Candidate Name	Centre Number					Candidate Number				

GCSE CHEMISTRY

COMPONENT 1

Concepts in Chemistry

HIGHER TIER

SAMPLE PAPER

(2 hours 15 minutes)

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1	**12**	
2	**10**	
3	**8**	
4	**12**	
5	**14**	
6	**9**	
7	**8**	
8	**20**	
9	**10**	
10	**11**	
11	**6**	
Total	**120**	

ADDITIONAL MATERIALS

In addition to this examination paper you will need:
- a calculator
- a ruler

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen. Do not use correction fluid.
Write your name, centre number and candidate number in the spaces at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

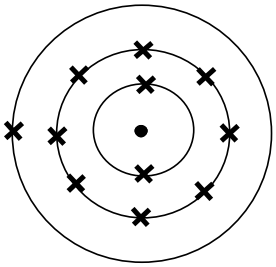
The number of marks is given in brackets at the end of each question or part-question.
The assessment of the quality of extended response (QER) will take place in question **11**.

Answer **all** *questions*.

1. (a) Complete the following table that shows information about atoms of some elements. [5]

Element	Symbol	Number of protons	Number of neutrons	Number of electrons
beryllium	$^{9}_{4}Be$	4	5	4
fluorine	$^{19}_{9}F$	9	……	……
calcium	……..	20	20	……
argon	$^{40}_{18}Ar$	…….	22	18

(b) The diagram below shows the electronic structure of an element in the Periodic Table.



Using X to represent an electron, draw a similar diagram to show the electronic structure of the element which:

(i) lies directly **below** this element in the Periodic Table; [1]

(ii) lies directly to the **right** of this element in the Periodic Table. [1]

(c) The diagram below shows the early form of the Periodic Table developed by Mendeleev.

I	II	III	IV	V	VI	VII			
H 1.01									
Li 6.94	Be 9.01	B 10.8	C 12.0	N 14.0	O 16.0	F 19.0			
Na 23.0	Mg 24.3	Al 27.0	Si 28.1	P 31.0	S 32.1	Cl 35.5		VIII	
K 39.1	Ca 40.1		Ti 47.9	V 50.9	Cr 52.0	Mn 54.9	Fe 55.9	Co 58.9	Ni 58.7
Cu 63.5	Zn 65.4			As 74.9	Se 79.0	Br 79.9			
Rb 85.5	Sr 87.6	Y 88.9	Zr 91.2	Nb 92.9	Mo 95.9		Ru 101	Rh 103	Pd 106
Ag 108	Cd 112	In 115	Sn 119	Sb 122	Te 128	I 127			
Ce 133	Ba 137	La 139		Ta 181	W 184		Os 194	Ir 192	Pt 195
Au 197	Hg 201	Ti 204	Pb 207	Bi 209					
			Th 232		U 238				

(i) State what information Mendeleev used to arrange the elements. [2]

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(ii) Describe and explain the differences between Period 4 of Mendeleev's table and that of the modern table. [3]

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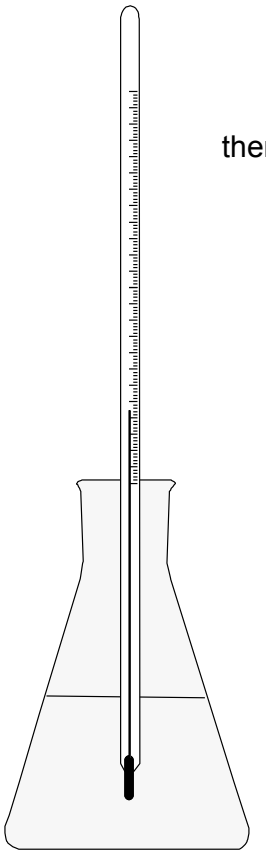
2. A pupil investigated how the temperature changes when dilute hydrochloric acid reacts with dilute sodium hydroxide solution.

