Questions are for both separate science and combined science students unless indicated in the question

Q1.

Potash alum is a chemical compound.

Potash alum contains potassium ions, aluminium ions and sulfate ions.

(a) Which **two** methods can be used to identify the presence of potassium ions in potash alum solution?

Tick (✓) **two** boxes. **(separate only)**

Flame emission spectroscopy	☐
Flame test	☐
Measuring boiling point of solution	☐
Paper chromatography	☐
Using litmus paper	☐

(2)

(b) Sodium hydroxide solution is used to test for some metal ions.

Sodium hydroxide solution is added to a solution of potash alum until a precipitate forms.

Complete the sentence. **(separate only)**

Choose the answer from the box.

blue	**brown**	**green**	**white**

The colour of the precipitate formed is ____________________.

(1)

(c) Complete the sentence.

Choose the answer from the box. **(separate only)**

barium chloride solution	**limewater**
red litmus paper	**silver nitrate solution**

Sulfate ions can be identified using dilute hydrochloric acid and ______________________________.

(1)

(d) A solution of potash alum has a concentration of 258 g/dm^3

Calculate the mass of potash alum needed to make 800 cm^3 of a solution of potash alum with a concentration of 258 g/dm^3

Give your answer to 3 significant figures.

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Mass (3 significant figures) = _______________ g

(4)

(Total 8 marks)

Q2.

This question is about displacement reactions.

(a) The displacement reaction between aluminium and iron oxide has a high activation energy.

What is meant by 'activation energy'?

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(1)

(b) A mixture contains 1.00 kg of aluminium and 3.00 kg of iron oxide.

The equation for the reaction is:

$$2\ Al + Fe_2O_3 \rightarrow 2\ Fe + Al_2O_3$$

Show that aluminium is the limiting reactant.

Relative atomic masses (A_r): O = 16 Al = 27 Fe = 56

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(4)

Magnesium displaces zinc from zinc sulfate solution.

(c) Complete the ionic equation for the reaction.

You should include state symbols.

$$Mg(s) + Zn^{2+}(aq) \rightarrow \_\_\_\_\_\_\_\_\_\_ + \_\_\_\_\_\_\_\_\_\_$$

(2)

(d) Explain why the reaction between magnesium atoms and zinc ions is both oxidation and reduction.

(2)
(Total 9 marks)

Q3.

This question is about the halogens.

Table 1 shows the melting points and boiling points of some halogens.

Table 1

Element	**Melting point in °C**	**Boiling point in °C**
Fluorine	–220	–188

Chlorine	–101	–35
Bromine	–7	59

(a) What is the state of bromine at 0 °C **and** at 100 °C?

Tick (✓) **one** box.

State at 0 °C	**State at 100 °C**	
Gas	Gas	☐
Gas	Liquid	☐
Liquid	Gas	☐
Liquid	Liquid	☐
Solid	Gas	☐
Solid	Liquid	☐

(1)

(b) Explain the trend in boiling points of the halogens shown in **Table 1**.

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(4)

(c) Why is it **not** correct to say that the boiling point of a single bromine molecule is 59 °C?

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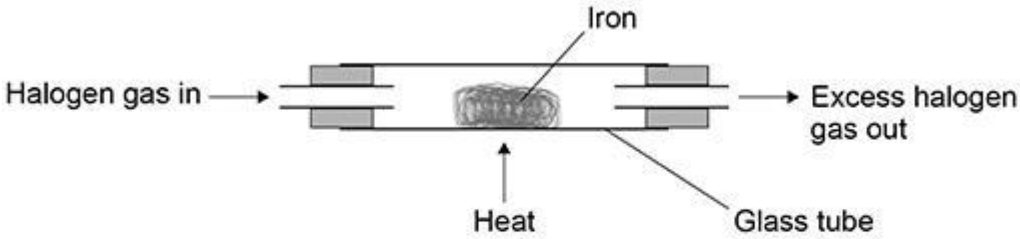
(1)

Iron reacts with each of the halogens in their gaseous form.

The diagram below shows the apparatus used.



(d) Give **one** reason why this experiment should be done in a fume cupboard.

(1)

(e) Explain why the reactivity of the halogens decreases going down the group.

(3)

(f) A teacher investigated the reaction of iron with chlorine using the apparatus in the above diagram.

The word equation for the reaction is:

iron + chlorine → iron chloride

The teacher weighed:

- the glass tube
- the glass tube and iron before the reaction
- the glass tube and iron chloride after the reaction.

Table 2 shows the teacher's results.

