

Surname	Centre Number	Candidate Number
First name(s)		0


GCSE – CONTINGENCY

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.



JUN223410UD0101

BLANK PAGE

**PLEASE DO NOT WRITE
ON THIS PAGE**



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]

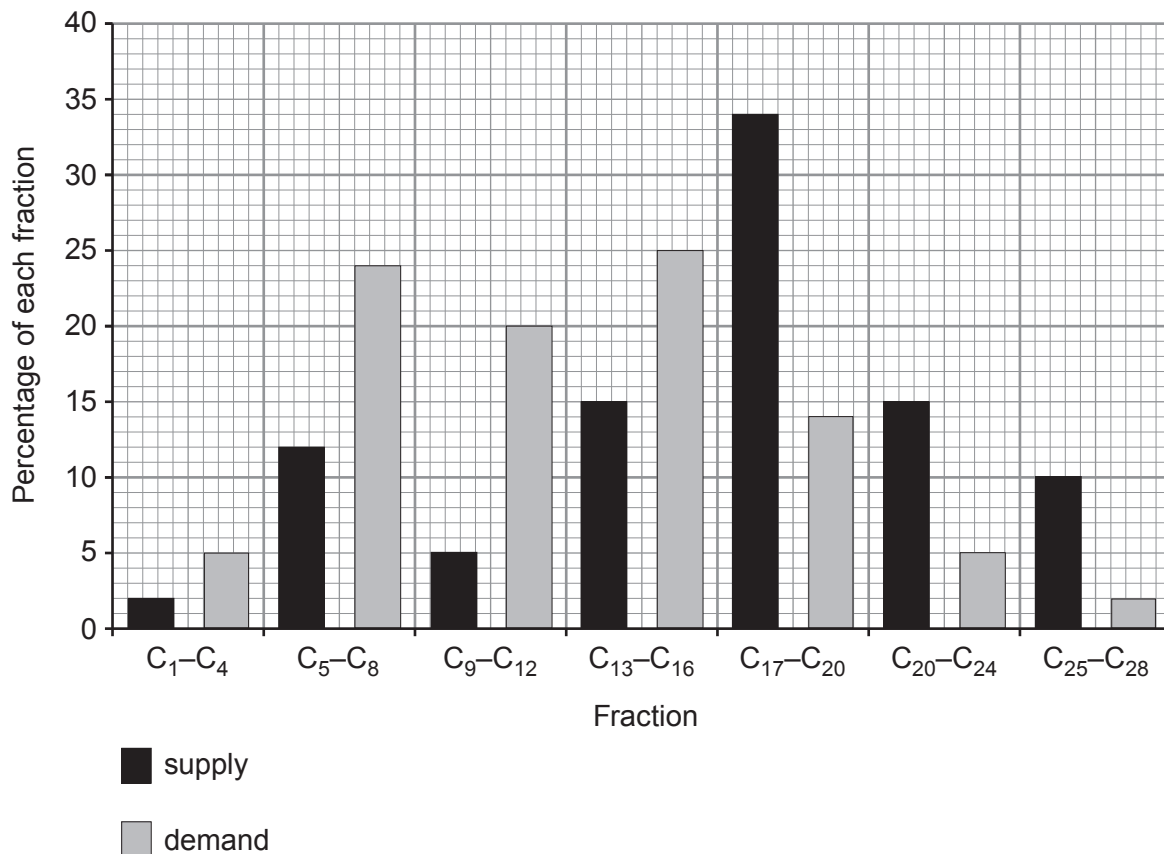
.....

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

.....



(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 C₁₆ after which demand is greater than supply

demand is greater than supply up to C₁₆ after which supply is greater than demand

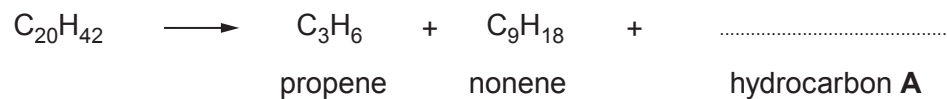
the difference between supply and demand increases up to C₁₆ after which it decreases



- (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]



- 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]

.....



