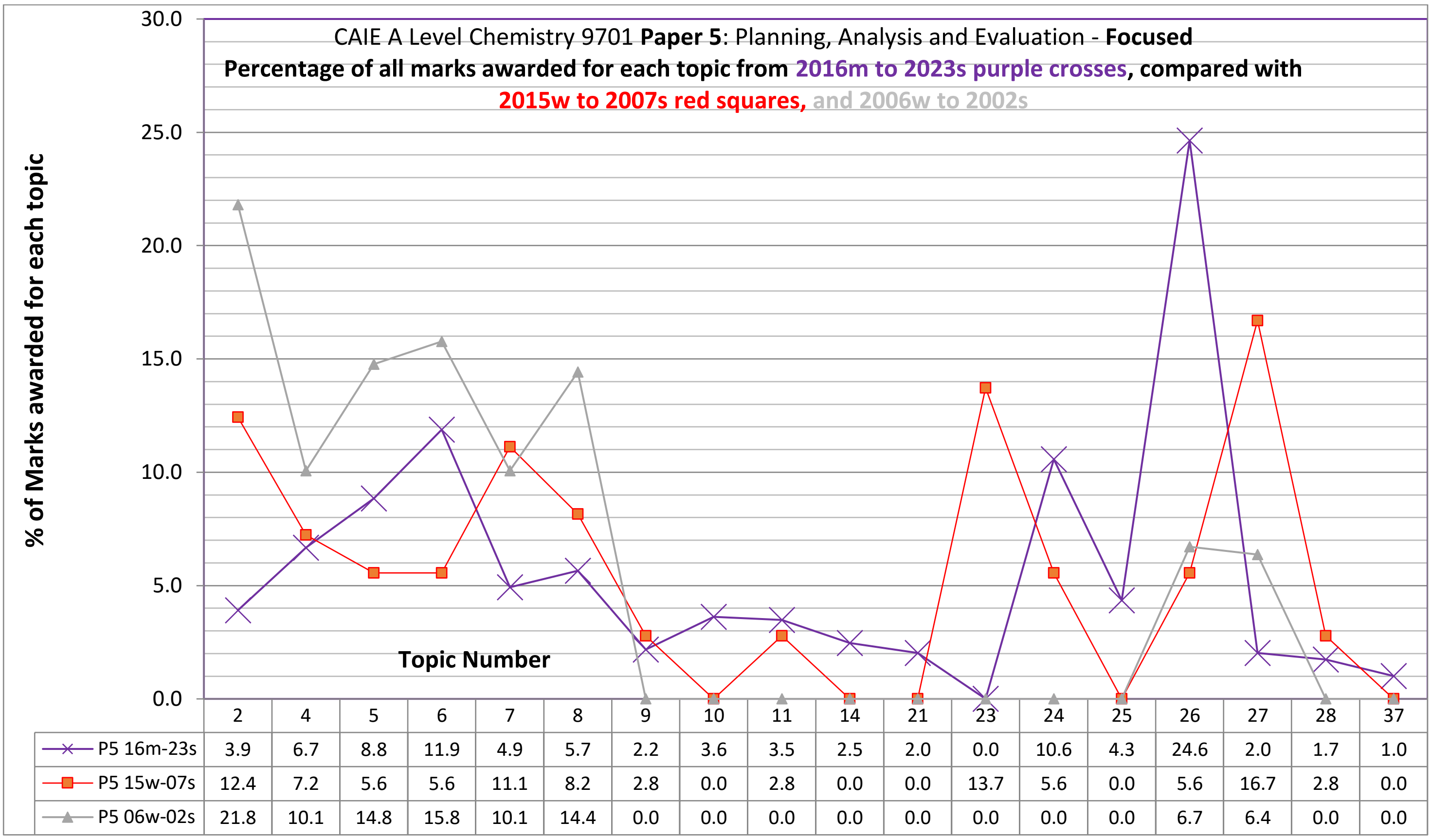
Name: Class: Date:

ALvl Chem 6 EQ P5 22w to 02s Paper 5 Electrochemistry 159marks

These questions are from an A2 Exam Paper on AS material. Most AS students will not benefit from working on these questions until their A2 year. AS students aiming for an A* *might* get some value looking at these questions, but only if they have made substantial progress in AS, so at least a "Winner" (50%) level or beyond for Papers 1, 2 and 3!

As you start and work through this worksheet you can tick off your progress to show yourself how much you have done, and what you need to do next. The first task is just to read the first question and should take you less than 3 minutes to complete.

Paper 5 Topic 6 **Checklist** Tick each task off as you go along	RANK:	P5 Noob	P5 Novice	P5 Bronze	P5 Silver	P4 Gold	P5[1] Winner	P5 Hero	P5 Legend
	Marks	1 Q Started	1 Q done	10% of marks	25% of marks	40% of marks	50% of marks	75% of marks	100% of marks
Topic (marks)	159		16	16	40	64	80	119	159
Time @150s/mark (minutes)	398		40	40	99	159	199	298	398



	2	4	5	6	7	8	9	10	11	14	21	23	24	25	26	27	28	37
P5 16m-23s	3.9	6.7	8.8	11.9	4.9	5.7	2.2	3.6	3.5	2.5	2.0	0.0	10.6	4.3	24.6	2.0	1.7	1.0
P5 15w-07s	12.4	7.2	5.6	5.6	11.1	8.2	2.8	0.0	2.8	0.0	0.0	13.7	5.6	0.0	5.6	16.7	2.8	0.0
P5 06w-02s	21.8	10.1	14.8	15.8	10.1	14.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.7	6.4	0.0	0.0

What the most thoughtful students will get out of their extensive studying will be a capacity to do meaningful brain-based work even under stressful conditions, which is a part of the self-mastery skillset that will continue to deliver value for the whole of their lives. Outstanding grades will also happen, but the most important outcome from skillful action in study is being better at any important tasks even if circumstances are do not feel ideal.

Learning how to manage oneself so we can more reliably get ambitious and successful outcomes out of our challenges in a productive and positive way is one aspect of life's most valuable pursuit summarised and inscribed on the Temple of Apollo at Delphi: "know thyself".

1. To complete these questions, as important as your answer, is checking your answer against the mark scheme.
2. For each question, or page, convert your mark score into a percentage. This will allow you to see (and feel) your progress as you get more experience and understanding with each topic.

---

[1] **DO NOT** work on these higher levels of completion in your A2 year unless you have also achieved at least a "**Gold**" (40%) in the same topic in **Paper 4**, which is **MOST** of your **A2 grade**.

3. If you find you get a higher percentage answering short answer questions than multiple choice questions that often means you are using the marking scheme correctly; your correct answer might not be fully complete. The marks easiest to miss rely on providing more details fully described.

Q# 32/ ALvl Chemistry/2021/s/TZ 1/ Paper 5/Q# 2/www.SmashingScience.org :o)

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.

(a) **(i)** Calculate the mass of $KMnO_4$ needed to make 500.0 cm^3 of 0.0200 mol dm^{-3} $KMnO_4$(aq).

[A_r: K, 39.1; Mn, 54.9; O, 16.0]

mass of $KMnO_4$ needed = ... g [1]

(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]

(d) The results for each set of titrations are shown.

set A

	rough	titration 1	titration 2	titration 3
final volume / cm^3	18.40	17.25	34.55	18.00
initial volume / cm^3	0.65	0.15	17.25	0.95
titre / cm^3				

set B

	rough	titration 1	titration 2	titration 3
final volume / cm^3	45.05	43.60	43.70	
initial volume / cm^3	0.20	0.15	0.10	
titre / cm^3				

(i) Complete both tables and calculate an appropriate average titre for each set of results. The student could **not** carry out titration 3 in **set B**.

