Surname	Centre Number	Candidate Number
First name(s)		0

GCSE

S25-3410U20-1

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

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**	

3410U201
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 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.

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.

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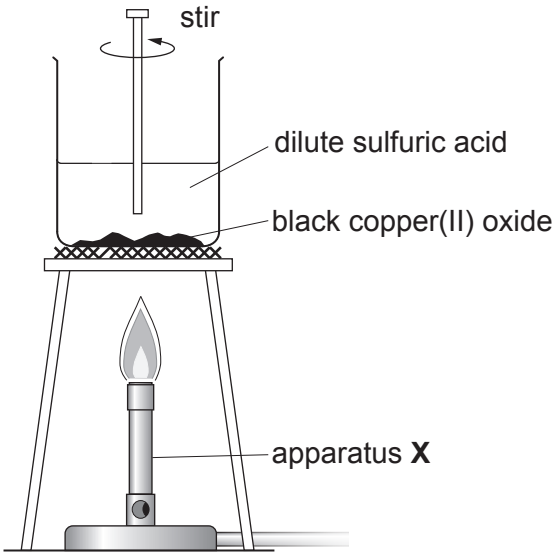
Answer **all** questions.

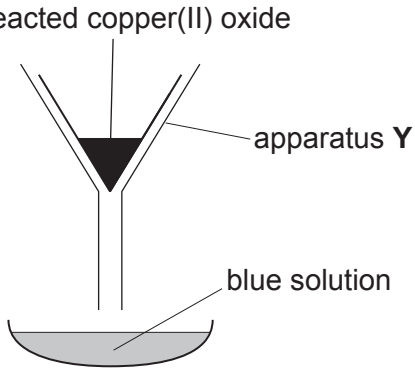
1. Megan carried out an experiment to prepare copper(II) sulfate crystals.

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

Stage **1**



Stage **2**



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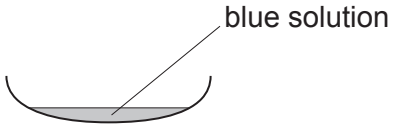
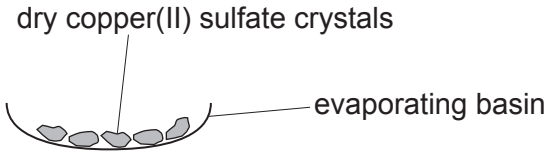
Stage **3**



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 ☐

3410U201
03

Turn over.

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(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]

$A_r(H) = 1$ $A_r(O) = 16$ $A_r(S) = 32$

M_r = ...

7

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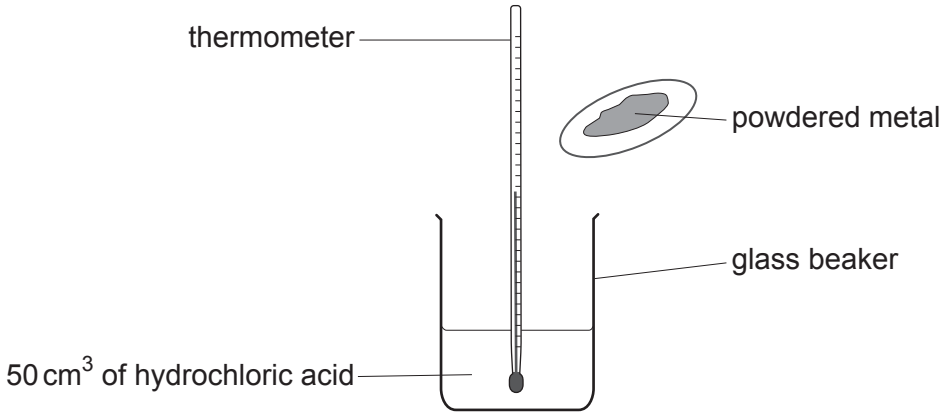
2. A student was asked to investigate the temperature rise when four metals were added to excess dilute hydrochloric acid. He added equal masses of each metal in powdered form to 50 cm^3 samples of hydrochloric acid solution.

He measured the temperature rise for each reaction.

