

Surname	Centre Number	Candidate Number
First name(s)		0



GCSE

3410U20-1



S25-3410U20-1

MONDAY, 19 MAY 2025 – MORNING

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

1 hour 45 minutes

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 a 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(s) at the back of the booklet, taking care to number the question(s) correctly.

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	7	
2.	8	
3.	8	
4.	6	
5.	5	
6.	12	
7.	5	
8.	9	
9.	6	
10.	7	
11.	7	
Total	80	

INFORMATION FOR CANDIDATES

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

Question 6(b) 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.



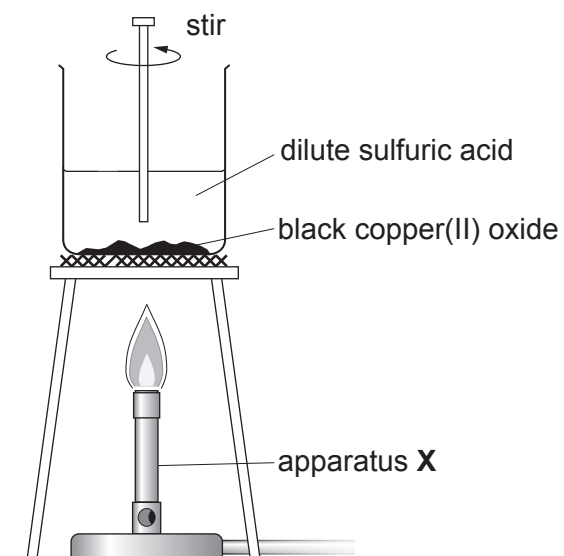
JUN253410U20101

Answer **all** questions.

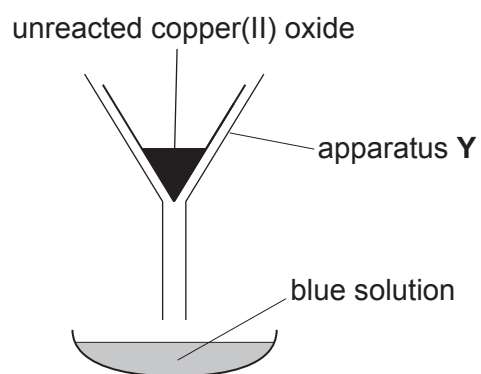
1. Megan carried out an experiment to prepare copper(II) sulfate crystals.

The diagrams show the stages of the method she carried out.

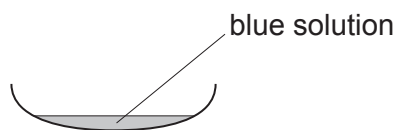
Stage 1



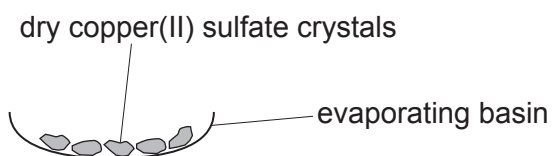
Stage 2



Stage 3



Stage 4



- (a) (i) Underline the name of apparatus **X** used in stage 1. [1]

beaker**tripod****Bunsen burner****stirrer**

- (ii) In stage 1 Megan added copper(II) oxide until **all** the dilute sulfuric acid was used up.

Tick (✓) the box next to the statement which best describes what Megan would see when **all** the acid had been used up. [1]

the copper(II) oxide turns blue

☐

black solid remains on the bottom of the beaker

☐

no black solid remains on the bottom of the beaker

☐


- (b) Choose words from the box to complete the following sentences. [2]

sulfuric acid	conical flask	water
test tube	filter funnel	

Apparatus **Y** used in stage **2** is called a

The liquid evaporated in stage **3** is

- (c) Use the information in the box below to answer this question.

Mass of the evaporating basin = 135.3 g

Mass of the evaporating basin and the dry copper(II) sulfate crystals = 144.8 g

Calculate the mass of the dry copper(II) sulfate crystals formed in stage **4**. [1]

Mass of dry crystals = g

- (d) Calculate the relative molecular mass, M_r , of sulfuric acid, H_2SO_4 . [2]

$A_r(\text{H}) = 1$

$A_r(\text{O}) = 16$

$A_r(\text{S}) = 32$

$M_r =$



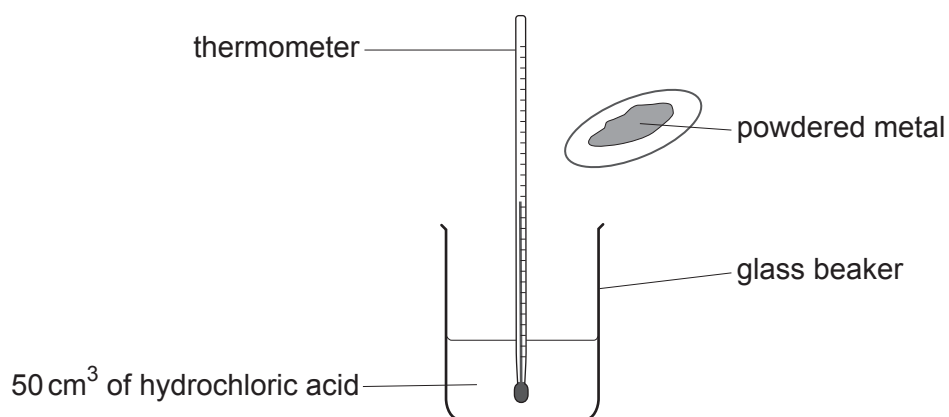
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2. A student was asked to investigate the temperature rise when four metals were added to excess dilute hydrochloric acid. He added equal masses of each metal in powdered form to 50 cm³ samples of hydrochloric acid solution.

He measured the temperature rise for each reaction.