Record the average titre to **one decimal place**.

set A average titre = ... cm^3

set B average titre = ... cm^3

[2]

(ii) The reaction taking place during the titrations is shown by the equation.

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

Calculate the mass of Fe^{2+} ions in 100 cm³ of the reduced solution, produced in **step 6**, by using the appropriate average titre from **(d)(i)**.

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

[A_r: Fe, 55.8]

mass of Fe^{2+} ions = ... g [2]

(iii) Calculate the mass of Fe^{2+} ions in the original 250.0 cm³ $Fe^{2+}(aq)/Fe^{3+}(aq)$ solution, using the appropriate average titre from **2(d)(i)**.

mass of Fe^{2+} ions = ... g [1]

(iv) Calculate the percentage by mass of Fe^{3+} ions in the original 250.0 cm³ $Fe^{2+}(aq)/Fe^{3+}(aq)$ solution.

percentage by mass of Fe^{3+} ions = ... % [1]

(v) State what change could be made to the procedure to enable titration 3 to be carried out in **set B**.

....

.... [1]

[Total: 16]

Q# 33/ ALvl Chemistry/2021/m/TZ 2/ Paper 5/Q# 2/www.SmashingScience.org :o)

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]

(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]

(vi) Determine the number of moles of $C_2O_4^{2-}$ ions in the 250.0 cm^3 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 cm^3 of solution **A** = ... mol [3]

If you were unable to calculate an answer to **(b)(vi)**, then you may use the value 1.18×10^{-2} mol for your calculations in **(c)**. This is **not** the correct value.

(c) The student then does an acid–base titration of solution **A** to determine the values of *a* and *b* in $K_aH_b(C_2O_4)_c{\bullet}dH_2O$.

(i) Suggest the name of a suitable reagent to use in this titration.

.... [1]

(ii) The student finds the concentration of $H^+(aq)$ in solution **A** is 6.10×10^{-2} mol dm^{-3}.

Use this value and your answer to **(b)(vi)** to determine the ratio of *c* to *b* to **two** decimal places.

Then deduce the value of *a* in $K_aH_b(C_2O_4)_c{\bullet}dH_2O$ to **two** decimal places.

ratio $c:b$ = 1 : ....

value of *a* = ...

[3]

(iii) Use your answer to **(b)(vi)**, **(c)(ii)** and other information given in the question to determine the mass of 1 mol of $K_aH_b(C_2O_4)_c{\bullet}dH_2O$ and hence determine the value of *d* to the nearest whole number.
[A_r: K, 39.1; H, 1.0; C, 12.0; O, 16.0]

If you were unable to calculate an answer to **(c)(ii)**, then you may use *a* = 0.30 and ratio *c* : *b* = 1 : 1.60. These are **not** the correct values.

mass of 1 mol of $K_aH_b(C_2O_4)_c{\bullet}dH_2O$ = ... g

value of *d* = ...

[2]

(d) A second student uses another method to determine *d*. Crystals of the sample, with known values of *a*, *b* and *c*, are heated in a crucible to remove the water molecules.

Construct a results table to show the readings that would need to be taken during this experiment.

[2]

[Total: 20]

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 cm^3 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 cm^3 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 cm^3 of 0.200 mol dm^{-3} $C_2O_4^{2-}$(aq) required 18.40 cm^3 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]

(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]

	rough	titration 1	titration 2	titration 3	titration 4
final burette reading / cm^3	45.50	44.75	44.45	44.80	44.40
initial burette reading / cm^3	0.00	0.10	0.15	0.00	0.00
titre / cm^3	45.50	44.65	44.30	44.80	44.40

(i) Circle the titres the student should use to obtain the most accurate value for the volume of 0.0200 mol dm^{-3} $KMnO_4$ that is needed to react with 25.0 cm^3 of the prepared iron solution. Explain your answer.

....

.... [1]

(ii) The burette used for the titration has graduations every 0.10 cm^3.

Calculate the maximum percentage error in the titre of titration 2.

Show your working.

percentage error = ... [1]

(iii) Derive an expression to show how you would calculate the percentage by mass of iron in the iron wire.
Use x to represent the average titre and y to represent the mass of iron wire used.

expression for mass of iron in the iron wire = ... [2]

(iv) The student left the solution of $Fe^{2+}(aq)$ in sulfuric acid without a stopper for a few days. The student repeated the titration and found that the average titre was lower.

Suggest why.

....

.... [1]

(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]

[Total: 13]

Q# 35/ ALvl Chemistry/2020/m/TZ 2/ Paper 5/Q# 1/www.SmashingScience.org :o)

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.

....

....

....

.... [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.

....

....

....

.... [2]

(g) The titration table the student used is shown.

(i) Complete the table and calculate the mean titre to be used in calculating the percentage of copper in brass.
Show your working.

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					

mean titre = ... cm^3 [2]

(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]

(h) **Steps 1–8** were repeated, this time using 1.88 g of brass. The end-point of the titration was found to be 16.50 cm³.

The equations for the reactions occurring are shown.

equation **1** (**step 6**) $2Cu^{2+}(aq) + 4I^{-}(aq) \rightarrow 2CuI(s) + I_2(aq)$

equation **2** (**step 8**) $I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^{-}(aq) + S_4O_6^{2-}(aq)$

(i) Determine the number of moles of I_2 formed when excess KI(aq) was added to 25.00 cm³ of solution **B** in **step 6**.

Use the data from the repeated experiment in your calculations.

moles of I_2 = ... [2]

(ii) Use your answer to **(h)(i)** to determine the mass of Cu^{2+} ions in solution **A** and therefore the percentage by mass of copper in this sample of brass.
If you were unable to obtain an answer to **(h)(i)**, assume the number of moles of I_2 to be 8.85×10^{-4} mol. This is **not** the correct value.
[A_r: Cu, 63.5]

percentage by mass of copper in the sample of brass = ... [3]

(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]

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 cm^3 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 cm^3.

step 2 To determine the concentration of $Fe^{2+}(aq)$ in solution **A**, titrate a 25.00 cm^3 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.

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

(a) (i) The end-point of the titration is 25.00 cm^3 of 0.0200 mol dm^{-3} $KMnO_4(aq)$.

Determine the concentration of $Fe^{2+}(aq)$ that was present in the 25.00 cm^3 sample of solution **A** at the start of the titration.

concentration of $Fe^{2+}(aq)$ = ... mol dm^{-3} [1]

If you were unable to calculate the concentration in **(i)**, assume for **(ii)** and **(iii)** that the concentration of $Fe^{2+}(aq)$ is 0.300 mol dm^{-3}. This is **not** the correct answer.

(ii) Determine the mass of lawn sand needed to prepare the 250.0 cm^3 of solution **A** at the concentration calculated in **(i)**.

Assume that lawn sand contains 8% $FeSO_4.7H_2O$ by mass.
[A_r: Fe, 55.8; S, 32.1; O, 16.0; H, 1.0]

mass of lawn sand = ... g [3]

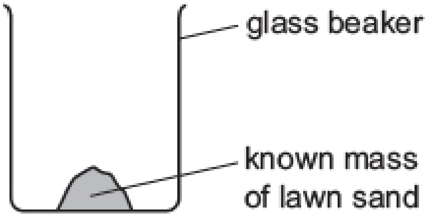
(iii) Solution **A** must contain enough $H^+(aq)$ ions for the reaction to take place during the titration.

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

Use the concentration of $Fe^{2+}(aq)$ from **(i)** to determine the minimum volume of 2.00 mol dm^{-3} $H_2SO_4(aq)$ which must be added to prepare the 250.0 cm^3 of solution **A**.

volume = ... cm^3 [2]

(b) Describe a method to prepare 250.0 cm^3 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.

....

....

....

....

....

....

....