(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

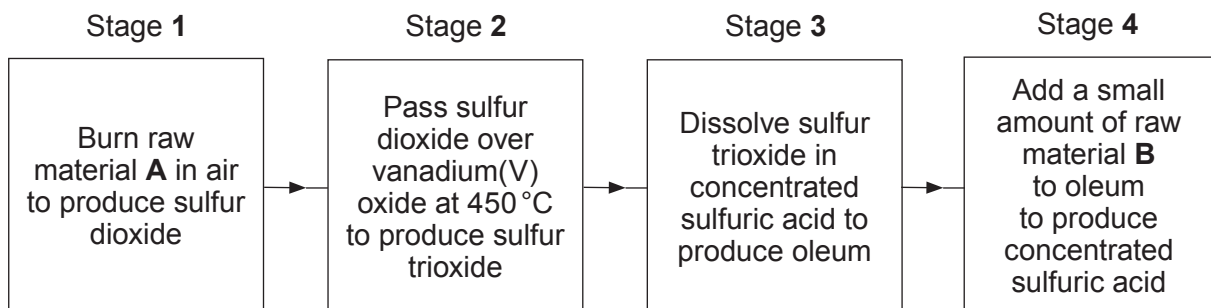
Method 3

Part of the fire triangle being removed

9



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



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

A

B

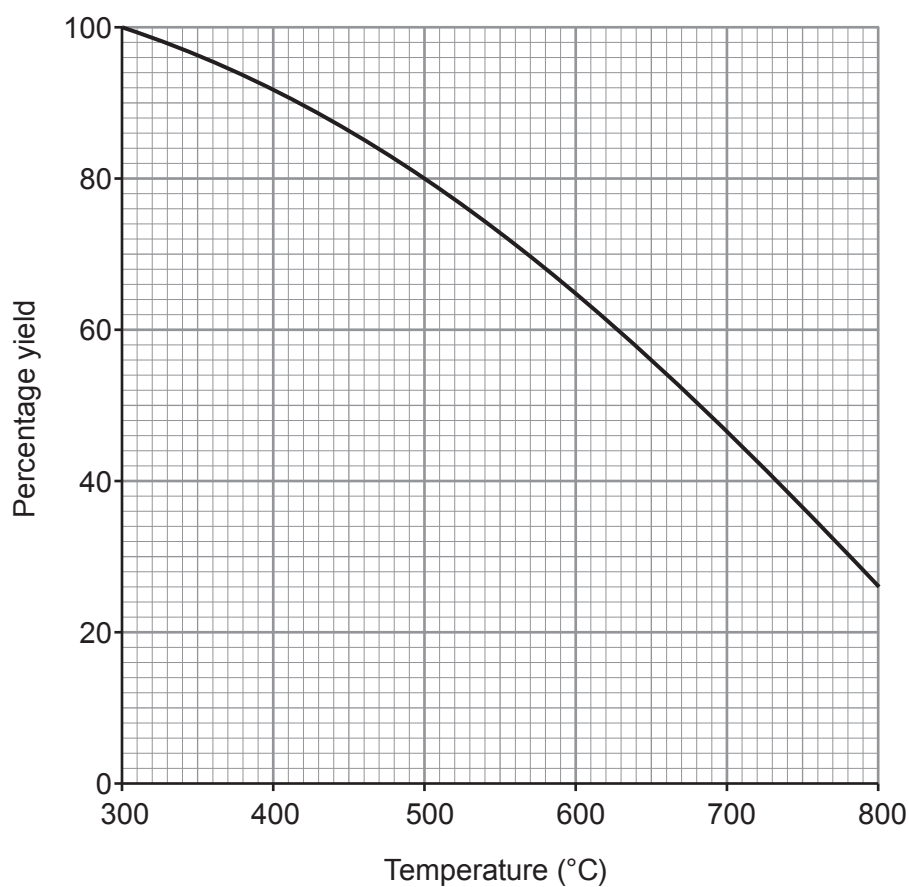
- (ii) State the purpose of vanadium(V) oxide in stage 2. [1]

.....