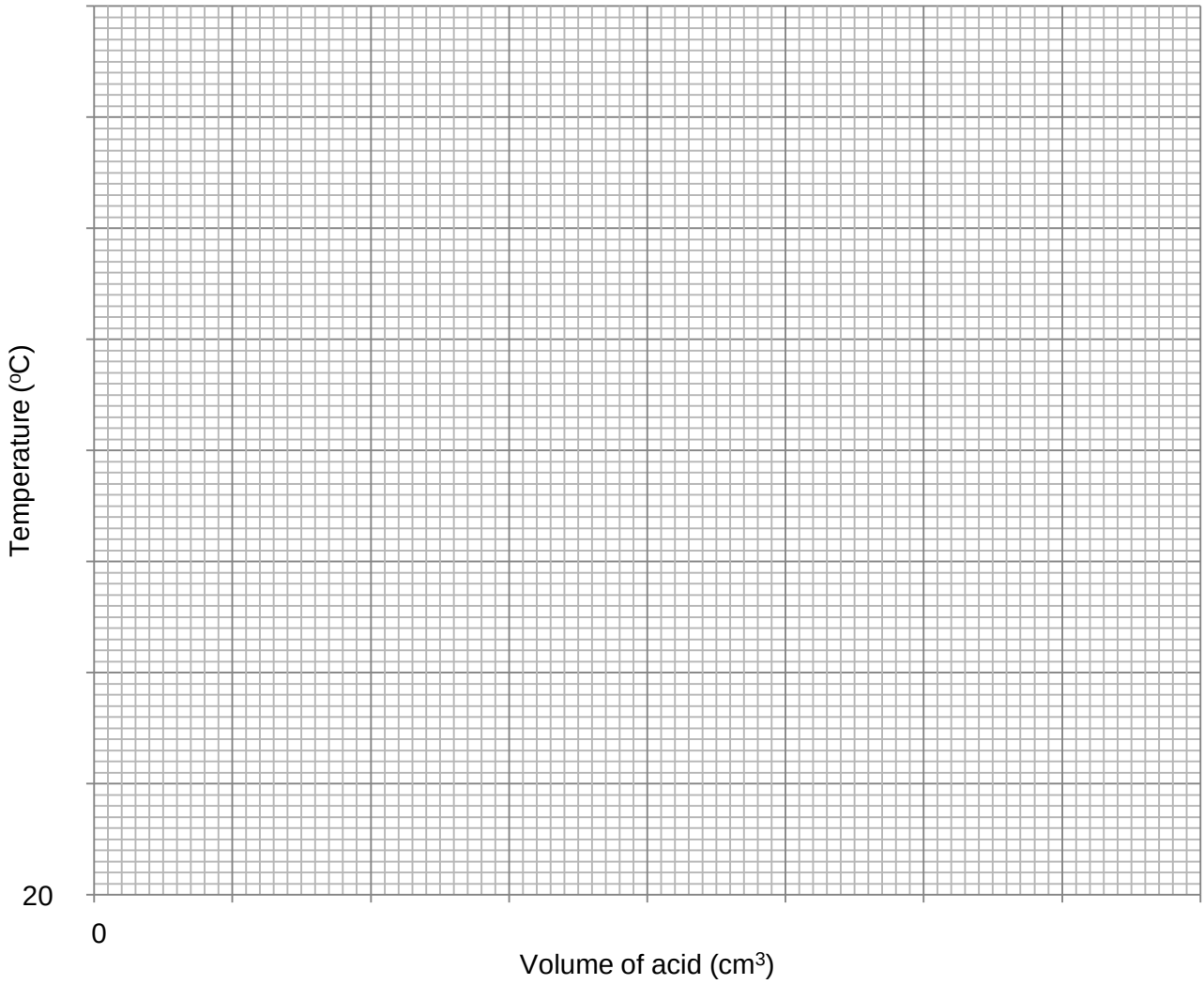


(a) 80 cm^3 of dilute acid was added, 10 cm^3 at a time, to 25 cm^3 of alkali in a conical flask. The highest temperature reached was recorded each time.

The table below shows the results obtained.

Volume of acid added (cm^3)	**Temperature (°C)**
0	21.0
10	22.8
20	24.2
30	25.4
40	26.4
50	27.0
60	26.7
70	26.2
80	25.6

(i) Use the grid provided on the next page to plot the volume of acid added against temperature.
Add a suitable line. [4]



(ii) Describe and explain the shape of the graph in relation to the chemical reaction taking place. [3]

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(b) (i) Apart from measuring the change in temperature, state a different method that could be used to show the stages of this reaction. [1]

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(ii) Explain how your new method would show the stages of the reaction. [2]

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3. (a) The electrolysis of water can be used to form hydrogen on an industrial scale. The overall equation for the electrolysis of water is:

$$2H_2O \longrightarrow 2\,H_2 + O_2$$

(i) Using the formula below calculate the atom economy for the production of hydrogen. [2]

$A_r(H) = 1$ $A_r(O) = 16$

$$\% \text{ atom economy} = \frac{\text{mass of desired product x100}}{\text{total mass of all reactant(s)}}$$

atom economy = ……..%

(ii) Explain how the atom economy calculated in a(i) supports the reason for not using the electrolysis of water as the main method for the industrial preparation of hydrogen. [2]

