 × 0.200 = 0.005 moles **M2:** number of moles MnO_4^-(aq) = answer to (b)(i) × 2 / 5 = 0.002 moles **M3:** concentration = 0.002 moles × 1000 / 18.4 = 0.109 mol dm^{-3}	3

Q# 30/ **Standard Solutions** ALvl Chemistry/2015/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 **(a) (i)**	M10	$HCOO^-$(aq) ——> CO_2(g) + H^+(aq) + $2e^-$ MnO_4^-(aq) + $8H^+$(aq) + $5e^-$ ——> Mn^{2+}(aq) + $4H_2O$(l)	[1] [1]
(ii)	M6	Magnesium methanoate is 1.312 mol dm^{-3} [$HCOO^-$(aq)] = 2.624 mol dm^{-3}	[1] [1]
(iii)	M6	Use volumetric apparatus (to measure 5.0 cm³ / saturated (magnesium) methanoate solution). Make (the above) up to the mark (with water) in a 250 cm³ volumetric / graduated flask	[1] [1]
(iv)	M3/P4	H^+ is needed for the reaction with manganite Provided the acid is in excess / sufficient / enough, the volume does not matter	[1] [1]
(v)	M5	A **pale** pink colour	[1]
(vi)	M10	0.051 mol dm^{-3}	[1]
(vii)	M10	1.28 mol dm^{-3}	[1]

(d)	P3	**Precipitate is formed** / barium sulfate is **insoluble** / **insoluble product**	[1]

Q# 31/ **Standard Solutions** ALvl Chemistry/2014/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

(d) (i)	Any **two** of the following: Na^+, A^-, HA	1	**[1]**
(ii)	They will all have (nearly) the same concentration **OR** A^- > Na^+ > HA	1	
	Half of the HA has reacted with/been neutralised by / used up by the NaOH	1	**[2]**

(g)	Any appropriate error discussion e.g.: • many readings / measurements are taken each of which will have an error., • the H^+ from the water has been ignored, • no pH reading was taken at 15.00cm³, • H^+ is not exactly equal to A^- temperature varies during titration, • graph drawn by hand is not very accurate, • experiment not repeated.	1	**[1]**
		Total	**15**

Q# 32/ **Standard Solutions** ALvl Chemistry/2016/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(a)(i)	silver chromate(VI) / silver chromate $2Ag^+ + CrO_4^{2-} \rightarrow Ag_2CrO_4$ OR $2Ag^+ + K_2CrO_4 \rightarrow Ag_2CrO_4 + 2K^+$ OR $2AgNO_3 + K_2CrO_4 \rightarrow Ag_2CrO_4 + 2KNO_3$	1 1	2
1(a)(ii)	insoluble / solid barium chromate(VI) / barium chromate would form	1	1
1(a)(iii)	insoluble / solid barium sulfate is formed	1	1

1(c)(i)	Volumetric/graduated flask 250 cm^3 pipette (graduated) 25 cm^3 burette 50 cm^3		2

1(c)(ii)	Dissolve / stir / mix known mass / all of hydrated salt in (a container with) (distilled water) (Transfer / add to a) volumetric flask, make to mark (with distilled water) or to the volume of the stated volumetric flask (in 1(c)(i) or 1(c)(ii)) NOTE: Water must be mentioned at least once for one mark to be awarded. Distilled/deionised/purified water must be mentioned for 2 marks to be awarded.	1 1	2
1(c)(iii)	first = sulfuric acid second = potassium chromate(VI) third = silver nitrate	1	1

Q# 33/ **Standard Solutions** ALvl Chemistry/2022/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(a)	number of moles NaC*l* = $\frac{250.0}{1000}$ × 0.200 = 0.05(00) mass of sodium chloride = 0.05(00) × (23.0 + 35.5) = 2.925 g	1
1(b)	(measure mass of weighing boat containing sodium chloride before transfer, **then**) measure the mass of weighing boat (and residue) (after transfer).	1
1(c)	**M1** add a (small) volume of distilled water (to the small beaker) **AND** dissolve the sodium chloride **M2** transfer the solution and washings into a 250 cm³ volumetric flask **AND** make up to the mark with distilled water	2

1(d)(i)	**M1** *Extra step* wash the precipitate / residue (with cold distilled water) ^{a} OR reheat (and reweigh) until mass is constant ^{b} OR rinse the beaker into filter (washings) ^{c} OR filter solution again ^{d} **M2** *Explanation* to remove (unreacted) sodium chloride and/or lead compound ^{a} OR to ensure all water has been removed from the solid ^{b} OR to ensure all solid/ppt has been transferred into the filter ^{c} OR to collect any precipitate that passed through the filter paper first time ^{d}	2

Q# 34/ **Standard Solutions** ALvl Chemistry/2019/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(b)(i)	(Prevents) reaction of Cu^{2+} with I^- OR (prevents) formation of CuI / Cu^+ / copper(I) OR (prevents) oxidation of I^- (to I_2) by Cu^{2+}	1
1(b)(ii)	I^- is oxidised (to I_2) in acidic solution	1
1(b)(iii)	2A	1
1(c)(i)	1.0 × 250.0 / 1000 × 294.0 = 73.5 (g)	1
1(c)(ii)	**M1:** Dissolve / make a solution in (beaker) in (small volume of distilled water) **M2: Add / transfer solution** to a <u>250 cm³</u> <u>volumetric flask</u> **M3:** Make to mark of (volumetric) flask with distilled water and the washings	3
1(d)	**M1:** titres are not concordant **M2:** repeat titration **until concordant titres are obtained** OR improved valid experimental technique	2

Q# 35/ **Standard Solutions** ALvl Chemistry/2019/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(b)(i)	100 / 1000 □ 0.200 = 0.020 moles Volume of 0.500 mol dm^{-3} = 0.020/0.500 = 40(.0) cm^3	1
1(b)(ii)	**M1** Transfer 40.0 cm^3 of 0.500 mol dm^{-3} solution into a (100.0 cm^3) volumetric flask using a burette	1
	M2 Make up to the <u>**mark / line**</u> with **distilled** water. (Stopper and shake).	1

Q# 36/ **Standard Solutions** ALvl Chemistry/2022/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2(a)(i)	solution of known concentration	1
2(a)(ii)	M1: measure 28.55 cm^3 of CH_3COOH M2: using burette / graduated pipette M3: (transfer/add CH_3COOH to) a 250 cm^3 volumetric flask M4: top the (volumetric) flask up to (250 cm^3) mark with distilled water	4

Q# 37/ **Standard Solutions** ALvl Chemistry/2023/s/TZ 2/ Paper 5/Q# 3/Smashing!!!

3(a)	**M1** add (a small volume of) distilled water (to the 50 cm^3 beaker) **AND** dissolve the (aromatic diazonium) compound / solid **M2** transfer the solution and washings (using a funnel) **AND** into a 100 cm^3 volumetric flask **M3** make up to the (calibration) mark / line with (distilled) water **AND** then mix the solution (by inverting the flask)	3

Q# 38/ **Standard Solutions** ALvl Chemistry/2023/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2(b)	M1 Dissolve the solid / potassium iodide (in the beaker) (using a small volume of) (distilled) water M2 Transfer / add to a (250 cm^3 volumetric) flask **AND** Rinse (with distilled water) M3 Top the 250 cm^3 volumetric flask up to mark (with distilled water)	3

Q# 39/ **Standard Solutions** ALvl Chemistry/2022/w/TZ 1/ Paper 5/Q# 3/Smashing!!!