....

.... [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 ....

....

....

[2]

[Total : 14]

Q# 37/ ALvl Chemistry/2012/w/TZ 1/ Paper 5/Q# 1/www.SmashingScience.org :o)

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.

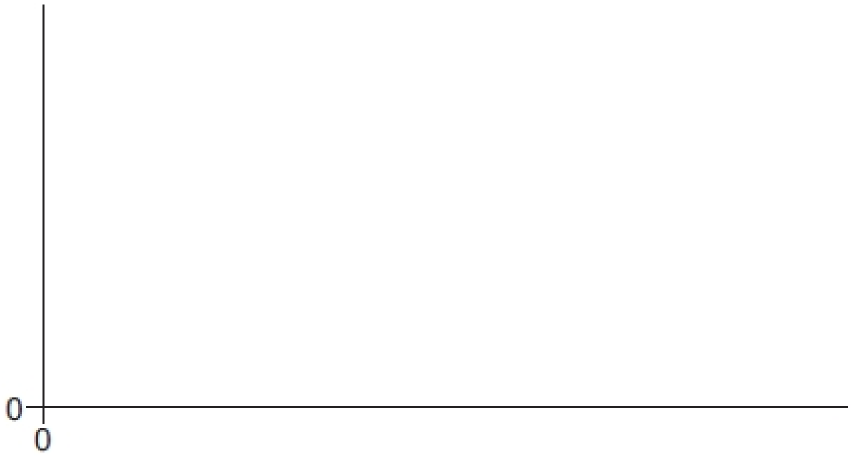
An unknown sample of an oxide of lead can be identified by investigating the molar ratio of oxygen atoms to lead atoms.

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.

(a) Calculate the number of moles of oxygen atoms that combine with one mole of lead atoms in each of the three oxides.

[2]

(b) Draw a sketch graph to show how the number of moles of oxygen atoms varies with the number of moles of lead for lead(II) oxide, PbO. Draw two more sketch graphs to show this relationship for the other two oxides.
Label clearly each axis and each graph.



[2]

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

(i) the independent variable ....

(ii) the dependent variable ....

[1]

(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]

(e) Using the apparatus shown in **(d)**, design a laboratory experiment which will enable you to determine the chemical formula of the oxide.

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

(i) stating a suitable mass of the oxide of lead,

(ii) stating how you would ensure that the decomposition is complete,

(iii) showing by calculation the minimum volume of hydrogen, measured at 25 °C, that would be needed to reduce the mass of oxide of lead stated in **(i)** above. For calculation purposes, you may assume that the oxide of lead is PbO,

(iv) stating how you would use your results to reach a conclusion.

[A_r: H, 1.0; O, 16.0; Pb, 207.0; the molar volume of a gas at 25 °C is 24.0 dm^3]

[4]

(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.

[1]

(g) Draw up a table with appropriate headings to show the data you would record when carrying out your experiments and the values you would calculate in order to determine graphically the formula of the oxide. The headings should include appropriate units.

[2]

[Total: 15]

2 A chloride of mercury has the formula $HgCl_x$.

The formula of the chloride can be determined experimentally. A solution of the chloride in water is reduced to mercury metal by the addition of hypophosphorous acid, H_3PO_2.

Method

- A 100 cm^3 beaker is weighed empty and then with $HgCl_x$.
- The solid is dissolved in distilled water.
- The resulting solution is heated in a water bath.
- 10 cm^3 of hypophosphorous acid is added from a measuring cylinder.
- The mixture is stirred and heated for a further 5 minutes.
- The aqueous solution remaining after the reaction is poured off to leave droplets of mercury in the bottom of the beaker.
- The mercury is washed several times with distilled water, discarding the wash water each time.
- The beaker and mercury are dried by rinsing several times with propanone which dissolves any remaining water drops.
- The remaining propanone is evaporated by warming the beaker.
- The beaker and mercury are weighed.
- The experiment is repeated using different masses of $HgCl_x$.

Observations

- $HgCl_x$ dissolves in water to form a colourless solution.
- On adding H_3PO_2 a white suspension forms which rapidly turns to a grey suspension of droplets of metallic mercury.
- On further heating, the suspended droplets merge to form large drops of mercury at the bottom of the beaker.

Results

	A	B	C	D	E	F
experiment	mass of beaker /g	mass of beaker + mercury chloride /g	mass of beaker + mercury /g			
1	54.87	55.52	55.30			
2	54.64	55.88	55.59			
3	56.70	58.38	57.94			
4	51.03	53.34	52.53			
5	55.33	58.74	57.84			
6	53.05	57.20	56.10			
7	53.92	58.57	57.17			
8	55.26	61.09	59.57			

(a) Process the results in the table to produce data that will enable you to plot a graph from which the formula of $HgCl_x$ can be determined.
Record this data in the additional columns of the table. You may use some or all of the columns.
Label the columns you use. For each column, include the units and an equation to show how your values are calculated. You may use the column headings **A** to **F** in the equations e.g. **C** – **B**. [2]

(b) Present the data calculated in **(a)** in graphical form. Draw the line of best-fit.

[4]

(c) Indicate clearly any anomalous points on the graph that you did not use when drawing the line of best-fit. By reference to the instructions for the experiment suggest an explanation for these anomalies.

....

....

....

....

....[3]

(d) Explain why the mass of $HgCl_x$ used in experiment 8 is more appropriate than that used in experiment 1.

....

....

....[1]

(e) Draw construction lines on the graph to derive values to enable you to calculate the value of **x** in $HgCl_x$.
[A_r: Hg, 201.0; C*l*, 35.5]

Experimental value of **x** is .... Formula of $HgCl_x$ is ....

[2]

(f) By considering the data you have processed and the graph you have drawn, explain whether the experimental procedure described is suitable for the determination of the formula of $HgCl_x$.

....

....

....

....

....[2]

(g) The mass of chlorine in $HgCl_x$ can also be determined by precipitation of an insoluble chloride. Use your knowledge of halogen chemistry to suggest a suitable reagent for this reaction.

....

....[1]

[Total: 15]

Q# 39/ ALvl Chemistry/2006/s/TZ 1/ Paper 5/Q# 2/www.SmashingScience.org :o)

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?

....

....

.... [1]

(c) Why is it necessary to continue passing hydrogen gas through the apparatus until the copper metal formed has cooled?

....

....

.... [1]

(d) How could you be certain that all of the copper oxide had been reduced to copper?

....

....

.... [1]

(e) Show how you would use the data you could obtain from the experiment in **(a)** to deduce the formula of the oxide used.
[A_r: Cu, 63.5; O, 16.0]

[2]

Q# 40/ ALvl Chemistry/2003/s/TZ 1/ Paper 5/Q# 1/www.SmashingScience.org :o)

EXPERIMENT Required, no longer needed from 2007 onwards.

1 **FB 1** is an aqueous solution containing 100.00 g dm^{-3} of sodium thiosulphate, $Na_2S_2O_3.5H_2O$.
FB 2 is an aqueous solution containing 0.023 mol dm^{-3} of the chromate ion, CrO_4^{2-}.

> Chromate ions, CrO_4^{2-}, oxidise iodide ions, I^-, in the presence of acid, H^+, and produce aqueous iodine, I_2 which can be titrated with sodium thiosulphate.
>
> You are to use this reaction to show that the CrO_4^{2-} ion is reduced to Cr^{3+} during this reaction.

(a) Use a burette to measure between 45.0 cm³ and 45.5 cm³ of **FB 1** into the 250 cm³ volumetric (graduated) flask labelled **FB 3**.
Record your burette readings in Table 1.1.

