Surname	Centre Number	Candidate Number
First name(s)		0

GCSE

3410U20-1

S24-3410U20-1

FRIDAY, 17 MAY 2024 – 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.	**6**	
2.	**6**	
3.	**5**	
4.	**9**	
5.	**8**	
6.	**6**	
7.	**11**	
8.	**9**	
9.	**7**	
10.	**7**	
11.	**6**	
Total	**80**	

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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 **8**(a) 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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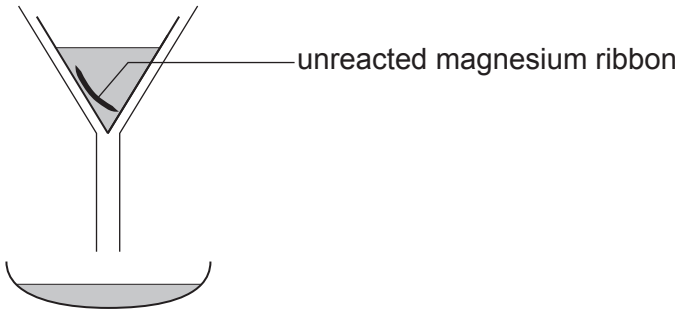
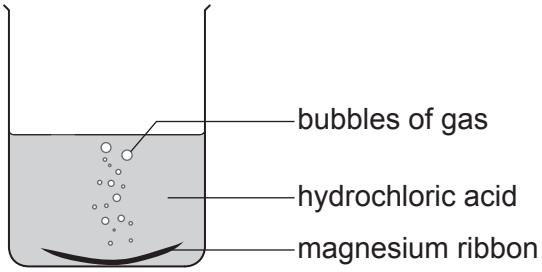
Answer **all** questions.

1. (a) A student carried out an experiment to prepare magnesium chloride crystals.

Diagrams **A**, **B** and **C** show the stages of the experiment she carried out. The stages are **not** in the correct order.



A



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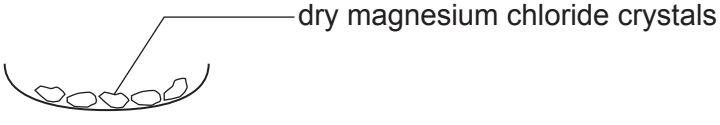

C

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(i) I. Give the **letter** that shows the **first** stage of the experiment. [1]

Letter .....

II. Give the **letter** of the stage that shows filtration. [1]

Letter .....

(ii) The gas formed in the reaction pops with a lighted splint.

Underline the name of this gas. [1]

oxygen **hydrogen** **carbon dioxide**

(iii) Magnesium chloride contains Mg^{2+} and Cl^- ions.

Tick (✓) the box next to the formula of magnesium chloride. [1]

$MgCl_2$ ☐ **Mg_2Cl** ☐ **$MgCl$** ☐ **Mg_2Cl_2** ☐

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(b) The word equations below show reactions of acids.

Underline the substance in each box that correctly completes the equation. [2]

zinc oxide + [**hydrochloric acid** / **nitric acid** / **sulfuric acid**] ⟶ zinc sulfate + water

sodium hydroxide + nitric acid ⟶ [**sodium chloride** / **sodium nitrate** / **sodium sulfate**] + water

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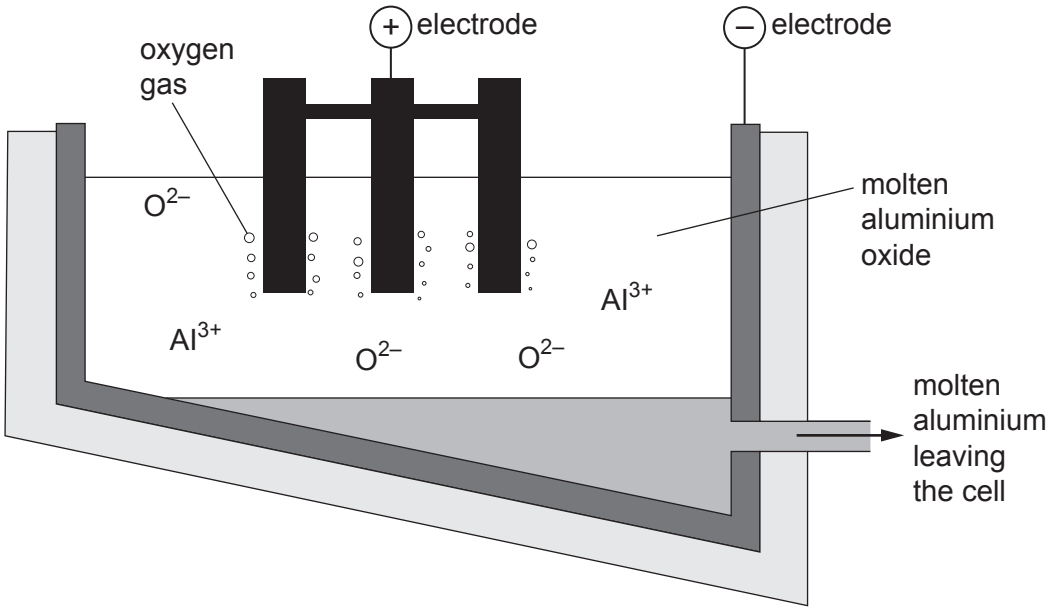
2. (a) The diagram shows a cell used in the extraction of aluminium from aluminium oxide.