3(b)	burette	1
3(c)	(changing) the temperature (of the reagents) will affect the rate of reaction (so it must be kept constant)	1
3(d)	**M1:** measure (a volume of) 1 $moldm^{-3}$ sulfuric acid using a <u>burette</u> into a <u>volumetric flask</u> **AND** make up to the (calibration) mark with **distilled** water	1
	M2: (0.15 × a) cm^3 of 1 mol dm^{-3} sulfuric acid is measured to make up a cm^3 (of the diluted solution)	1

Q# 40/ **Standard Solutions** ALvl Chemistry/2019/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1(a)(i)	**M1** moles needed 0.100 □ 250 / 1000 = 0.025(0) mol **M2** M1 □ 166.0 = 4.15 g	2
1(a)(ii)	(Re)weigh the empty weighing boat (and the difference should be 4.15 g)	1
1(a)(iii)	**M1** (pour using a funnel and) rinse the beaker with (distilled) water **M2** add (distilled) water dropwise near the mark	2
1(b)	the solution in the burette is at the expected concentration	1
1(c)	12.50 (cm^3)	1

Q# 41/ **Standard Solutions** ALvl Chemistry/2017/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2(a)(i)	**M1** mol of $Fe(NO_3)_3.9H_2O$ needed = 0.05 × 100/1000 = 0.005(00) mol	1
	M2 0.0005 × 403.8 = 2.02 g	1
2(a)(ii)	**M1** *dissolving of solid / making of a solution* dissolve (2.02 g / answer to **2(a)(i)** of) hydrated salt in (a container with) distilled water / less than 100 cm^3 of water	1
	M2 *making it into a standard solution* (transfer / add to) a (100 cm^3) volumetric flask; make to mark(with (distilled) water) (and shake)	1

Q# 42/ Drawing Apparatus ALvl Chemistry/2004/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

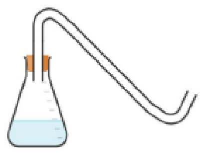
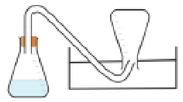
2

(a) Give **one mark** if the apparatus drawn is suitable for the reaction of lithium with water and the collection of gas. *Do not allow delivery tubes etc to pass through apparatus.*
In assessing apparatus consider "Could it be set up with real apparatus?" "Would it work?"

Give **one further mark** if the apparatus drawn or named in the diagram is suitable for measuring the volume of gas collected.
An unnamed gas syringe or inverted measuring cylinder must show graduations in the diagram to score this mark.
No graduations need be drawn if the apparatus has been correctly labelled.

[2]

Q# 43/ **Drawing Apparatus** ALvl Chemistry/2022/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

2(a)	(wear) chemically resistant gloves.	1
2(b)(i)	**M1** leakproof apparatus capable of delivering a sample of gas (for collection over water) 	1
	M2: a suitable collection vessel filled with water **correctly positioned** in a water containing trough to collect the gas (via delivery tube) 	1
2(b)(ii)	do not collect the first gas to be delivered	1

Q# 44/ Drawing Apparatus ALvl Chemistry/2018/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1(a)	Surrounding vessel of polystyrene / styrofoam / plastic containing water **and** Ice within the cooling mixture	1

Q# 45/ Drawing Apparatus ALvl Chemistry/2015/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

(c)	Place water / oil / sand within the outer VM tube **AND** heat the outer tube	**[1]**
	Shows appropriate connections to collect the air over water / in syringe (any size) using the side tube	**[1]**

Q# 46/ Drawing Apparatus ALvl Chemistry/2021/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1(a)	1 °C	1
1(b)	**M1:** diagram of labelled polystyrene cup in a beaker **AND** containing labelled aqueous copper(II) sulfate **M2:** diagram of free-standing labelled thermometer with bulb clearly within the solution	2

Q# 47/ Drawing Apparatus ALvl Chemistry/2017/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(a)	diagram of a labelled insulated container containing a liquid	1
	labelled timing device and a labelled thermometer in / touching the liquid	1

Q# 48/ Drawing Apparatus ALvl Chemistry/2012/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

(d)	PLAN Method	Diagram shows a heated piece of apparatus containing some lead oxide with hydrogen passing over it with inlet and outlet shown.	[1]
		Diagram shows apparatus to generate hydrogen using Mg/Al/Zn/Fe **AND** any dilute acid (labelled) **OR** group 1 metal/alcohol **OR** Ca with water or dilute acid.	[1]
		Shows excess hydrogen being burned **OR** led away from apparatus/collected.	[1]

Q# 49/ Drawing Apparatus ALvl Chemistry/2006/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

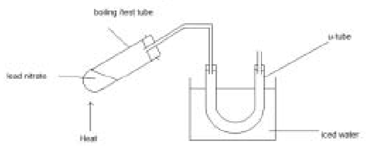
ASSESSMENT OF PLANNING SKILLS.

(a) Give **one mark** if the apparatus is suitable for: heating and reducing the copper oxide in a stream of hydrogen gas.

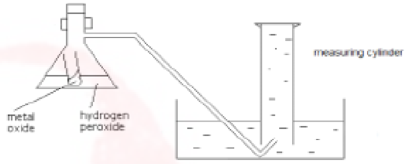
Give **one mark** for "real apparatus" that:
is capable of being disconnected to weigh oxide/copper and water *(Ignore any chemical included to absorb condensate)*;
shows how the steam is condensed to water.

Give **one mark** for a suitable means of burning excess hydrogen at the end of the apparatus. **[3]**

Q# 50/ Drawing Apparatus ALvl Chemistry/2020/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2(a)	 **M1** Heating a tube containing lead nitrate. Labels: Lead nitrate AND Heat A Bunsen for heat **M2** Use of iced water for cooling an unsealed collection vessel Labels: Iced water A Cold water	2

Q# 51/ Drawing Apparatus ALvl Chemistry/2021/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(c)	correctly drawn diagram showing:  **M1:** contents of flask **M2:** sealed apparatus **M3:** collection of the gas in a measuring cylinder (graduations assumed) (via a delivery tube into water) / gas syringe	3

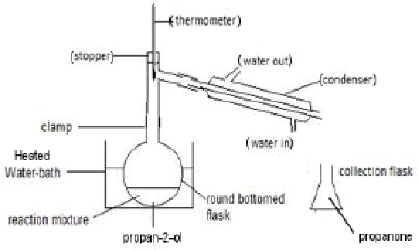
Q# 52/ Drawing Apparatus ALvl Chemistry/2016/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 (a)	lithium and water being labelled in an arrangement that shows them coming into contact at some time	[1]
	gas syringe OR collection over water, both using a leak-proof connection to the reaction vessel that would collect gas **after** the reagents have been mixed	[1]
	a valid separation of the two reagents	[1]