Table 2

	Mass in g
Glass tube	51.56
Glass tube and iron	56.04
Glass tube and iron chloride	64.56

Calculate the simplest whole number ratio of:

moles of iron atoms : moles of chlorine atoms

Determine the balanced equation for the reaction.

Relative atomic masses (A_r): Cl = 35.5 Fe = 56

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Moles of iron atoms : moles of chlorine atoms = ___________ **:** ___________

Equation for the reaction

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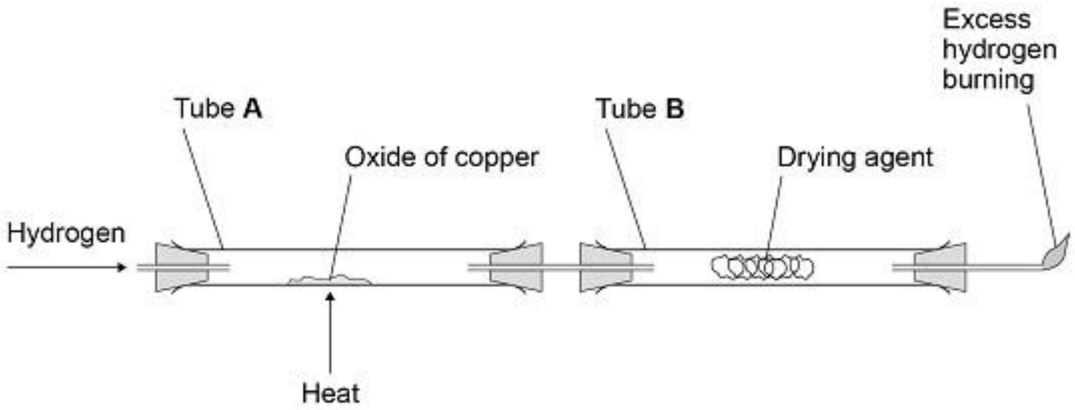
(6)
(Total 16 marks)

Q4.

Copper forms two oxides, Cu_2O and CuO

A teacher investigated an oxide of copper.

The following figure shows the apparatus.



This is the method used.

1. Weigh empty tube **A**.
2. Add some of the oxide of copper to tube **A**.
3. Weigh tube **A** and the oxide of copper.
4. Weigh tube **B** and drying agent.
5. Pass hydrogen through the apparatus and light the flame at the end.
6. Heat tube **A** for 2 minutes.
7. Reweigh tube **A** and contents.
8. Repeat steps 5 to 7 until the mass no longer changes.
9. Reweigh tube **B** and contents.
10. Repeat steps 1 to 9 with different masses of the oxide of copper.

(a) Suggest **one** reason why step 8 is needed.

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(1)

(b) Explain why the excess hydrogen must be burned off.

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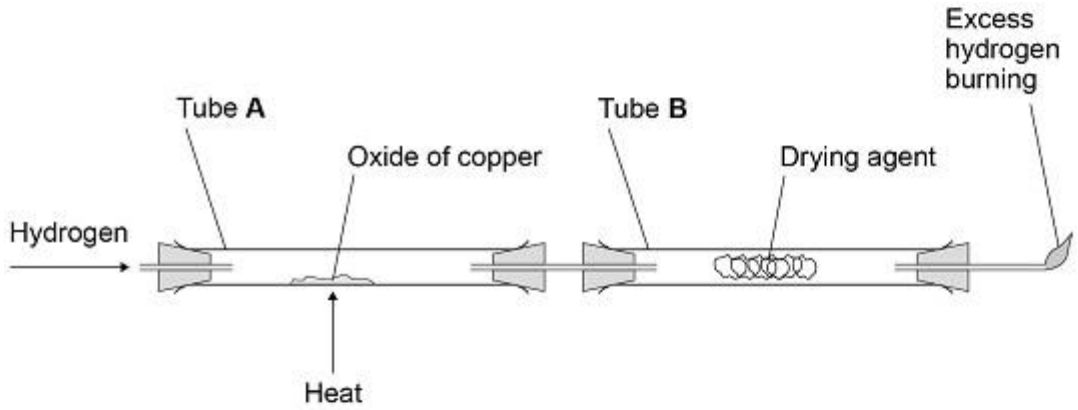
(2)

The figure above is repeated here.



The table below shows the teacher's results.