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

The process of extracting aluminium from aluminium oxide is called (**corrosion** / **electrolysis** / **cracking**).

Aluminium ions, Al^{3+}, move towards the negative electrode because (**opposite** / **similar** / **neutral**) charges attract.

Aluminium leaves the cell as a (**gas** / **solid** / **liquid**).

(ii) Balance the **symbol** equation that shows the overall reaction. [1]

$$2Al_2O_3 \longrightarrow \square\, Al + 3O_2$$

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(b) Tick (✓) the box next to the **two** properties of aluminium that makes it suitable for making aeroplane wings. [2]

low density	☐
resists corrosion	☐
good thermal conductor	☐
non-toxic	☐
shiny	☐

6

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3. (a) When a mixture of zinc and copper(II) oxide is heated it ignites and burns brightly.

When silver is heated with copper(II) oxide no reaction takes place.

(i) List silver, copper and zinc in order of reactivity. [1]

Most reactive .....

.....

Least reactive .....

(ii) The boxes below show the word equation and an incomplete symbol equation for the reaction taking place between zinc and copper(II) oxide.

Complete the symbol equation. [2]

zinc Zn	+	copper(II) oxide CuO	→	zinc oxide	+	copper .....

(b) A **solid** precipitate of silver chloride is formed when silver nitrate solution is added to sodium chloride solution.

(i) Complete the equation for this reaction by writing the **state symbol** for the silver chloride formed in the brackets. [1]

$AgNO_3(aq) + NaCl(aq) \longrightarrow AgCl(\ldots\ldots) + NaNO_3(aq)$

(ii) Underline the correct word(s) in the bracket to complete the sentence. [1]

The reaction shows that silver chloride is (**soluble** / **insoluble** / **a mixture**) in water.

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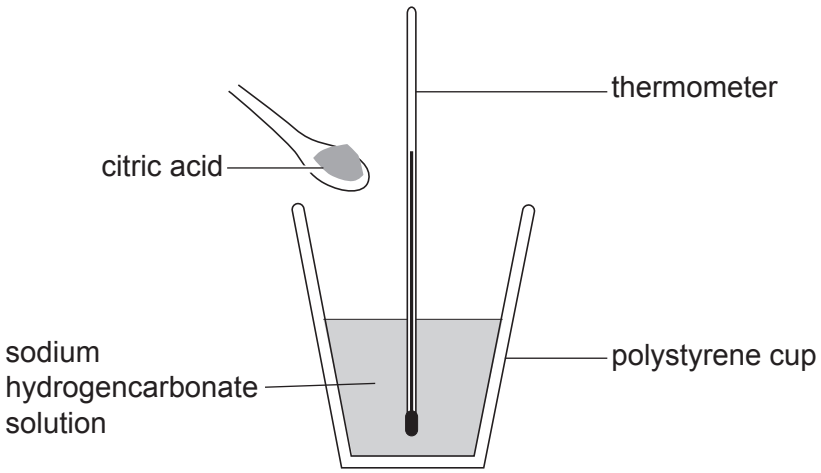
4. (a) Flying Saucers sweets contain sherbet. Sherbet is a mixture of two solid substances – citric acid and sodium hydrogencarbonate.

When put in your mouth, the mixture fizzes and goes cold as it dissolves in your saliva.

A student investigated the temperature change during the reaction between citric acid and a solution of sodium hydrogencarbonate.