Q# 53/ Drawing Apparatus ALvl Chemistry/2019/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2(a)	$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$	1
2(b)(i)	**M1** (buchner) funnel (with filter paper) **M2** sealed with a cork around the funnel	2

Q# 54/ Drawing Apparatus ALvl Chemistry/2019/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2(a)(ii)	 Marks awarded for correctly labelled diagram showing the following: ☐ Thermometer in the correct position ☐ Condenser showing coolant ☐ Sealed apparatus around the round bottomed flask and thermometer. No seal around collection flask. **Three points shown, award 2 marks** **Two points shown, award 1 mark** **Propan-2-ol and propanone in correct locations, award 1 mark**	3
2(a)(iii)	Propan-2-ol is flammable AND should not be heated directly / keep away from a naked flame / Bunsen burner	1

Q# 55/ Drawing Apparatus ALvl Chemistry/2013/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

(c)	Diagram shows a container labelled with its capacity (between 25 cm³ and 250 cm³) and with the thermometer in a solution.	1
	The apparatus is insulated and has a lid.	1
	Thermometer range must include 25 °C and with a precision of between 0.1°C and 0.5°C.	1

Q# 56/ Drawing Apparatus ALvl Chemistry/2007/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

Question	Sections	Indicative material	Mark
1 (c)	PLAN Methods	Apparatus diagram showing (insulated) container and thermometer. *Non-insulated beaker is acceptable. (Do **not** give this mark if there is a Bunsen or a water bath)*	1
	ACE Evaluation	Give **one mark** for any <u>**two**</u> of the following; **1.** solid absorbing water vapour, **2.** heat loss from apparatus, *(accept open cup/calorimeter)* *(conduction, convection and radiation are treated as separate errors)* **3.** loss of material – *solution overflows or spray*, **4.** inaccurate temperature measurement, **5.** small temperature rise. *Do **not** give this mark for reference to laboratory temperature or draughts in the laboratory.*	1
	PLAN Methods	Give **one mark** for any <u>**two**</u> of the following - <u>if linked to the source of error above;</u> **1.** keep weighed solid in closed container **or** use as soon as weighed *(not kept under oil or in a vacuum)* **2.** practical improvement to insulation, **3.** larger container or smaller quantities used, *(accept use of lid <u>for minimising spray</u>)* **4.** more accurately <u>calibrated</u> thermometer, **5.** use larger mass of the hydroxide **or** smaller volume of water. *(Give one of these two marks for one error and step to minimise the error)*	1

Q# 57/ Drawing Apparatus ALvl Chemistry/2018/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(a)	Complete circuit with ammeter in series and DC power supply	1
	Anode, cathode and solution labelled	1

Q# 58/ Drawing Apparatus ALvl Chemistry/2021/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

2(a)	**M1** Addition of solid and acid must not lead to initial escape of gas from sealed system or produce excess volume measurement leading to a false volume reading e.g. Adding acid to solid already in the flask or vice versa. **M2** Allow any **leakproof** apparatus capable of delivering a sample of gas into one collection vessel over water. **M3** A vertical inverted measuring cylinder or burette filled with water positioned to collect the gas (via delivery tube).	3

Q# 59/ Drawing Apparatus ALvl Chemistry/2018/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2(a)	Water bath/beaker of water containing thermometer around flask	1
	Controlled heat source or heater/temperature regulator	1

Q# 60/ Drawing Apparatus ALvl Chemistry/2014/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

(b) (i)	Directly heated vessel labelled (magnesium) nitrate(V) with tube at exit	[1]
	Gas stream led into a liquid labelled alkali which will absorb the nitrogen(IV) oxide / NO_2	[1]
	Collects a gas in a syringe or over a liquid, provided it is properly connected	[1]
	All parts of the apparatus are connected and air-tight **AND** nitrogen(IV) oxide absorption precedes oxygen collection.	[1]

Q# 61/ Drawing Apparatus ALvl Chemistry/2011/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

(c)	PLAN Methods	Diagram to show only experimental setup	
		(i) Any suitable closed container and heat (no baths).	[1]
		(ii) Syringe labelled with the volume ($10\,cm^3$ to $1000\,cm^3$). Or inverted measuring cylinder/burette ($10\,cm^3$ to $1000\,cm^3$). Must be calibrated.	[1]

Q# 62/ Drawing Apparatus ALvl Chemistry/2009/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

(c)	PLAN Methods	Give one mark for a suitable apparatus for heating the solid to effect decomposition. Heating needs to be present and labelled but the word 'heat' with or without an arrow is sufficient. The use of a water-bath negates.	[1]
		Give a second mark for apparatus to collect and measure the volume of the gas. The volume of the apparatus must be given. (Maximum volume 5 dm^3). If a gas jar or test tube is used, it must be graduated, even if its total volume is given. Deduct one mark if these two criteria are fulfilled but the two items of apparatus are not connected. If there is a further item of apparatus between the heating and collection it must work otherwise treat it as a 'no connection'.	[1]
		Allow gases from both equations or a chosen one consistent with dry or wet conditions. i.e. O_2 alone or a mixture of O_2/NO_2 justified for apparatus used and the equation chosen. If the gas is collected over water, only O_2 is acceptable. This mark depends on there being a gas collection device.	[1]

Q# 63/ Drawing Apparatus ALvl Chemistry/2002/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 **Assessment of Planning Skills**

(a) **Give one mark** for a diagram showing apparatus suitable for heating caesium nitrate, collecting and measuring the volume of gas given off.

Heating		*Collection*	
test-tube	✓	(gas)-syringe	✓
boiling-tube	✓	inverted measuring cylinder full of water	✓
combustion-tube	✓	inverted burette full of water	✓
round-bottomed flask**	✓	eudiometer	✓
beaker**	✗	uncalibrated gas jar	✗
		uncalibrated test-tube/boiling-tube	✗

** **Do not accept any apparatus that has sharp corners**

Do not give this mark if the collection apparatus is inverted and full of water but shows no graduations **unless** it has been correctly labelled. **No mark** should be given if solution or solid + water is heated.

Give **one mark** for correctly labelling the **apparatus and** indicating the volume of apparatus used **to collect the gas**, e.g. 100 cm^3 gas syringe, 250 cm^3 measuring cylinder.

2

Q# 64/ Error ALvl Chemistry/2005/s/TZ 1/ Paper 5/Q# 3/Smashing!!!

3 **ANALYSIS AND EVALUATION**

(a) Give one mark if errors of the appropriate size are indicated for the thermometer used.

-10 °C to 110 °C by 1 degree	Error (±) 0.5 °C
0 °C to 50 °C by 0.5 degree	Error (±) 0.25 °C
0 °C to 50 °C by 0.2 degree	Error (±) 0.1 °C

Units are not required.

The answer given must relate to the graduations given on page 4. [1]

(b) Give **one mark** for an answer that indicates the acid is in excess (precise measurement of volume not necessary). **[1]**

(c) Give **one mark** for need to saturate the acid with carbon dioxide before carrying out the experiment or similar argument.

