Surname	Centre Number	Candidate Number
First name(s)		0

GCSE

S23-3410U20-1

3410U20-1

MONDAY, 22 MAY 2023 – 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.	**9**	
2.	**8**	
3.	**9**	
4.	**12**	
5.	**12**	
6.	**10**	
7.	**9**	
8.	**11**	
Total	**80**	

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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.

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 **4**(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. (a) A student investigated the pH of several substances using universal indicator solution. The colour produced with each substance is shown.

Substance	Colour
hand wash	blue
battery fluid	red
water	green
lemon juice	orange
drain cleaner	purple

(i) Name **one** substance in the table which is an alkali. [1]

.....

(ii) State which substance is the strongest acid. [1]

.....

(iii) Drain cleaner contains sodium hydroxide.

Circle the correct formula of sodium hydroxide. [1]

NaO **NAOH** **NaOH** **NaOh**

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(b) The student carried out some reactions using hydrochloric acid. She recorded the following observations.

Reaction	Reactant added to acid	Observations
A	magnesium	fizzing temperature increase of 25 °C magnesium disappears
B	sodium hydroxide	no fizzing temperature increase of 8 °C
C	sodium carbonate	fizzing temperature increase of 5 °C
D	copper(II) oxide	no fizzing temperature increase of 11 °C mixture turns blue

(i) Reaction **A** produced a gas. Give the **letter** of the other reaction that produced a gas. Which observation shows that a gas was produced? [2]

Letter .....

Observation .....

(ii) One of the gases produced is hydrogen.

Describe how you could test for hydrogen gas. Give the observation you would expect for a positive test. [2]

Test .....

Observation .....

(iii) Give the **letter** of the reaction which was the **least** exothermic. Give the reason for your answer. [2]

Letter .....

Reason .....

9

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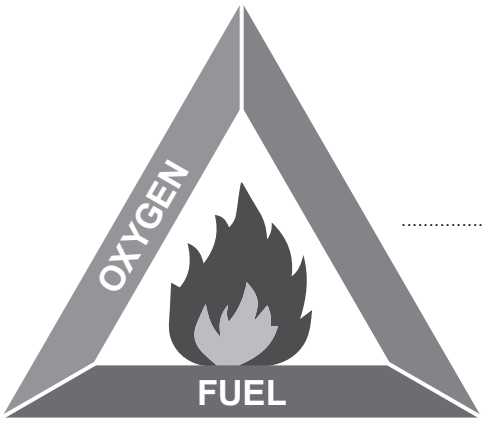
2. (a) In the diagram of the fire triangle, two sides have been labelled.



.....

(i) **Complete the fire triangle** by labelling the third side. [1]

(ii) Complete the following sentences to explain how a fire is extinguished by the following methods. [2]

Using a fire blanket removes the ..... from the fire triangle.

Cutting down trees in a forest fire removes the ..... from the fire triangle.

(b) Choose a **number** from the box below to balance the equation for the burning of propane gas. [1]

2	3	4	8

$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + \square H_2O$

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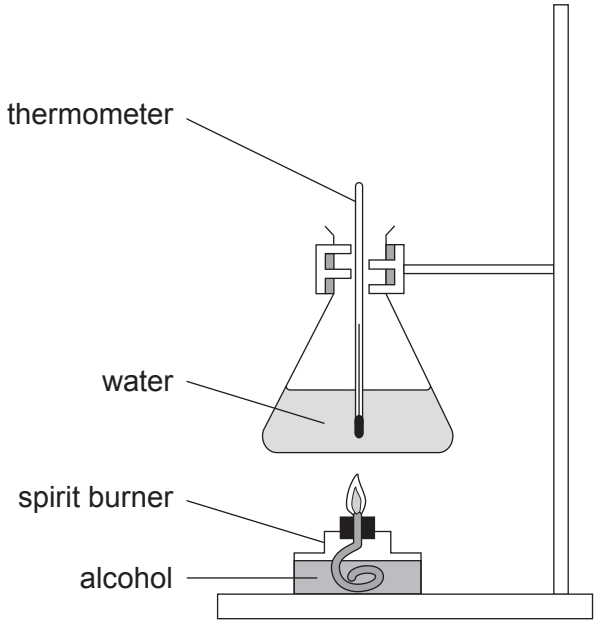
(c) A class used the apparatus shown to compare the combustion of different alcohols. They burned each alcohol for 1 minute. They measured the temperature of the water before and after burning each alcohol.