Some sodium hydrogencarbonate solution was added to a polystyrene cup and the temperature of the solution was recorded. Citric acid was added to the solution and the temperature was recorded every 10 seconds for 60 seconds.



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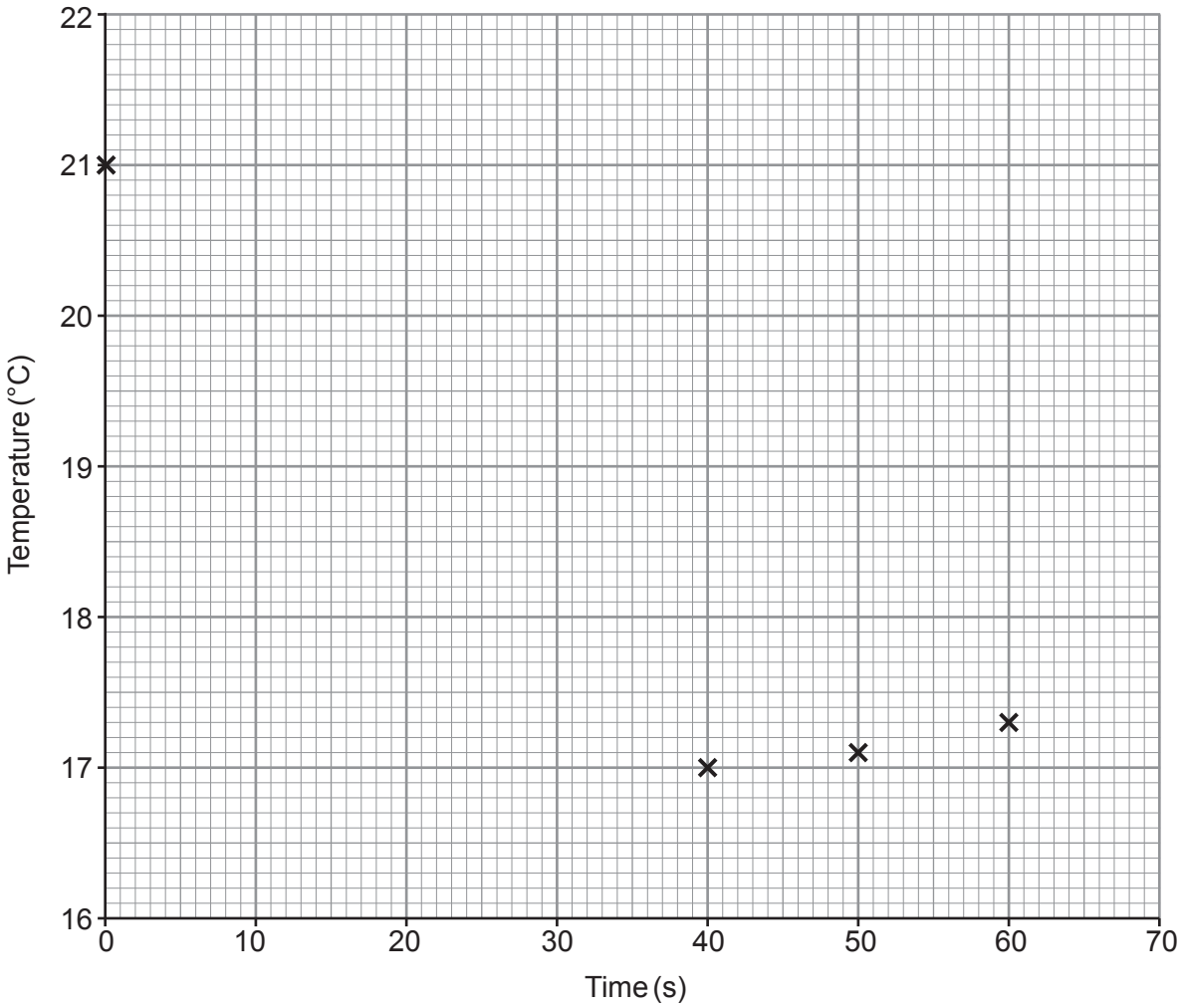
The results are shown in the table below.

Time (s)	0	10	20	30	40	50	60
Temperature (°C)	21.0	19.0	17.8	17.2	17.0	17.1	17.3

(i) Complete the grid below by plotting the results for 10, 20 and 30 seconds.

The results for 0, 40, 50 and 60 seconds have been plotted for you.