	Mass in g
Tube **A** empty	105.72
Tube **A** and oxide of copper before heating	115.47
Tube **A** and contents after 2 minutes	114.62
Tube **A** and contents after 4 minutes	114.38
Tube **A** and contents after 6 minutes	114.38
Tube **B** and contents at start	120.93
Tube **B** and contents at end	123.38

When an oxide of copper is heated in a stream of hydrogen, the word equation for the reaction is:

copper oxide + hydrogen → copper + water

(c) Determine the mass of copper and the mass of water produced in this experiment.

Use the table.

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____

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Mass of copper = ___________________________ g

Mass of water = ___________________________ g

(2)

(d) The teacher repeated the experiment with a different sample of the oxide of copper.

The teacher found that the oxide of copper produced 2.54 g of copper and 0.72 g of water.

Two possible equations for the reaction are:

Equation 1: $Cu_2O + H_2 \rightarrow 2\ Cu + H_2O$

Equation 2: $CuO + H_2 \rightarrow Cu + H_2O$

Determine which is the correct equation for the reaction in the teacher's experiment.

Relative atomic masses (A_r): H = 1 O = 16 Cu = 63.5

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(3)
(Total 8 marks)

Q5.

A student investigated the temperature change in the reaction between dilute sulfuric acid and potassium hydroxide solution.

This is the method used.

1. Measure 25.0 cm^3 potassium hydroxide solution into a polystyrene cup.

2. Record the temperature of the solution.

3. Add 2.0 cm^3 dilute sulfuric acid.

4. Stir the solution.

5. Record the temperature of the solution.

6. Repeat steps 3 to 5 until a total of 20.0 cm^3 dilute sulfuric acid has been added.

(a) Suggest why the student used a polystyrene cup rather than a glass beaker for the reaction.

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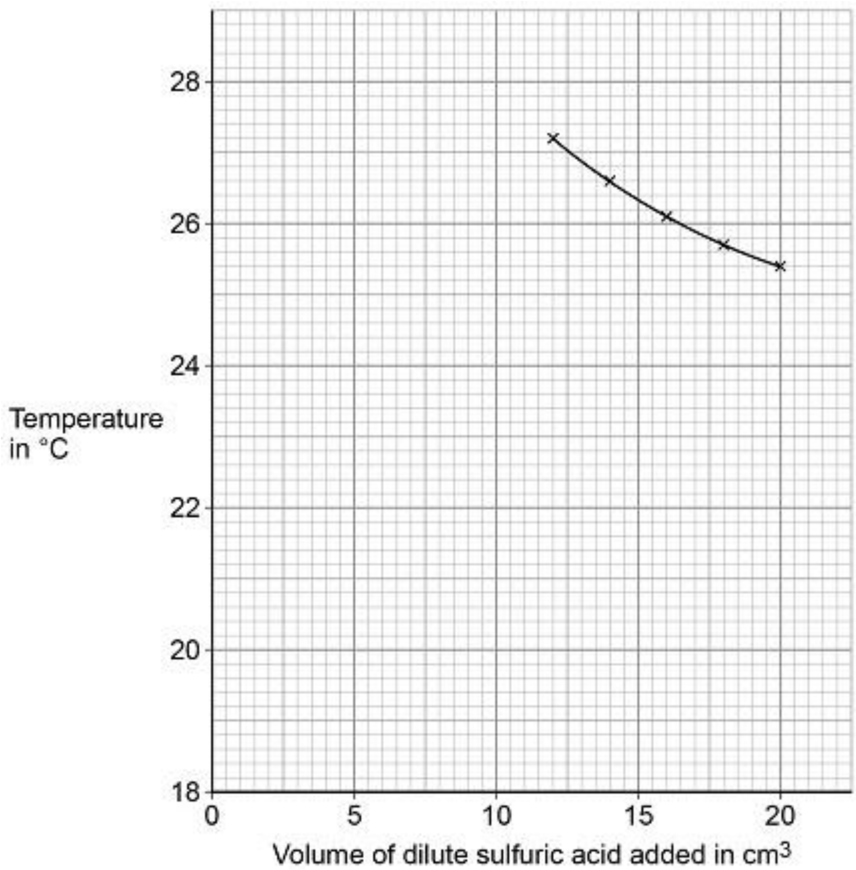
____

(2)

The following table shows some of the student's results.

Volume of dilute sulfuric acid added in cm³	Temperature in °C
0.0	18.9
2.0	21.7
4.0	23.6
6.0	25.0
8.0	26.1
10.0	27.1

The figure below shows some of the data from the investigation.



(b) Complete the figure:

- plot the data from the table
- draw a line of best fit through these points

- extend the lines of best fit until they cross.