The table shows the increase in temperature of the water for each alcohol.

Alcohol	Temperature increase (°C)
methanol	8
ethanol	19
propanol	23
butanol	38

(i) The starting temperature of the water each time was 18 °C. Calculate the final temperature of the water after burning ethanol. [1]

Final temperature = ... °C

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(ii) Tick (✓) the question that the class were trying to answer. [1]

Which alcohol gives out the most heat energy?	
Which gases are produced when alcohols burn?	
Which alcohol has the lowest boiling point?	
Which alcohol burns for the longest?	

(d) Methanol has the chemical formula CH_3OH.

Calculate the relative molecular mass, M_r, of methanol. [2]

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

M_r = ...

8

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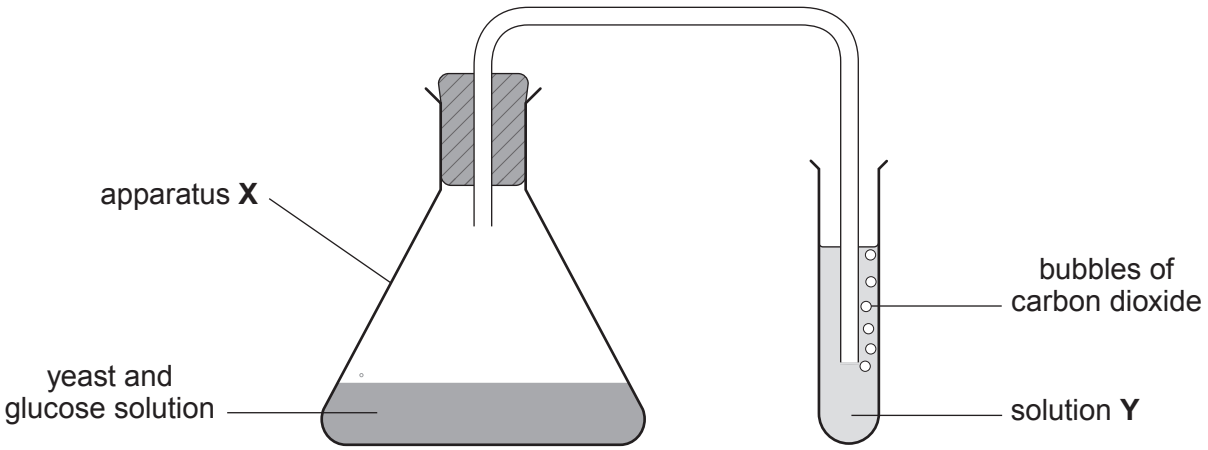
3. (a) Ethanol can be produced by fermentation using the apparatus shown.



(i) Circle the name of apparatus **X**. [1]

conical flask **measuring cylinder** **beaker**

(ii) Solution **Y** can be used to show the presence of carbon dioxide gas.

Give the name of solution **Y** and state what is seen when carbon dioxide is bubbled through it. [2]

Name of solution **Y** .....

What is seen .....

