Surname	Centre Number	Candidate Number
First name(s)		0

GCSE – CONTINGENCY

3410UD0-1

Z22-3410UD0-1

THURSDAY, 23 JUNE 2022 – MORNING

CHEMISTRY – Unit 2:
Chemical Bonding, Application of Chemical Reactions and Organic Chemistry

HIGHER TIER

1 hour 45 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**9**	
2.	**11**	
3.	**13**	
4.	**11**	
5.	**11**	
6.	**7**	
7.	**10**	
8.	**8**	
Total	**80**	

3410UD01
01

ADDITIONAL MATERIALS

In addition to this examination paper you will need a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.
You may use pencil for graphs and diagrams only.

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. If you run out of space, use the additional page at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

Question **4**(c) is a quality of extended response (QER) question where your writing skills will be assessed.

The Periodic Table is printed on the back cover of this paper and the formulae for some common ions on the inside of the back cover.

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Answer **all** questions.

1. (a) Crude oil can be separated into simpler mixtures called fractions. The table shows information about some of the main fractions obtained from crude oil by fractional distillation.

Fraction	Boiling point range (°C)	Number of carbon atoms present in the alkanes
petroleum gases	< 20	C_1–C_4
petrol	30–75	C_5–C_8
naphtha	70–180	C_9–C_{12}
kerosene	180–250	C_{13}–C_{16}
diesel oil	250–340	C_{17}–C_{20}
lubricating oil	340–500	C_{20}–C_{24}
fuel oil	490–580	C_{25}–C_{28}

(i) Decane has a boiling point of 174 °C. Give the name of the fraction which contains decane. [1]

.....

(ii) One alkane is found in both diesel oil and lubricating oil. Give the number of carbon atoms in this alkane. [1]

.....

3410UD01 03

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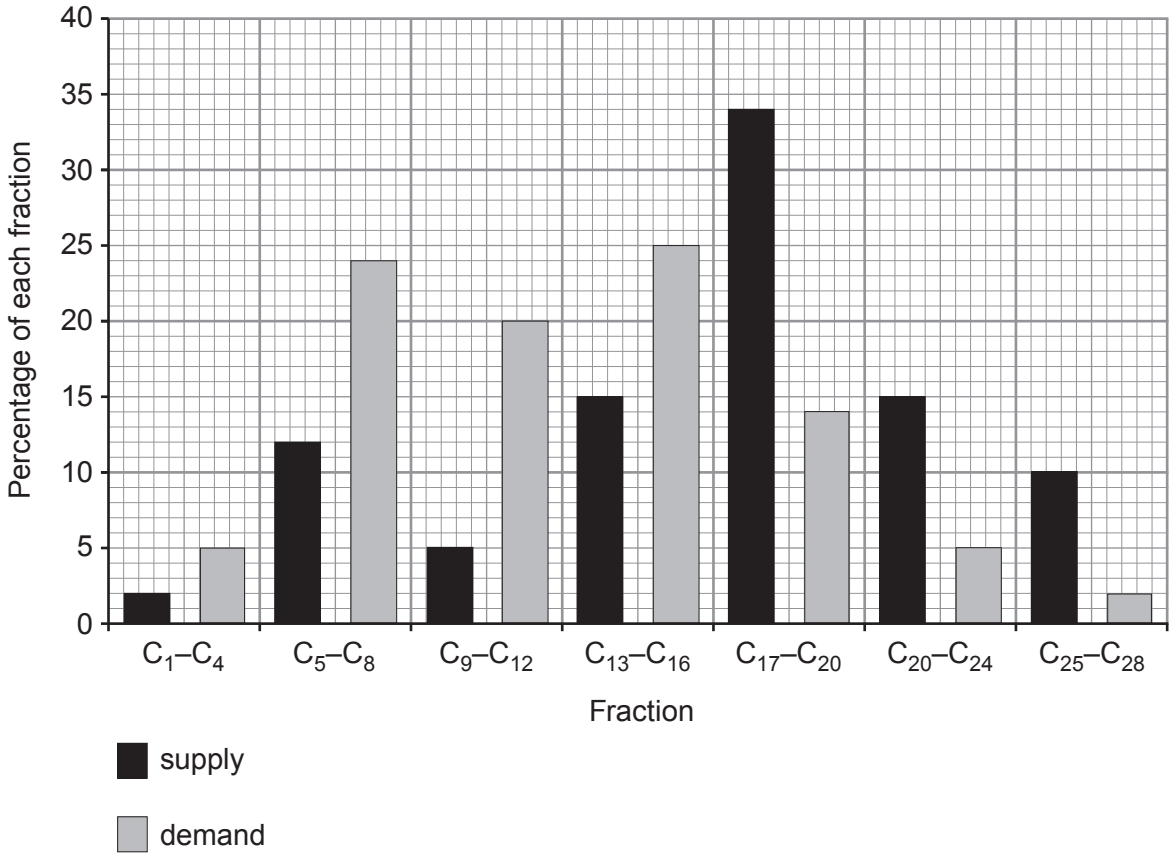
(b) The bar chart shows the supply and demand for some of the fractions obtained from crude oil.