(4)

(c) Determine the volume of dilute sulfuric acid needed to react completely with 25.0 cm^3 of the potassium hydroxide solution.

Use the figure above.

Volume of dilute sulfuric acid to react completely =
______________________ cm^3

(1)

(d) Determine the overall temperature change when the reaction is complete.

Use the figure above.

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Overall temperature change = __________________________ °C

(1)

(e) The student repeated the investigation.

The student used solutions that had different concentrations from the first investigation.

The student found that 15.5 cm^3 of 0.500 mol/dm^3 dilute sulfuric acid completely reacted with 25.0 cm^3 of potassium hydroxide solution.

The equation for the reaction is:

$$2\,KOH + H_2SO_4 \rightarrow K_2SO_4 + 2\,H_2O$$

Calculate the concentration of the potassium hydroxide solution in mol/dm^3 and in g/dm^3

Relative atomic masses (A_r): H = 1 O = 16 K = 39 **(separate only)**

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Concentration in mol/dm^3 = ____________________ mol/dm^3

Concentration in g/dm^3 = ____________________ g/dm^3

(6)

(Total 14 marks)

Q6.

This question is about elements in Group 1.

A teacher burns sodium in oxygen.

(a) Complete the word equation for the reaction.

sodium + oxygen ⟶ ____________________

(1)

(b) What is the name of this type of reaction?

Tick **one** box.

Decomposition ☐

Electrolysis ☐

Oxidation ☐

Precipitation ☐

(1)

(c) The teacher dissolves the product of the reaction in water and adds universal indicator.

The universal indicator turns purple.

What is the pH value of the solution?

Tick **one** box.

1		4		7		13	

(1)

(d) The solution contains a substance with the formula NaOH

Give the name of the substance.

____

(1)

(e) All alkalis contain the same ion.

What is the formula of this ion?

Tick **one** box.

H^+	☐
Na^+	☐
OH^-	☐
O^{2-}	☐

(1)

(f) A solution of NaOH had a concentration of 40 g/dm^3

What mass of NaOH would there be in 250 cm^3 of the solution?

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____

Mass = ____________________ g

(2)

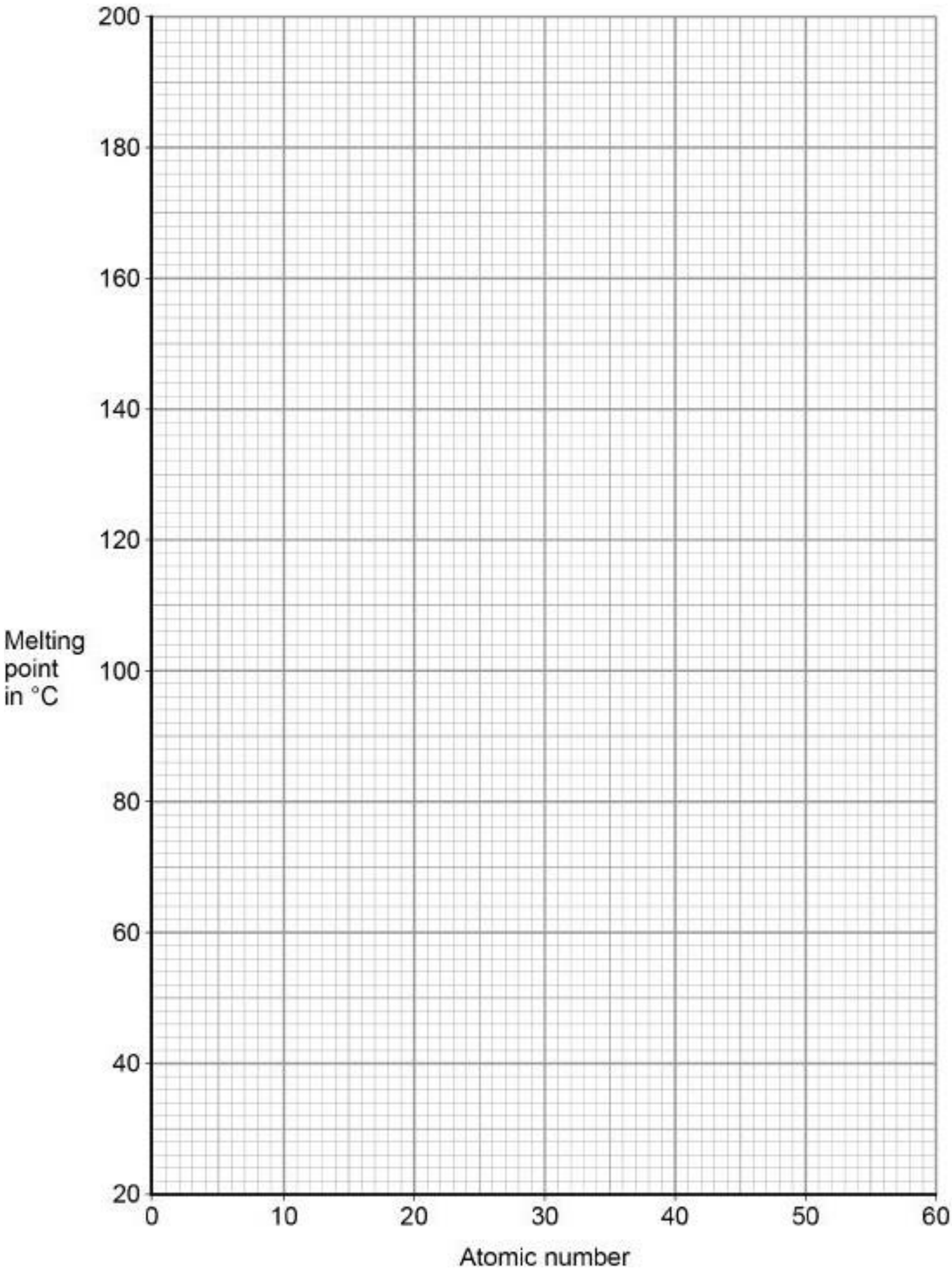
(g) The melting points of the elements in Group 1 show a trend.