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



- (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]



- (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]
.....



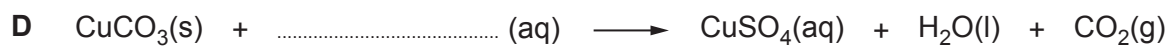
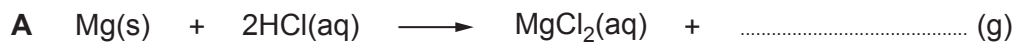
BLANK PAGE

**PLEASE DO NOT WRITE
ON THIS PAGE**



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

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



(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]

.....

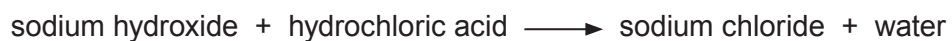
.....

.....

.....



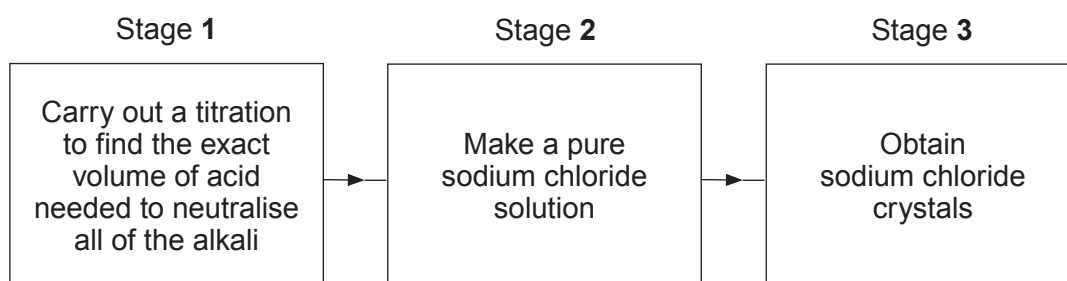
- (b) Sodium chloride is made when sodium hydroxide reacts with hydrochloric acid.



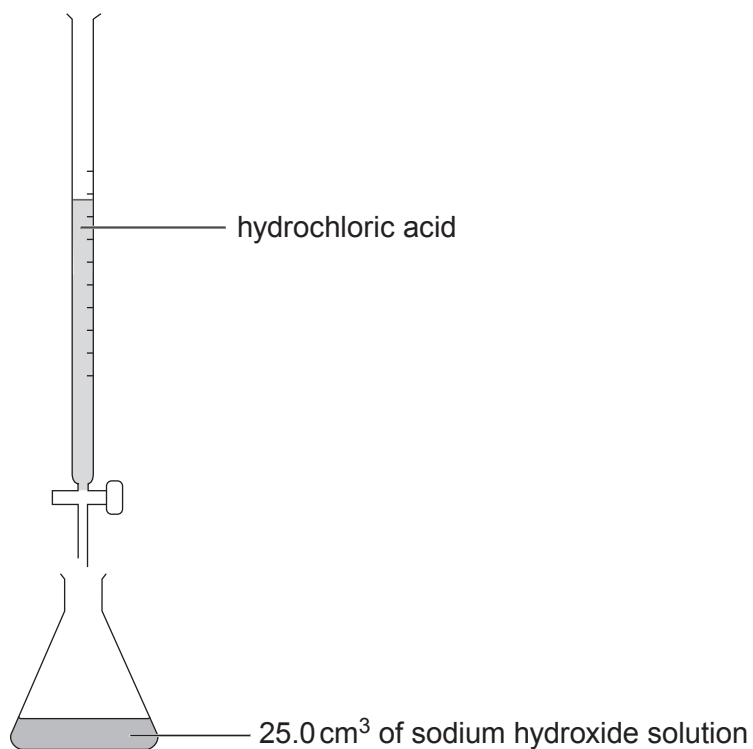
- (i) Write a balanced equation for the reaction. [2]
-

- (ii) A student was asked to prepare pure sodium chloride crystals using 25.0 cm³ of sodium hydroxide solution.