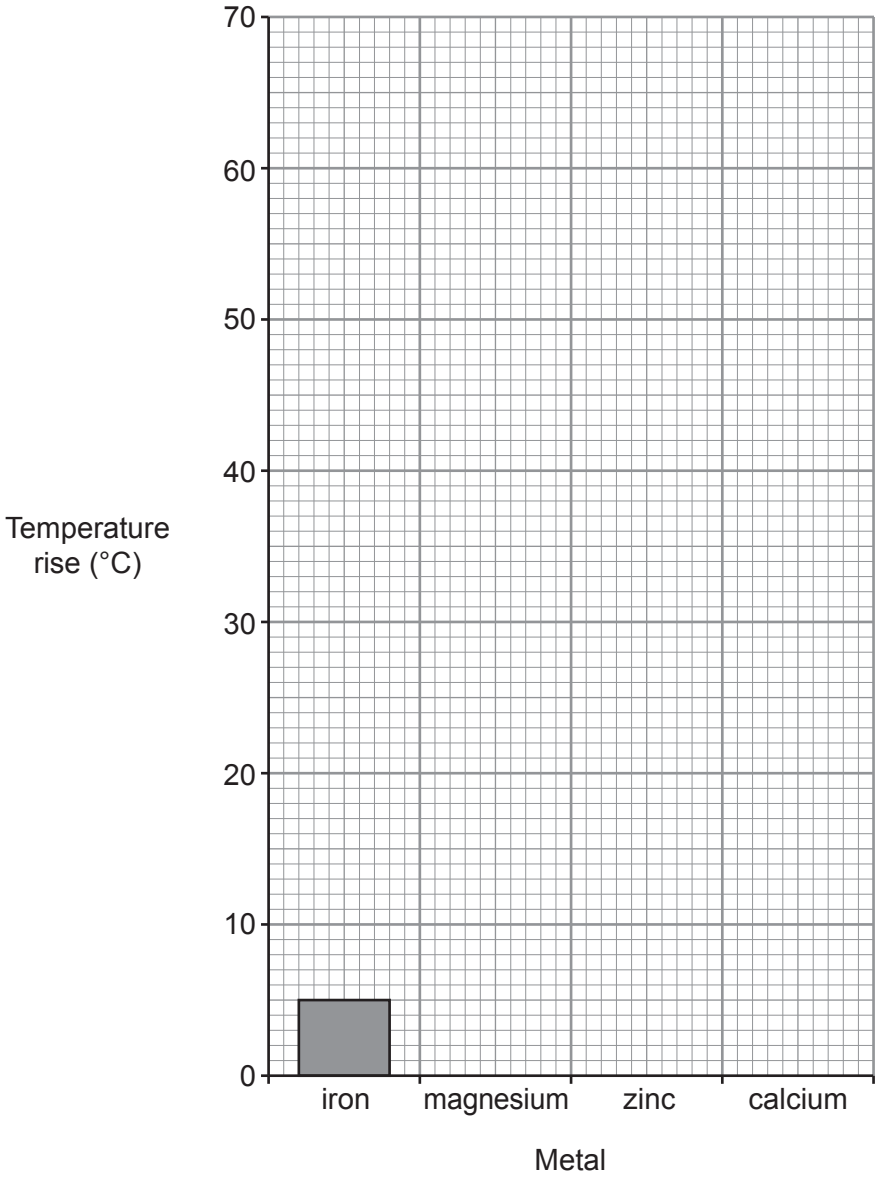


His results are shown in the table below.

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

Examiner only

(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 .....

Examiner only

(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.

energy given out = volume of solution × 4.2 × temperature rise

Calculate the energy given out during the reaction between aluminium and 50 cm^3 of hydrochloric acid solution. [2]