Give **one mark** for answers such as:
to ensure that all the CO_2 produced is collected/measured, **or**
so that all the CO_2 liberated will be from the X_2CO_3, **or**
so that no more CO_2 dissolves (in the acid) during the experiment **or**
explaining that a reduction in the mass of carbon dioxide evolved or volume of carbon dioxide collected will lead to a higher inaccurate value of M_r or A_r. **[2]**

(d) For **each** major error identified:

Give **one mark** for stating the nature of the error **(E mark)**.

This mark is given for identifying any deficiency/variable that will have an influence on the calculated value of M_r.
e.g. Solubility of CO_2 in water/temperature changes alter the volume of gas collected.

Give **one mark** for indicating a suitable method of eliminating the error **(M mark)**.

This mark is for a **practical** way of rectifying the deficiency/keeping the variable constant.
e.g. Collect the gas in a gas syringe/use of a water bath to control temperature.

Give **one mark** for explaining how the error will be eliminated/reduced **by the method selected (P mark)**.

This mark must be for an explanation based on the **method selected**.
e.g. No water involved in collection to dissolve the gas/knowing the temperature pV=nRT can be used in calculating moles of gas.

Some candidates may miss the idea of saturating the HC*l* with CO_2 in test (c) but give an error in (c) that would score one or more marks from section (d).
These marks may be awarded unless the same error has been repeated on page 10.

If the idea of saturating the acid with CO_2 is given on p10 rather than on p8 the marks can be awarded retrospectively.

The three marks in each section may be found at any point in a candidate's answer.

The error will often be found within the explanation.

Annotate each mark as shown in the table which lists some possible answers.
Other acceptable answers that meet the criteria above may be seen.

	Error **✓E**	**Method** **✓M**	**Explanation** **✓P**
1	Loss of gas at start of experiment	Carbonate placed inside flask before mixing *If dropping funnel used…*	Sealed system Needs to compensate for acid added
2	Poor measurement of volume using measuring cylinder	Replace cylinder with burette or gas syringe	Greater accuracy of scales
3	Solubility of CO_2 in (collecting) water	Use gas syringe to collect the gas	No water in collecting apparatus
		Raise temperature of the water in the trough	Solubility of CO_2 decreases at higher temperatures
		Use an alternative solvent	CO_2 insoluble in the solvent
		Saturate (collecting) water with CO_2	*All of gas collected as no more can dissolve*
4	Gas collected in measuring cylinder is not at atmospheric pressure	Equalise water levels inside and outside of measuring cylinder	Read volume at atmospheric pressure
5	*Gas collected contains water vapour*	*Dry gas (but must not then be collected over water)*	Suitable drying agent suggested *(even if dried and collected over water)*
		Use gas syringe to collect the gas	*No water in collecting apparatus*
6	*water contained in gas or vapour pressure of water varies with temperature*	Lower temperature	
		Control temperature - *appropriate method described*	Make adjustment for svp to pressure of gas for controlled temperature
7	Gas collected contains water vapour which contributes to the gas pressure	Correct for pressure for svp or Use a solvent with low vapour pressure	(Temperature and) pressure readings necessary and correction from table
8	Volume of gas varies with changes in pressure	Need to measure temperature of water bath and atmospheric pressure	Moles of gas calculated using pV=nRT
9	Volume of gas varies with changes in temperature or Temperature not known/measured	Use a constant temperature water bath	Apply pV=nRT
10	Solid is damp or Reference to 0.35% water from the assay	Dehydrate/heat the solid	Lower volume of CO_2 or too great a mass if not dried
11	CO_2 is a non-ideal gas	Use modified gas equation	
12	Solubility of carbon dioxide in water varies with temperature	Maintain a constant temperature - *appropriate method described*	Use data to obtain to correct for dissolved carbon dioxide at the constant temperature
13	Reference to the solid only being 99% pure. The purity must be quoted from the assay		Explaining: that carbonate impurities would increase carbon dioxide or unreactive components reduce carbon dioxide

2 x [3]

[Total: 10]

[Total for Paper: 30]

Q# 65/ Error ALvl Chemistry/2022/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1(e)(ii)	*If value of x in 1(e)(i) is above 5:* $CuSO_4$ must have decomposed / crystals were wet before heating / some crystals were lost when heated (e.g. during spitting) / impurity that decomposes or evaporates *If value of x in 1(e)(i) is below 5:* did not heat it enough / not all water driven off / unreactive impurity	1
1(f)	[(2 × 0.005) / 13.60] × 100 = 0.0735 (%)	1

Q# 66/ Error ALvl Chemistry/2010/s/TZ 1/ Paper 5/Q# 3/Smashing!!!

(e)	ACE Evaluation	Suggests the crucible lid has been omitted when weighing the magnesium oxide, OR different lid. Not loss of oxide since end mass < start mass.	[1]
(f)	ACE Evaluation	Magnesium must have reacted with nitrogen. Accept forms magnesium nitride.	[1]

Q# 67/ Error ALvl Chemistry/2021/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1(e)(i)	no change / effect AND zinc is (already) in excess	1
1(e)(ii)	(heat loss) increases AND increased energy output / temperature rise OR more exothermic change occurs	1
1(e)(iii)	no change / effect AND twice the energy output nullified / cancelled out by twice the volume of water to be heated	1

Q# 68/ Error ALvl Chemistry/2020/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(b)	one of: • Use a polystyrene cup instead of the glass beaker / insulate the glass beaker / use a dewar flask • Cover the beaker with a lid • Insulate the glass beaker	1
1(c)	The experiment must not be performed near any naked flames OR Use an electric heater	1
1(d)	Use a burette / graduated pipette instead of a measuring cylinder OR Use larger volumes of liquids OR Use a more accurate thermometer	1

Q# 69/ Error ALvl Chemistry/2017/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1(f)	weighing by mass difference ensures that the exact mass of solid transferred is known	1
1(g)(i)	(0.5/50 × 100) = 1%	1
1(g)(ii)	HC*l* is in excess	1
1(g)(iii)	decrease the volume of HC*l* (aq) used OR increase the mass of the Na_2CO_3 used	1

Q# 70/ Error ALvl Chemistry/2016/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

(f)	(i)	((2 × 0.0005) / 0.391) × 100 = 0.256% **and** (0.05 / 40.0) × 100 = 0.125%;	[1]
	(ii)	(total) errors in weighing do not account for the (large) error in enthalpy change determined; **or** heat loss (is more significant);	[1]

Q# 71/ Error ALvl Chemistry/2021/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2(a)(ii)	(2 × 0.005 / 1.58) × 100 = 0.63%	1
2(a)(iii)	rinse the solid off the weighing boat into the beaker OR weighing the mass directly into the beaker OR (re)-weigh the weighing boat after transferring the $KMnO_4$ into the beaker	1
2(a)(iv)	*Any two from:* stir / agitate / mix (to ensure that the solid has dissolved) rinse the beaker and transfer the washings shaking / inverting / homogenising of volumetric solution	2
2(b)(i)	rinse / run through / wash the burette with some of the $KMnO_4$ solution OR run some of the $KMnO_4$ solution from the burette to fill to the tip	1
2(b)(ii)	add the $KMnO_4$ dropwise (near the end point)	1
2(c)(i)	the $Fe^{2+}(aq) / Fe^{3+}(aq)$ mixture measured using a measuring cylinder AND leads to increased likelihood of non-concordant titres	1
2(c)(ii)	(measure the volume) using a (volumetric / 25 cm^3) pipette	1