The flow diagram shows the student's plan.



- 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]

.....

.....

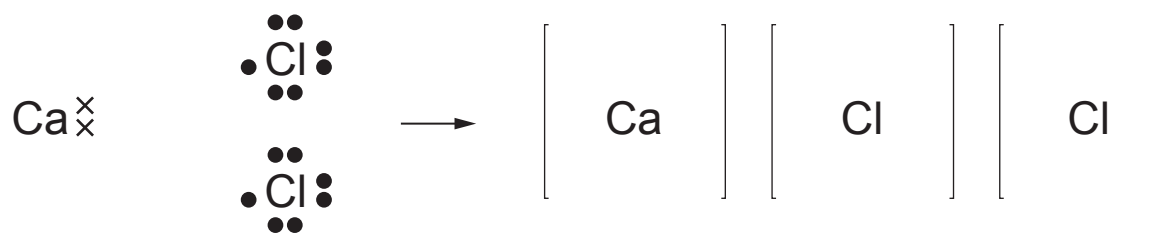


4. (a) Calcium reacts with chlorine to form the ionic compound calcium chloride.

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]



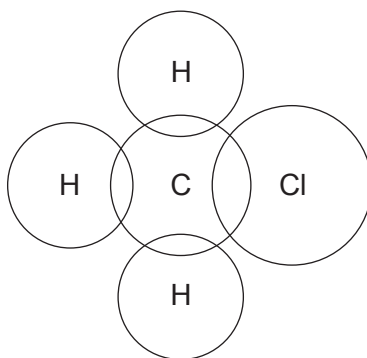
- (b) Complete the dot and cross diagram to show the bonding in a molecule of chloromethane.

[2]

hydrogen 1

carbon 2,4

chlorine 2,8,7



Examiner
only

(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]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