(iii) The chosen temperature for this reaction is 35 °C. Tick (✓) the correct reason why carbon dioxide would **not** be produced at a temperature of 90 °C. [1]

the reaction is finished	
the yeast is used up	
the enzymes in the yeast are denatured	

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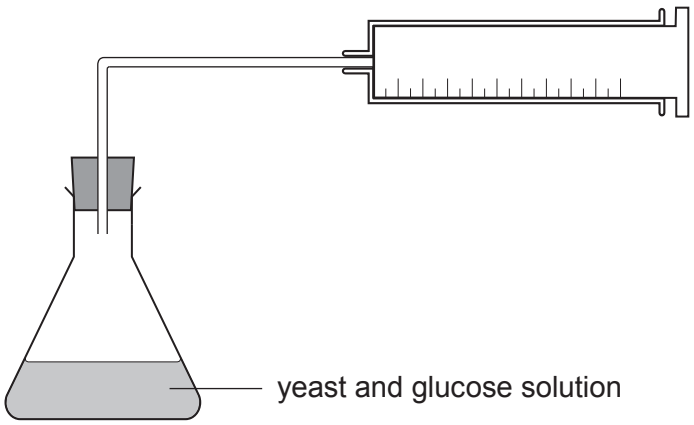
(b) In a different experiment, using the apparatus shown below, the volume of carbon dioxide produced at 35 °C was measured and recorded every 10 minutes for 60 minutes.



Time (minutes)	Volume of carbon dioxide produced (cm^3)
0	0
10	6
20	12
30	17
40	25
50	30
60	36

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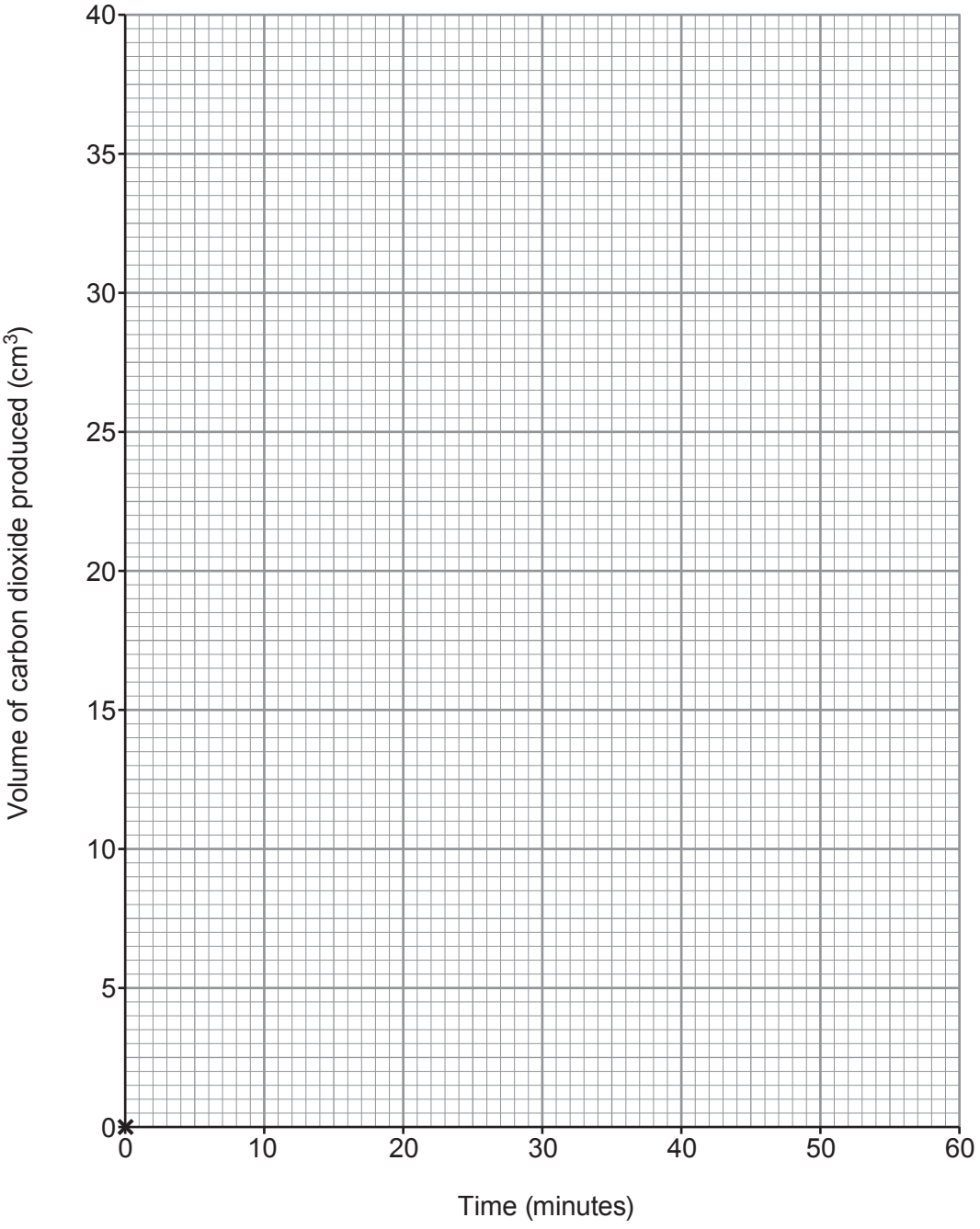
(i) Plot the data on the grid below and draw a suitable line.