Table 1.1 Dilution of FB 1

Final burette reading / cm³	
Initial burette reading / cm³	
Volume of **FB 1** / cm³	

[2]

Fill the flask to the mark with distilled or deionised water and mix the contents thoroughly by shaking.
This solution is **FB 3. Fill the second burette with the solution FB 3 you have prepared.**

(b) Pipette 25.0 cm³ of **FB 2** into a conical flask and add, from a measuring cylinder, 10 cm³ of dilute sulphuric acid and 10 cm³ of 5% aqueous potassium iodide, KI.
Titrate the contents of the conical flask with **FB 3** until the colour of the iodine solution has faded to a light orange/yellow colour. Add 1 cm³ of starch indicator and continue the titration until the blue-black colour of the starch-iodine complex disappears leaving the transparent pale blue colour of Cr^{3+}. Record your burette readings in Table 1.2.

Repeat the titration as many times as you think necessary to obtain accurate results.
Make certain that the recorded results show the precision of your practical work.

Table 1.2 Titration of FB 2 with FB 3

Final burette reading / cm³ Initial burette reading / cm³				
Volume of **FB 3** used / cm³				

[10]

Summary

25.0 cm³ of **FB 2** reacted with .... cm³ of **FB 3**.

Show which results you used to obtain this volume of **FB 3** by placing a tick (✓) under the readings in Table 1.2.

(c) Calculate the concentration in mol dm^{-3} of sodium thiosulphate, $Na_2S_2O_3.5H_2O$, in **FB 1**.
[Na, 23.0; S, 32.1; O, 16.0; H, 1.0.]

[1]

(d) Calculate the concentration in mol dm^{-3} of sodium thiosulphate in the diluted solution **FB 3**.

[1]

(e) Calculate the number of moles of sodium thiosulphate run into the flask during the titration and use this figure and the equations below to calculate the moles of iodine, I_2, present in the titration flask.

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

$$I_2(aq) + 2e^- \rightarrow 2I^-(aq)$$

[2]

(f) Calculate the number of moles of CrO_4^{2-} ion pipetted into the titration flask.

[1]

(g) Calculate the number of moles of iodine, I_2, produced by 1 mole of CrO_4^{2-}.

[1]

(h) Use your answer to **(g)** and oxidation numbers to show that CrO_4^{2-} has been reduced to Cr^{3+}.

[2]

[Total 20]

Q# 41/ ALvl Chemistry/2002/s/TZ 1/ Paper 5/Q# 1/www.SmashingScience.org :o)

EXPERIMENT Required, no longer needed from 2007 onwards.

1 **FB 1** is 0.02 mol dm^{-3} potassium manganate(VII), $KMnO_4$.
FB 2 is a solution containing iron(II) ions, Fe^{2+}.
FB 3 is an aqueous solution of a substance, **X**.

Under acid conditions **X** oxidises iron(II) to iron(III).

You are required to determine

- the concentration of iron(II) ions in **FB 2** and, by a graphical method,
- the volume of **FB 3** that will oxidise the iron(II) ions in 25.0 cm^3 of **FB 2**.

(a) *Experiment 1*

Fill a burette with potassium manganate(VII), **FB 1**.

Pipette 25.0 cm^3 of **FB 2** into a conical flask and add, using the measuring cylinder provided, 10 cm^3 of 1 mol dm^{-3} sulphuric acid.

Run **FB 1** from the burette into the conical flask until the first permanent pale pink colour remains. This is the end point of the titration.

Record your burette readings in Table 1.1.

Repeat the titration as many times as you think necessary to obtain accurate results.
Make certain that the recorded results show the precision of your practical work.

Table 1.1 Titration of FB 2 with FB 1

Final burette reading / cm^3 Initial burette reading / cm^3				
Volume of **FB 1** used / cm^3				

[8]

Summary

25.0 cm^3 of **FB 2** reacted with .... cm^3 of **FB 1**.

Show which results you used to obtain this volume of **FB 1** by placing a tick (✓) under the readings in Table 1.1.

You are advised to show full working in all parts of the calculations.

(b) Calculate how many moles of potassium manganate(VII) were run from the burette into the conical flask during the titration of **FB 2** with **FB 1**.

[1]

(c) Use the half equations for the reaction

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

and your answer to **(b)** to calculate the concentration of Fe^{2+}, in mol dm^{-3}, in **FB 2**.

[2]

(d) *Experiment 2*

Fill the second burette with **FB 3**, the aqueous solution of **X**.

Pipette 25.0 cm^3 of **FB 2** into a conical flask and add, using the measuring cylinder provided, 10 cm^3 of 1 mol dm^{-3} sulphuric acid.

Add, from the second burette, 4.00 cm^3 of FB 3. This oxidises some of the Fe^{2+} that has been pipetted into the flask.

Titrate the remaining Fe^{2+} in the conical flask with **FB 1**, potassium manganate(VII) until the first permanent pink colour remains.

Record the volume of **FB 3** added and your burette readings in Table 1.2.

One accurate titration will be sufficient. Remember that the volume added will be less than in *Experiment 1* as some of the Fe^{2+} has been oxidised by X.

Table 1.2 Titration of FB 2/FB 3 mixture with FB 1

Volume of **FB 3** added	/ cm^3	0.00	4.00	8.00	12.00
Final burette reading	/ cm^3	▨			
Initial burette reading	/ cm^3	▨			
Volume of **FB 1** added	/ cm^3				

↑ Enter the titration value from *Experiment 1*.

[3]

Empty and rinse the conical flask.

Repeat *Experiment 2*, using the volumes of **FB 3** shown in Table 1.2.

Record your results in Table 1.2.

use

(e) Plot the volume of **FB 1** against the volume of **FB 3**.

Your scale on the **FB 3** axis should extend to 30.00 cm^3.

i	
ii	
iii	
iv	

[5]

(f) Draw the best-fit straight line through the plotted points. [1]

(g) From your graph find the volume of **FB 3** that reacts with the Fe^{2+} present in 25.0 cm^3 of **FB 2**.

[1]

[Total 21]

Q# 32/ ALvl Chemistry/2021/s/TZ 1/ Paper 5/Q# 2/www.SmashingScience.org :o)

1(f)	measuring the decrease / change in (total) mass of the solution / mixture / reaction vessel (and contents) (and time) OR measuring the mass / weight of the mixture/reaction vessel (and contents) AND time	1
1(g)	**M1:** (filter/remove) dry the residue/metal oxide **M2:** weigh the residue / metal oxide to see if the mass is unchanged OR **M1:** re-use with new hydrogen peroxide / do the same reaction again with the same catalyst **M2:** and check if the gas volumes identical / rate of reaction the same	2
1(h)	to allow the oxygen / gas (that is formed) to be released / escape / diffuse out	1

Question	Answer	Marks
2(a)(i)	*M*$_r$ $KMnO_4$ = 158.0 500 × 0.02 / 1000 = 0.01 0.01 × 158.0 = 1.58 g	1
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