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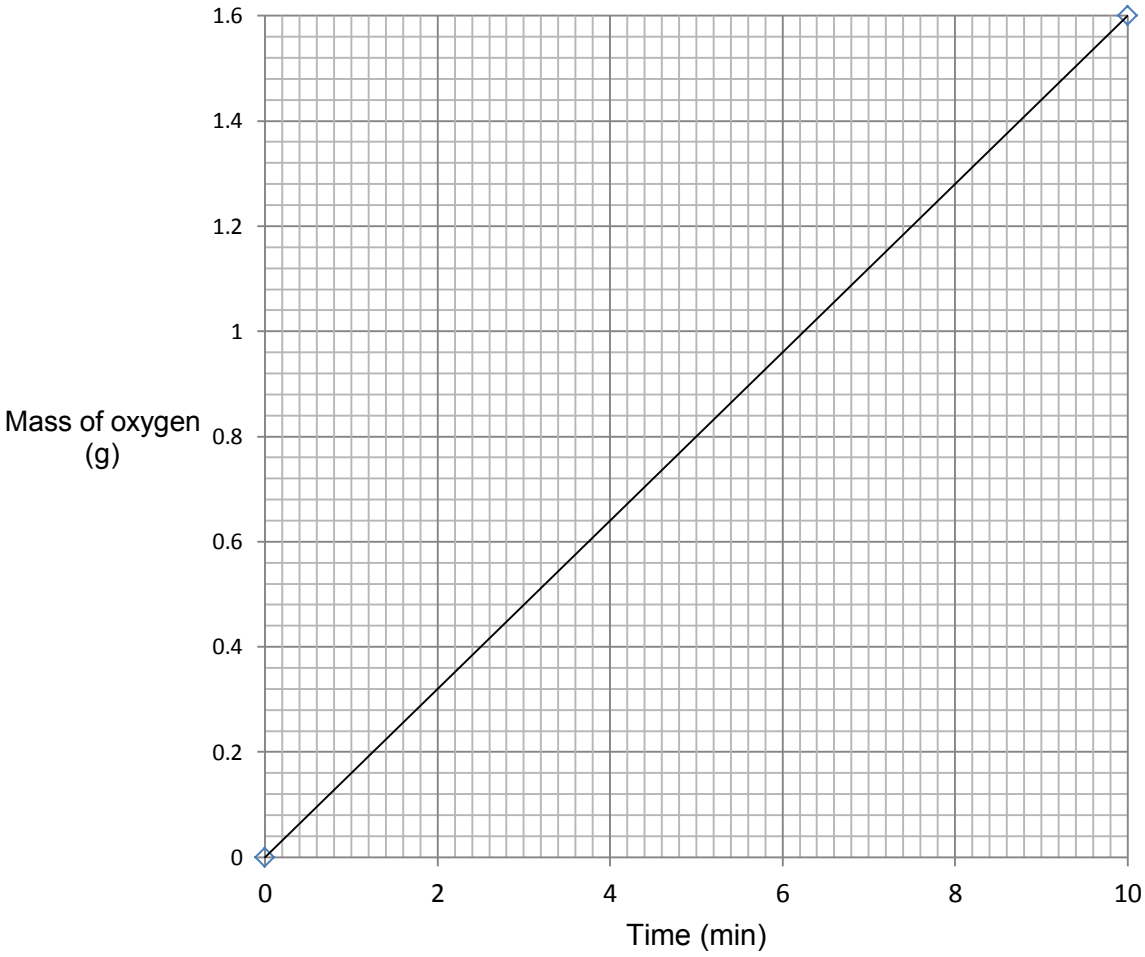
(b) The graph below shows the total mass of oxygen formed over 10 minutes.



Draw a second line on the grid to show the mass of **hydrogen** that you would expect to be collected during the same 10 minutes. [2]

(c) Use **only** information from the table below to explain **two** advantages of using hydrogen as a fuel for cars. [2]

Raw material	water
Extraction method	electrolysis
Combustion product(s)	water
State at room temperature and pressure	gas
Storage	thick steel containers

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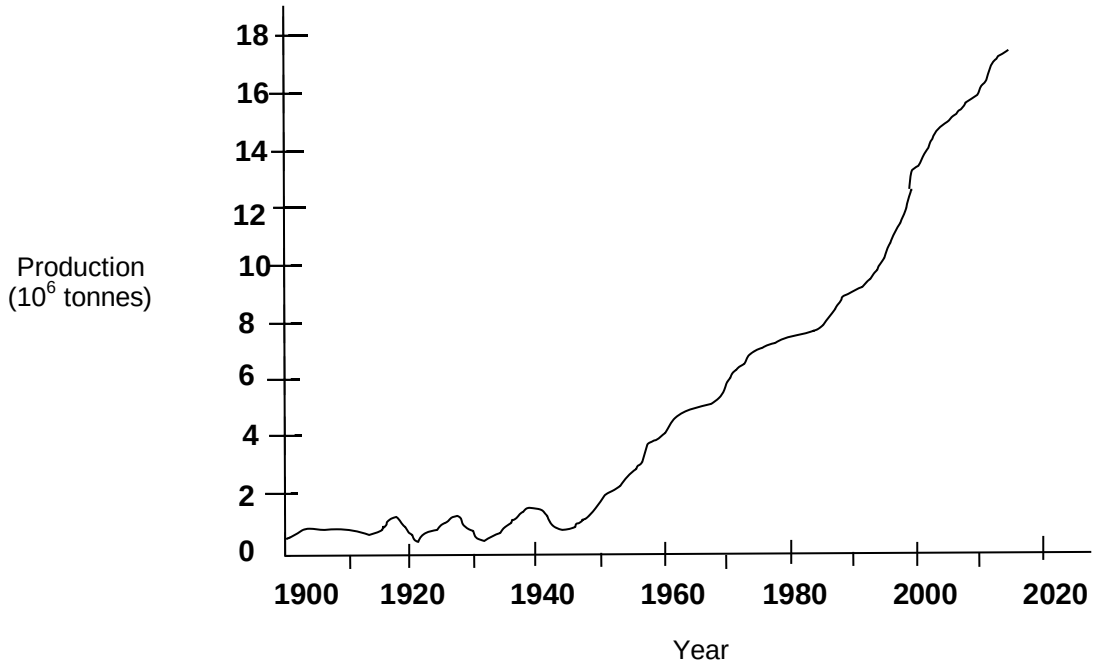
4. (a) The graph below shows the production of copper between 1900 and 2015, and the predicted production to 2020.