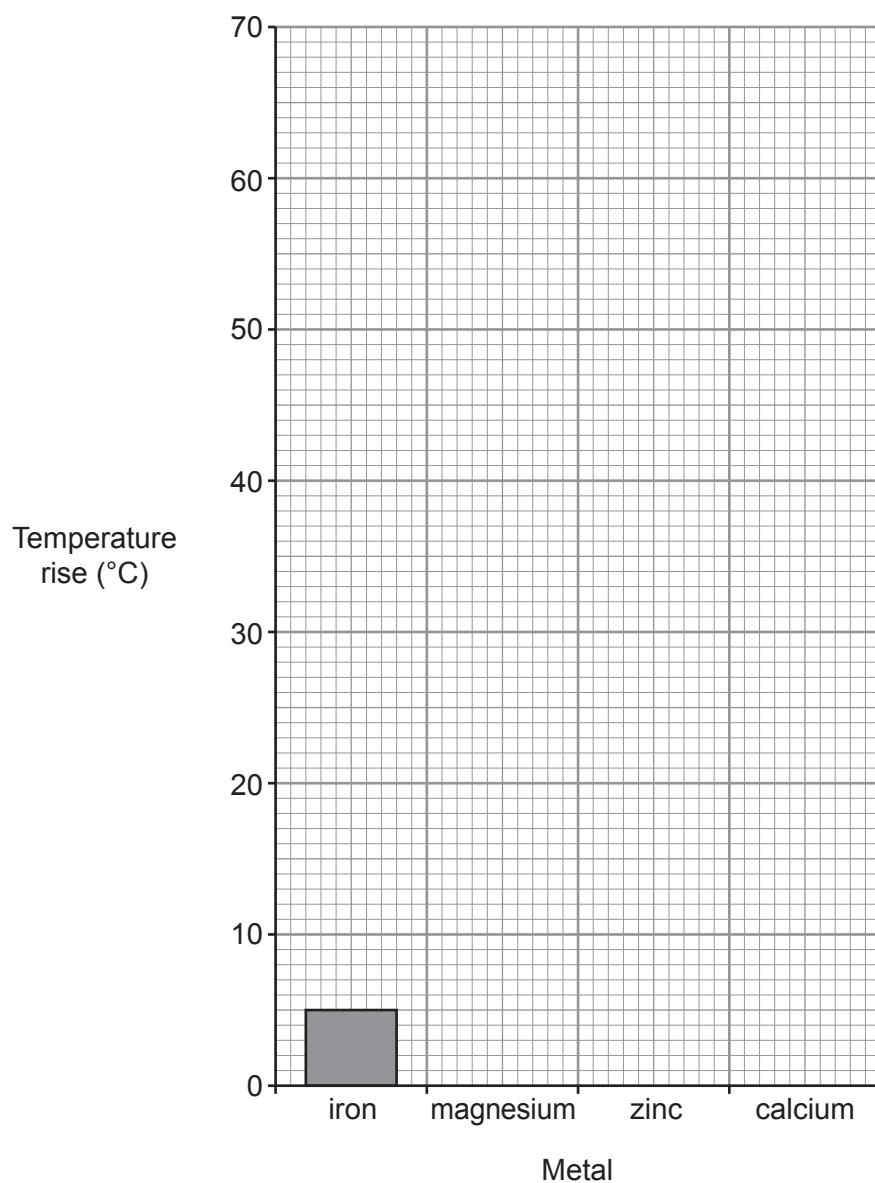


His results are shown in the table below.

Metal	Temperature rise (°C)
iron	5
magnesium	55
zinc	12
calcium	62



- (a) (i) Draw a bar chart on the grid to show the results. One bar has been drawn for you. [2]



- (ii) Put the **four** metals in order of reactivity. [1]

Most reactive

.....

.....

Least reactive



- (iii) The temperature rise for each metal was lower than expected.

Tick (✓) the box next to the statement that describes how the apparatus could be improved so that the temperature rise recorded for each metal was closer to the true value. [1]

change the glass beaker to a copper can

☐

repeat the experiment for each metal three times

☐

wrap insulating material around the glass beaker

☐

- (iv) The gas formed when the metals react with dilute hydrochloric acid pops with a lighted splint.

Underline the name of this gas. [1]

carbon dioxide

nitrogen

oxygen

hydrogen

- (b) The student repeated the experiment using aluminium and recorded a temperature rise of 46°C.

The energy given out by the reaction can be calculated using the formula below.

$$\text{energy given out} = \text{volume of solution} \times 4.2 \times \text{temperature rise}$$

Calculate the energy given out during the reaction between aluminium and 50 cm³ of hydrochloric acid solution. [2]

Energy given out = J



- (c) Copper and silver do **not** react with dilute hydrochloric acid.

Tick (✓) the box next to the pair of substances that would react together and therefore show that copper is above silver in the reactivity series. [1]

silver and copper(II) sulfate solution

☐

copper and silver nitrate solution

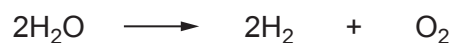
☐

silver nitrate solution and copper(II) sulfate solution

☐

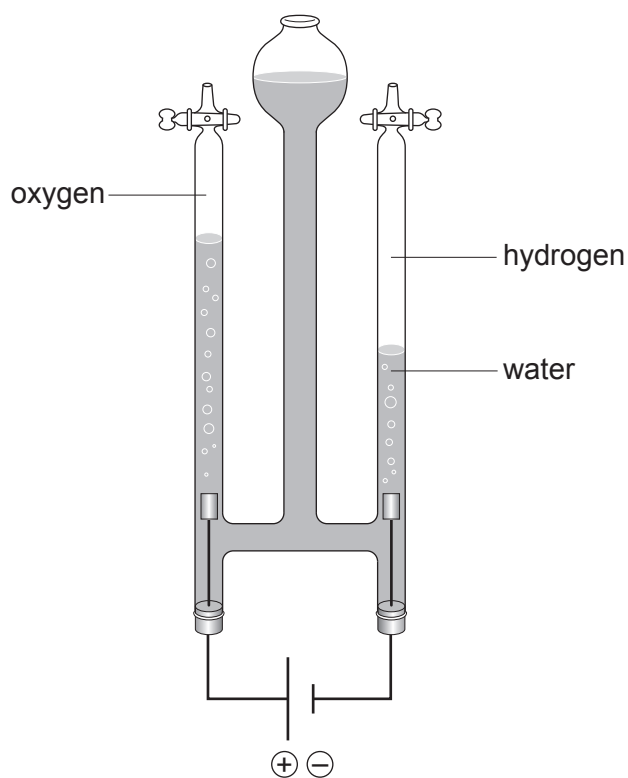
3. (a) The diagram shows the apparatus used by a group of students to investigate the volume of hydrogen and oxygen gases formed during the electrolysis of water.