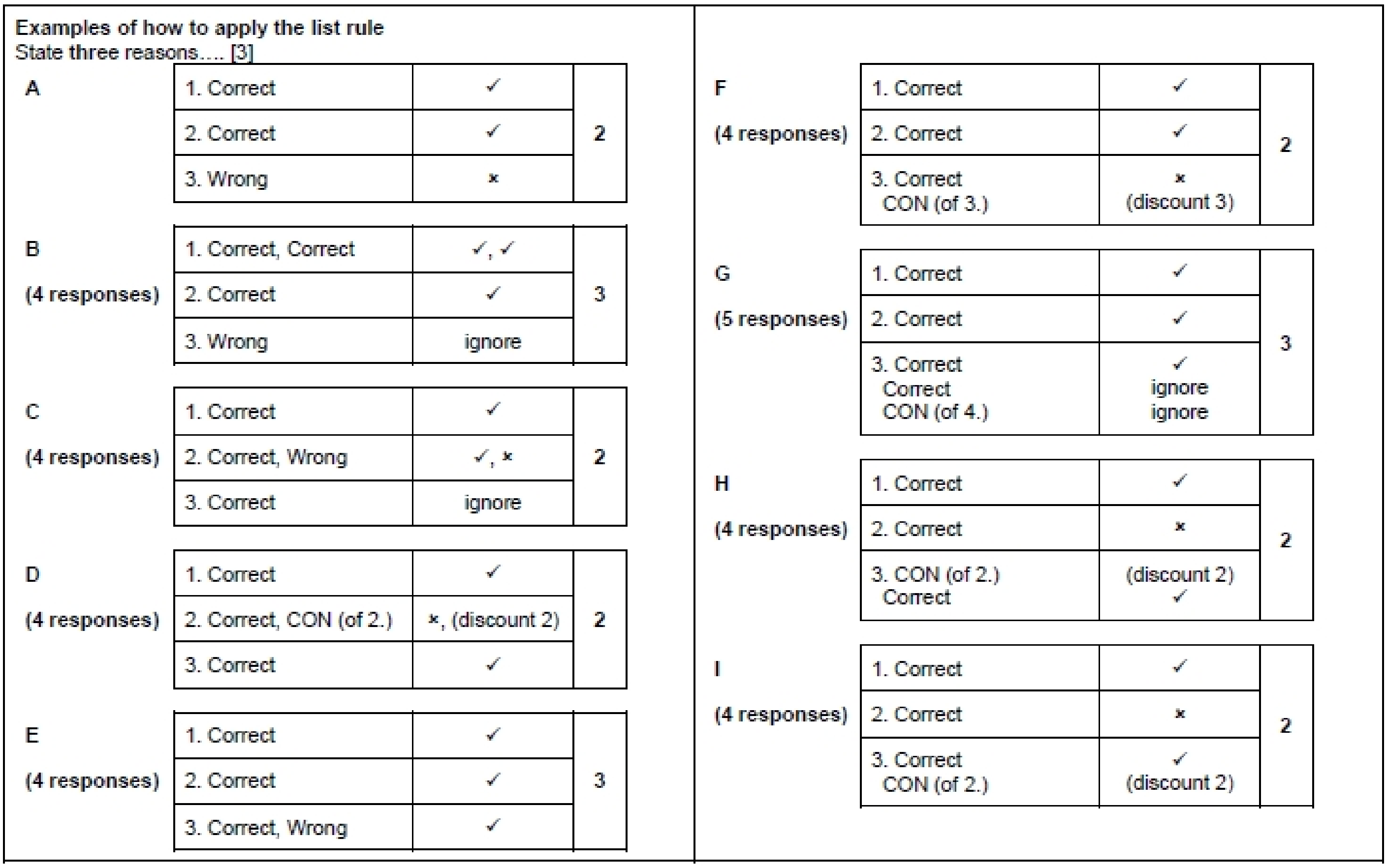
<table>
<tr><td>2(d)(i)</td><td>
Set A
<table>
<tr><td></td><td>rough</td><td>titration 1</td><td>titration 2</td><td>titration 3</td></tr>
<tr><td>final volume / cm^3</td><td>18.40</td><td>17.25</td><td>34.55</td><td>18.00</td></tr>
<tr><td>initial volume / cm^3</td><td>0.65</td><td>0.15</td><td>17.25</td><td>0.95</td></tr>
<tr><td>titre / cm^3</td><td>17.75</td><td>17.10</td><td>17.30</td><td>17.05</td></tr>
</table>
mean titre = 17.1 (cm^3)
Set B
<table>
<tr><td></td><td>rough</td><td>titration 1</td><td>titration 2</td></tr>
<tr><td>final volume / cm^3</td><td>45.05</td><td>43.60</td><td>43.70</td></tr>
<tr><td>initial volume / cm^3</td><td>0.20</td><td>0.15</td><td>0.10</td></tr>
<tr><td>titre / cm^3</td><td>44.85</td><td>43.45</td><td>43.60</td></tr>
</table>
mean titre = 43.5 (cm^3)
M1: correct titres (to 2 decimal places)
M2: correct means
</td><td>2</td></tr>
</table>

2(d)(ii)	**M1:** n MnO_4^- (aq) = 43.5 × 0.02 / 1000 = 8.70 × 10^{-4} n Fe^{2+} (aq) = 8.70 × 10^{-4} × 5 = 4.35 × 10^{-3} **M2:** mass of Fe^{2+} (aq) = 4.35 × 10^{-3} × 55.8 × $\frac{100}{25}$ = 0.971 g	2
2(d)(iii)	n MnO_4^- (aq) = 17.1 × 0.02 / 1000 = 3.42 × 10^{-4} n Fe^{2+} (aq) = 3.42 × 10^{-4} × 5 = 1.71 × 10^{-3} mass of Fe^{2+} (aq) = 1.71 × 10^{-3} × 55.8 × $\frac{250}{25}$ = 0.954 g	1
2(d)(iv)	% Fe^{3+} = ((2(d)(ii) × $\frac{250}{100}$) – 2(d)(iii))/(2(d)(ii) × $\frac{250}{100}$)) × 100% OR (2(d)(ii) × 2.5 – 2(d)(iii)) / (2(d)(ii) × 2.5) × 100%	1
2(d)(v)	reduce / use (in step 6) more than 100 cm³ of solution (Fe^{2+} and Fe^{3+})	1

Q# 33/ ALvl Chemistry/2021/m/TZ 2/ Paper 5/Q# 2/www.SmashingScience.org :o)

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
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 cm³) = 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
2(c)(i)	(aqueous) sodium hydroxide	1
2(c)(ii)	**M1:** mol H^+(aq) in 250 cm³ = 6.10 × 10^{-2} / 4 = 1.525 × 10^{-2} (mol) **M2:** ratio $C_2O_4^{2-}$(aq) : H^+(aq) (1.22 × 10^{-2} / 1.22 × 10^{-2}) : 1.525 × 10^{-2} / 1.22 × 10^{-2} = 1 : 1.25 and *b* = 1.25 **M3:** 2 – 1.25 *a* = 0.75	3
2(c)(iii)	**M1:** M_r of hydrated $K_{0.75}H_{1.25}C_2O_4 \bullet dH_2O$ = 1.89 / 1.22 × 10^{-2} = 154.9 OR M_r of anhydrous $K_{0.75}H_{1.25}C_2O_4$ = [(0.75 × 39.1) + (1.25 × 1.0) + (2 × 12.0) + (4 × 16.0)] = 118.575 **M2:** mass of water = hydrated mass – anhydrous mass = 154.9 – 118.575 = 36.325 AND 36.325 / 18 = 2	2
2(d)	**M1:** initial readings mass of (empty) crucible / g mass of crucible + crystals before heating / g mass of crucible + crystals after heating / g **M2:** second reading of mass of crucible + crystals after re-heating	2