The table below shows the atomic numbers and melting points of the Group 1 elements.

Element	**Atomic number**	**Melting point in °C**
Lithium	3	181

Sodium	11	98
Potassium	19	63
Rubidium	37	**X**
Caesium	55	29

Plot the data from the table on the graph below.



(2)

(h) Predict the melting point, **X**, of rubidium, atomic number 37

Use the graph above.

Melting point = ______________________ °C

(1)

(Total 10 marks)

Q7.

Titanium is a transition metal.

Titanium is extracted from titanium dioxide in a two-stage industrial process.

Stage 1 $TiO_2 + 2\ C + 2\ Cl_2 \longrightarrow TiCl_4 + 2\ CO$

Stage 2 $TiCl_4 + 4\ Na \longrightarrow Ti + 4\ NaCl$

(a) Suggest **one** hazard associated with **Stage 1**.

____

____

(1)

(b) Water must be kept away from the reaction in **Stage 2**.

Give **one** reason why it would be hazardous if water came into contact with sodium.

____

____

(1)

(c) Suggest why the reaction in **Stage 2** is carried out in an atmosphere of argon and **not** in air.

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(2)

(d) Titanium chloride is a liquid at room temperature.

Explain why you would **not** expect titanium chloride to be a liquid at room temperature.

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(3)

In **Stage 2**, sodium displaces titanium from titanium chloride.

(e) Sodium atoms are oxidised to sodium ions in this reaction.

Why is this an oxidation reaction?

(1)

(f) Complete the half equation for the oxidation reaction.

$$Na \longrightarrow \_\_\_\_\_\_\_\_\_\_ + \_\_\_\_\_\_\_\_\_\_$$

(1)

(g) In Stage 2, 40 kg of titanium chloride was added to 20 kg of sodium.

The equation for the reaction is:

$$TiCl_4 + 4\ Na \longrightarrow Ti + 4\ NaCl$$

Relative atomic masses (A_r): Na = 23 Cl = 35.5 Ti = 48

Explain why titanium chloride is the limiting reactant.

You **must** show your working.

(4)

(h) For a **Stage 2** reaction the percentage yield was 92.3%

The theoretical maximum mass of titanium produced in this batch was 13.5 kg.

Calculate the actual mass of titanium produced. **(separate only)**

Mass of titanium = ______________ kg

(2)

(Total 15 marks)

Q8.

This question is about methanol.

(a) Methanol is broken down in the body during digestion.

What type of substance acts as a catalyst in this process?

Tick **one** box.

Amino acid ☐

Enzyme ☐

Ester ☐

Nucleotide ☐

(1)

In industry, methanol is produced by reacting carbon monoxide with hydrogen.

The equation for the reaction is:

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

(b) How many moles of carbon monoxide react completely with 4.0×10^3 moles of hydrogen?

Tick **one** box.

1.0×10^3 moles ☐

2.0×10^3 moles ☐

4.0×10^3 moles ☐

8.0×10^3 moles ☐

(1)

(c) The reaction is carried out at a temperature of 250 °C and a pressure of 100 atmospheres.