Energy given out = ... J

Examiner only

(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 ☐

8

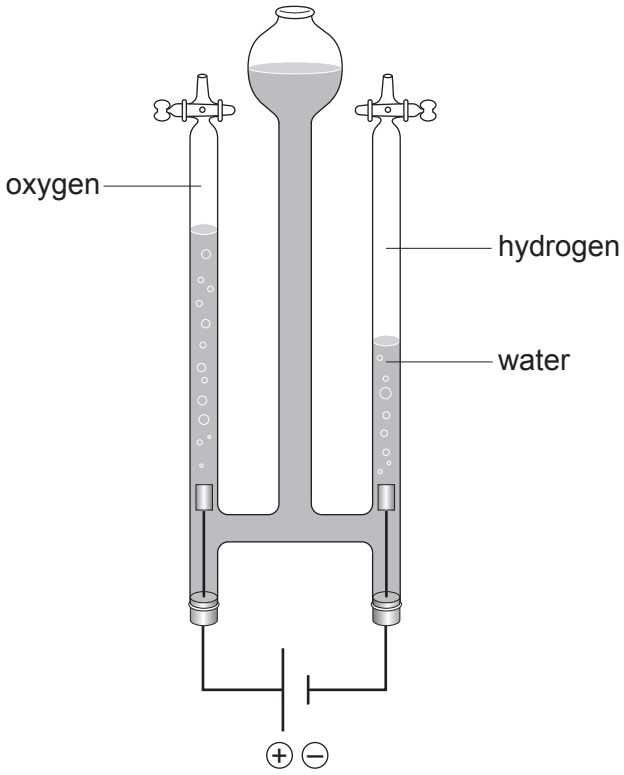
3. (a) The diagram shows the apparatus used by a group of students to investigate the volume of hydrogen and oxygen gases formed during the electrolysis of water.

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

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

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.



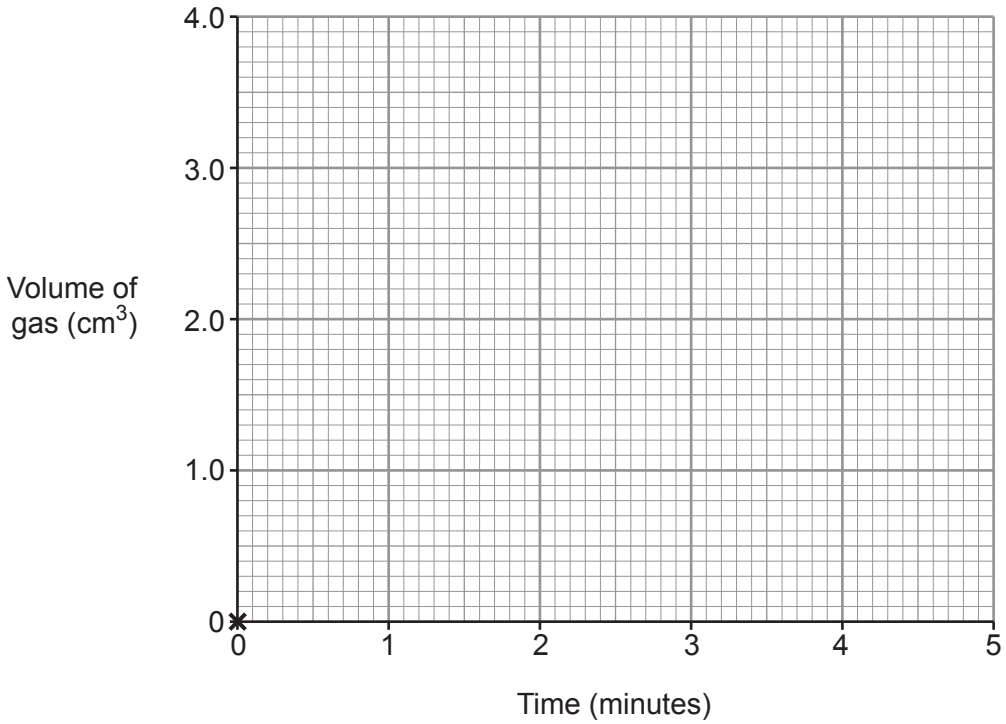
The table shows the volume of hydrogen formed over 5 minutes.

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

Examiner only

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

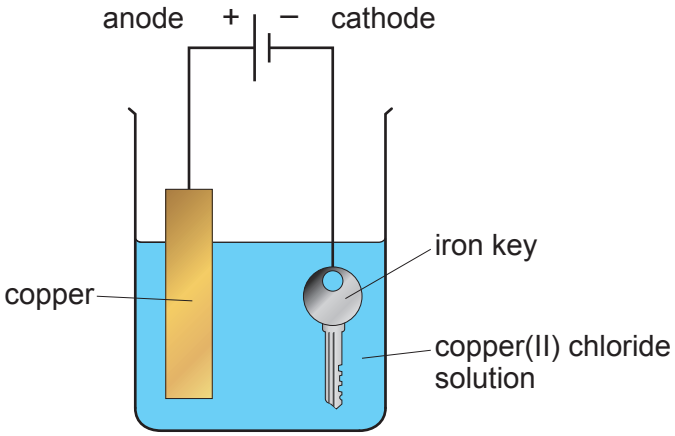
Draw a suitable line. Label this line 'hydrogen'. [3]