The first point has been plotted for you. [3]



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(ii) Use the graph to find the volume of carbon dioxide produced after 25 minutes. [1]

Volume ..... cm^3

(iii) Use the data to **estimate** how long it would take to produce 100 cm^3 of carbon dioxide gas. Assume that the rate of the reaction does not change. [1]

Time = ... minutes

9

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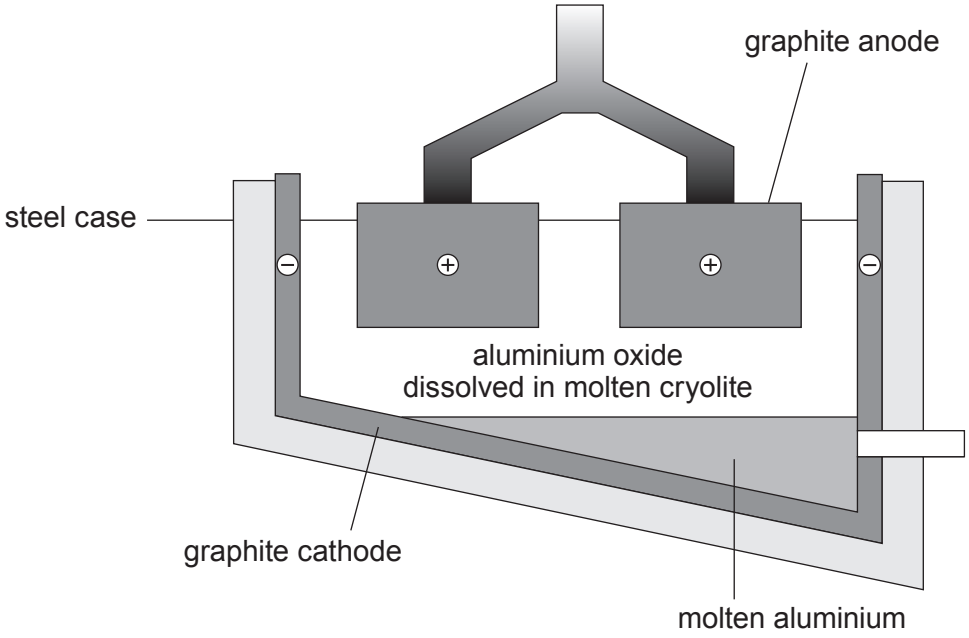
4. (a) Aluminium metal is produced from aluminium oxide in a process called electrolysis. The diagram shows a cell used in electrolysis.



(i) Underline the correct word in the brackets to complete each sentence. [4]

Aluminium oxide is a **(compound / mixture / element)** of aluminium and oxygen.

Cryolite is added to **(raise / lower / maintain)** the temperature used for electrolysis.

Electrolysis uses a lot of **(electrical / solar / chemical)** energy.

Aluminium is produced as a **(solid / liquid / gas)**.

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(ii) Aluminium oxide contains the ions Al^{3+} and O^{2-}.

Give the formula of aluminium oxide. [1]

.....