The forward reaction is exothermic.

Explain what happens to the yield of methanol if a temperature higher than 250 °C is used.

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(2)

(d) A pressure of 100 atmospheres is used instead of atmospheric pressure.

The higher pressure gives a greater yield of methanol and an increased rate of reaction.

Explain why.

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(4)

A catalyst is used in the reaction to produce methanol from carbon monoxide and hydrogen.

(e) Explain how a catalyst increases the rate of a reaction.

(2)

(f) Suggest why a catalyst is used in this industrial process.

Do **not** give answers in terms of increasing the rate of reaction.

(1)

(g) Suggest the effect of using the catalyst on the equilibrium yield of methanol.

(1)
(Total 12 marks)

Q9.

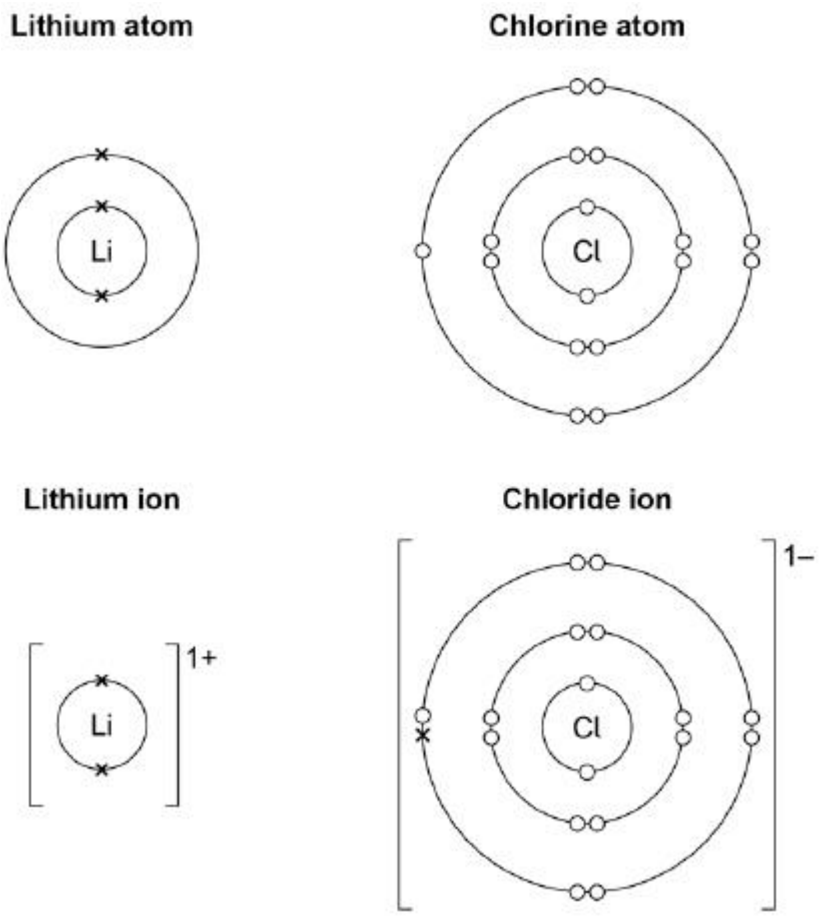
This question is about metal compounds.

(a) Lithium reacts with chlorine to produce lithium chloride.

When lithium atoms and chlorine atoms react to produce lithium chloride, lithium ions and chloride ions are formed.

The diagram shows the electronic structures of the atoms and ions.

The symbols **o** and **x** are used to represent electrons.



Describe what happens when a lithium atom reacts with a chlorine atom.

Answer in terms of electrons.

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(4)

Zinc sulfate can be made by two methods.

The equations for the two methods are:

Method 1: $ZnO + H_2SO_4 \longrightarrow ZnSO_4 + H_2O$

Method 2: $ZnCO_3$ + H_2SO_4 ⟶ $ZnSO_4$ + H_2O + CO_2

(b) Calculate the percentage atom economy for making zinc sulfate in **Method 1**.

Use the equation:

percentage atom economy =

$$\frac{\text{relative formula mass of } ZnSO_4}{\text{relative formula mass of } ZnO + \text{relative fomula mass of } H_2SO_4} \times 100$$

Give your answer to 3 significant figures.

Relative formula masses (M_r): ZnO = 81 H_2SO_4 = 98 $ZnSO_4$ = 161 **(separate only)**

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____

Percentage atom economy = ______________________ %

(3)

(c) **Method 1** gives a higher percentage atom economy for making zinc sulfate than **Method 2**.