Suggest an explanation for the increase in copper production since the 1940s. [1]

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(b) The traditional method of obtaining copper is to extract it from high grade copper ore obtained from a copper mine.

Describe **two** problems with obtaining copper ore from copper mines. [2]

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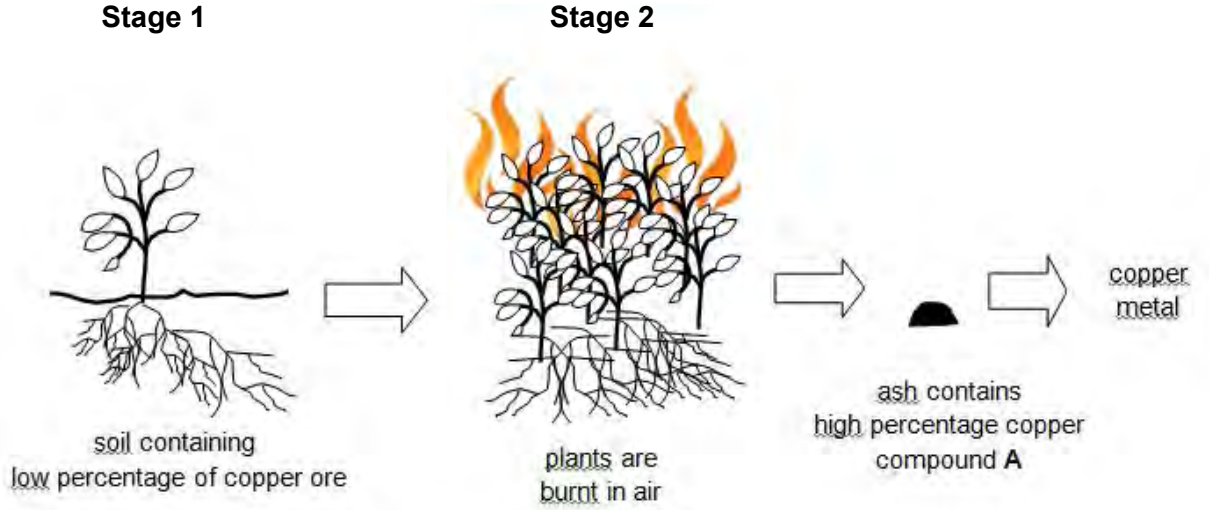
(c) The flow diagram below shows the steps taken in obtaining copper by the process of phytomining.



(i) Describe the role of the plant in **Stage 1**. [1]

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(ii) Give the chemical name for the compound **A**. [1]

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(iii) Describe **three** disadvantages of obtaining copper using phytomining compared with traditional mining. [3]

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(iv) The ash obtained from **Stage 2** can be reacted with sulfuric acid to form aqueous copper(II) sulfate.
Describe and explain one method used to obtain copper metal from aqueous copper(II) sulfate.
Include a balanced **symbol** equation in your answer. [4]

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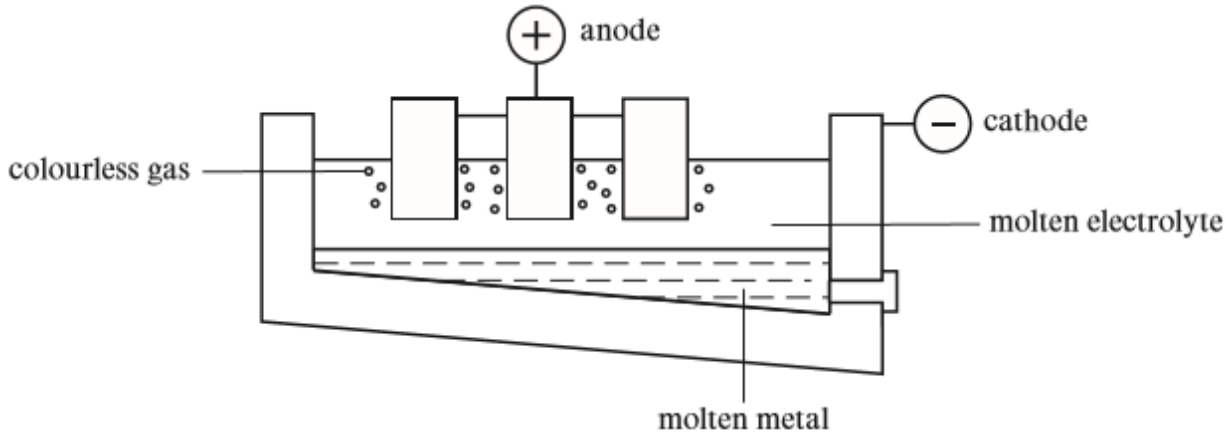
5. (a) Aluminium is extracted from molten aluminium oxide by electrolysis.