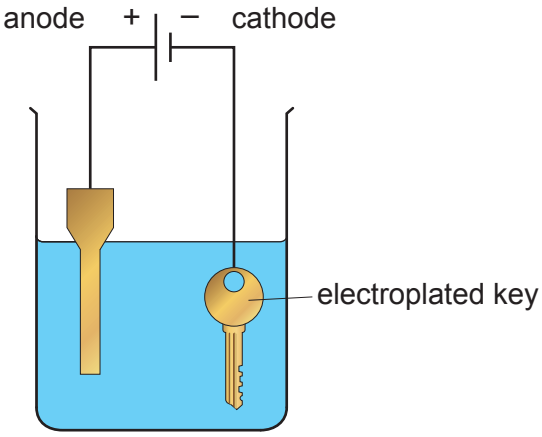
(ii) Use the information in the box opposite to help you answer this question.

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

Examiner only

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

Underline the correct formula for copper(II) chloride. [1]

CuCl **$CuCl^2$** **$CuCl_2$** **Cu_2Cl**

(ii) Underline the correct word(s) in the brackets to complete each sentence. [3]

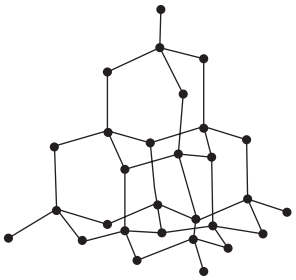
The electrolyte used in the experiment is
(**copper** / **copper(II) chloride solution** / **iron**).

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

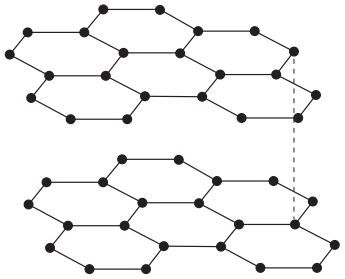
The mass of the key (**increases** / **decreases** / **stays the same**) during the experiment.

Examiner only

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.

Examiner only

(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]

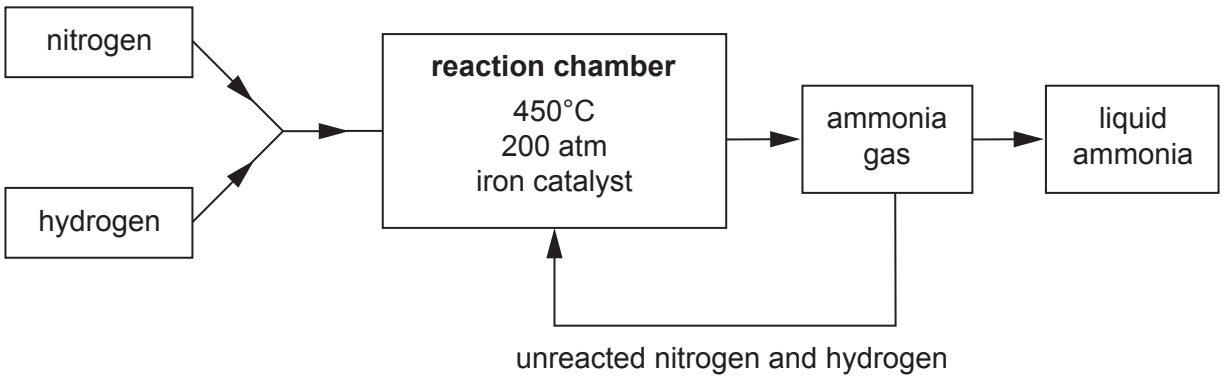
Nano-sized silver is used in plasters and wound dressings because it is (**sticky** / **absorbent** / **antibacterial**).