Q# 72/ Error ALvl Chemistry/2020/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1(g)(ii)	$\left[\frac{(0.05 \times 2)}{19.90}\right] \times 100 = 0.503\%$ working must be shown	1
1(g)(iii)	increase mass of brass OR decrease concentration of $Na_2S_2O_3(aq)$	1

Q# 73/ Error ALvl Chemistry/2015/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

(e)	(i)	Loss of heat (to the surroundings) Greater temperature gradient **OR** the reaction is slower **OR** (rate of) heat loss is greater	[1] [1]
	(ii)	Give polystyrene cup a lid or cover / use a finer powder	[1]

Q# 74/ Error ALvl Chemistry/2014/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

(g)	Any appropriate error discussion e.g.: • many readings / measurements are taken each of which will have an error., • the H^+ from the water has been ignored, • no pH reading was taken at 15.00cm^3, • H^+ is not exactly equal to A^- temperature varies during titration, • graph drawn by hand is not very accurate, • experiment not repeated.	1	[1]
		Total	**15**

Q# 75/ Error ALvl Chemistry/2017/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(c)(ii)	repeat the experiment (and take average)	1
1(c)(iii)	% error= $\frac{2 \times 0.05}{5.0}$ × 100% = 2(.0) %	1

1(d)	No thiosulfate had been added	1

Q# 76/ Error ALvl Chemistry/2007/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 (e)	ACE Conclusions	Identifies as a further source of error **one** of the following – and gives an <u>appropriate</u> method of reducing the error; 1. gas collected before timing starts **or** gas pushed into syringe when bung inserted – **if not already given in (d)**, 2. use of 500 cm^3 measuring cylinder to measure 100 cm^3 of acid, 3. 0.01 g of magnesium weighed on a balance weighing to 2 decimal places. 4. loss of gas before the bung is inserted	1

Q# 77/ Error ALvl Chemistry/2014/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

(c)	Heat (the hydroxides) To constant mass	1 1	**[2]**

(f)	The mass/amount/percentage of copper is small	1	**[1]**

Q# 78/ Error ALvl Chemistry/2019/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2(c)(i)	warm / heat to constant mass	1

2(c)(iv)	increase because tap water contains chloride ions	1

Q# 79/ Error ALvl Chemistry/2022/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(b)(i)	stir (when solid is mixed with water) OR increase temperature (of water) OR increase state of division of the (solid) mixture	1
1(b)(ii)	to remove magnesium nitrate / (excess) silver nitrate (from the precipitate before drying)	1
1(b)(iii)	(It is dried in an oven) to avoid (thermal) decomposition (of silver chloride / precipitate / solid)	1
1(c)(i)	((2 × 0.005) / 1.52) × 100 (= 0.66%) (0.6578947) correct working **must** be shown along with correct answer. answer to at least **1SF**	1
1(c)(ii)	use a larger mass of solid (mixture).	1
1(c)(iii)	(continue drying and) reweigh until mass remains constant	1

1(d)	the (measured) mass / amount (of '$AgCl$' / solid / precipitate) would be greater (than the true value) **AND** the % by mass (of $MgCl_2$ in the sample) would be greater (than the true value)	1

Q# 80/ Error ALvl Chemistry/2022/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(d)(i)	**M1** ***Extra step*** wash the precipitate / residue (with cold distilled water) ᵃ OR reheat (and reweigh) until mass is constant ᵇ OR rinse the beaker into filter (washings) ᶜ OR filter solution again ᵈ **M2** ***Explanation*** to remove (unreacted) sodium chloride and/or lead compound ᵃ OR to ensure all water has been removed from the solid ᵇ OR to ensure all solid/ppt has been transferred into the filter ᶜ OR to collect any precipitate that passed through the filter paper first time ᵈ	2
1(d)(ii)	$\frac{2\times0.05}{10}\times100$ = 1(.0%) correct working **must** be shown	1
1(d)(iii)	repeat the experiment and/or compare with results from other students **AND** consistent results are obtained	1

1(g)	**investigation 1** repeat measurement (of height of precipitate) until it is constant OR leave (for a longer time) until height of precipitate is constant (before measuring) **investigation 2** use a smaller volume of lead compound (in each case) OR add larger volumes of sodium chloride (until it is in excess)	2

Q# 81/ Error ALvl Chemistry/2018/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(h)	(Faraday) value is smaller AND (apparent) mass / moles / amount is more (for same charge passed)	1
1(i)	CuO is formed / oxidation of copper / carbon / soot is formed	1
1(j)	Some copper falls off the electrode during electrolysis / falls to the bottom of the beaker OR Some copper is lost during washing	1

Q# 82/ Error ALvl Chemistry/2017/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

2(g)	No effect at cathode	1
	Less gas produced at anode	1
	Copper anode will dissolve / is (an) active (anode) OR copper has lower / more negative E$^⦵$	1

Q# 83/ Error ALvl Chemistry/2023/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2(c)(i)	Repeat the experiment to show the results are reproducible.	1

2(d)(v)	percentage error of experimental value = (2(d)(iv) – 1.00) / 1.00] × 100 *(assuming 2(d)(iv) is 1.10)* = [(1.10 – 1.00) / 1.00] × 100 = 10% (10% > maximum percentage error / 5.25%) **AND** other factors (beyond measurement caused the error)	1

Q# 84/ Error ALvl Chemistry/2019/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1(b)	the solution in the burette is at the expected concentration	1
1(c)	12.50 (cm³)	1
1(d)(i)	step 4	1
1(d)(ii)	the recorded times are repeatable / the recorded times can be duplicated / the repeated times are close to one another	1
1(d)(iii)	0.5(00)%	1
1(d)(iv)	acid is in excess	1

Q# 85/ Error ALvl Chemistry/2018/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(c)(v)	**M1** (Recording / determining) the time when opaque / cross disappears **M2** dilute the solution (to give a longer time)	2

Q# 86/ Error ALvl Chemistry/2021/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(b)(i)	Mass of $KHCO_3$ = 2.503 g AND Mass of K_2CO_3 = 3.455 g	1
1(b)(ii)	$= \frac{2 \times 0.0005 \times 100}{2.503} = 0.04(00)\%$ Correct working **must** be shown	1

1(e)	Any two from: • Heat loss OR heat gain (to / from surroundings) • Amount of solid not exactly 0.0250 moles • Experiment not carried out under standard conditions.	2

1(f)	Add a lid to the polystyrene cup.	1
1(g)	Burette.	1

Q# 87/ Error ALvl Chemistry/2013/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

2 (a)