Draw a suitable line using all the results. [3]



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(ii) Use the graph to answer parts I and II.

I. Circle the maximum **change** in temperature during the reaction. [1]

3.7 °C **4.0 °C** **21.0 °C** **17.3 °C**

II. This is described as an endothermic reaction. [1]

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

In an endothermic reaction the temperature
(**increases** / **stays the same** / **decreases**).

III. The temperature of the contents of the cup was recorded two hours later.

Underline the most likely temperature reading. [1]

4.0 °C **18.0 °C** **17.3 °C** **21.0 °C**

(iii) All the temperature readings were higher than expected due to heat being taken in from the surroundings.

Tick (✓) the box next to the change that would **not** result in the temperature readings being closer to their expected values. [1]

put bubble wrap around the cup ☐

put a lid on the cup ☐

use a cup made from copper ☐

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(b) Calculate the relative formula mass (M_r) of sodium hydrogencarbonate, $NaHCO_3$. [2]

$A_r(H) = 1$ $A_r(C) = 12$ $A_r(O) = 16$ $A_r(Na) = 23$

M_r = ...

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5. (a) The table shows information about the Haber process and the contact process.

	Haber process	Contact process
Raw materials	nitrogen comes from the air hydrogen is made from natural gas	sulfur is made from impurities in natural gas oxygen comes from the air
Conditions	iron catalyst 450 °C 200 atm	vanadium(V) oxide catalyst 450 °C 1 atm
Equation	$N_2 + 3H_2 \rightleftharpoons 2NH_3$	$2SO_2 + O_2 \rightleftharpoons 2SO_3$

Use the information in the table and your own knowledge to answer this question.

State whether the statements below are **true** or **false**. [3]

	True or **false**?
Both processes use a catalyst that is a metallic element	.....
Both processes are carried out at the same temperature and pressure	.....
Both processes are reversible reactions	.....
Both processes use air as a raw material	.....

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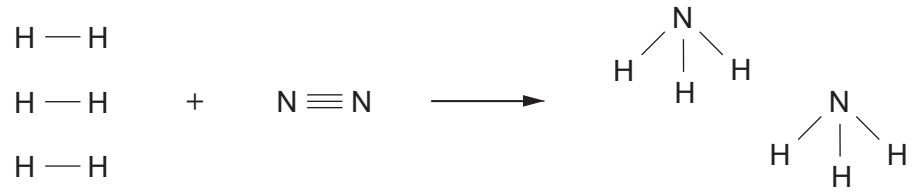
(b) The equation below shows the bonds that are broken and the bonds that are formed when ammonia is produced.



hydrogen nitrogen ammonia

(i) The energy released when one N—H bond forms is 391 kJ.

Give the total number of N—H bonds in two molecules of ammonia and show that the amount of energy released when all the bonds are formed is 2346 kJ. [1]

(ii) The energy released when all the bonds in the **product** are formed is 2346 kJ.

The energy needed to break all the bonds in the **reactants** is 2253 kJ.

I. Give the term that describes a reaction where more energy is released in forming bonds than is needed to break the bonds in the reactants. [1]

.....

II. Calculate the overall energy change that takes place during this reaction. [1]

Overall energy change = ... kJ

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(c) Ammonia is used to make ammonium sulfate and ammonium carbonate.

Tests can be carried out to identify the negative ion in each of these compounds.

Draw a line from each ion to the appropriate test and observation. [2]

Ion	Test and observation
carbonate ion, CO_3^{2-}	add dilute hydrochloric acid; gas formed turns limewater milky
	carry out a flame test; flame turns brick red
	add sodium hydroxide solution; pungent smelling gas is formed
sulfate ion, SO_4^{2-}	carry out a flame test; flame turns apple green
	add barium chloride solution; white precipitate is formed

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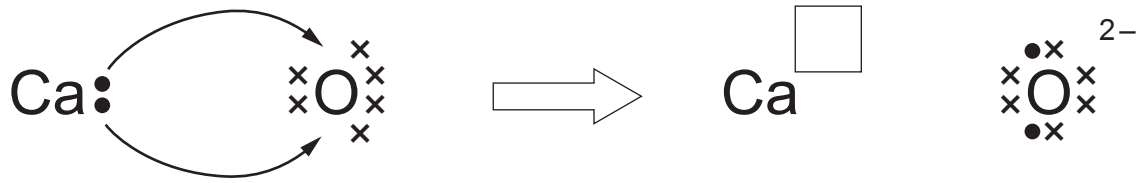
6. (a) The diagram shows the electronic changes that occur when calcium reacts with oxygen to form calcium oxide. The ● and × symbols represent outer shell electrons.



calcium atom	oxygen atom		calcium ion	oxide ion
(2,8,8,2)	(2,6)		(2,8,8)	(.....)