(iii) Iron oxide is reduced by heating with carbon in a blast furnace.

Tick (✓) the box that states why aluminium oxide cannot be reduced in this way. [1]

carbon is more reactive than aluminium	
iron is more reactive than aluminium	
aluminium is more reactive than carbon	

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Turn over.

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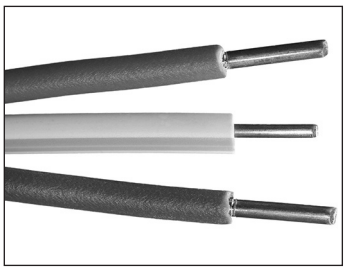
(b) The pictures show copper metal used in electrical wiring, saucepans and water pipes.



Describe how the properties of copper make it suitable for each of these uses. [6 QER]

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5. Plant and crop growth can be improved using fertilisers containing nitrogen. Fertilisers are substances that are added to the soil in order to increase the supply of nutrients that boost the growth of plants. With the rapid increase in global population, the demand for food has been rising tremendously. It is estimated that 40-60 % of agricultural crops are now grown with the use of different types of fertilisers. Many fertilisers are produced using ammonia.

When you use too much fertiliser in the soil, it can lead to eutrophication. Fertilisers contain substances like nitrates and phosphates that are washed into lakes, oceans and rivers by rain water. These substances lead to excessive growth of algae and plants in the waterways resulting in a decrease in the levels of oxygen. The decrease in oxygen levels leads to the death of fish and other aquatic animals and contributes to changes in food chains.

Figure 1 shows the relative populations of world continents in 2016.

Figure 2 shows the relative world consumption of ammonia in 2016.