The electrolysis of water is represented by the following symbol equation.



The equation shows that the volume of hydrogen formed at any time is **twice** the volume of the oxygen formed.

You can clearly see this in the diagram.



The table shows the volume of hydrogen formed over 5 minutes.

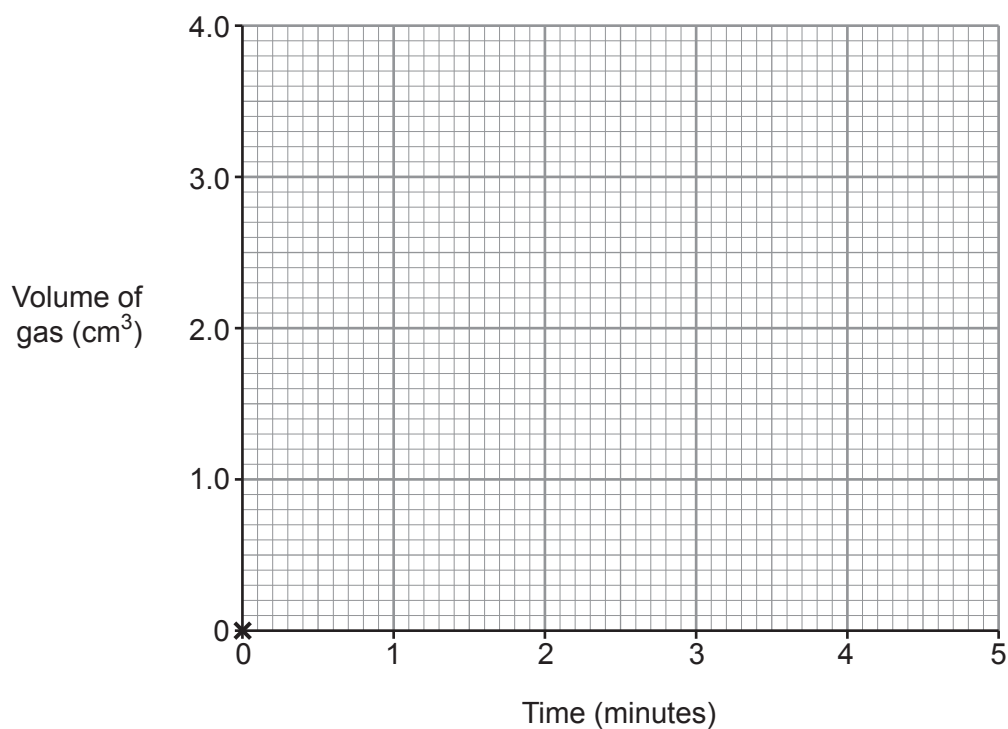
Time (minutes)	0	1	2	3	4	5
Volume of hydrogen (cm ³)	0	0.8	1.6	2.4	3.2	4.0



- (i) Plot the results from the table on the grid below. The point at (0,0) has been plotted for you.

Draw a suitable line. Label this line 'hydrogen'.

[3]



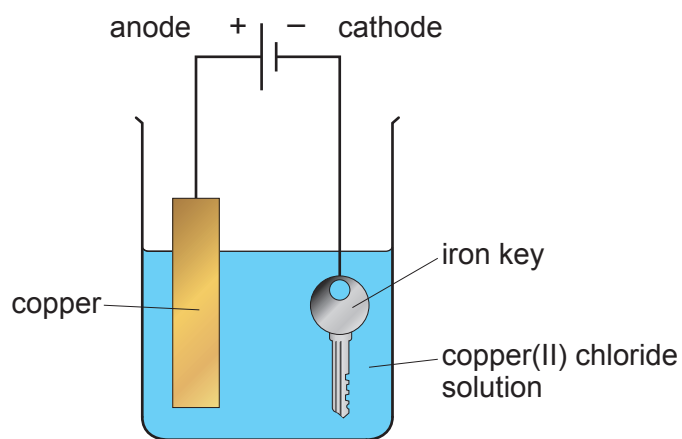
- (ii) Use the information in the box opposite to help you answer this question.

Using a ruler, draw a second line on the grid to show the volume of oxygen that would be collected over the same 5 minutes. Label this line 'oxygen'.

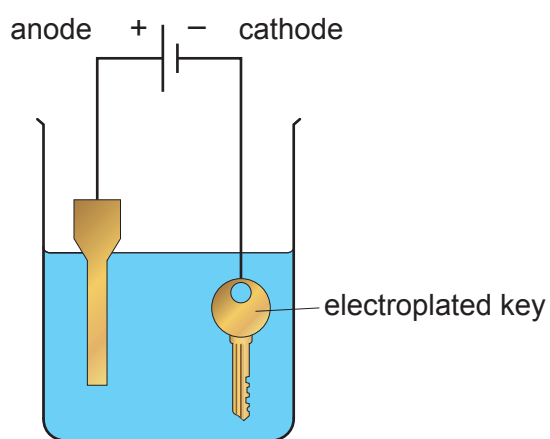
[1]



(b) The diagrams below show how an iron key can be electroplated.



Start



Apparatus after 30 minutes



- (i) Copper(II) chloride contains the ions Cu^{2+} and Cl^- .

Underline the correct formula for copper(II) chloride.

[1]



- (ii) Underline the correct word(s) in the brackets to complete each sentence.