(i) Give the fraction where the demand is 100 % greater than the supply. [1]

.....

(ii) Put a **tick** (✓) in the box next to the statement that best describes how the supply and demand of the fractions change as the chain length increases. [1]

supply is greater than demand for all fractions ☐

supply is greater than demand up to C_{16} after which demand is greater than supply ☐

demand is greater than supply up to C_{16} after which supply is greater than demand ☐

the difference between supply and demand increases up to C_{16} after which it decreases ☐

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(iii) Oil companies have solved the problem of over-supply of some fractions using a process called cracking.

The alkane $C_{20}H_{42}$ can be cracked forming propene, nonene and **one molecule** of hydrocarbon **A**.

I. Complete the equation for the cracking of $C_{20}H_{42}$. [1]

$$C_{20}H_{42} \longrightarrow C_3H_6 + C_9H_{18} + \text{.....}$$

propene nonene hydrocarbon **A**

II. Propene is an important raw material in the production of polypropene.

Give the name of the process used to make polypropene from propene. [1]

.....

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(c) Every year thousands of acres of forests are destroyed by wildfires. Fire-fighters use several different methods to put out this type of fire.

State **three** methods that are used to put out forest fires.

Give the part of the fire triangle being removed in each method.

Each method should refer to a different part of the fire triangle. [3]

Method 1 .....

Part of the fire triangle being removed .....

Method 2 .....

Part of the fire triangle being removed .....

Method 3 .....

Part of the fire triangle being removed .....

9

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2. (a) Sulfuric acid is produced by the contact process. The flow diagram shows the main stages in the process.

Stage **1**		Stage **2**		Stage **3**		Stage **4**
Burn raw material **A** in air to produce sulfur dioxide	→	Pass sulfur dioxide over vanadium(V) oxide at 450 °C to produce sulfur trioxide	→	Dissolve sulfur trioxide in concentrated sulfuric acid to produce oleum	→	Add a small amount of raw material **B** to oleum to produce concentrated sulfuric acid

(i) Give the name of raw materials **A** and **B**. [2]

A .....

B .....

(ii) State the purpose of vanadium(V) oxide in stage **2**. [1]

.....

(iii) Complete and balance the equation for the reaction in stage **2**. [2]

$$\square \; \text{.....} + O_2 \rightleftharpoons 2SO_3$$

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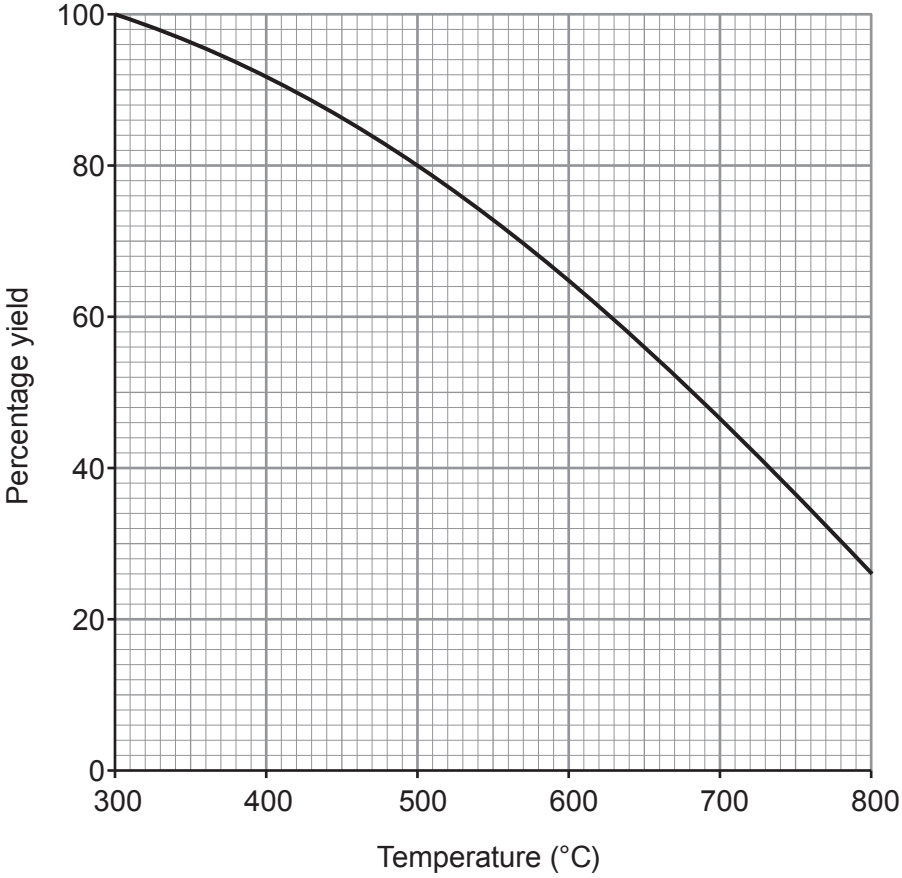
(iv) The graph shows how the percentage yield of sulfur trioxide changes with temperature between 300 °C and 800 °C.