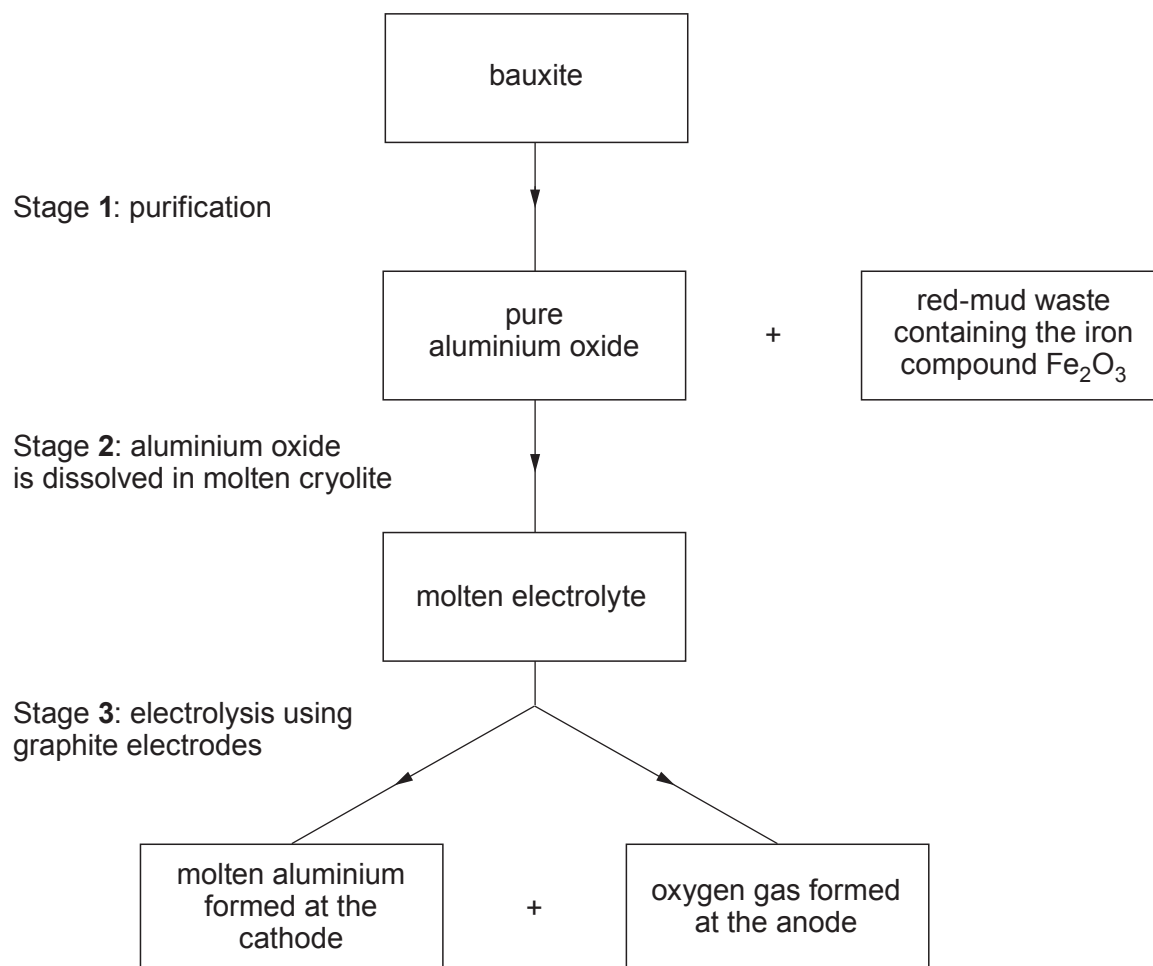
.....

3410UD01
15

11



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.



- (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]



- (b) The recycling rate for aluminium drinks cans in the UK reached 72% in 2017. Suggest why most aluminium waste is recycled. [2]

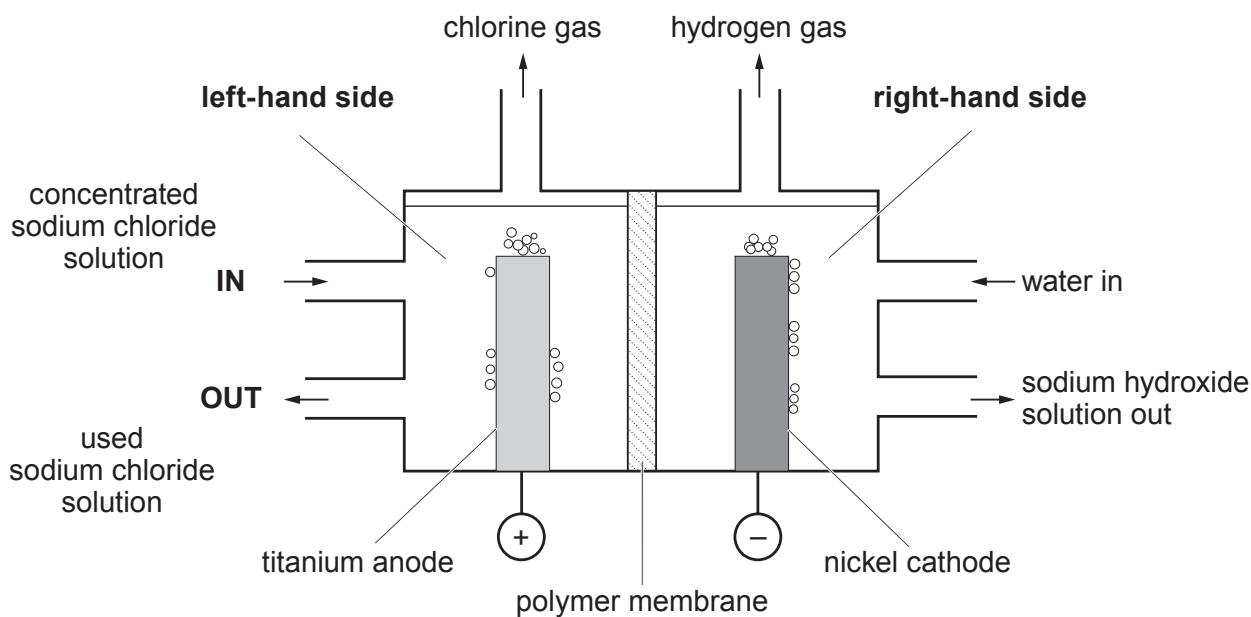
.....