(i) Complete the right-hand side of the diagram by putting the **charge** of the calcium ion in the box and the **electronic structure** of the oxide ion in the brackets. [2]

(ii) Complete and balance the symbol equation for the reaction between calcium and oxygen. [2]

$\square$ Ca + O_2 ⟶ 2 .....

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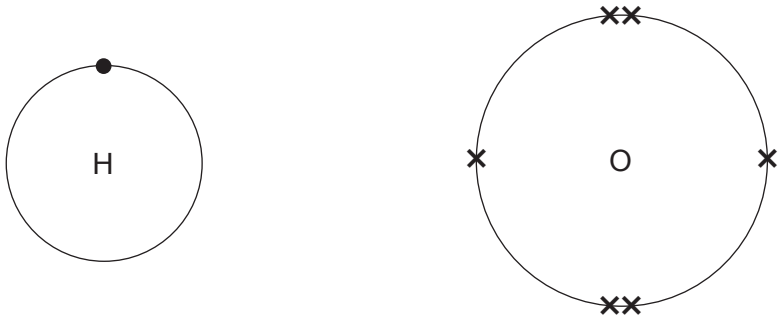
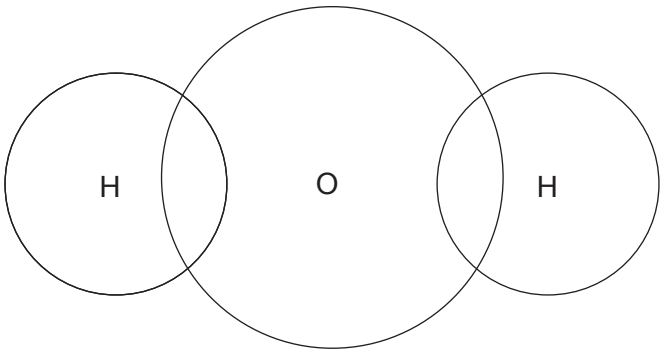
(b) The diagrams below show the outer shell electrons in an atom of hydrogen and an atom of oxygen.



Complete the following diagram to show the outer shell electrons in a molecule of water. [2]



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6

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7. (a) Crude oil can be separated into simpler mixtures, called fractions. Fractions contain hydrocarbon compounds called alkanes.

The table shows information about some of the fractions obtained from crude oil.

Fraction	Boiling point range (°C)	Number of carbon atoms in the alkanes
refinery gases	−160 to 20	1–4
petrol	20 to 240	4–12
naphtha	100 to 250	7–14
kerosene	200 to 280	11–15
diesel oil	280 to 350	15–19

Use only the information in the table to answer parts (i)–(iii).

(i) Complete the sentence below by underlining the correct word(s). [1]

As the number of carbon atoms in an alkane increases,

the boiling point (**increases** / **decreases** / **stays the same**).

(ii) Hexane has a boiling point of 69 °C.

Give the name of the fraction that contains hexane. [1]

.....

(iii) One alkane is found in the kerosene and diesel oil fractions.

Give the number of carbon atoms in this alkane. [1]

.....

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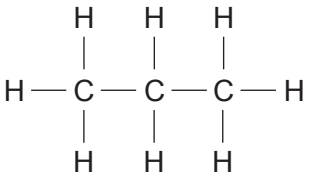
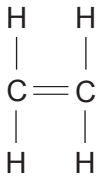
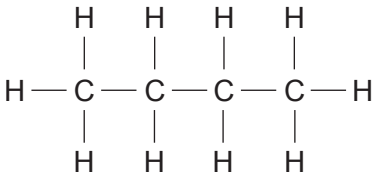
(b) Diagrams **A–E** show the structural formulae of some carbon compounds.



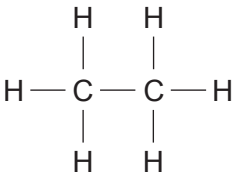
A



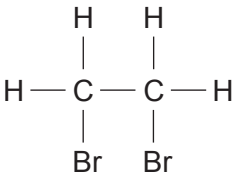
B



C



D



E

(i) Circle the molecular formula for compound **A**. [1]

C_3H_3 **C_8H_3** **C_3H_8** **3C8H** **C^3H^8**

(ii) Give the **letter** of the compound that is unsaturated. [1]

.....