(i) Complete the following **electrode** equations. [2]

At the cathode: ……. + $3e^-$ ⟶ Al

At the anode: $2O^{2-}$ – …..... ⟶ O_2

(ii) State and explain how the production costs of aluminium are reduced.[4]

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(iii) The overall equation for the extraction of aluminium is as follows.

$2Al_2O_3$ ⟶ $4Al + 3O_2$

I Calculate how many tonnes of aluminium can be obtained from 2040 tonnes of aluminium oxide. [3]

mass of aluminium = ... tonnes

II Calculate the volume of oxygen in m^3 that could be formed from 2040 tonnes of aluminium oxide. The volume of 1 mol of gas at room temperature and pressure is 0.024 m^3. [3]

volume of oxygen = ... m^3

(b) Explain, in terms of the metallic bonding model, why aluminium:

(i) conducts electricity; [1]

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(ii) is malleable and ductile. [1]

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14

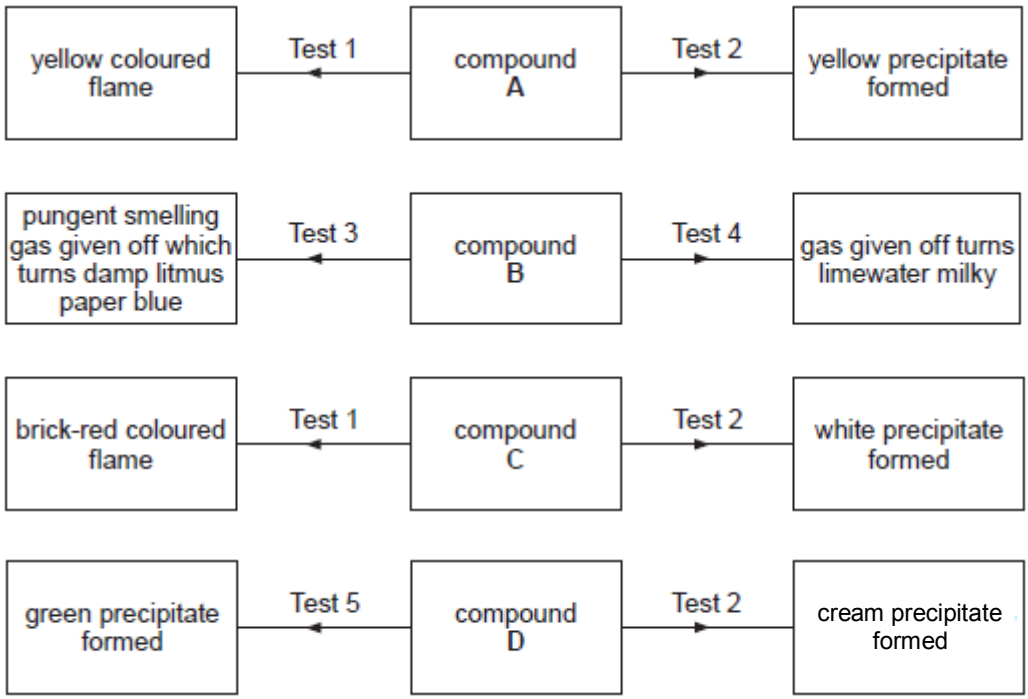
6. (a) A pupil used the following tests to identify unknown compounds **A**, **B**, **C** and **D**.

add sodium hydroxide solution and warm mixture, test gas given off with damp litmus paper	add dilute hydrochloric acid, bubble gas given off into limewater

add silver nitrate solution	add sodium hydroxide solution	flame test

These are described below as tests **1** to **5** but not necessarily in that order.

The charts show the results obtained for each compound.



Deduce which test is which and hence identify compounds **A**, **B**, **C** and **D**. [4]

A .....

B .....

C .....

D .....

(b) Sodium hydroxide solution can be used to detect the presence of aqueous copper(II) ions.

(i) The equation below represents the reaction occurring between copper(II) chloride solution and sodium hydroxide solution.

$CuCl_2(aq) + 2NaOH(aq) \longrightarrow Cu(OH)_2(s) + 2NaCl(aq)$

Write the **ionic** equation for the reaction, including state symbols. [2]

..... + ... ⟶ .....

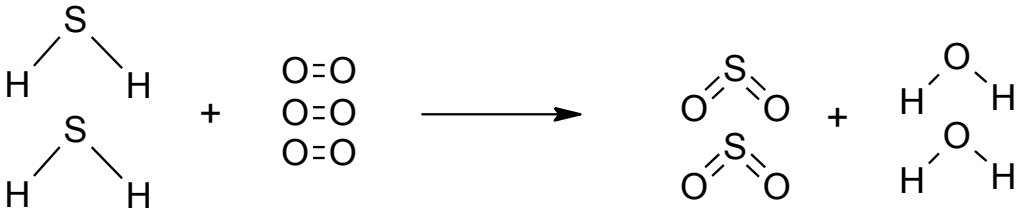
(ii) When sodium hydroxide solution is added to iron(III) bromide solution, $FeBr_3(aq)$, a brown precipitate is formed.