Use the graph to answer parts I and II.

I. State the trend in the percentage yield of sulfur trioxide as the temperature increases. [1]

.....

II. Give the temperature **range** to be used to obtain a yield of sulfur trioxide greater than 80 %. [1]

..... to ..... °C

(v) One molecule of sulfur trioxide reacts with one molecule of sulfuric acid to form one molecule of oleum as the **only product**.

Complete the equation for this reaction by giving the formula of oleum. [1]

$SO_3 + H_2SO_4 \longrightarrow$ .....

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(b) The photograph shows the exothermic reaction between concentrated sulfuric acid and sugar, $C_{12}H_{22}O_{11}$.

(i) Name the **two** products formed. [2]

..... and .....

(ii) State the type of reaction taking place. [1]

.....

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3. (a) **A**, **B**, **C** and **D** are equations for reactions used to make salts.

(i) Complete the equation for each reaction. [4]

A $Mg(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) +$ ..... (g)

B $AgNO_3(aq) + NaCl(aq) \longrightarrow AgCl(s) +$ ..... (aq)

C $ZnO(s) + 2HNO_3(aq) \longrightarrow$ ..... (aq) $+ H_2O(l)$

D $CuCO_3(s) +$ ..... (aq) $\longrightarrow CuSO_4(aq) + H_2O(l) + CO_2(g)$

(ii) Outline the **three** steps you would carry out to get a **pure** sample of silver chloride, AgCl, from the reaction mixture in equation **B**. [2]

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11

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(b) Sodium chloride is made when sodium hydroxide reacts with hydrochloric acid.

sodium hydroxide + hydrochloric acid ⟶ sodium chloride + water

(i) Write a balanced equation for the reaction. [2]

.....

(ii) A student was asked to prepare pure sodium chloride crystals using 25.0 cm^3 of sodium hydroxide solution.

The flow diagram shows the student's plan.

Stage **1**		Stage **2**		Stage **3**
Carry out a titration to find the exact volume of acid needed to neutralise all of the alkali	→	Make a pure sodium chloride solution	→	Obtain sodium chloride crystals

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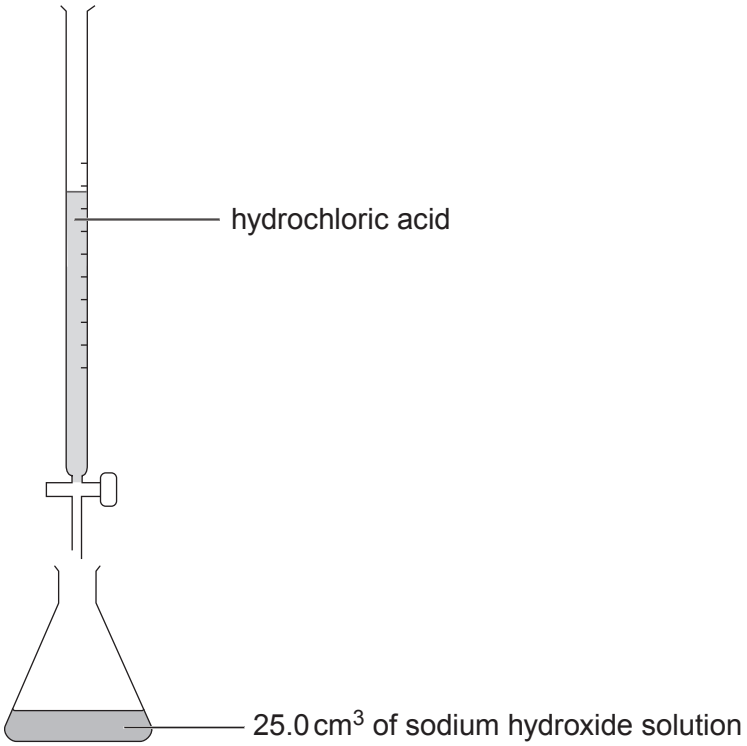
I. The student sets up the apparatus below to carry out stage **1**.