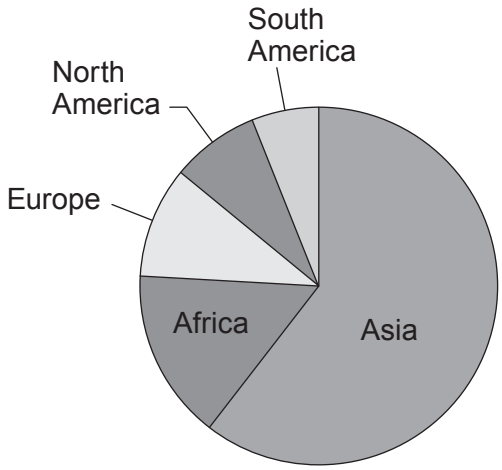

Figure 1

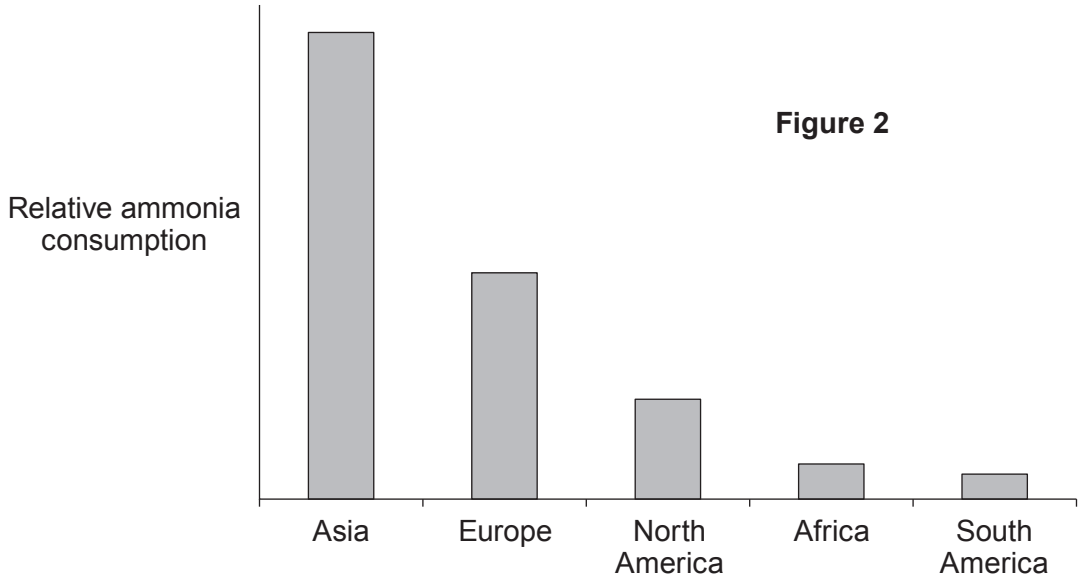

Figure 2

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(a) (i) Tick (✓) **three** boxes that state the effects of fertiliser use which contribute to the death of aquatic animals in eutrophication. [2]

crop growth on fields increases	
fertilisers run into waterways	
plant growth in rivers and lakes increases	
aquatic animals do not have enough oxygen	
farmers' profits increase	

(ii) State whether the information in **Figure 1** and **Figure 2** shows a link between the number of people living on each continent and the amount of ammonia used. Give reasons for your answer. [2]

.....

.....

.....

.....

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(b) The label on a bag of fertiliser shows the formula of the nitrogen compound that the fertiliser contains.

1.5 kg fertiliser

(i) Give the name of the compound $(NH_4)_2SO_4$. [1]

.....

(ii) Tick (✓) the box that gives the correct reason why plants need nitrogen. [1]

plants use nitrogen to make sugar	
plants use nitrogen to make water	
plants use nitrogen to make oxygen	
plants use nitrogen to make protein	

(iii) 1.5 kg of fertiliser treats an area of 75 m^2. Calculate the mass needed to treat a lawn with an area of 15 m^2. Give your answer in **grams**. [2]

Mass = ... g

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(c) Ammonia is used to make many fertilisers. Ammonia gas is produced from nitrogen and hydrogen using the Haber process.

(i) Balance the equation for the reaction between nitrogen and hydrogen in the Haber process. [1]

N_2 + $\square$ H_2 $\rightleftharpoons$ $\square$ NH_3

(ii) State what is meant by the symbol $\rightleftharpoons$ used in the reaction equation. [1]

.....

(iii) A catalyst is used in the Haber process.

I. Give the name of the catalyst used. [1]

.....

II. State why a catalyst is used. [1]

.....

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6. (a) The table shows some information about substances **A**-**E**.

Substance	Soluble in water?	Malleable?	Boiling point (°C)	Conducts electricity?
A	no	no	4200	no
B	yes	no	–79	no
C	yes	no	1413	only when molten or in solution
D	no	yes	5555	yes
E	no	yes	2562	yes

(i) Give the **letters** of the **two** substances which are metals. [1]

..... and .....

(ii) Give the **letter** of the substance which could be carbon dioxide. [1]

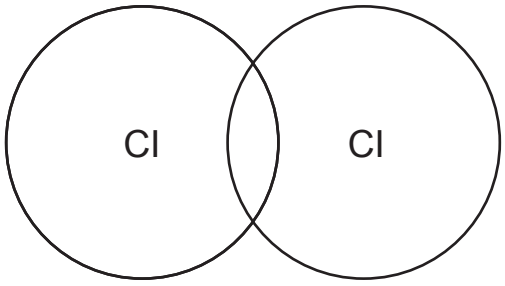
.....

(iii) Give the **letter** of the substance which has a giant ionic structure. [1]

.....

(b) Complete the dot and cross diagram to show the outer electrons in a chlorine molecule, Cl_2.

Each atom of chlorine has 7 electrons in its outer shell. [2]



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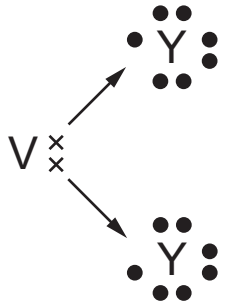
(c) The diagram below shows the electronic changes that occur when atoms **V** and **Y** form ionic bonds. The dots and crosses show outer shell electrons.

V and **Y** are **not** the chemical symbols of the elements.