Write the balanced **symbol** equation for this reaction. [3]

..... + ... ⟶ ..... + ...

9

7. Hydrogen sulfide (H_2S) burns in air to give sulfur dioxide and water.
The following equation shows the rearrangement of atoms as hydrogen sulfide burns.



The relative energies of these bonds are given in the table below.

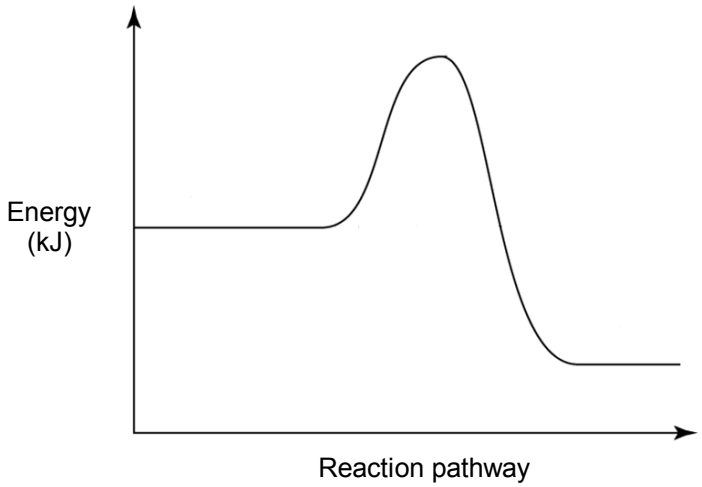
Bond	Bond energy (kJ)
H–S	339
O=O	.....
S=O	523
O–H	463

The overall relative energy change during the reaction is –1103 kJ, which shows that the reaction is exothermic.

(a) Use the information given above to calculate the energy needed to break the O=O bond. [5]

energy needed = ... kJ

(b) Draw arrows (↕) on the reaction profile to show the activation energy (**A**) and the overall energy change (**B**) for the burning of hydrogen sulfide. [2]



(c) Use the graph to explain why this reaction is exothermic. [1]

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8. Ammonia is an important compound used by industry and agriculture.

(a) (i) Describe, in terms of outer shell electrons, the bonding in a molecule of ammonia.
You should include a suitable diagram showing outer shell electrons in your answer. [2]

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(ii) Explain why ammonia is a gas at room temperature. [2]

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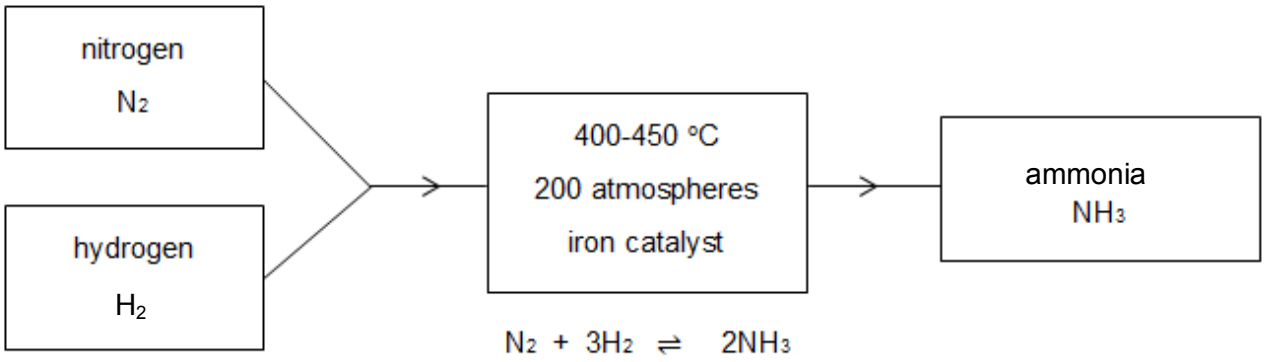
(b) The diagram and equation below outline the manufacture of ammonia by the Haber process.



$N_2 + 3H_2 \rightleftharpoons 2NH_3$

The forward reaction is exothermic

(i) Using atmospheric pressure would be safer and cheaper. Explain the effect on yield of using atmospheric pressure in the process. [3]

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(ii) Increasing the temperature would increase the rate of reaction. Explain why a catalyst is used to increase the rate rather than using a higher temperature. [3]