Describe how the student will find the exact volume of acid needed to neutralise all of the alkali. [2]

.....

.....

II. The neutral solution obtained in stage **1** is not pure.

Describe what the student must do in stage **2** to make a pure sodium chloride solution. [2]

.....

.....

.....

III. State what the student must do in stage **3** to obtain sodium chloride crystals. [1]

.....

.....

3410UD01 13

13

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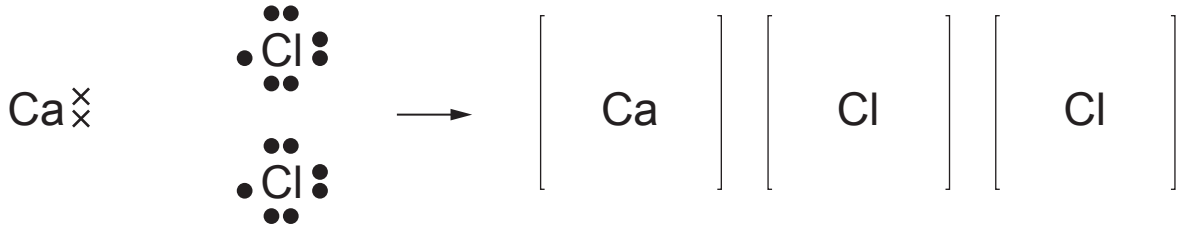
4. (a) Calcium reacts with chlorine to form the ionic compound calcium chloride.

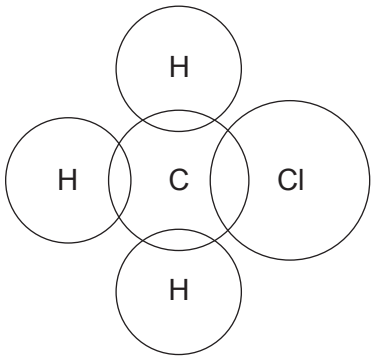
Complete the dot and cross diagram to show the electronic changes that take place when calcium reacts with chlorine to form calcium chloride.

Show the charge on each ion. [3]



(b) Complete the dot and cross diagram to show the bonding in a molecule of chloromethane. [2]

hydrogen 1 carbon 2,4 chlorine 2,8,7



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(c) Calcium and calcium chloride have different bonding and structures.

Explain how each substance conducts electricity.

You may include diagrams in your answer. [6 QER]