(iii) Explain why compound **E** is **not** a hydrocarbon. [1]

.....

.....

(iv) Give the **letter** of the compound that belongs to the family of carbon compounds with the general formula C_nH_{2n}. [1]

.....

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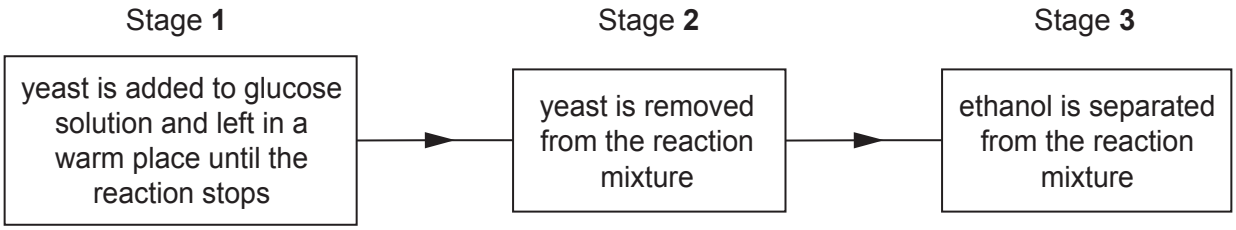
(c) The chart shows the stages used in the laboratory to make ethanol from glucose solution.



(i) Give the number of the stage in which distillation is used. [1]

Stage .....

(ii) The formula of ethanol is C_2H_5OH.

Complete the structure of ethanol by adding all the atoms and bonds present. [1]

C — C

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(iii) Ethanol is the alcohol found in alcoholic drinks.

The following information appears on a bottle of wine.

Volume	750 millilitres
Alcohol by volume	13.5%

The formula below can be used to calculate the mass of ethanol in an alcoholic drink.

mass of ethanol (g) = 8 × volume (litres) × alcohol by volume (%)

Use the formula to find the mass of ethanol in a bottle of wine. [2]

1 litre = 1000 millilitres

Mass = ... g

11

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8. (a) The photographs show three different methods of fighting fires.

Each method removes a different part of the fire triangle.

Method A

Method B

Method C

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Use the fire triangle to explain how the different methods shown in the photographs help to extinguish fires or prevent them from spreading. [6 QER]

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(b)

Fighting Fires

There are five main types of fire extinguisher – water, foam, dry powder, carbon dioxide and wet chemical. Modern fire extinguishers have a red body with a coloured band at the top. Each colour represents a different type of extinguisher, used on different types or 'classes' of fire.

There is no one extinguisher type that works on all classes of fire.

The chart below shows which type of extinguisher should be used on each class of fire.

TYPE ▶ FIRE ▼ EXTINGUISHER	CLASS A Flammable solids, for example paper	CLASS B Flammable liquids, for example ethanol	CLASS C Flammable gases, for example methane	CLASS D Flammable metals, for example magnesium	CLASS E Electrical equipment, for example computer	CLASS F Cooking oil, for example deep fat fryer
WATER	✓	✗	✗	✗	✗	✗
FOAM	✓	✓	✗	✗	✗	✗
DRY POWDER	✓	✓	✓	✓	✓	✗
CO_2	✗	✓	✗	✗	✓	✗
WET CHEMICAL	✓	✗	✗	✗	✗	✓

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Use only the information in the chart to answer parts (i)–(iii).

(i) Underline the type of extinguisher used to put out a fire involving burning cooking oil. [1]

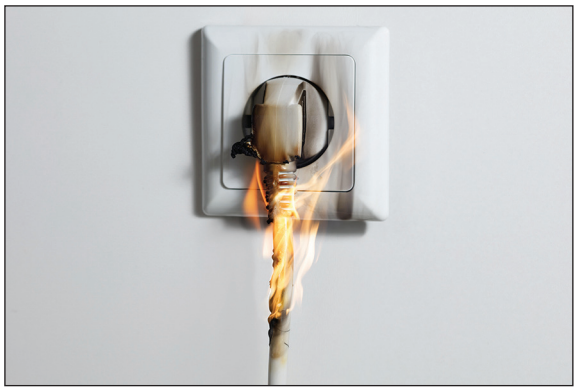
water **foam** **dry powder** **carbon dioxide** **wet chemical**