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

6

Examiner only

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]

$$N_2(g) + 3H_2(g) \rightleftharpoons \square NH_3(g)$$

(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	☐

Examiner only

(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 ☐

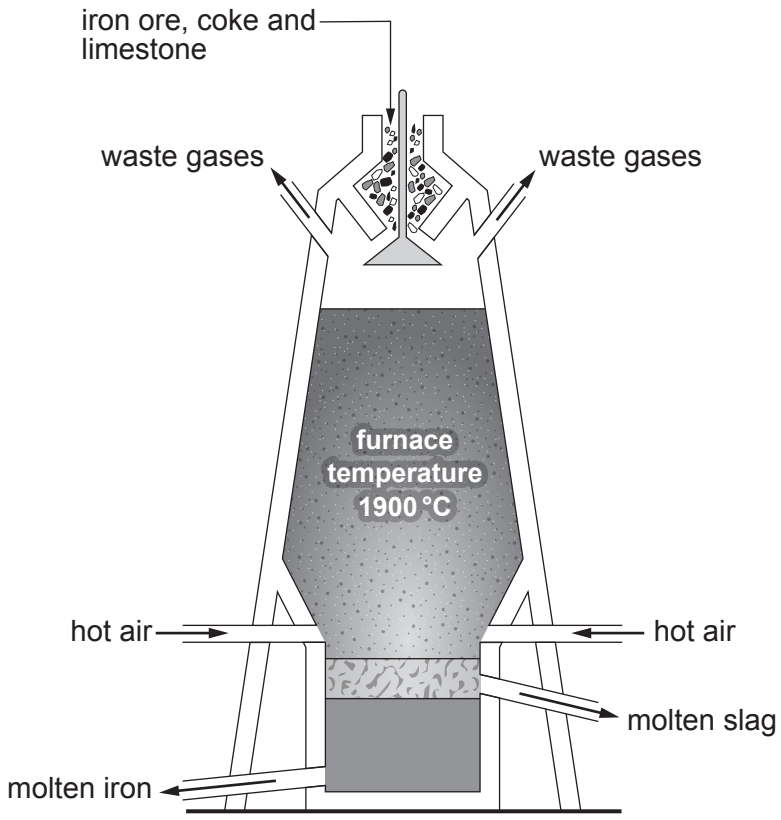
ammonium sulfate ☐

ammonium chloride ☐

3410U201
17

5

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

Examiner only

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.

$$Fe_2O_3 + 3C \longrightarrow 2Fe + 3CO$$

iron(III) oxide carbon iron carbon monoxide

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

carbon is reduced ☐

iron is reduced ☐

iron(III) oxide is reduced ☐

carbon monoxide is reduced ☐

3410U201
19

Examiner only

(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

Examiner only

Turn over.

(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.