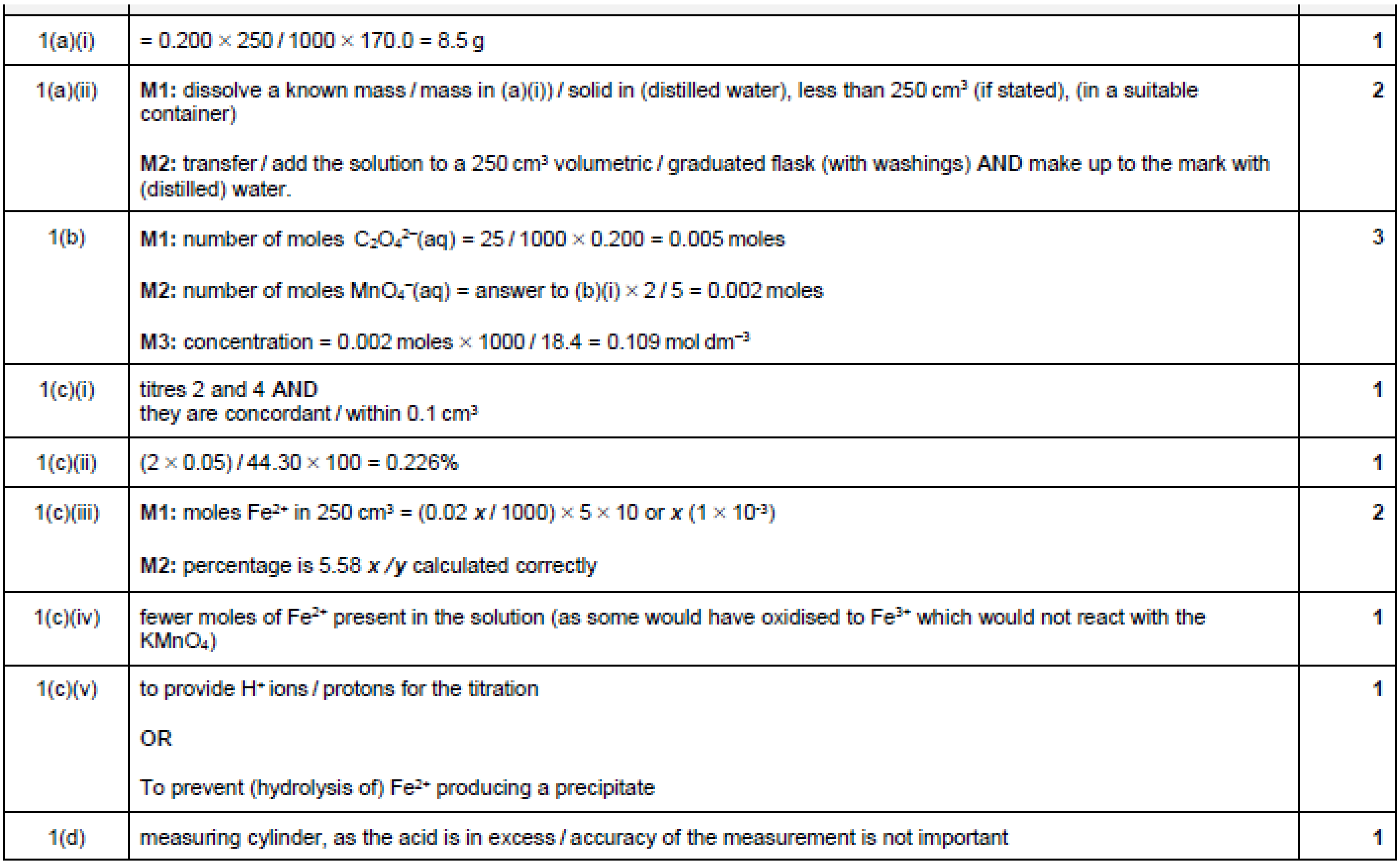
Q# 34/ ALvl Chemistry/2020/w/TZ 1/ Paper 5/Q# 1/www.SmashingScience.org :o)



Examples of how to apply the list rule

State three reasons…. [3]

A	1. Correct	✓	**2**
	2. Correct	✓	
	3. Wrong	✗	
B **(4 responses)**	1. Correct, Correct	✓, ✓	**3**
	2. Correct	✓	
	3. Wrong	ignore	
C **(4 responses)**	1. Correct	✓	**2**
	2. Correct, Wrong	✓, ✗	
	3. Correct	ignore	
D **(4 responses)**	1. Correct	✓	**2**
	2. Correct, CON (of 2.)	✗, (discount 2)	
	3. Correct	✓	
E **(4 responses)**	1. Correct	✓	**3**
	2. Correct	✓	
	3. Correct, Wrong	✓	
F **(4 responses)**	1. Correct	✓	**2**
	2. Correct	✓	
	3. Correct CON (of 3.)	✗ (discount 3)	
G **(5 responses)**	1. Correct	✓	**3**
	2. Correct	✓	
	3. Correct Correct CON (of 4.)	✓ ignore ignore	
H **(4 responses)**	1. Correct	✓	**2**
	2. Correct	✗	
	3. CON (of 2.) Correct	(discount 2) ✓	
I **(4 responses)**	1. Correct	✓	**2**
	2. Correct	✗	
	3. Correct CON (of 2.)	✓ (discount 2)	



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 cm^3 (if stated), (in a suitable container) **M2:** transfer / add the solution to a 250 cm^3 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
1(c)(i)	titres 2 and 4 AND they are concordant / within 0.1 cm^3	1
1(c)(ii)	(2 × 0.05) / 44.30 × 100 = 0.226%	1
1(c)(iii)	**M1:** moles Fe^{2+} in 250 cm^3 = (0.02 ***x*** / 1000) × 5 × 10 or ***x*** (1 × 10^{-3}) **M2:** percentage is 5.58 ***x*** /***y*** calculated correctly	2
1(c)(iv)	fewer moles of Fe^{2+} present in the solution (as some would have oxidised to Fe^{3+} which would not react with the $KMnO_4$)	1
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# 35/ ALvl Chemistry/2020/m/TZ 2/ Paper 5/Q# 1/www.SmashingScience.org :o)

Science-Specific Marking Principles

1 Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly.

2 The examiner should not choose between contradictory statements given in the same question part, and credit should not be awarded for any correct statement that is contradicted within the same question part. Wrong science that is irrelevant to the question should be ignored.

3 Although spellings do not have to be correct, spellings of syllabus terms must allow for clear and unambiguous separation from other syllabus terms with which they may be confused (e.g. ethane / ethene, glucagon / glycogen, refraction / reflection).

4 The error carried forward (ecf) principle should be applied, where appropriate. If an incorrect answer is subsequently used in a scientifically correct way, the candidate should be awarded these subsequent marking points. Further guidance will be included in the mark scheme where necessary and any exceptions to this general principle will be noted.

5 <u>'List rule' guidance</u> (see examples below)

For questions that require *n* responses (e.g. State two reasons …):

- The response should be read as continuous prose, even when numbered answer spaces are provided
- Any response marked *ignore* in the mark scheme should not count towards *n*
- Incorrect responses should not be awarded credit but will still count towards *n*
- Read the entire response to check for any responses that contradict those that would otherwise be credited. Credit should **not** be awarded for any responses that are contradicted within the rest of the response. Where two responses contradict one another, this should be treated as a single incorrect response
- Non-contradictory responses after the first *n* responses may be ignored even if they include incorrect science.

6 <u>Calculation specific guidance</u>

Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'.

For questions in which the number of significant figures required is not stated, credit should be awarded for correct answers when rounded by the examiner to the number of significant figures given in the mark scheme. This may not apply to measured values.

For answers given in standard form, (e.g. $a \times 10^n$) in which the convention of restricting the value of the coefficient (a) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme.

Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.

7 <u>Guidance for chemical equations</u>

Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme.