(ii) Underline the type of extinguisher that would be the most useful in a school chemistry laboratory. [1]

water **foam** **dry powder** **carbon dioxide** **wet chemical**

(iii) Tick (✓) the box next to the fire that should be put out using a water extinguisher. [1]

chip pan fire ☐



burning plug and socket ☐

burning butane cylinder ☐

burning waste cardboard ☐

9

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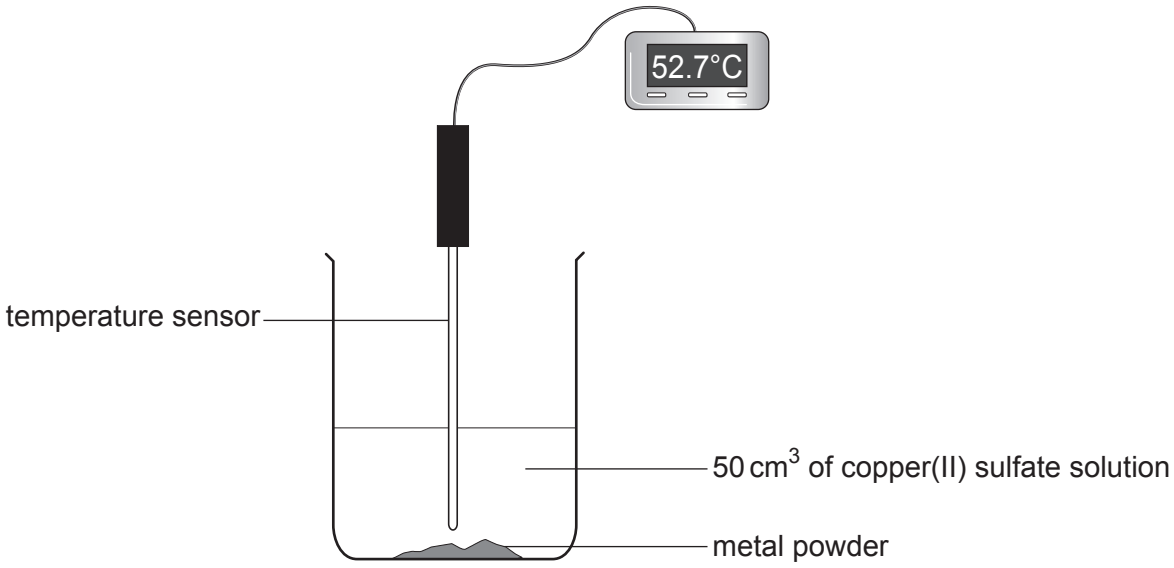
9. The list below shows part of the reactivity series.

magnesium
zinc
iron
nickel

A student investigated the temperature rise when four different metal powders were added to excess copper(II) sulfate solution.

The same mass of each metal was added to 50 cm^3 samples of copper(II) sulfate solution.

The maximum temperature for each reaction was measured. The temperature rise was calculated in each case and used to find the energy given out.



The results are shown in the table below.

Metal	Temperature rise (°C)	Energy given out (J)
magnesium	40.5	8500
zinc	33.0	6900
iron	23.2	4900
nickel	19.0	4000

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(a) In one of the reactions, the initial temperature was 19.7 °C and the maximum temperature was 52.7 °C.

State which one of the four metals was used in this reaction. [1]

.....

(b) Tick (✓) the box next to the conclusion the student can draw from the results. [1]

The higher the metal in the reactivity series, the greater the energy given out ☐

The lower the metal in the reactivity series, the greater the energy given out ☐

The energy given out is not related to the metal's position in the reactivity series ☐

(c) The word equation below represents the reaction between iron and nickel(II) sulfate solution.

iron + nickel(II) sulfate ⟶ iron(II) sulfate + nickel

Iron(II) sulfate contains Fe^{2+} and SO_4^{2-} ions.

Complete the symbol equation for the reaction. [2]

$Fe + NiSO_4 \longrightarrow$ ..... + ...

(d) The experiment shows that a more reactive metal will replace a less reactive metal in its compounds.

Give the term used to describe this type of reaction. [1]

.....

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(e) When the experiment was repeated using **titanium**, the temperature rise recorded was 35.4 °C.