F D–C / g	G C–B / g	H solubility [(F × 100)] / G / g/ 100 g
1.25	25.00	5.00
1.25	20.00	6.25
5.00	25.00	20.00
7.76	19.40	40.00
11.11	23.00	48.30
11.75	25.00	47.00
9.62	21.00	45.81
9.10	20.00	45.50
11.25	25.00	45.00
13.35	30.00	44.50

Heading for final column calculating the solubility is given correctly with units.	1
All data is to 2 decimal places. Allow 1 error.	1
Data in final column is correct. Allow 1 error in computation.	1

(e)	Solubility is 47.6 (g / 100g) 1.2% **OR** 1.21% **OR** 1.28% **OR** 1.3%	1 1

Q# 88/ Naming Apparatus ALvl Chemistry/2022/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

1(a)	allow (crucible / contents) to cool	1
1(b)	to prevent spitting of crystals	1
1(c)	pipe-clay triangle	1
1(d)	heat to constant mass	1

Q# 89/ Naming Apparatus ALvl Chemistry/2021/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2(a)	**M1:** (250 cm³) volumetric flask **M2:** dissolve the solid / acid salt (1.89 g) (in the beaker) (using distilled) water **M3:** transfer / add to a (250 cm³ volumetric) flask **AND** rinse (with distilled water) **M4:** top up to mark (with distilled water)	4
2(b)(i)	to ensure that (exactly) 25.0 cm³ of solution has been delivered into the flask	1
2(b)(ii)	measuring cylinder	1
2(b)(iii)	difficult to see the 0.00 cm³ line	1
2(b)(iv)	(two) titres / readings within 0.1(0) (cm³) of each other	1

2(b)(v)	colourless to pale purple	1

Q# 90/ Naming Apparatus ALvl Chemistry/2020/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(c)(v)	to provide H^+ ions / protons for the titration OR To prevent (hydrolysis of) Fe^{2+} producing a precipitate	1
1(d)	measuring cylinder, as the acid is in excess / accuracy of the measurement is not important	1

Q# 91/ Naming Apparatus ALvl Chemistry/2020/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2(c)(i)	Thermostatically controlled water bath	1

Q# 92/ Naming Apparatus ALvl Chemistry/2022/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(b)	(measure mass of weighing boat containing sodium chloride before transfer, **then**) measure the mass of weighing boat (and residue) (after transfer).	1

Q# 93/ Naming Apparatus ALvl Chemistry/2019/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(a)(ii)	heat solid again (and allow to cool) **AND** (to) constant mass	1

Q# 94/ Naming Apparatus ALvl Chemistry/2019/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(a)	P = Voltmeter Q = Salt bridge Conc = 1(.00) mol dm^{-3}	1
1(g)	The equilibrium between the metal and its ions moves to produce more Mn^{2+} or electrons / more reaction Mn → $Mn^{2+} + 2e^-$ / the tendency to ionise / oxidise increases.	1

Q# 95/ **Naming Apparatus** ALvl Chemistry/2018/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

2(a)(i)	Temperature / thermostatically controlled water bath	1
2(a)(ii)	water may evaporate / [Ag$^+$] will change	1

2(d)(ii)	burette	1

2(f)	**M1** Potassium chloride AND / OR sodium chloride **M2** Chloride ions would form a precipitate with Ag$^+$ ions / reduce [Ag$^+$] concentration	1

Q# 96/ **Naming Apparatus** ALvl Chemistry/2022/w/TZ 1/ Paper 5/Q# 3/Smashing!!!

3(a)(i)	description of a (clock) method to measure the time taken for a particular amount of product (Br_2) to be produced	1
3(a)(ii)	X = 1, Y = 1 and Z = 2 all 3 correct = ✓✓ 2 correct = ✓ 1 or 0 correct = ×	2
3(b)	burette	1
3(c)	(changing) the temperature (of the reagents) will affect the rate of reaction (so it must be kept constant)	1
3(d)	**M1:** measure (a volume of) 1 moldm^{-3} sulfuric acid using a <u>burette</u> into a <u>volumetric flask</u> **AND** make up to the (calibration) mark with **distilled** water	1
	M2: (0.15 × a) cm^3 of 1 mol dm^{-3} sulfuric acid is measured to make up a cm^3 (of the diluted solution)	1

Q# 97/ **Naming Apparatus** ALvl Chemistry/2022/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2(a)(i)	thermostatically controlled water bath	1
2(a)(ii)	flammable substance(s) are used (in the experiment)	1
2(b)(i)	(50 cm^3) burette	1
2(b)(ii)	10(.00) cm^3 (volumetric) pipette	1
2(c)	reduces the reaction rate (of hydrolysis reaction) OR quenches the reaction	1

Q# 98/ **Naming Apparatus** ALvl Chemistry/2017/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2(a)(ii)	**M1** *dissolving of solid / making of a solution* dissolve (2.02 g / answer to **2(a)(i)** of) hydrated salt in (a container with) distilled water / less than 100 cm^3 of water	1
	M2 *making it into a standard solution* (transfer / add to) a (100 cm^3) volumetric flask; make to mark(with (distilled) water) (and shake)	1

2(b)(v)	burette(s)	1

Q# 99/ Hazards and Safety ALvl Chemistry/2022/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

2(a)	(wear) chemically resistant gloves.	1

Q# 100/ **Hazards and Safety** ALvl Chemistry/2015/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

(d)	Hexane: • is (in)flammable / burns readily • causes irritation to the skin • causes breathing difficulties • forms explosive mixture (with air) **OR** is combustible Any **one** from the list above	[1]

Q# 101/ **Hazards and Safety** ALvl Chemistry/2020/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(c)	The experiment must not be performed near any naked flames OR Use an electric heater	1

Q# 102/ **Hazards and Safety** ALvl Chemistry/2010/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

(e)	PLAN Methods	Risks or hazards identified **(i)** <u>apparatus</u> unstable (chemical spills on persons) or getting very hot / high heat / burns. Do not accept just temperature increase. Melting plastic is neutral. Do not accept irritant / harmful or itching or damage to clothing. **(ii)** NaOH is corrosive / burns / damage to skin. BOTH needed for mark. Do not accept burns twice.	[1]

(f)	PLAN Methods	Mark here is dependent on correct responses in **(e)**. BOTH needed for mark. **(i)** plastic cup put in beaker / clamp for stability or appropriate handling of hot plastic cup. **(ii)** **two of:** gloves, face shield / goggles or lab coat in handling corrosive liquid. *Where only 1 risk and the associated way of minimising that risk are given – award one mark maximum for **(e)** and **(f)***	[1]

Q# 103/ **Hazards and Safety** ALvl Chemistry/2012/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

(d)	PLAN Method	Diagram shows a heated piece of apparatus containing some lead oxide with hydrogen passing over it with inlet and outlet shown.	[1]
		Diagram shows apparatus to generate hydrogen using Mg/Al/Zn/Fe **AND** any dilute acid (labelled) **OR** group 1 metal/alcohol **OR** Ca with water or dilute acid.	[1]
		Shows excess hydrogen being burned **OR** led away from apparatus/collected.	[1]

(f)	Plan Method	Hydrogen is explosive in air, so expel air from the apparatus before lighting flame to burn hydrogen **OR** lead/lead oxide is harmful/toxic, so wear a mask/use a fume cupboard to prevent **inhalation** of hydrogen/lead/lead oxide **OR** acids are corrosive/irritant, use chemically resistant gloves **OR** reduction tube is hot, allow to cool before handling/use heat resistant gloves/tongs.	[1]

Q# 104/ Hazards and Safety ALvl Chemistry/2006/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

ASSESSMENT OF PLANNING SKILLS.