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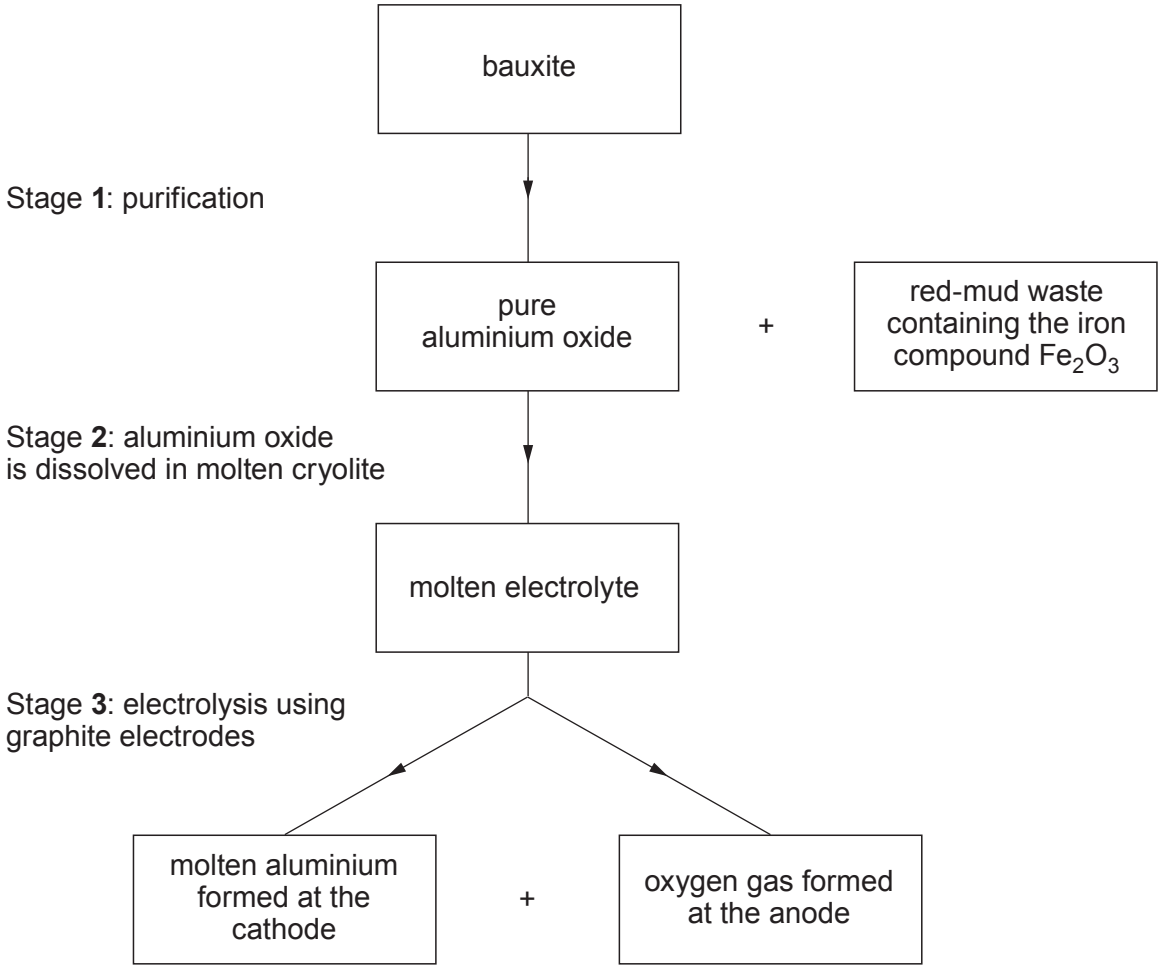
5. (a) The flow chart shows the stages involved in the extraction of aluminium from bauxite. Bauxite is a mixture of mainly aluminium oxide and a compound of iron.



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(i) Underline the chemical name for the iron compound, Fe_2O_3, found in the red-mud waste. [1]

iron(V) oxide **iron(II) oxide** **iron(III) oxide** **iron(I) oxide**

(ii) Give **one** reason why aluminium oxide is dissolved in molten cryolite in stage **2**. [1]

.....

.....

(iii) Explain why the anode is regularly replaced in stage **3**. [2]

.....

.....

(iv) Complete and balance the equation for the electrolysis of aluminium oxide. [2]

$$2Al_2O_3 \longrightarrow \boxed{}\,Al + 3\ \ldots\ldots$$

(b) The recycling rate for aluminium drinks cans in the UK reached 72 % in 2017.

Suggest why most aluminium waste is recycled. [2]

.....

.....

.....

.....

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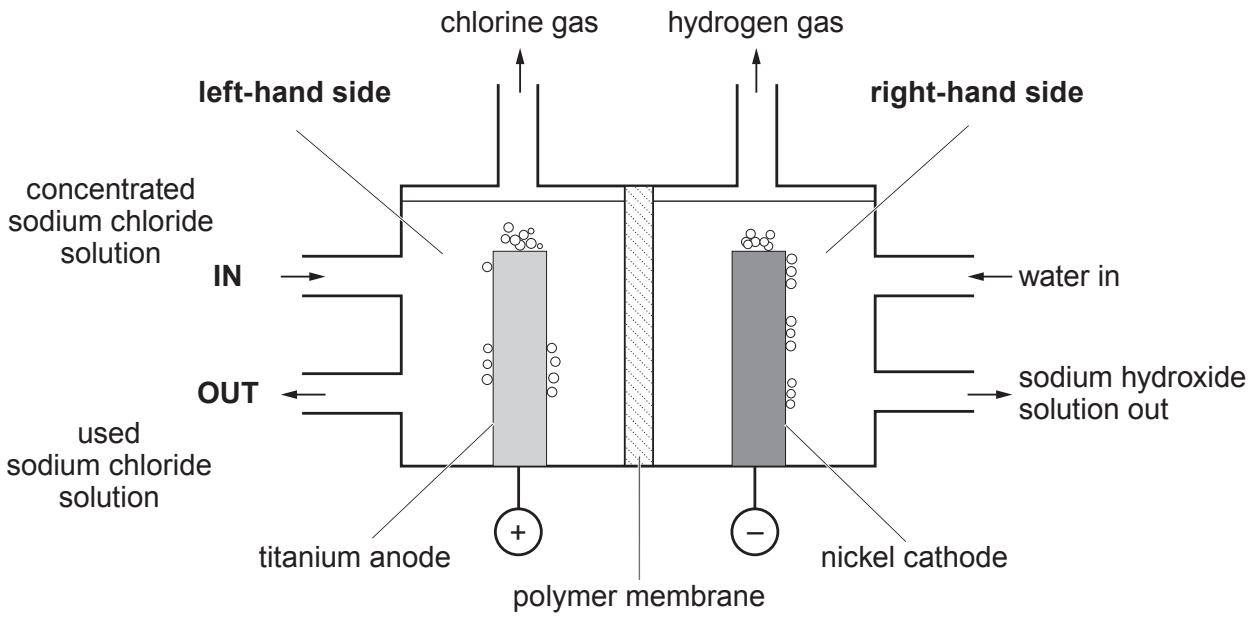
(c) The diagram shows a model of a membrane cell used to manufacture sodium hydroxide solution, chlorine and hydrogen by the electrolysis of aqueous sodium chloride.