Calculate the energy given out during the reaction between **titanium** and 50 cm^3 of copper(II) sulfate solution. Give your answer to the nearest 100 J. [2]

energy given out (J) = volume of solution × 4.2 × temperature rise

Energy given out = ... J

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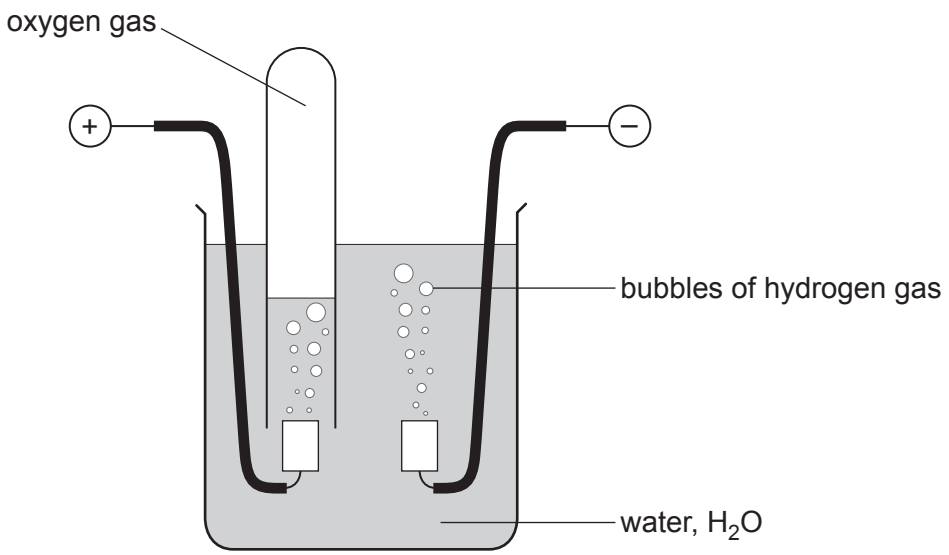
10. (a) The diagram shows the apparatus used by a student to investigate the electrolysis of water.



(i) The student collected a sample of the oxygen formed in a test tube.

Give the test the student would carry out to show the presence of oxygen in the test tube. Include the observation the student would expect. [1]

.....

.....

(ii) Use the formula of water, H_2O.

Give the volume of hydrogen that would form in the same time as 10 cm^3 of oxygen. [1]

..... cm^3

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(b) The table shows information about the electrolysis of three different electrolytes. The table is incomplete.

Electrolyte	Ions present in the electrolyte		Observations	
	Positive ion(s)	Negative ion(s)	At the negative (−) electrode	At the positive (+) electrode
molten lead(II) bromide	Pb^{2+}	.....	grey metal **A** formed	orange gas formed
aqueous copper(II) chloride	..... and H^+	Cl^- and OH^-	brown metal formed	green-yellow gas **B** formed
aqueous compound **C**	Zn^{2+} and H^+	I^- and OH^-	grey metal formed	brown solution formed

(i) Complete the table by adding the **symbols** of the missing **ions**. [2]

(ii) Name substances **A**, **B** and **C**. [3]

Metal **A** .....

Gas **B** .....

Compound **C** .....

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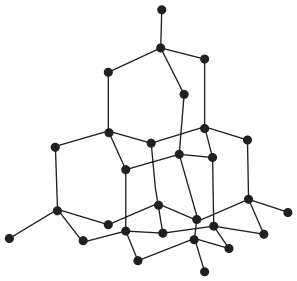
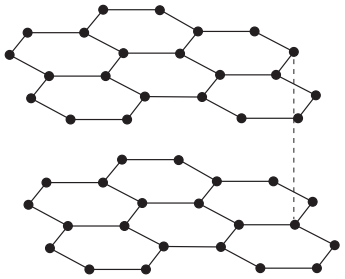
11. The diagrams show the structure of diamond and graphite.



diamond



graphite

(a) Name the atom being represented by a • in both diagrams. [1]

.....

(b) Name the type of **bonding** found in both diamond and graphite. [1]

.....

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(c) The table shows some properties of graphite.

Properties of graphite
soft
high melting point
insoluble in water
conducts electricity

Use only properties from the table to answer this question.

Give **two** properties of graphite that are **different** from those of diamond. Give a use relating to each property. [4]

Property 1 .....

Use .....

Property 2 .....

Use .....

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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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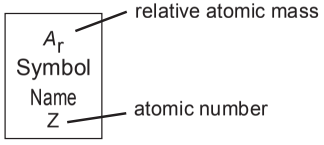
THE PERIODIC TABLE

1	2	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



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