[3]

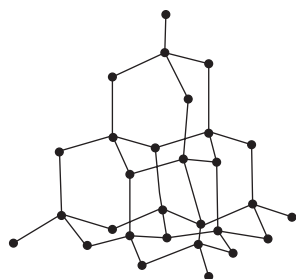
The electrolyte used in the experiment is
(**copper** / **copper(II) chloride solution** / **iron**).

The key is coated with (**copper** / **iron** / **chlorine**) during the experiment.

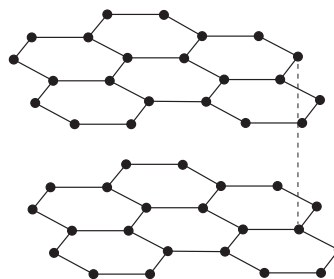
The mass of the key (**increases** / **decreases** / **stays the same**) during the experiment.



4. (a) Diamond and graphite are different forms of carbon.



diamond



graphite

Underline the correct word(s) in the brackets to complete each sentence.

[2]

Diamond is used to make drill bits because it is very (**brittle** / **hard** / **soft**).

Graphite is used to make (**pencils** / **electrodes in batteries** / **electrical wires**)
because it conducts electricity.



(b) The box contains the names of four types of smart materials.

thermochromic pigment	shape memory polymer	polymer gel	photochromic pigment
-----------------------	----------------------	-------------	----------------------

Use the information given to complete the table.

[2]

Smart material	Property
shape memory polymer	regains original shape when heated
.....	absorbs water and swells up to 1000 times its volume
.....	changes colour with changing temperature

(c) Underline the correct word in the brackets to complete each sentence.

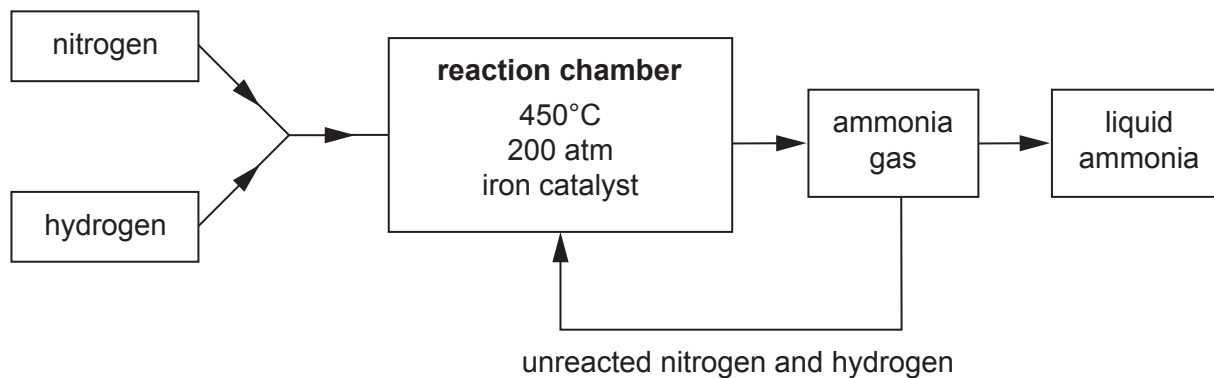
[2]

Nano-sized silver is used in plasters and wound dressings because it is (**sticky** / **absorbent** / **antibacterial**).

Many people prefer suncreams which contain nano-sized titanium oxide because they block UV radiation and they are (**white** / **greasy** / **transparent**).



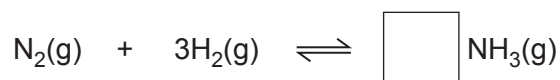
5. (a) The flow diagram shows information about the Haber process.



- (i) Nitrogen and hydrogen react forming ammonia.

Complete the balancing of the equation for this reaction.

[1]



- (ii) State the purpose of the iron catalyst in the process.

[1]

- (iii) Tick (✓) the box next to the statement that shows the reaction is reversible.

[1]

nitrogen, hydrogen and ammonia are all gases

☐

the $\rightleftharpoons$ symbol is used in the equation

☐

ammonia gas condenses on cooling to form liquid ammonia

☐

unreacted nitrogen and hydrogen are recycled

☐


(b) Ammonia dissolves in water forming an alkaline solution.

(i) Underline the correct word in the brackets to complete the sentence.

Ammonia turns damp litmus paper (**red** / **blue** / **green**).

[1]

(ii) Ammonia solution neutralises acids forming ammonium salts.

Tick (✓) the box next to the name of the salt formed when ammonia solution neutralises nitric acid.

[1]

ammonium nitrate

☐

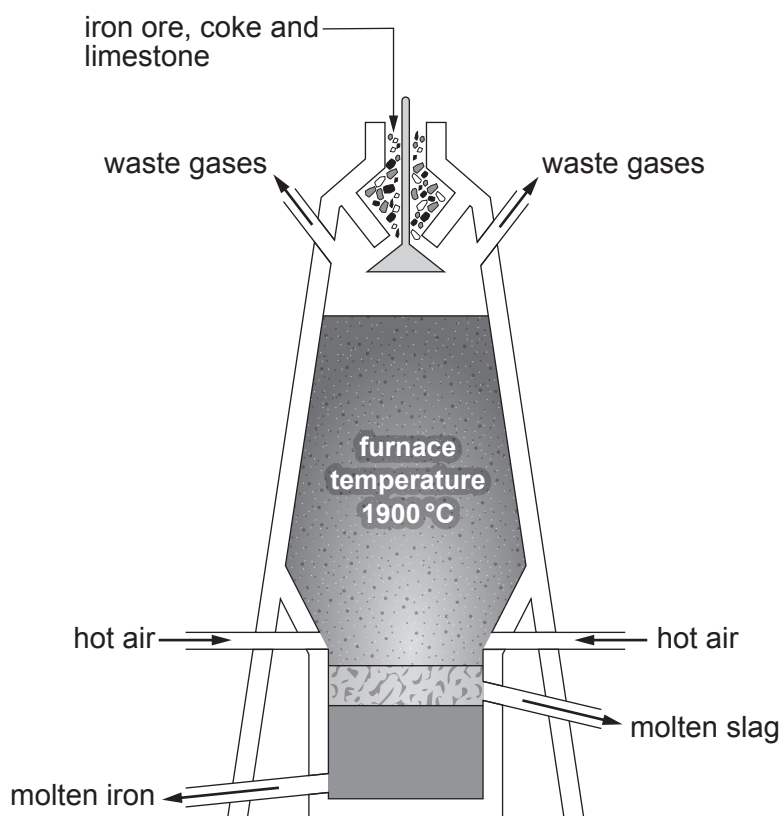
ammonium sulfate

☐

ammonium chloride

☐

6. (a) Iron is extracted from its ore in the blast furnace. The diagram shows information about the process and the products formed.