The membrane cell is designed so that chlorine is kept separate from hydrogen and aqueous sodium hydroxide.

The polymer membrane only allows positive ions to pass through it. Sodium ions and hydrogen ions pass through from the left-hand side to the right-hand side of the cell.



Chlorine is an extremely corrosive substance which reacts with most metals. Titanium reacts quickly with chlorine gas but it resists attack by chlorine in aqueous conditions.

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(i) Put a **tick** (✓) in the box next to the correct list of ions found on either side of the membrane during the process. [1]

Left-hand side of the membrane	Right-hand side of the membrane	
Na^+ Cl^- H^+ OH^-	Cl^- H^+ OH^-	☐
H^+ OH^- Cl^-	Na^+ H^+ OH^-	☐
Na^+ Cl^- H^+ OH^-	Na^+ H^+ OH^-	☐
Na^+ Cl^-	Na^+ OH^-	☐

(ii) Put a **tick** (✓) in the box next to the correct statement. [1]

titanium burns in chlorine in aqueous conditions ☐

titanium doesn't react with chlorine under any conditions ☐

aqueous conditions prevent chlorine from reacting with titanium ☐

aqueous conditions prevent chlorine from reacting with sodium chloride ☐

(iii) Put a **tick** (✓) in the box next to the two substances formed on the right-hand side of the membrane if the sodium chloride solution were contaminated with magnesium bromide. [1]

sodium hydroxide and magnesium hydroxide ☐

sodium hydroxide and sodium bromide ☐

sodium hydroxide and magnesium bromide ☐

magnesium chloride and sodium ☐

11

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6. (a) The table shows the formulae of the first four members of the alcohol family.

Alcohols
CH_3OH
C_2H_5OH
C_3H_7OH
C_4H_9OH

Give the general formula for the alcohol family. [1]

.....

(b) The following word equation represents the formation of ethanol by fermentation.

glucose solution $\xrightarrow{\text{yeast}}$ ethanol solution + carbon dioxide gas

(i) Complete and balance the equation for the production of ethanol and carbon dioxide from glucose.

Include the state symbols for the reactant and the products. [3]

$C_6H_{12}O_6$ (.....) $\longrightarrow$ 2 ..... (.....) + $\boxed{}$ CO_2 (.....)

(ii) Yeast contains a substance which catalyses the breakdown of glucose.

Give the **general** name of this type of catalyst. [1]

.....

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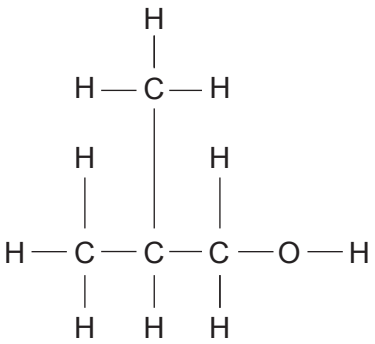
(c) (i) C_4H_9OH has four isomers. The diagram below shows the structure of one of the isomers.



Put a **tick** (✓) in the box next to the name of this isomer. [1]

butan-1-ol ☐

2-methylpropan-1-ol ☐

butan-2-ol ☐

2-methylpropan-2-ol ☐

(ii) Pentan-3-ol is one of the isomers of $C_5H_{11}OH$.