peony chrysanthemum flying fish

Diagram 1

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

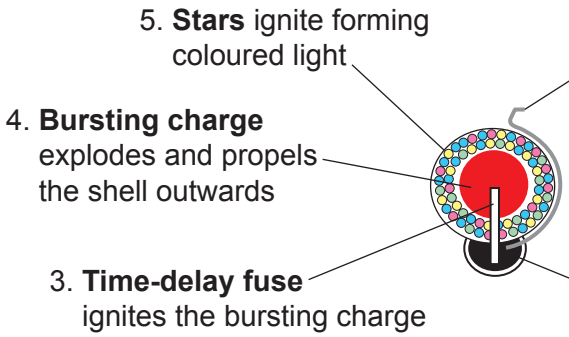


Diagram 2

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

Examiner only

(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 ☐

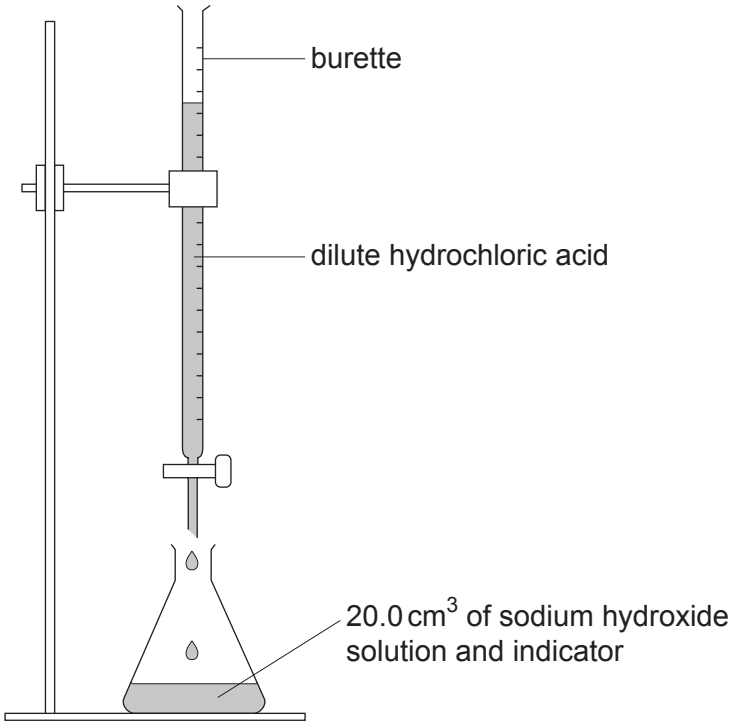
12

Examiner only

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.

$$NaOH(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l)$$

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]

.....

Examiner only

(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 cm^3 of the alkali. [2]

Mean volume = ... cm^3

(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 cm^3 of alkali containing no indicator ☐

add the mean volume of acid needed to a new 20.0 cm^3 of alkali with fresh indicator ☐

add a new 20.0 cm^3 of acid to a new 20.0 cm^3 of alkali containing no indicator ☐

Examiner only

(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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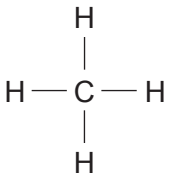
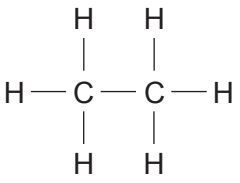
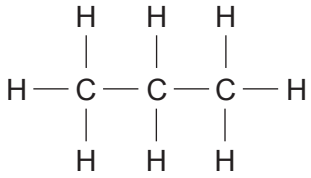
Examiner only

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	
ethane	.....	
propane	C_3H_8	
butane	C_4H_{10}	

Examiner only

(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]

$C_{10}H_{22}$ ⟶ ..... + C_2H_4

decane octane ethene

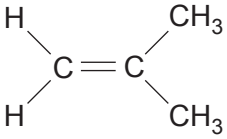
(ii) Ethene belongs to the alkene family of hydrocarbons.

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

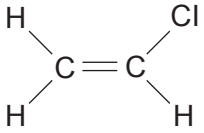
Propene contains three carbon atoms. Give the formula of propene. [1]

.....

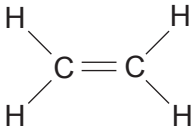
(c) Monomers **A**, **B**, **C** and **D** are shown below.



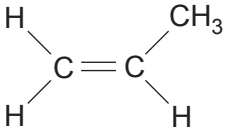
A



B

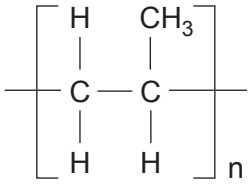


C



D

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

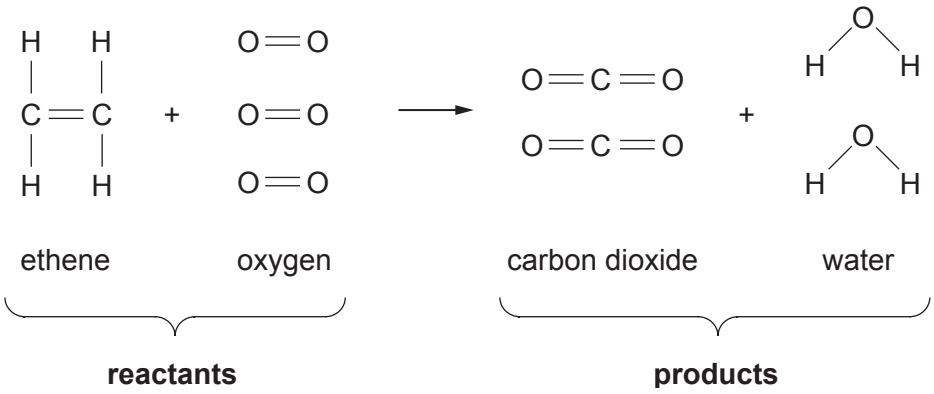


polypropene

Letter .....