- (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.



- (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 ⁻	<input type="checkbox"/>
H ⁺ OH ⁻ Cl ⁻	Na ⁺ H ⁺ OH ⁻	<input type="checkbox"/>
Na ⁺ Cl ⁻ H ⁺ OH ⁻	Na ⁺ H ⁺ OH ⁻	<input type="checkbox"/>
Na ⁺ Cl ⁻	Na ⁺ OH ⁻	<input type="checkbox"/>

- (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



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

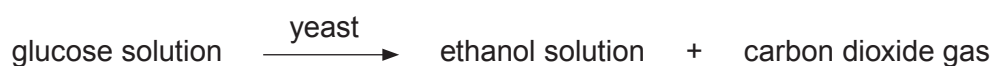
Alcohols
CH ₃ OH
C ₂ H ₅ OH
C ₃ H ₇ OH
C ₄ H ₉ OH

Give the general formula for the alcohol family.

[1]

.....

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



- (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]



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

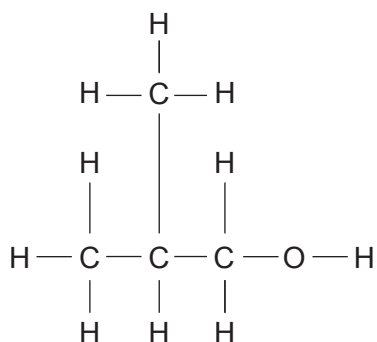
Give the **general** name of this type of catalyst.

[1]

.....



- (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 $C_5H_{11}OH$.

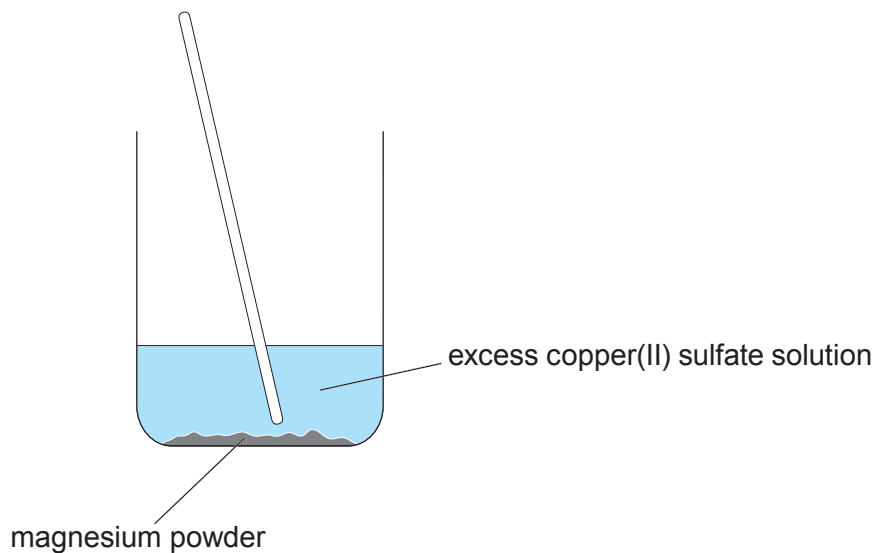
Draw the structure of pentan-3-ol.