Draw the structure of pentan-3-ol. [1]

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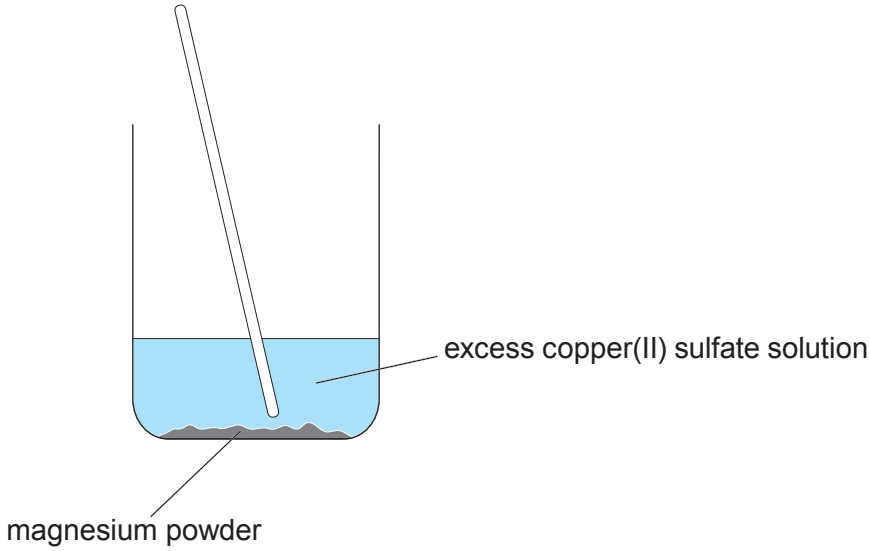
7. (a) A student investigated the mass of copper formed when magnesium powder was added to excess copper(II) sulfate solution.



The student added four different masses of magnesium powder to separate 50 cm^3 samples of copper(II) sulfate solution.

The table shows the results obtained.

Mass of magnesium added (g)	Mass of copper formed (g)
0.00	0.00
0.05	0.13
0.10	0.26
0.15	0.39
0.20	0.52

(i) Give **one** observation that would show that copper(II) sulfate is always in excess in this investigation. [1]

.....

.....

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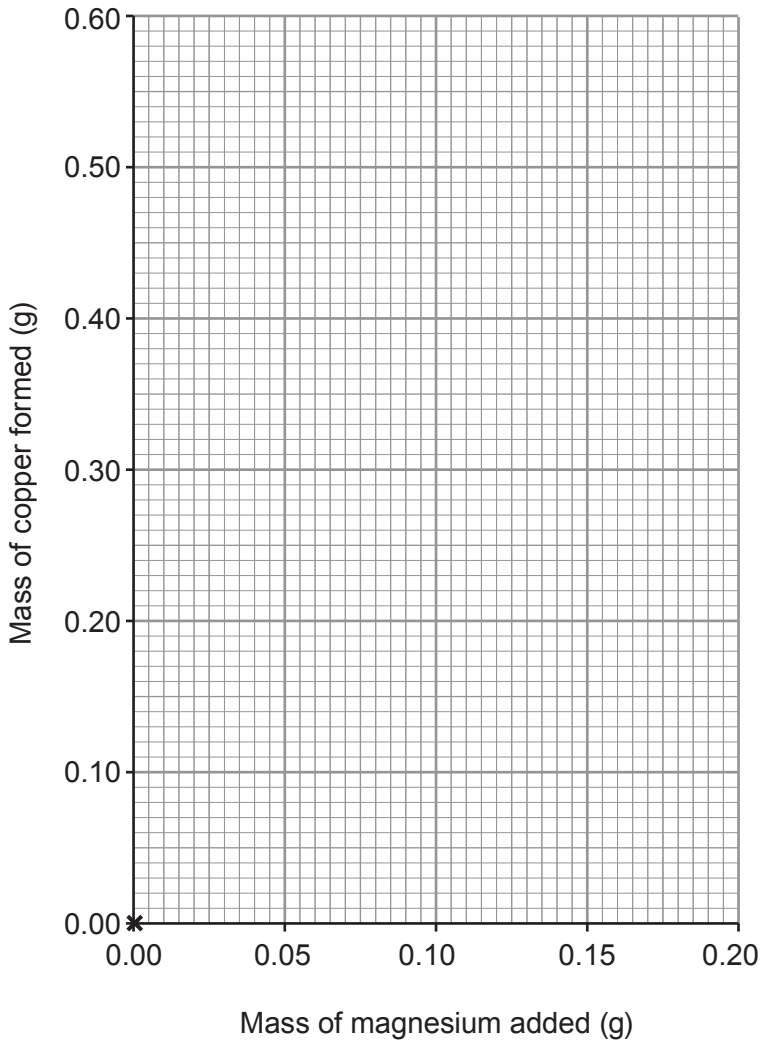
(ii) Plot the results from the table on the grid and draw a suitable line. [3]

The point (0,0) has been plotted for you.