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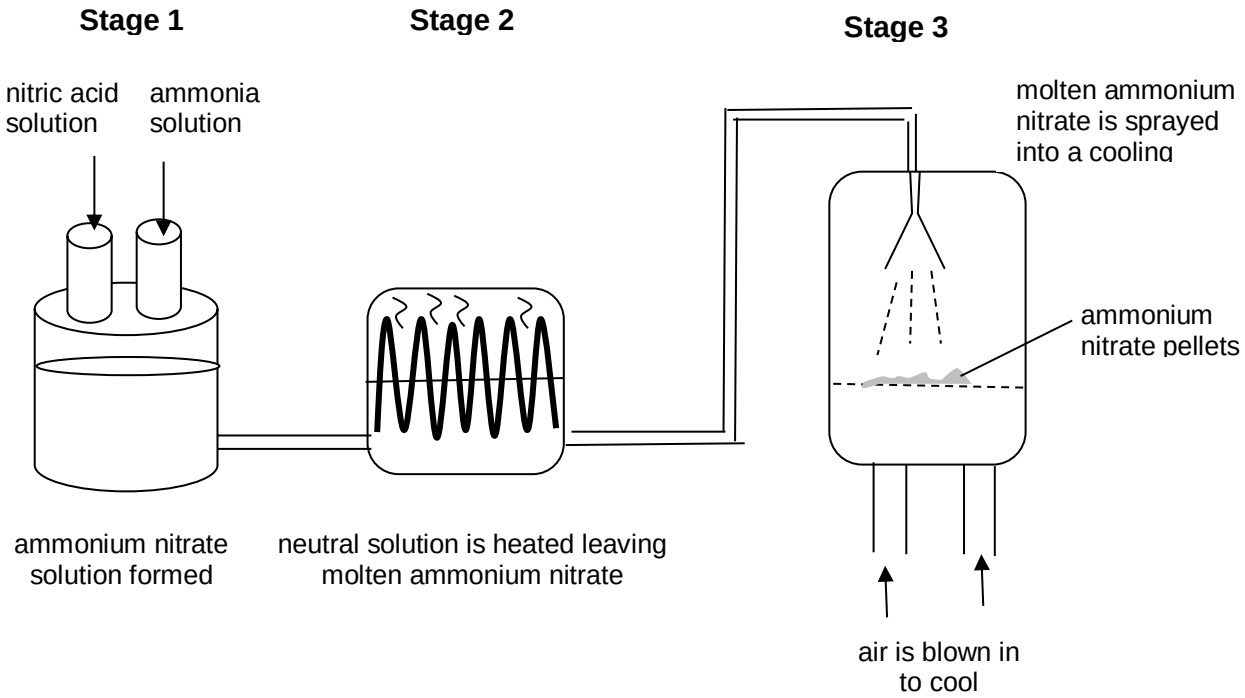
(c) The diagram below shows the stages in the industrial production of ammonium nitrate.



(i) Write a balanced **symbol** equation for the reaction occurring in stage 1. [2]

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(ii) The industrial process can be adapted and carried out using simple laboratory apparatus.

Describe and explain the laboratory method for obtaining a sample of ammonium nitrate from 1.0 M solutions of nitric acid and ammonia. [3]

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(d) Ammonium phosphate, $(NH_4)_3PO_4$ is used as a fertiliser.

(i) Calculate the percentage (%) of nitrogen in ammonium phosphate to **one** decimal place. [2]

$A_r(H) = 1$ $A_r(N) = 14$ $A_r(O) = 16$ $A_r(P) = 31$

% of nitrogen = ……..%

(ii) Fertilisers often contain more than one compound. Suggest how you could carry out a test to distinguish between the two fertilisers below. Both fertiliser **A** and **B** are in pellet form and contain compounds which are all water soluble.
Practical details are not required. [3]

Fertiliser	Composition
Fertiliser **A**	Mixture of ammonium nitrate, ammonium nitrate, potassium nitrate, magnesium sulfate
Fertiliser **B**	Mixture of ammonium nitrate, potassium nitrate

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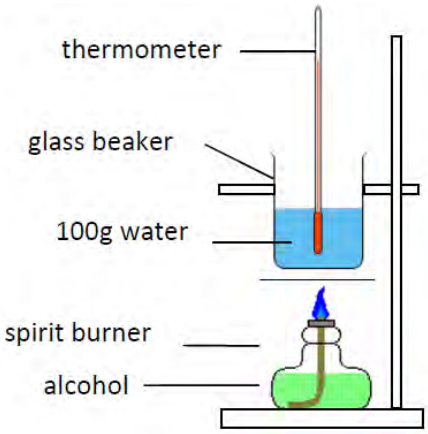
9. An investigation was carried out to find out which alcohol gives out the most energy when burned.
The diagram below shows the apparatus used.



In each case sufficient alcohol was burned to increase the temperature of 100 g of water by 40 °C.
Each alcohol was tested three times and the mean mass required was calculated.
The results are shown in the table below.

Alcohol	Total mass before (g)	Total mass after (g)	Mass of alcohol required (g)	Mean mass of alcohol required (g)	Energy released (kJ/g)
ethanol	184.29	182.79	1.50	1.50	11.2
	182.79	181.26	1.53		
	181.20	179.83	1.48		
propanol	198.21	196.99	1.22	1.22	13.8
	196.86	195.67	1.19		
	195.57	194.43	1.26		
butanol	177.05	175.59	1.46	0.98	
	175.26	174.20	1.06		
	174.94	174.03	0.90		

(a) The energy in joules (J) released by 1.0 g of an alcohol can be calculated using the formula:

$$\text{energy released} = \frac{\text{mass of water} \times 4.2 \times \text{temperature change}}{\text{mean mass of alcohol required}}$$

Use this formula to calculate the energy released in **kJ / g** when 0.98 g of butanol is burned.
Give your answer to **three** significant figures. [2]

energy released = ... kJ / g

(b) One of the mass values for butanol was not used in calculating the mean mass required.
Identify this value and suggest **one** experimental error that would explain why this result was recorded. [2]

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(c) The theoretical values for the energy released by each alcohol are given in the table below.