State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

<table>
<tr><td>1(a)</td><td>M1 Order of weighing
• boat + brass is weighed
• (brass transferred)
• empty boat reweighed

M2 table + units
<table>
<tr><td></td><td>/ g</td></tr>
<tr><td>Mass of boat + brass before transfer</td><td></td></tr>
<tr><td>Mass of boat after transfer</td><td></td></tr>
<tr><td>Mass of brass transferred</td><td></td></tr>
</table>
</td><td>2</td></tr>
<tr><td>1(b)</td><td>toxic / poisonous gas given off</td><td>1</td></tr>
<tr><td>1(c)</td><td>M1 transfer of solution A into a 250 cm^3 volumetric flask and rinsing of beaker

M2 top up to mark of (250 cm^3) volumetric flask using distilled water</td><td>2</td></tr>
<tr><td>1(d)</td><td>(25 cm^3) pipette</td><td>1</td></tr>
<tr><td>1(e)</td><td>no more effervescence is seen</td><td>1</td></tr>
<tr><td>1(f)</td><td>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</td><td>2</td></tr>
</table>

1(g)(i)	**M1** all titres recorded to 2 dp: 20.50; 19.65; 19.90; 19.75 **M2** (titres 1 and 3 averaged and) answer given as 19.7(0)	2
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
1(h)(i)	**M1** mol of thio used = $\frac{0.1\times 16.50}{1000} = 1.65\times 10^{-3}$ mol **M2** mol of I_2 produced = $\frac{1.65\times 10^{-3}}{2} = 8.25\times 10^{-4}$ mol	2
1(h)(ii)	**M1** mol of Cu^{2+} produced from brass in 25.00 cm³ $= 8.25\times 10^{-4}\times 2 = 1.65\times 10^{-3}$ mol **M2** mass of Cu in brass in 250.0 cm³ = $1.65\times 10^{-3}\times \frac{250}{25}\times 63.5 = 1.04(775)$ g **M3** percentage of Cu in brass = $\left[\frac{1.04(775)}{1.88}\right]\times 100 = 55.7\ \%$ OR **M1** $8.85\times 10^{-4}\times 2 = 1.77\times 10^{-3}$ mol **M2** M1 $\times\frac{250}{25}\times 63.5$ OR $1.77\times 10^{-2}\times 63.5 = 1.12(395)$ g **M3** $\left(\frac{M2}{1.88}\right)\times 100$ or $\left[\frac{1.12(395)}{1.88}\right]\times 100 = 59.8\ \%$	3
1(i)	(Ag^+) react with I^- / iodide (ions) to form a precipitate / solid	1

Q# 36/ ALvl Chemistry/2018/m/TZ 2/ Paper 5/Q# 2/www.SmashingScience.org :o)

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

1	**(a)**	PLAN Problem	PbO 1:1, Pb_3O_4 1:1.33, PbO_2 1:2 All three correct two marks. Two correct one mark.	[2]
	(b)	PLAN Problem	Correctly labelled axes and three straight lines drawn converging at the origin. Correct order of the lines. If 'O' is on the *y*-axis, order on axes is PbO_2 (steepest gradient), Pb_3O_4, PbO. Allow 'Pb' on *y*-axis, order reversed.	[2]
	(c)	PLAN Problem	(i) lead (allow lead oxide or oxide) **AND** (ii) oxygen (allow O_2 **OR** lead)	[1]
	(d)	PLAN Method	Diagram shows a heated piece of apparatus containing some lead oxide with hydrogen passing over it with inlet and outlet shown. **Diagram** shows apparatus to generate hydrogen using Mg/A*l*/Zn/Fe **AND** any dilute acid (labelled) **OR** group 1 metal/alcohol **OR** Ca with water or dilute acid. Shows excess hydrogen being burned **OR** led away from apparatus/collected.	[1] [1] [1]
	(e)	PLAN Method	Chooses mass (M) of lead oxide between 1 g and 25 g. Re-heats to constant mass. Calculates a volume of hydrogen sufficient to reduce the oxide. (mark is for the method, units are required.) Suggests calculating the moles of Pb and O/mole ratio of Pb to O.	[1] [1] [1] [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]
	(g)	PLAN Method	Columns are: mass/weight of the oxide; mass/weight of lead; mass/weight of oxygen; (mass units needed for these three) moles of lead; moles of oxygen; (no units). If five/four are fully correct, 2 marks, if only three/two are correct, 1 mark.	[2]
		Total		**[15]**

Q# 38/ ALvl Chemistry/2007/s/TZ 1/ Paper 5/Q# 2/www.SmashingScience.org :o)

Question	Sections	Indicative material	Mark	
2 (a)	ACE Data	**Correct headings for two or three of the following columns:** mass of mercury chloride (B–A) mass of mercury (C–A) mass of chlorine (B–C) *Mass of chlorine can be obtained from mass of mercury chloride and mass of mercury (D–E or vice versa)* ***The correct equation must be included but units are not necessary in these columns***	[1]	
		Correct subtractions for all values (Allow 1 error only) ***Each subtraction recorded to 1 decimal place (zero omitted in the 2nd decimal place is a separate error)***	[1]	[2]
(b)	ACE Data	Plots, with correct labels – (**not** (D, E, F etc)) and units: mass of mercury against mass of mercury chloride **or** mass of chlorine against mass of mercury chloride *mass of mercury chloride must be on x axis (as independent variable)* **or** mass of mercury against mass of chlorine *(either axes)* *Candidate may convert masses to moles and plot the latter*	[1]	
		Suitable scales selected – data to be plotted over more than half of each axis	[1]	
		Candidate plots all 8 points	[1]	
		Candidate draws a straight line <u>which passes through (0,0) or would pass through (0,0) if extrapolated</u> and has a maximum number of points close to or on the line	[1]	[4]
(c)	ACE Evaluation	Identifies any point(s) that do not lie on the line drawn **Do not give this mark unless experiment 4 is one of the points identified** If there are more points on the same side of the graph as (correctly plotted) data for experiment 4 the mass of Hg is too low Award marks as follows: (i) Refers to loss of mercury **or** <u>if mass of chlorine</u> has been plotted on one axis refers to too high a mass of chlorine [1] (ii) Reference to experimental method – describes mercury being poured away or reaction not going to completion [1] **OR** If there are more points on the <u>opposite</u> side of the graph as (correctly plotted) data for experiment 4 the mass of Hg is too high Award marks as follows: (i) Refers to mass of mercury being greater than expected/it should be **or** <u>if mass of chlorine</u> has been plotted on one axis refers to too low a mass of chlorine	[1]	

		(ii) Reference to experimental method – describes mercury not being adequately dried (water or propanone) [1] If there are equal numbers of points on either side of the line only award marks if the explanation is linked to relative position of the points and the line. [1]	[2]	**[3]**
(d)	**ACE Evaluation**	Refers to balance error or % error being less significant if larger masses are weighed	[1]	**[1]**
(e)	**ACE Data**	Two construction lines to graph **or** one construction line to graph are seen on the graph **and** values of a pair of points **or** a single point are **correctly read** from the graph The points read from the graph should be used in some form of calculation e.g. calculating a gradient. Correctly calculates (using the candidate's figures from the graph) the value of **x** in $HgCl_x$ and gives the formula with an integral value of **x** in the final answer *Where a candidate obtains a ratio of Hg:Cl of 1:1.5 accept* Hg_2Cl_3 *or Cl rounded up or down to 1 or 2 as appropriate.*	[1] [1]	**[2]**

Question	**Sections**	Indicative material	**Mark**	
(f)	**ACE Conclusions**	Supporting evidence must be given from and fit the data plotted Suitable experimental method: Refers to a straight line, (passing through the origin), with few points off the line or Experimental method not suitable: Reverse argument to above or Suitable experimental method: Experimental data gives a value of **x** that is very close to an integer or Experimental method not suitable: Experimental data does not give an integral value of **x**	[1] [1]	**[2]**
(g)	**ACE Conclusions**	Soluble silver salt named e.g. silver nitrate/ $AgNO_3$ *Accept* Ag^+*(aq), solution containing* Ag^+ *or solution containing silver(I)* *Do not accept* Ag^+ *or silver* **or** Soluble lead(II) salt named e.g. lead nitrate/ $Pb(NO_3)_2$ *Accept* Pb^{2+}*(aq), solution containing* Pb^{2+} *or solution containing lead(II)* *Do not accept* Pb^{2+} *or lead* ***If formula or cation is given it must be correct*** *Ignore any potential reaction of an anion in the reagent with* Hg^{2+}	[1]	**[1]**
				[Total: 15]