[1]

7



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 cm³ 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]

.....

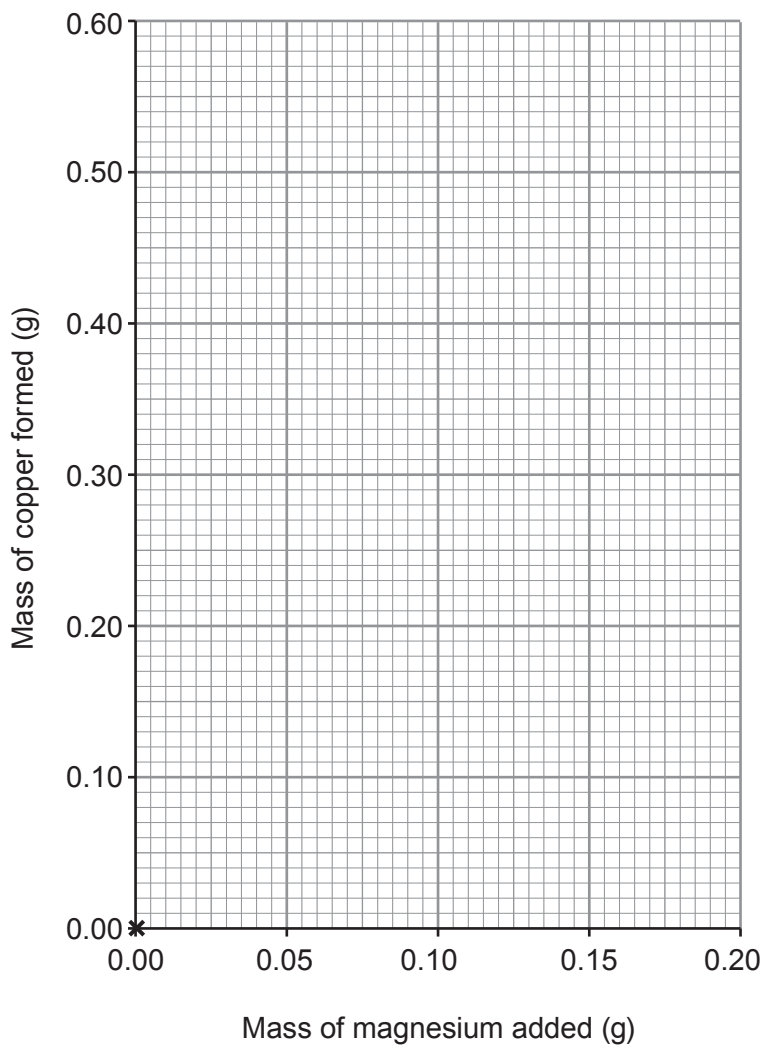
.....



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

Examiner only

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]

.....



(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]

$$A_r(\text{O}) = 16 \quad A_r(\text{S}) = 32 \quad A_r(\text{Cu}) = 63.5$$

Number of moles = mol

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

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

Concentration = mol/dm^3

10



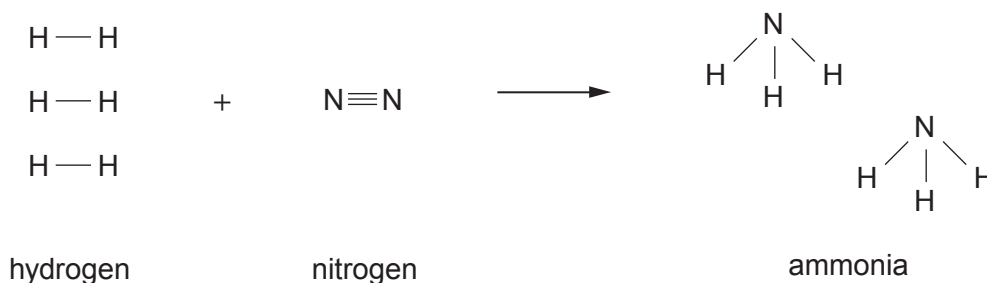
BLANK PAGE

**PLEASE DO NOT WRITE
ON THIS PAGE**



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.