Alcohol	Theoretical values for energy released (kJ/g)
ethanol	29.7
propanol	33.6
butanol	36.1

Compare the experimental and the theoretical values and give **two** conclusions that can be drawn from the results of the investigation. [2]

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(d) Describe and explain **two** improvements that could be made to the method to obtain experimental values closer to the theoretical values of energy released. [4]

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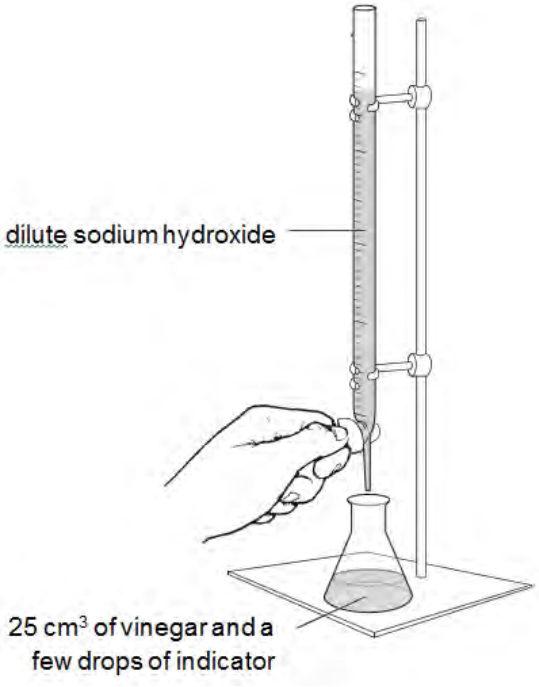
10. (a) A food scientist was asked to check the quality of a bottle of vinegar. Vinegar contains ethanoic acid, CH_3COOH.

The apparatus shown was used to find the concentration of ethanoic acid in vinegar.

Dilute sodium hydroxide of concentration 0.90 mol/dm^3 was added a little at a time to 25.0 cm^3 of vinegar until the indicator changed colour. The procedure was carried out three times.

	Run 1	Run 2	Run 3
Volume of sodium hydroxide added (cm^3)	24.1	23.9	24.0



(i) Ethanoic acid reacts with sodium hydroxide solution according to the equation below.

$$CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$$

I Calculate the mean volume of sodium hydroxide needed to neutralise 25.0 cm^3 of vinegar. [1]

mean volume = ... cm^3

II Using the mean volume of sodium hydroxide, calculate the concentration of the ethanoic acid in mol/dm^3. [3]

concentration = ... mol / dm^3

(ii) The label on the vinegar bottle states that it contains a minimum of 5 g of ethanoic acid, CH_3COOH, in 100 cm^3 vinegar.

I Calculate the relative molecular mass, M_r, of ethanoic acid. [1]

M_r = ...

II Show whether the information on the label is correct. [2]

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(b) Jo measured the pH of two different acids in his laboratory. He knew the concentration of the hydrochloric acid. His results and conclusion are below.

Acid	pH
0.10 mol / dm^3 hydrochloric acid	1
ethanoic acid	3

Jo's conclusion stated:

'that since the pH difference is 2 then the concentration of the hydrochloric acid must be 100 (10x10) times great than the ethanoic acid. Since the hydrochloric acid concentration is 0.10 mol/dm^3 then the ethanoic acid concentration must be 0.0010 mol / dm^3.
Explain whether Jo has correctly interpreted the information. [4]

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11. Explain the differences between addition polymerisation and condensation polymerisation. [6 QER]
Include relevant equations in your answer.

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FORMULAE FOR SOME COMMON IONS

POSITIVE IONS		NEGATIVE IONS	
Name	Formula	Name	Formula
Aluminium	Al^{3+}	Bromide	Br^{-}
Ammonium	NH_4^{+}	Carbonate	CO_3^{2-}
Barium	Ba^{2+}	Chloride	Cl^{-}
Calcium	Ca^{2+}	Fluoride	F^{-}
Copper(II)	Cu^{2+}	Hydroxide	OH^{-}
Hydrogen	H^{+}	Iodide	I^{-}
Iron(II)	Fe^{2+}	Nitrate	NO_3^{-}
Iron(III)	Fe^{3+}	Oxide	O^{2-}
Lithium	Li^{+}	Sulfate	SO_4^{2-}
Magnesium	Mg^{2+}		
Nickel	Ni^{2+}		
Potassium	K^{+}		
Silver	Ag^{+}		
Sodium	Na^{+}		
Zinc	Zn^{2+}		

THE PERIODIC TABLE