Product	Melting point (°C)	Density (g/cm ³)
iron	1540	7.9
slag	1780	2.4



Use the information opposite to help you answer part (i).

- (i) I. The temperature inside the furnace reaches 1900 °C.

Give the reason why the iron is molten when it forms in the furnace. [1]

.....

.....

- II. Tick (✓) the box next to the statement that best explains why the slag layer forms above the iron layer in the furnace. [1]

iron and slag have the same density

☐

iron is more dense than slag

☐

slag is more dense than iron

☐

- (ii) The equation shows one of the reactions that takes place in the blast furnace.



Tick (✓) the box next to the correct statement. [1]

carbon is reduced

☐

iron is reduced

☐

iron(III) oxide is reduced

☐

carbon monoxide is reduced

☐

- (b) The box shows some properties of copper.

electrical conductor	heat conductor	malleable
high melting point	high density	unreactive

Use only the properties in the box in your answer to this part-question.

Choose **two** properties that make copper suitable for making water pipes and **two different** properties that make it suitable for making saucepan bases.

State why these properties are important for each use.

[6 QER]



water pipe



saucepan base





(c)

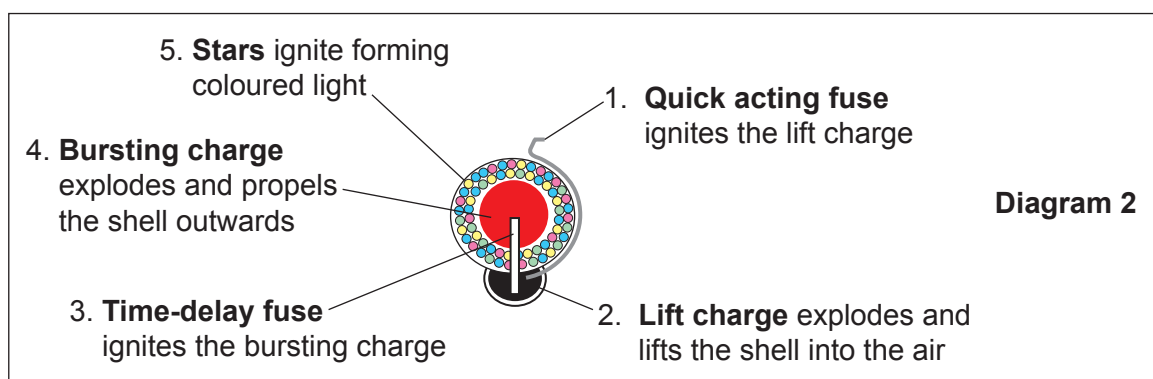
Fireworks

You have to be 18 years-old to buy fireworks but even then, only some such as rockets, roman candles and sparklers can be bought to use at your own event. The more spectacular fireworks can only be used by pyrotechnicians at official public displays. Many of these are classed as 'shells'.

Diagram 1 shows some shell fireworks which can only be used in official public displays.



Diagram 2 shows the inside of a shell firework used in public displays.



Each shell contains metal compounds packed in pellets called 'stars'.

When the stars are ignited the different metal ions produce different colours of light.

The table shows some metal compounds which are commonly used in fireworks and the colours they produce.

Colour	Metal ion	Metal compound
red	strontium	strontium carbonate
orange	calcium	calcium chloride
green	barium	barium chloride
blue	copper	copper(II) chloride
violet	mixture of strontium and copper	strontium carbonate and copper(II) chloride



- (i) Underline the name of a firework that the general public can buy.

[1]

peony**roman candle****chrysanthemum****flying fish**

- (ii) Tick (✓) the box next to the part of a shell that gives a firework its colours.

[1]

bursting charge

☐

star

☐

fuse

☐

- (iii) A pyrotechnician wanted to make a multicoloured red and green firework.

Tick (✓) the box next to the compounds she should choose to make a red and green firework.

[1]

calcium chloride and barium chloride

☐

strontium carbonate and barium chloride

☐

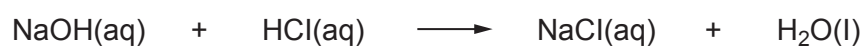
strontium carbonate and calcium chloride