(i) Give the **charge** on each ion produced. [2]

V .....

Y .....

(ii) Circle the formula of the compound formed. [1]

V_2Y **VY** **VY_2** **V_2Y_2**

(iii) Potassium oxide, K_2O, is another ionic compound.

The relative formula mass of potassium oxide is 94.

Calculate the percentage of potassium in potassium oxide, K_2O. Give your answer to the nearest **whole number**. [2]

$A_r(K) = 39$

Percentage = ... %

10

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7. (a) A student made some copper(II) sulfate crystals by reacting copper(II) carbonate powder with sulfuric acid using the following method.

Stage **1** Measure 50 cm^3 of sulfuric acid into a beaker.

Stage **2** Add copper(II) carbonate powder, one spatula at a time, until all the acid has reacted.

Stage **3** Filter the mixture.

Stage **4** Obtain crystals from the solution.

(i) State how you would carry out Stage **4** to get the largest possible crystals. [1]

.....

.....

(ii) Crystals of copper(II) sulfate could also be made using copper(II) oxide powder instead of copper(II) carbonate powder. State and explain how the observations in Stage **2** would be different. [2]

.....

.....

.....

(iii) Complete the symbol equation for the reaction between copper(II) oxide and sulfuric acid. Copper(II) sulfate is one of the products. [2]

$CuO + H_2SO_4 \longrightarrow$ ..... + ...

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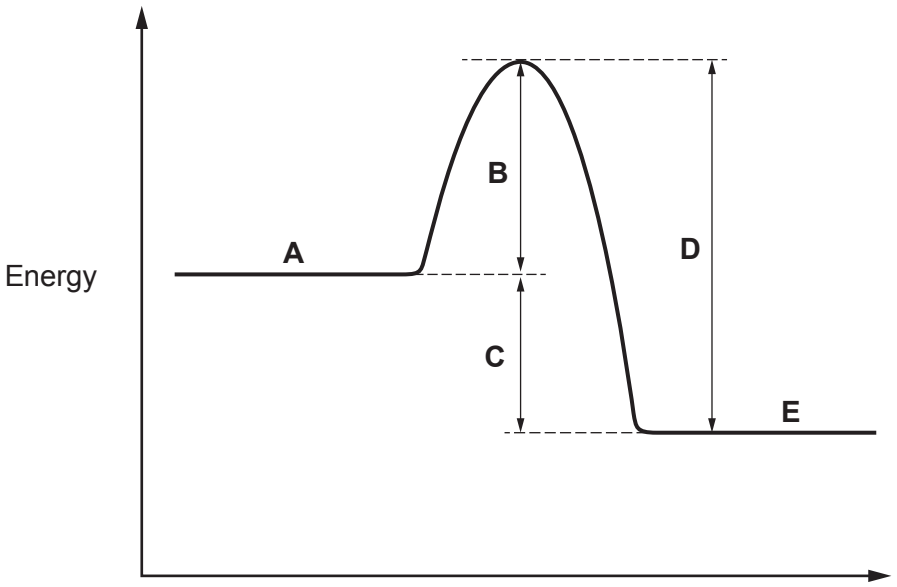
(b) The diagram shows an energy profile for a reaction.



(i) Give the **letter** that represents each of the following parts of the energy profile. [2]

Part of the energy profile	Letter
energy change for the reaction	
energy of the reactants	
activation energy of the reaction	

(ii) Give the meaning of the term activation energy. [1]

.....

.....

(iii) State how the energy profile shows that this is an exothermic reaction. [1]

.....

.....