(a) Give **one mark** if the apparatus is suitable for: heating and reducing the copper oxide in a stream of hydrogen gas.

Give **one mark** for "real apparatus" that:
is capable of being disconnected to weigh oxide/copper and water *(Ignore any chemical included to absorb condensate)*;
shows how the steam is condensed to water.

Give **one mark** for a suitable means of burning excess hydrogen at the end of the apparatus. [3]

(b) Give **one mark** for any of the following:

(i) flushing the apparatus with an inert gas,

(ii) passing hydrogen through the apparatus to flush out air,

(iii) testing small portions of mixture (e.g. in a test-tube) before igniting excess.

(iv) remove air from the apparatus – **by some practical method, e.g. evacuation** [1]

Q# 105/ Hazards and Safety ALvl Chemistry/2015/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

(d)	**P4**	The hydrogen with air / oxygen is explosive at 760K / raised temperature	[1]

Q# 106/ Hazards and Safety ALvl Chemistry/2021/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(h)	to allow the oxygen / gas (that is formed) to be released / escape / diffuse out	1

Q# 107/ Hazards and Safety ALvl Chemistry/2017/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(e)	Ammonium persulfate must be stated along with its hazard **and** linked to the precaution. Ammonium persulfate is a skin irritant so wear gloves OR Ammonium persulfate is an irritant to the respiratory system; do the experiment in fume cupboard / face mask OR Ammonium persulfate is harmful if swallowed so avoid mouth contact / wear face mask OR Ammonium persulfate is oxidising so avoid contact with flammable / combustible materials. OR Ammonium persulfate is harmful / hazardous to the environment so do not dispose of down the drain / use (large quantities) of water to dilute before disposal	1

Q# 108/ Hazards and Safety ALvl Chemistry/2016/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

(iii)	safety precautions – in a Li / LiOH / H_2 context Any two from • avoid skin contact / wear gloves / lab coat / use tongs in context of prevention of burns or corrosive contact only • keep piece of lithium / storage vessel / apparatus away from water • ensure unused lithium is all returned to storage vessel or stored under oil • keep away from naked flames / burner / sources of ignition	[2]

Q# 109/ Hazards and Safety ALvl Chemistry/2016/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(d)	Potassium chromate (solution) – (health hazard in context of) respiratory irritation AND fume cupboard / face / nose / mouth mask OR Potassium chromate – (health hazard in context of) skin irritation AND (chemical resistant) gloves OR barium chloride (solid) as toxic AND (chemical resistant) gloves / large dilution on disposal OR Sulfuric acid as irritant / skin irritant AND (chemical resistant) gloves	1 1
	Total:	**15**

Q# 110/ Hazards and Safety ALvl Chemistry/2013/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

(d)	Chlorine **OR** iodine are harmful Wear a mask/use a fume cupboard/for iodine if harmful to skin/eyes given, allow resistant gloves/goggles	1 1
		[Total: 15]

Q# 111/ Hazards and Safety ALvl Chemistry/2020/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

2(d)(ii)	keep the collected gas / pressurised cylinder away from sources of ignition	1

Q# 112/ Hazards and Safety ALvl Chemistry/2019/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2(a)(iii)	Propan-2-ol is flammable **AND** should not be heated directly / keep away from a naked flame / Bunsen burner	1

Q# 113/ Hazards and Safety ALvl Chemistry/2008/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

(d)	PLAN Methods	M7	***Corrosive nature of sulphuric acid*** identified as the hazard or any risk associated with this hazard. Alternatively, accept reference to the toxicity of cerium compounds or any risk associated with the use of this reagent.	[1]

Q# 114/ Hazards and Safety ALvl Chemistry/2007/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 (d)	PLAN Methods	Identify the corrosive nature of the solid/aqueous hydroxides. If corrosive is identified as the hazard give **this mark** for using gloves **or** If solution boils over or sprays out but is not described as corrosive give **this mark** for using two of gloves, lab coat, eye protection, (face) mask	1 1

Q# 115/ Hazards and Safety ALvl Chemistry/2018/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(b)	wear gloves	1
	do not dispose into the water waste / sink OR do not put down drain / sewage OR put in waste bottles	1

Q# 116/ Hazards and Safety ALvl Chemistry/2022/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2(b)	(pure) CH_3COOH is corrosive	1

Q# 117/ Hazards and Safety ALvl Chemistry/2022/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2(a)(i)	thermostatically controlled water bath	1
2(a)(ii)	flammable substance(s) are used (in the experiment)	1

Q# 118/ Hazards and Safety ALvl Chemistry/2018/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(b)	**M1** No naked flames AND (highly) flammable **M2** Perform experiment in fume cupboard AND irritant to respiratory system / may cause dizziness / drowsiness	2

Q# 119/ Hazards and Safety ALvl Chemistry/2014/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

(f)	Make sure all apparatus is airtight / no leakage before heating allow other sensible suggestions regarding exposure to nitrogen(IV) oxide or use of apparatus	[1]

Q# 120/ Hazards and Safety ALvl Chemistry/2009/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

(h)	PLAN Methods	Identifies a potential risk. NO_2 poisonous; O_2 an oxidant; $CsNO_3$ is an oxidant; $CsNO_2$ is poisonous; Potential suck back if collecting over water **Ignore items such as 'hot apparatus'** ***OXYGEN FLAMMABLE negates***	[1]
		Suggests way of minimising risk. NO_2 – work in fume cupboard O_2 – remove any oxidisable material Suck Back – remove delivery tube from water when heating stops.	[1]

Q# 121/ Hazards and Safety ALvl Chemistry/2002/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

(e) Give **one mark** for a suitable safety feature with associated reason, e.g. use of fume cupboard as NO_2 is toxic.