(iii) I. Use the graph to find the mass of magnesium needed to form 0.18 g of copper. [1]

..... g

II. The student stated that 0.78 g of copper would be formed when 0.30 g of magnesium is used. Suggest how she arrived at this value. [1]

.....

.....

.....

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(b) To ensure that the copper(II) sulfate solution was always in excess the technician dissolved 3.19 g of $CuSO_4$ in 500 cm^3 of water.

(i) Calculate the number of moles of copper(II) sulfate in 3.19 g. [2]

$A_r(O) = 16$ $A_r(S) = 32$ $A_r(Cu) = 63.5$

Number of moles = ... mol

(ii) Use the equation below to calculate the concentration of the copper(II) sulfate solution in mol / dm^3. [2]

$$\text{concentration (mol/dm}^3) = \frac{\text{number of moles}}{\text{volume (dm}^3)}$$

Concentration = ... mol / dm^3

10

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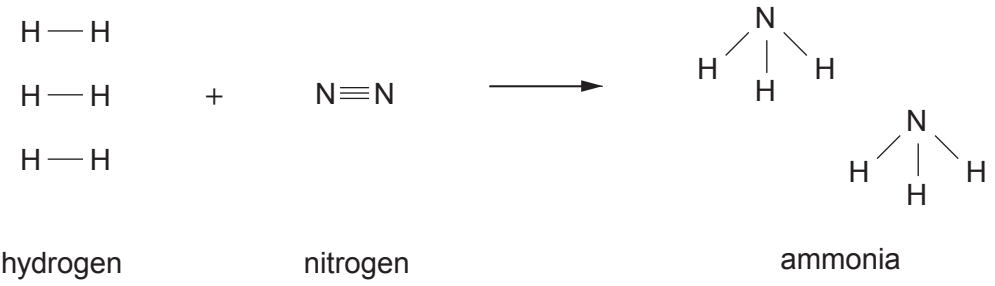
8. Ammonia is manufactured from hydrogen and nitrogen in the Haber process.

(a) The equation shows the bonds which are broken and the bonds which are formed in the production of ammonia.

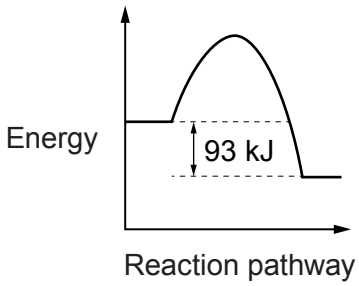


The bond energy of a H—H bond is 436 kJ. The energy needed to break **all** the bonds in the **reactants** is 2253 kJ.

(i) Calculate the energy needed to break a N≡N bond. [2]

Energy = ... kJ

(ii) The diagram below is the energy profile for the reaction.



Calculate the energy released when **all** the bonds in the ammonia molecules are formed. [1]

Energy = ... kJ

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(b) The table below shows the percentage yield of ammonia under different pressure and temperature conditions.

Pressure (atm)	Temperature (°C)			
	200	300	400	500
	Percentage yield of ammonia			
100	81.7	52.5	25.2	10.6
200	89.0	66.7		18.3
400	94.6	79.7	55.4	31.9
1000	98.3	92.6	79.8	57.5

(i) Describe the relationship between the percentage yield of ammonia and the temperature. [1]

.....

(ii) **Circle** the most likely percentage yield of ammonia if the process were carried out at 200 atm and 400 °C. [1]

20 % **30 %** **40 %** **50 %**

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(c) A student carries out a series of chemical tests on solutions of three unknown compounds, **A**, **B** and **C**. Her results are recorded in the table.

Compound	Flame test	Add NaOH(aq)	Add HCl(aq)	Add $BaCl_2$(aq)	Add $AgNO_3$(aq)
A	no colour	pungent gas given off turns damp red litmus paper blue	no reaction	no reaction	white precipitate forms
B	green flame	blue precipitate forms	no reaction	white precipitate forms	no reaction
C	lilac flame	no reaction	gas given off turns limewater milky	no reaction	no reaction

Use the information provided to identify compounds **A**, **B** and **C**. [3]

A .....

B .....

C .....

8

END OF PAPER

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Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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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+}		

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THE PERIODIC TABLE

1	2											3	4	5	6	7	0
																	4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	63.5 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
86 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	99 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57	179 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89															

Key

A_r	relative atomic mass
Symbol	
Name	
Z	atomic number

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32