Examiner only

(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** O═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 C═O bond is formed is 805 kJ and the energy released when one O—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]

Examiner only

(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]

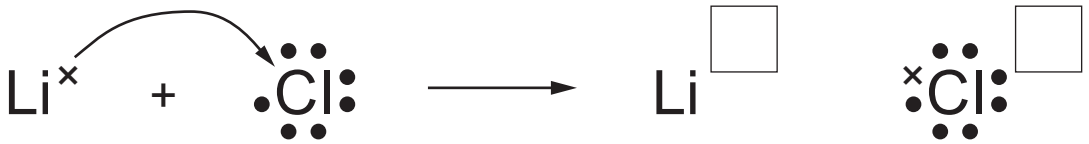
.....

9

Examiner only

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 ● and × symbols represent outer shell electrons.



(2,1) (2,8,7) (.....) (.....)

lithium atom chlorine atom lithium ion chloride ion

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

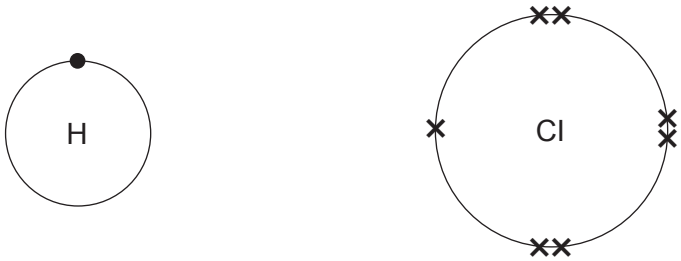
(ii) Give **two** properties of ionic compounds such as lithium chloride. [2]

Property 1 .....

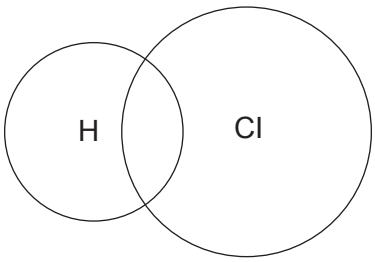
Property 2 .....

Examiner only

(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]



6

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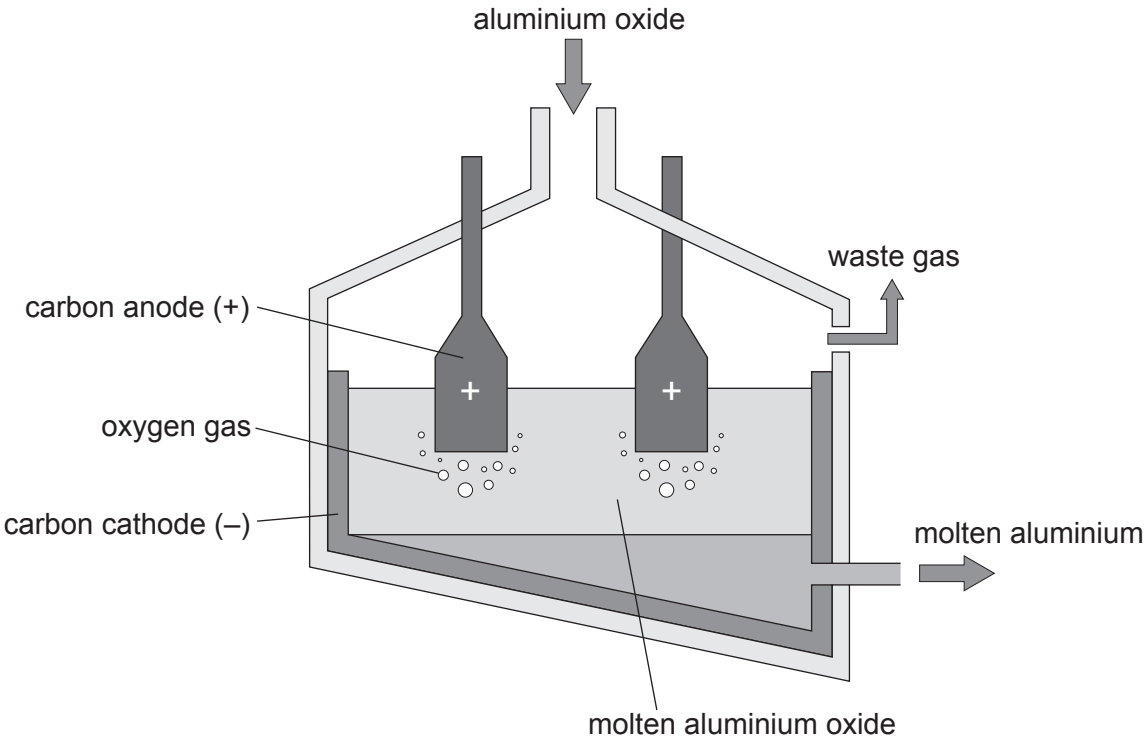
10. (a) The diagram shows a cell used in the electrolysis of aluminium oxide.