☐

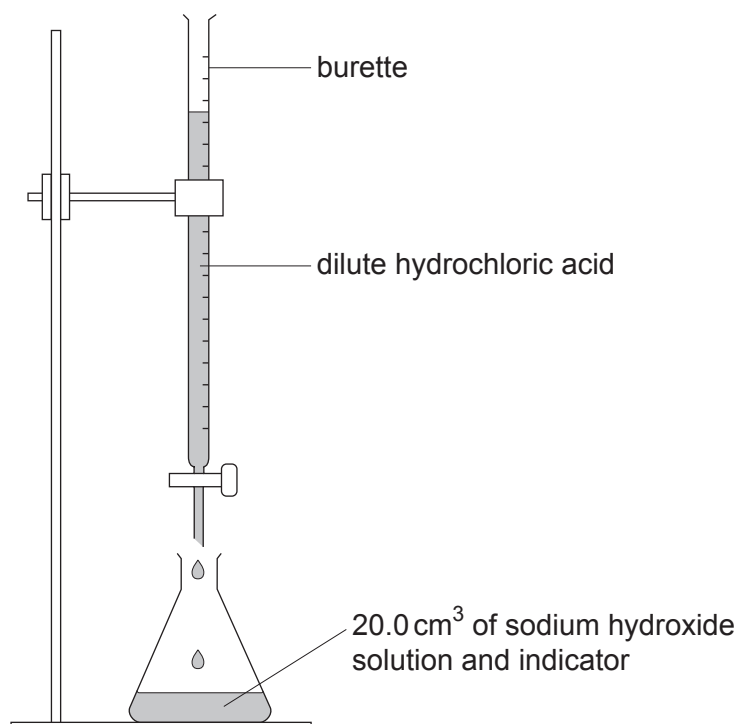
barium chloride and copper(II) chloride

☐

7. Jamal, Leanne and Steffan were asked to find the volume of hydrochloric acid solution needed to neutralise 20.0 cm^3 of sodium hydroxide solution.



They each carried out a titration using the following apparatus.



- (a) State what the students would **see** at exactly the point when all the sodium hydroxide is neutralised. [1]



- (b) Their results are shown in the table.

Student	Volume of acid needed to neutralise 20.0 cm ³ of alkali (cm ³)
Leanne	10.2
Steffan	10.7
Jamal	10.6

Use **all** the volumes in the table to calculate the mean volume of acid needed to neutralise 20.0 cm³ of the alkali.

[2]

Mean volume = cm³

- (c) Titrations can be used to prepare salts. The salt produced in this experiment is sodium chloride.

The sodium chloride solutions prepared by all three students are impure.

Tick (✓) the box next to the additional step needed to obtain a pure solution of sodium chloride.

[1]

add the mean volume of acid needed to a new 20.0 cm³ of alkali containing no indicator

☐

add the mean volume of acid needed to a new 20.0 cm³ of alkali with fresh indicator

☐

add a new 20.0 cm³ of acid to a new 20.0 cm³ of alkali containing no indicator

☐


- (d) Jamal and Leanne were asked to suggest a method they could use to obtain crystals from a pure sodium chloride solution.

Jamal suggested boiling the solution to dryness.

Leanne suggested leaving the solution to evaporate for several days.

Both methods work.

State how the appearance of the crystals made using Leanne's method would differ from those made using Jamal's method.

[1]

5



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8. (a) The table shows the names, molecular formulae and structural formulae of some alkanes.

Complete the table.

[2]

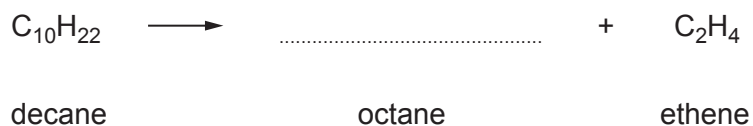
Name	Molecular formula	Structural formula
methane	CH_4	<pre> H H — C — H H </pre>
ethane		<pre> H H H — C — C — H H H </pre>
propane	C_3H_8	<pre> H H H H — C — C — C — H H H H </pre>
butane	C_4H_{10}	



- (b) Naphtha is one of the fractions separated from crude oil. Naphtha contains decane, $C_{10}H_{22}$.

Decane undergoes cracking to form octane and ethene.

- (i) Complete the equation for this reaction. [1]



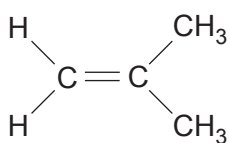
- (ii) Ethene belongs to the alkene family of hydrocarbons.

The general formula of the alkene family is C_nH_{2n} .

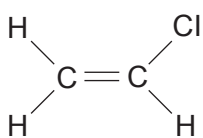
Propene contains three carbon atoms. Give the formula of propene. [1]

.....

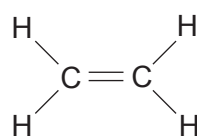
- (c) Monomers **A**, **B**, **C** and **D** are shown below.



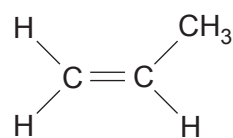
A



B

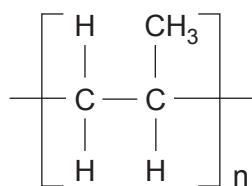


C



D

Give the **letter** of the monomer used to make polypropene. [1]

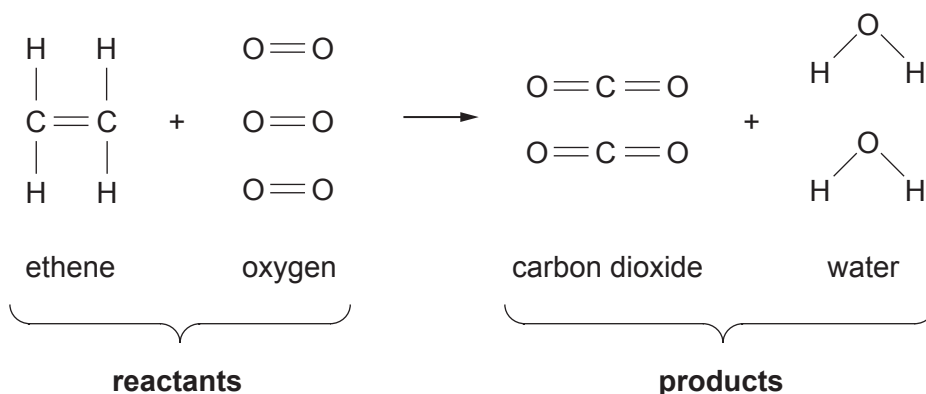


polypropene

Letter



- (d) The equation shows the bonds which are broken and the bonds which are formed when ethene burns in air.



- (i) The amount of energy needed to break **one** $\text{O}=\text{O}$ bond is 498 kJ.

Calculate the amount of energy needed to break the bonds in **all** the oxygen molecules shown in the equation.