Appendix

Data for Question 2

	A	B	C	D	E	F
expt	mass of beaker /g	mass of beaker + mercury chloride /g	mass of beaker + mercury /g	mass of mercury chloride /g	mass of mercury /g	mass of chlorine /g
				(B–A)	(C–A)	(B–C) (D–E)
1	54.87	55.52	55.30	0.65	0.43	0.22
2	54.64	55.88	55.59	1.24	0.95	0.29
3	56.70	58.38	57.94	1.68	1.24	0.44
4	51.03	53.34	52.53	2.31	1.50	0.81
5	55.33	58.74	57.84	3.41	2.51	0.90
6	53.05	57.20	56.10	4.15	3.05	1.10
7	53.92	58.57	57.17	4.65	3.25	1.40
8	55.26	61.09	59.57	5.83	4.31	1.52

Zero required as second decimal place. Treat each error as a separate error

Candidate plots the following masses:

y axis	x axis	equation
mercury	mercury chloride	slope x (201 + 35.5x) = 201
mercury chloride	mercury	slope x 201 = (201 + 35.5x)
chlorine	mercury chloride	slope x (201 + 35.5x) = 35.5x
mercury chloride	chlorine	slope x 35.5x = (201 + 35.5x)
mercury	chlorine	slope x 35.5x = 201
chlorine	mercury	slope x 201 = 35.5x

Q# 39/ ALvl Chemistry/2006/s/TZ 1/ Paper 5/Q# 2/www.SmashingScience.org :o)

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]**

(c) Give **one mark** for preventing copper from re-oxidising / keeping air away from the hot copper or equivalent. **[1]**

(d) Give **one mark** for reference to reheating/reweighing or heating to constant mass. **[1]**

(e) Give **one mark** for a calculation to obtain appropriate moles of CuO and Cu_2O, water, copper.

Give **one mark** for relating the calculated moles to quantities in the equation. **[2]**

[Total: 8]

Question 1

(a) Titration Tables 1.1 and 1.2

Give **one mark** if

all final burette readings in both tables are to 2 decimal places, in the correct places in both tables and the subtraction in Table 1.1 is correct. titrations in Table 1.2 that are labelled Rough do **not** need to be to 2 d.p. and subtraction need not be checked **unless** the value has been included in calculating the average.

Titration Table 1.1

Give **one mark** if

A **candidate recorded** volume between 45.00 cm^3 and 45.50 cm^3 has been diluted.

Titration Table 1.2

Give **one mark** if

Two (uncorrected) titres are within 0.10 cm^3

Give **one mark** if

a suitable average has been selected. (Do not give this mark if there is an error in subtraction in Table 1.2)

4

Accuracy

From the Supervisor's results calculate, **to 2 decimal places,**

$$\frac{\text{Volume of FB 1 diluted}}{45.00} \times \text{Titre}$$

Record this value as a ringed total below Table 1.2.

Calculate the same ratio for each candidate and compare with the Supervisor's value.

Award accuracy marks as shown in the table below.

The spread penalty may have to be applied using the table below.

Accuracy Marks	
Mark	**Difference from Supervisor**
8	Up to 0.10
7	0.10+ to 0.15
6	0.15+ to 0.20
5	0.20+ to 0.30
4	0.30+ to 0.40
3	0.40+ to 0.60
2	0.60+ to 0.80
1	0.80+ to 1.00
0	Greater than 1.00

Spread Penalty	
Range used/cm^3	**Deduction**
0.20+ to 0.25	1
0.25+ to 0.30	2
0.30+ to 0.35	3
0.35+ to 0.40	4
0.40+ to 0.50	5
0.50+ to 0.60	6
0.60+ to 0.80	7
Greater than 0.80	8

8

In all calculations, ignore evaluation errors if working is shown

(c) Give **one mark** for

$\frac{100.0}{248.2}$ or 0.403 or 0.4029

1

Do not give this mark if 32 is seen to be used instead of 32.1 for A_r of sulphur
0.403 without working gains this mark

(d) Give **one mark** for **Answer to (c) x $\frac{\text{volume of FB 1 diluted}}{250}$**

1

(e) Give **two marks** for **Answer to (d) x $\frac{\text{titre}}{1000}$ (1) x ½ (1)**

2

(f) Give **one mark** for **$\frac{25}{1000}$ x 0.023 or 0.000575**

1

(g) Give **one mark** for **$\frac{\text{answer to (e)}}{\text{answer to (f)}}$**

1

(h) Give **one mark** for correctly calculating the oxidation numbers of

Chromium in CrO_4^{2-}	(+)6
Iodine in I^-	-1
Iodine in 1_2	0

Give **one mark** for **using the reacting quantities** in **(g)** to show that

$CrO_4^{2-} \equiv 1½ I_2 \equiv 3e^-$.

And that the oxidation number of +6 is reduced to +3.

2

Total for Question 1 20

Q# 41/ ALvl Chemistry/2002/s/TZ 1/ Paper 5/Q# 1/www.SmashingScience.org :o)

N.B. Boxed references within this marking scheme relate to the accompanying booklet of Standing Instructions

1 (a) ***Experiment 1***

Titration table $\boxed{\text{Standing Instructions (f)}}$

Check the Candidate's subtraction of each titration unless labelled Rough. The subtraction of a Rough titration should be checked if the Candidate has ticked the value and used it in calculating the average titre.

Give **one mark** if all burette readings are in the correct spaces in the table, the volume has been filled in, and all final burette readings are to at least 2 d.p. Ignore any titre which has been labelled **Rough**.

Give **one mark** for a sufficient number of titrations (any two titres differing by 0.10 cm^3 or less). Award this mark on uncorrected titres – **Rough** values may be included in assessing sufficient number of titrations.

Give **one mark** for a value of volume used from the burette and **quoted in the Summary**, which is clearly justified by the Candidate's indication of the results used. **Do not give this mark if no value is quoted in the Summary, no Values are ticked in the titration table or no calculation of the average is shown**. This will usually be the value of two identical titres or any other average provided it is correct to at least 2 d.p. or to the nearest 0.05 cm^3 (first and second d.p.s may be omitted here if they are 0)

3

Accuracy

See section (g).

As soon as the candidate's average titre has been checked or corrected, the titre value transferred to page 4 should be confirmed and corrected as necessary.

Assign accuracy marks by comparing the candidate's average titre (corrected as necessary) with the Supervisor's value.

The Supervisor's Titre, corrected if necessary, should be recorded on the front of the script.

Apply spread penalty as shown below

Accuracy marks	
Mark	Difference from Supervisor / cm^3
5	up to 0.20
4	0.20+ to 0.25
3	0.25+ to 0.30
2	0.30+ to 0.50
1	0.50+ to 1.00
0	Greater than 1.00

Spread Penalty	
Range used / cm^3	Deduction
0.20+ to 0.25	1
0.25+ to 0.30	2
0.30+ to 0.35	3
0.35+ to 0.40	4
greater than 0.40	5

5

Suspect Supervisor Values

Adopt procedure (ii) in (h) for any suspect Supervisor results

If there is not an obvious value from the Candidates' results, use 24.20 as the Standard Value. Report your action to Team Leader on the Centre Accuracy Return.

Calculations

In all calculations, ignore evaluation errors if working is shown

(b) Give **one** mark for $\frac{\textbf{titre}}{\textbf{1000}} \times 0.02$ **1**

(c) Give **two** marks for **ans (a)** $\times$ **5** $\times$ $\frac{1000}{25}$ **2**

(one) **(one)**