The following equation represents the overall reaction.

$$2Al_2O_3 \longrightarrow 4Al + 3O_2$$



(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.

.....

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(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]

$Al^{3+} - 3e^- \longrightarrow Al$ ☐

$Al^{3+} + 3e^- \longrightarrow 3Al$ ☐

$Al^{3+} - 3e^- \longrightarrow Al_3$ ☐

$Al^{3+} + 3e^- \longrightarrow Al$ ☐

(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]

.....

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(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]

$$2Al + \square\ Cl_2 \longrightarrow 2AlCl_3$$

7

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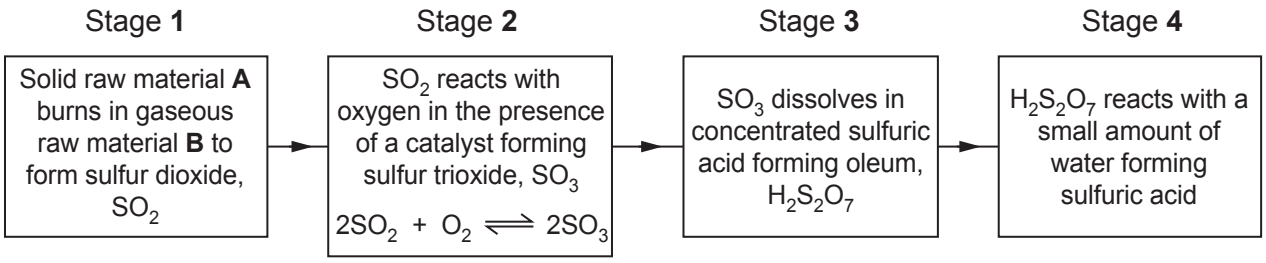
11. (a) Sulfuric acid is produced by the contact process.

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** .....

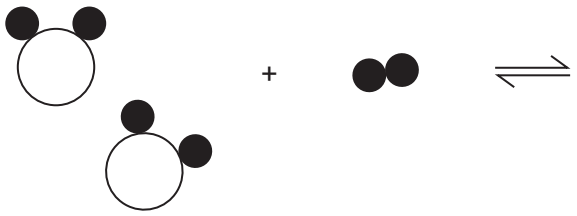
Gaseous raw material **B** .....

(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]

$$2SO_2 + O_2 \rightleftharpoons 2SO_3$$



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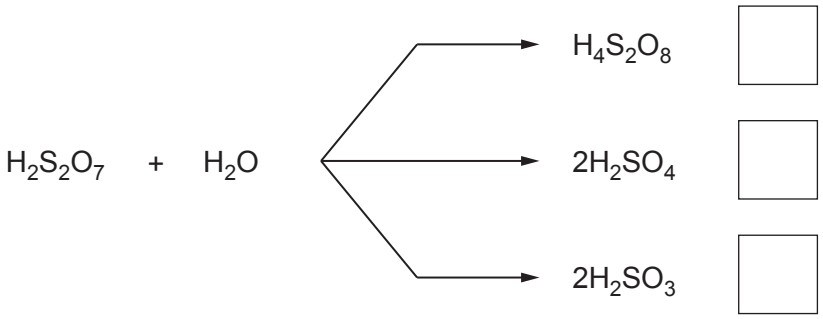
(iv) In stage **4**, one molecule of oleum, $H_2S_2O_7$, reacts with one molecule of water to form sulfuric acid.

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



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

The equation represents the reaction.

$$C_{12}H_{22}O_{11} \longrightarrow 12C + 11H_2O$$

sugar — carbon — steam

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 ☐

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7

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

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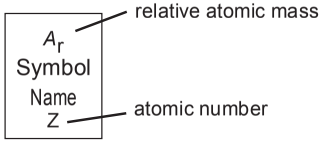
FORMULAE FOR SOME COMMON IONS

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+}		

THE PERIODIC TABLE

1	2	Group										3	4	5	6	7	0
							1 H Hydrogen 1										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



44