1

Q# 122/ Hazards and Safety ALvl Chemistry/2012/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

(d)	PLAN Method	Identifies that copper(II) sulfate is harmful/a danger to the environment.	[1]
		Identifies that sodium hydroxide is corrosive (from the hazcard information).	[1]
		Give one mark for a precaution for either hazard of (chemical) resistant gloves or large dilution when disposing of chemicals.	[1]

Q# 123/ Variables **ALvl** Chemistry/2010/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

(c)	PLAN Problem	Independent variable – volume/mass/moles of NaC*l* Dependent variable – moles/mass of PbC*l*$_2$ / ppt Other variables – temperature. **NOT** amount and **NOT** concentration of the NaC*l*. Three points correct – 2 marks Two points correct – 1 mark Any incorrect suggestions cancel correct suggestions	[2]

Q# 124/ Variables ALvl Chemistry/2022/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

2(e)(i)	(absolute) temperature (of the gas)	1

Q# 125/ Variables ALvl Chemistry/2017/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(a)	diagram of a labelled insulated container containing a liquid	1
	labelled timing device and a labelled thermometer in / touching the liquid	1

Q# 126/ Variables ALvl Chemistry/2010/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1	(a)	PLAN Methods	Selects a volume of 3 mol dm^{-3} NaOH between 10 and 80 cm^3.	[1]
		PLAN Problem	Calculates the volume of 2 mol dm^{-3} H_2SO_4 that reacts with the volume of NaOH given. Ignore decimal places or significant figures. (ecf from **(a)** and accept 0.75x).	[1]
			Sketches a graph showing increasing temperature, reaching a maximum, then decreasing (or staying on plateau). AND indicating the neutralisation point at the maximum or the volume calculated above, Accept straight lines or curves with a maximum.	[1]
	(b)	PLAN Problem	(i) volume of acid.	[1]
			(ii) temperature / temperature increase / temperature change.	[1]
			(iii) heat loss (given as being controlled) / use of same cup / apparatus. or same initial temperatures of both start solutions.	[1]
	(c)	PLAN Methods	Burette / pipette to add acid.	[1]
	(d)	PLAN Methods	The acid is added in successive volume portions (not dropwise). or adding the calculated acid volume in **(a)** slowly or gradually.	[1]

Q# 127/ Variables ALvl Chemistry/2008/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 (c)	PLAN Problem	P1	**Independent (Controlled) variable** (i) mass/moles of alcohol identified as independent variable. (do not accept **amount**) (ii) temperature rise or change identified as independent variable. (iii) (alcohol chosen / number of carbon atoms in alcohol / carbon chain length) identified as independent variable or duration of experiment identified as independent variable	1
		P2	**Dependent variable (consequential to the Independent variable)** (i) (temperature rise or change / heat produced / energy change) identified as dependent variable. (ii) *Ignore any reference to* ΔH_c (iii) mass/moles of alcohol identified as dependent variable. (do not accept **amount**) (iv) (temperature rise or change or final temperature / heat produced / energy change) identified as dependent variable or mass/moles of alcohol identified as dependent variable. *Ignore any reference to* ΔH_c	1

Q# 128/ Variables ALvl Chemistry/2012/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

(c)	PLAN Problem	**(i)** lead (allow lead oxide or oxide) **AND** **(ii)** oxygen (allow O_2 **OR** lead)	[1]

Q# 129/ Variables ALvl Chemistry/2015/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

(b)	P1/P2	(Independent) Temperature (Dependent) Concentration of magnesium methanoate	[1]

Q# 130/ Variables ALvl Chemistry/2021/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

1(a)(i)	the metal oxide	1
1(a)(ii)	count bubbles in a set time OR measure volume (of oxygen) in a certain time OR measure time to produce a certain volume	1
1(b)	*Any two from:* the volume of the hydrogen peroxide / solution the concentration of the hydrogen peroxide temperature particle size	2

Q# 131/ Variables ALvl Chemistry/2020/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2(d)	time	1

Q# 132/ Variables ALvl Chemistry/2009/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

(b)	PLAN Problem	**(i)** [Persulfate] as independent variable. Accept the correct ion instead of the correct name. Do not accept volume or amount. **(ii)** Elapsed time identified as dependent variable / rate (of reaction) or equivalent. Time alone scores zero but rate alone is OK.	[1] [1]
(c)	PLAN Problem	Explains that [iodide] remains constant – (controlled variable)/so that the iodide does not run out/continuous supply of iodide ions (for reaction with persulfate). NOT allowed are reformed/regenerated alone – rubric.	[1]

Q# 133/ Variables ALvl Chemistry/2007/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

(b)	**PLAN Problem**	<u>Concentration</u> of HC*l* identified as independent variable *[HCl] is acceptable*	[1]	**[1]**
(c)	**PLAN Problem**	States that the (total) volume of solution must be kept constant, **or** States that the amount/size/length/mass/surface area of the magnesium ribbon must be kept constant	[1]	**[1]**

Q# 134/ Variables ALvl Chemistry/2013/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

(b) (i)	concentration/concentration change	
(ii)	temperature change/decrease in temperature (allow ecf on **(a)(i)**)	**1**

Q# 135/ Variables ALvl Chemistry/2008/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

(b)	PLAN Problem	P1	**<u>Concentration</u>** of sulphuric acid identified as independent variable.	[1]
		P2	Mass/moles of cerium sulphate dissolved identified as the dependent variable/solubility (accept other concentration units).	[1]
		P4	Temperature identified as the variable to be controlled. **<u>(any other suggestion negates any or all of these points)</u>**	[1]

Q# 136/ Variables ALvl Chemistry/2007/w/TZ 1/ Paper 5/Q# 1/Smashing!!!

1 (b)	PLAN Problem	**Independent variable** accept any of the following; **1.** mass/weight/moles/amount of **MOH** *(**not** metal)*, **2.** "which *M*OH used", **3.** Group I hydroxide.	1
		Dependent variable accept any of the following; **1.** temperature rise/change, **2.** heat produced/energy change, **3.** ΔH_{soln}.	1
		Controlled variable accept either of the following; **1.** volume/weight of water, *(**not** amount)* **2.** mass of hydroxide – ***only allowed** if "which hydroxide" is given as the independent variable.*	1

Q# 137/ Variables ALvl Chemistry/2023/m/TZ 2/ Paper 5/Q# 2/Smashing!!!

2(c)(ii)	Volume of KI	1

Q# 138/ Variables ALvl Chemistry/2022/s/TZ 1/ Paper 5/Q# 2/Smashing!!!

2(d)	volume of sodium hydroxide (solution used in titration)	1

Q# 139/ Variables ALvl Chemistry/2021/w/TZ 1/ Paper 5/Q# 2/Smashing!!!

2(d)(ii)	time (taken for fizzing to stop)	1

Q# 140/ Variables ALvl Chemistry/2016/m/TZ 2/ Paper 5/Q# 1/Smashing!!!

(e)	time **and** units of s; volume of thiosulfate **and** units of cm^3;	[2]
(f)	temperature;	[1]

Q# 141/ Variables ALvl Chemistry/2011/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

(b)	PLAN Problem	(i)	Element/carbonate as the independent variable. Mass negates.	[1]
		(ii)	Time identified as dependent variable/ rate (of reaction) or equivalent.	[1]

Q# 142/ Variables ALvl Chemistry/2009/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

(b) (i)	PLAN Problem	Amount/mass/weight/moles of $CsNO_3$ identified as independent variable. **Do not accept concentration or volume.**	[1]
(ii)		Volume/amount/mass of gas collected identified as the dependent variable. Alternatively accept mass of residue.	[1]

Q# 143/ Variables ALvl Chemistry/2012/s/TZ 1/ Paper 5/Q# 1/Smashing!!!

(b)	PLAN Problem	(i) concentration of copper(II) sulfate.	[1]
		(ii) moles of copper(II) hydroxide	[1]