[1]

Energy = kJ

- (ii) The energy released when one $\text{C}=\text{O}$ bond is formed is 805 kJ and the energy released when one $\text{O}-\text{H}$ bond is formed is 464 kJ.

Use these values and the equation above to show that the total amount of energy released when all the products are formed is 5076 kJ.

[2]



- (iii) During the reaction, more energy is released when making the bonds in the products than is needed to break all the bonds in the reactants. This means the reaction gives out more energy than it takes in.

State the name given to this type of reaction.

[1]

.....

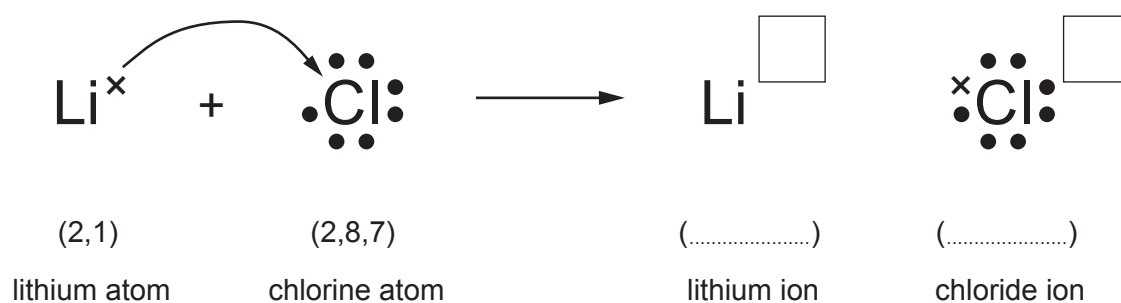
Examiner
only

9



9. (a) Lithium reacts with chlorine to form the ionic compound lithium chloride.

- (i) The diagram shows the electronic changes that occur when lithium reacts with chlorine to form lithium chloride. The $\bullet$ and $\times$ symbols represent outer shell electrons.



Complete the diagram by writing the electronic structures of the lithium and chloride ions in the brackets and their charges in the boxes. [2]

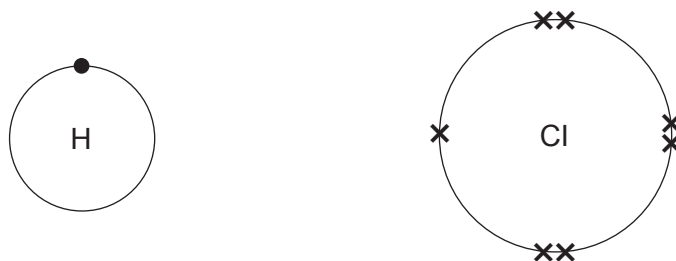
- (ii) Give **two** properties of ionic compounds such as lithium chloride. [2]

Property 1

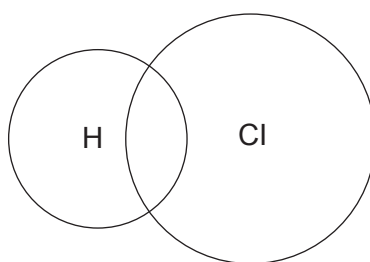
Property 2



- (b) The • and × symbols in the diagram represent the outer shell electrons in an atom of hydrogen and an atom of chlorine.

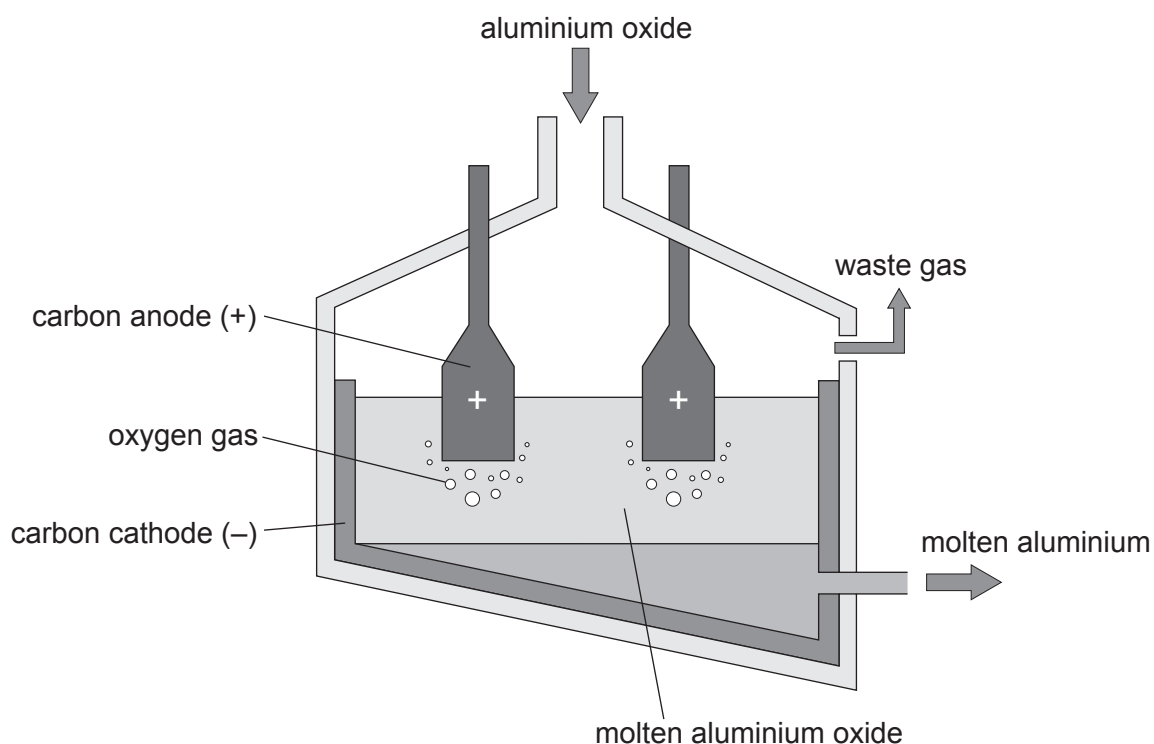


Complete the diagram below to show the electrons in a molecule of hydrogen chloride. [2]



10. (a) The diagram shows a cell used in the electrolysis of aluminium oxide.