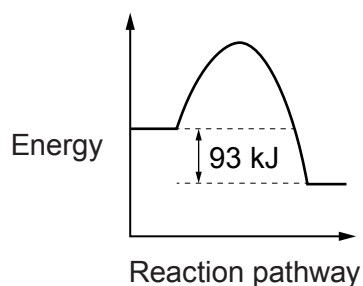


The bond energy of a H—H bond is 436 kJ. The energy needed to break **all** the bonds in the **reactants** is 2253 kJ.

- (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



- (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%



- (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

END OF PAPER



BLANK PAGE

**PLEASE DO NOT WRITE
ON THIS PAGE**



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

1 2 3 4 5 6 7 0

Group

7 Li Lithium 3	9 Be Beryllium 4	11 Na Sodium 11	12 C Carbon 6	13 Al Aluminium 13	14 N Nitrogen 7	15 O Oxygen 8	16 F Fluorine 9	17 Ne Neon 10
19 K Potassium 19	20 Ca Calcium 20	23 Sc Scandium 21	24 Ti Titanium 22	25 V Vanadium 23	26 Cr Chromium 24	27 Mn Manganese 25	28 Fe Iron 26	29 Co Cobalt 27
37 Rb Rubidium 37	38 Sr Strontium 38	39 Y Yttrium 39	40 Zr Zirconium 40	41 Nb Niobium 41	42 Mo Molybdenum 42	43 Tc Technetium 43	44 Ru Ruthenium 44	45 Rh Rhodium 45
55 Cs Caesium 55	56 Ba Barium 56	57 La Lanthanum 57	72 Hf Hafnium 72	73 Ta Tantalum 73	74 W Tungsten 74	75 Re Rhenium 75	76 Os Osmium 76	77 Ir Iridium 77
87 Fr Francium 87	88 Ra Radium 88	89 Ac Actinium 89	81 Tl Thallium 81	80 Hg Mercury 80	79 Au Gold 79	78 Pt Platinum 78	47 Ag Silver 47	48 Cd Cadmium 48
			49 In Indium 49	50 Tl Thallium 50	51 Pb Lead 82	52 Bi Bismuth 83	53 Po Polonium 84	54 At Astatine 85
			115 Sb Antimony 51	112 Sn Tin 50	108 Cd Cadmium 48	106 Pd Palladium 46	105 Ag Silver 47	104 Cu Copper 29
			122 As Arsenic 33	75 Ge Germanium 32	65 Zn Zinc 30	59 Ni Nickel 28	59 Co Cobalt 27	58 Ni Nickel 28
			79 Se Selenium 34	73 Ge Germanium 32	63.5 Cu Copper 29	56 Fe Iron 26	56 Fe Iron 26	55 Mn Manganese 25
			84 Kr Krypton 36	80 Br Bromine 35	79 Se Selenium 34	78 Br Bromine 35	77 Se Selenium 34	76 Br Bromine 35
			131 Xe Xenon 54	127 I Iodine 53	128 Te Tellurium 52	127 I Iodine 53	126 Te Tellurium 52	125 I Iodine 53
			209 Bi Bismuth 83	207 Pb Lead 82	201 Hg Mercury 80	197 Au Gold 79	197 Au Gold 79	196 Hg Mercury 80
			210 Po Polonium 84	210 Po Polonium 84	209 Bi Bismuth 83	209 Bi Bismuth 83	208 Po Polonium 84	207 Pb Lead 82
			222 Rn Radon 86	222 Rn Radon 86	222 Rn Radon 86	222 Rn Radon 86	222 Rn Radon 86	222 Rn Radon 86

Key

A_r	relative atomic mass
Symbol	
Name	
Z	atomic number