Give a reason why it is important to use a reaction with a high atom economy. **(separate only)**

____

____

(1)

(d) A student uses 50 cm^3 of a zinc sulfate solution of 80 g/dm^3

What mass of zinc sulfate is dissolved in 50 cm^3 of this zinc sulfate solution?

____

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____

____

Mass = ______________________ g

(2)

(Total 10 marks)

Q10.

A scientist produces zinc iodide (ZnI_2).

This is the method used.

1. Weigh 0.500 g of iodine.
2. Dissolve the iodine in ethanol.
3. Add an excess of zinc.
4. Stir the mixture until there is no further change.
5. Filter off the excess zinc.
6. Evaporate off the ethanol.

(a) Ethanol is flammable.

Suggest how the scientist could carry out **Step 6** safely.

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(1)

(b) Explain why the scientist adds excess zinc rather than excess iodine.

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(3)

(c) Calculate the minimum mass of zinc that needs to be added to 0.500 g of iodine so that the iodine fully reacts.

The equation for the reaction is:

$$Zn + I_2 \longrightarrow ZnI_2$$

Relative atomic masses (M_r): Zn = 65 I = 127

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Minimum mass of zinc = ____________________ g

(3)

A different scientist makes zinc iodide by the same method.

The scientist obtains 12.5 g of zinc iodide.

The percentage yield in this reaction is 92.0%.

(d) What is the maximum theoretical mass of zinc iodide produced in this reaction? **(separate only)**

Maximum theoretical mass = ____________________ g

(3)

(e) Suggest **one** reason why the percentage yield in this reaction is **not** 100%. **(separate only)**

(1)

(f) The scientist makes a solution of zinc iodide with a concentration of 0.100 mol / dm^3

Calculate the mass of zinc iodide (ZnI_2) required to make 250 cm^3 of this solution.

Relative atomic masses (A_r): Zn = 65 I = 127 **(separate only)**

Mass = ____________________ g

(3)

(Total 14 marks)

Q11.

Potable water is water that is safe to drink.

Seawater can be changed into potable water by desalination.

(a) Name the substance removed from seawater by desalination.

(1)

(b) Desalination requires large amounts of energy.

Desalination is only used when there is no other source of potable water.

Give **one** reason why.

(1)

Water from lakes and rivers can be treated to make it potable.

(c) The first stage is to filter the water from lakes and rivers.

Why is the water filtered?

(1)

(d) Chlorine gas is then added to the filtered water.

Why is chlorine gas used to treat water?

(1)

(e) Describe a test for chlorine gas.

Give the result of the test if chlorine is present.

Test

___

Result ___

(2)

Some students investigated different water samples.

The table shows some of their results.

Water	**pH**	**Mass of dissolved solid in g / dm³**
Tap water	6.5	0.5
Seawater	8.1	35.0
Pure water		

(f) Complete the table above to show the expected results for pure water.

(2)

(g) What mass of dissolved solid is present in 100 cm^3 of the sample of tap water?

Tick (✓) **one** box.

0.05 g ☐

0.5 g ☐

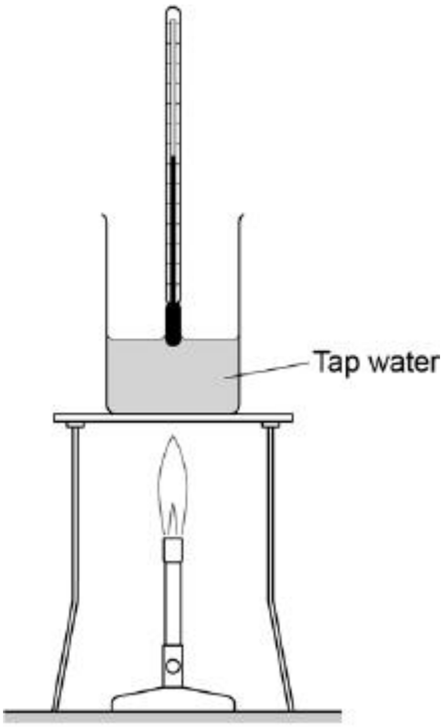
5 g ☐

50 g ☐

(1)

(h) Boiling points can be used to show whether substances are pure.

The diagram shows the apparatus the students used to find the boiling point of tap water.



The students made a mistake setting up the apparatus.

What mistake did the students make?

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____

(1)
(Total 10 marks)

Q12.