The following equation represents the overall reaction.



- (i) Give the **symbol** of the **ion** attracted to the positive electrode.

[1]

.....

- (ii) Oxygen is formed at the carbon anode. At the high temperature of the cell, the carbon anode burns.

[1]

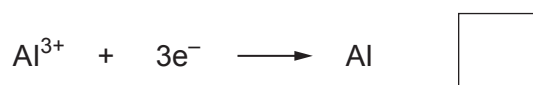
Name the gas formed when the carbon anode burns in oxygen.

.....



- (iii) During the process each aluminium ion, Al^{3+} , gains three electrons forming an aluminium atom at the cathode.

Tick (✓) the box next to the electrode equation for the process at the cathode. [1]



- (iv) Aluminium is a good electrical conductor. It is used to make over-head power cables.

Give **one** other property of aluminium that makes it a suitable material for this use. [1]

.....



- (b) The ore most commonly used for the extraction process is bauxite, which contains a lot of impurities.

The UK has no bauxite deposits meaning it must be imported from other countries, including Australia and Guinea. Bauxite is processed forming aluminium oxide to be used in the electrolysis process.

Tick (✓) the box next to **two** statements that describe the requirements for the siting of an aluminium extraction plant in the UK. [2]

near a port to import bauxite

☐

nearby limestone quarries

☐

near a direct supply of electricity

☐

near a port to export bauxite

☐

nearby recycling centre

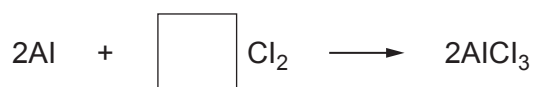
☐

nearby bauxite deposit

☐

- (c) Aluminium reacts with chlorine to form aluminium chloride.

Complete the balancing of the symbol equation for this reaction. [1]



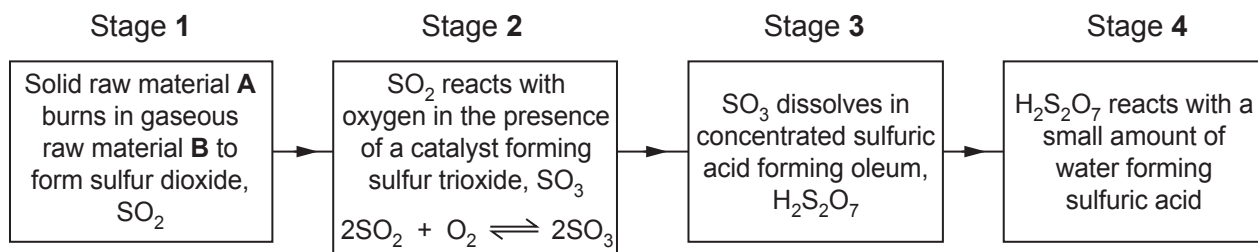
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11. (a) Sulfuric acid is produced by the contact process.

The flow diagram shows the main stages in the process.



- (i) Name the **two** raw materials used in stage 1. [2]

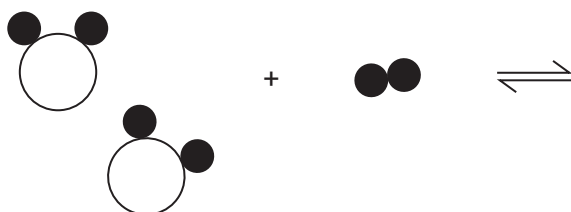
Solid raw material **A**

Gaseous raw material **B**

- (ii) Name the catalyst used in stage 2. [1]

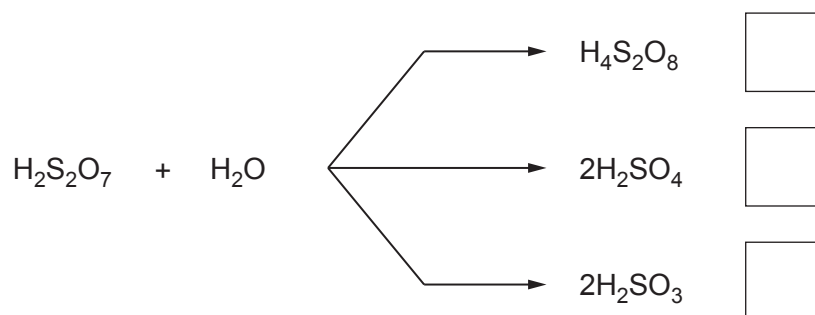
.....

- (iii) Use the symbol equation for the reaction in stage 2 to complete the diagram below. [2]



- (iv) In stage 4, one molecule of oleum, $\text{H}_2\text{S}_2\text{O}_7$, reacts with one molecule of water to form sulfuric acid.

Tick (✓) the box next to the product that correctly balances the equation for this reaction. [1]



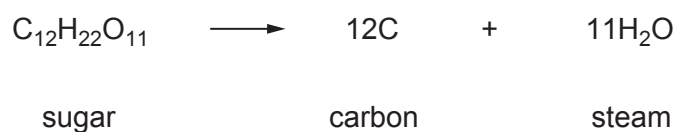
Examiner
only



- (b) The photograph shows concentrated sulfuric acid acting as a dehydrating agent in its reaction with sugar.



The equation represents the reaction.



Tick (✓) the box next to the statement that explains why this is a dehydration reaction.

[1]

carbon, hydrogen and oxygen react to make sugar

☐

sugar turns black and expands up the beaker

☐

the reaction is exothermic

☐

the elements hydrogen and oxygen are removed from the sugar

☐

sugar splits up into carbon, hydrogen and oxygen

☐

END OF PAPER



[illegible]

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+}		



Group

2
1

02

6



4



no

[illegible]

relative atomic mass

atomic number

$$A_r$$

Symbol

ame

Z