A student investigated the reactions of copper carbonate and copper oxide with dilute hydrochloric acid.

In both reactions one of the products is copper chloride.

(a) Describe how a sample of copper chloride crystals could be made from copper carbonate and dilute hydrochloric acid.

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(4)

(b) A student wanted to make 11.0 g of copper chloride.

The equation for the reaction is:

$$CuCO_3 + 2HCl \rightarrow CuCl_2 + H_2O + CO_2$$

Relative atomic masses, A_r: H = 1; C = 12; O = 16; Cl = 35.5; Cu = 63.5

Calculate the mass of copper carbonate the student should react with dilute hydrochloric acid to make 11.0 g of copper chloride.

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Mass of copper carbonate = ______________________________ g

(4)

(c) The percentage yield of copper chloride was 79.1 %.

Calculate the mass of copper chloride the student actually produced. **(separate only)**

____

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Actual mass of copper chloride produced = ______________ g

(2)

(d) Look at the equations for the two reactions:

Reaction 1 $CuCO_3(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + H_2O(l) + CO_2(g)$

Reaction 2 $CuO(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + H_2O(l)$

Reactive formula masses: CuO = 79.5; HCl = 36.5; $CuCl_2$ = 134.5; H_2O = 18

The percentage atom economy for a reaction is calculated using:

$$\frac{\text{Relative formula mass of desired product from equation}}{\text{Sum of relative formula masses of all reactants from equation}} \times 100$$

Calculate the percentage atom economy for Reaction 2. **(separate only)**

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____

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____

Percentage atom economy = ____________________ %

(3)

(e) The atom economy for Reaction 1 is 68.45 %.
Compare the atom economies of the two reactions for making copper chloride.

Give a reason for the difference. **(separate only)**

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(1)

(Total 14 marks)

Q13.

Sodium carbonate reacts with dilute hydrochloric acid:

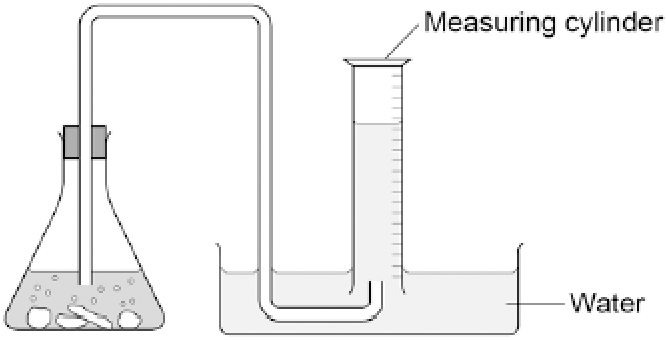
$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$$

A student investigated the volume of carbon dioxide produced when different masses of sodium carbonate were reacted with dilute hydrochloric acid.

This is the method used.

1. Place a known mass of sodium carbonate in a conical flask.
2. Measure 10 cm^3 of dilute hydrochloric acid using a measuring cylinder.
3. Pour the acid into the conical flask.
4. Place a bung in the flask and collect the gas until the reaction is complete.

(a) The student set up the apparatus as shown in the figure below.



Identify the error in the way the student set up the apparatus.

Describe what would happen if the student used the apparatus shown.

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___

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(2)

(b) The student corrected the error.

The student's results are shown in the table below.

Mass of sodium carbonate in g	Volume of carbon dioxide gas in cm^3
0.07	16.0
0.12	27.5
0.23	52.0
0.29	12.5
0.34	77.0
0.54	95.0
0.59	95.0
0.65	95.0

The result for 0.29 g of sodium carbonate is anomalous.

Suggest what may have happened to cause this anomalous result.

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(1)

(c) Why does the volume of carbon dioxide collected stop increasing at 95.0 cm^3?

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(1)

(d) What further work could the student do to be more certain about the minimum mass of sodium carbonate needed to produce 95.0 cm^3 of carbon dioxide?

____

____

(1)

(e) The carbon dioxide was collected at room temperature and pressure. The volume of one mole of any gas at room temperature and pressure is 24.0 dm^3.

How many moles of carbon dioxide is 95.0 cm^3?

Give your answer in three significant figures. **(separate only)**

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____

____

____

______________________________________ mol

(2)

(f) Suggest **one** improvement that could be made to the apparatus used that would give more accurate results.

Give a reason for your answer.

____

____

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(2)

(g) One student said that the results of the experiment were wrong because the first few bubbles of gas collected were air.

A second student said this would make no difference to the results.

Explain why the second student was correct.

(2)
(Total 11 marks)