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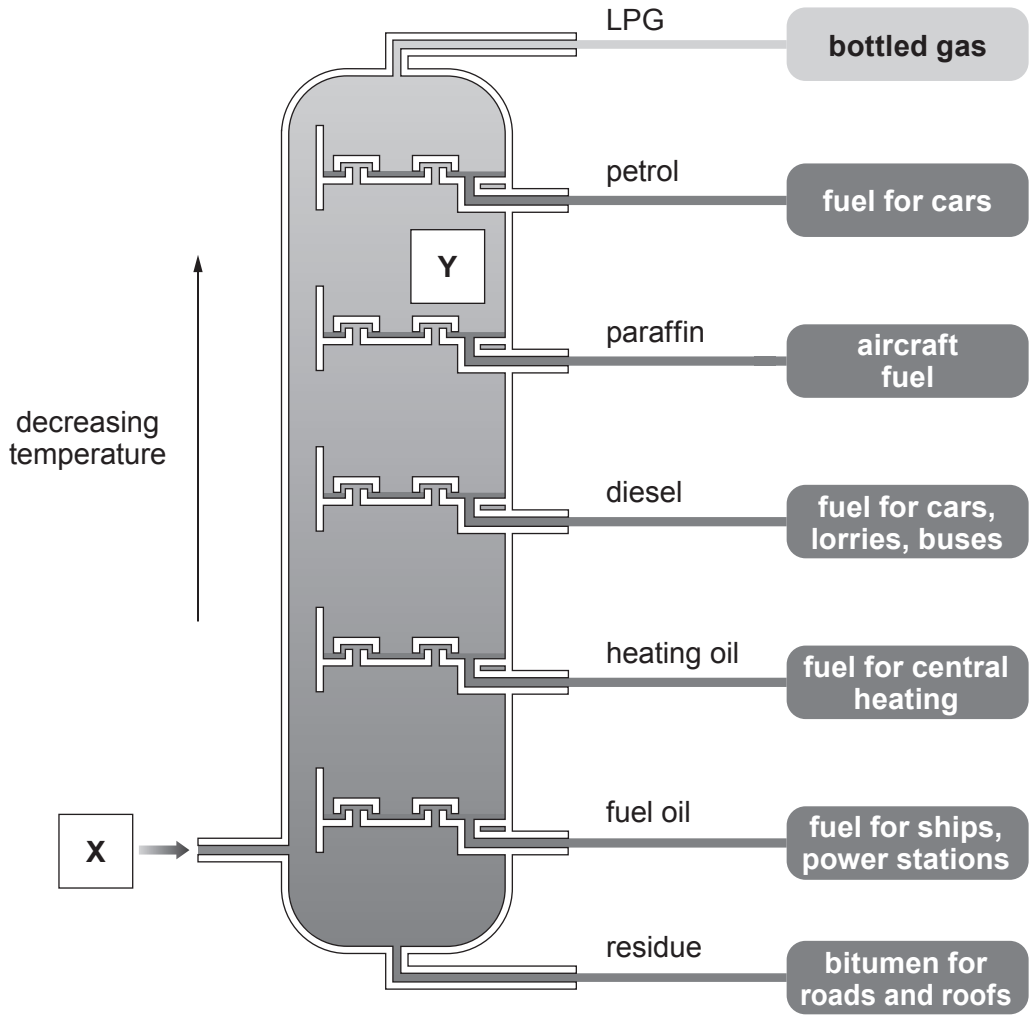
8. (a) Crude oil is separated into mixtures of hydrocarbon compounds in the process of fractional distillation. Many of these fractions are used as fuels.



(i) Name the changes of state happening at **X** and at **Y**. [1]

X .....

Y .....

(ii) Explain why different fractions are formed at different levels. [2]

.....

.....

.....

.....

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(iii) A hydrocarbon fuel was burned and used to heat 100 g of water. The water temperature rose from 18.5 °C to 38.2 °C.

Use the equation below to calculate the amount of energy released by this fuel. Give your answer to **two** significant figures. [3]

energy (J) = mass of water (g) × 4.2 × temperature rise (°C)

Energy = ... J

(b) The products of fractional distillation can undergo a process called cracking to produce smaller, more useful hydrocarbons.

(i) Complete the equation for the cracking of $C_{16}H_{34}$. [1]

$C_{16}H_{34} \longrightarrow C_8H_{18}$ + ... + C_2H_4

(ii) State the **two** conditions used for cracking. [1]

.....

(iii) The molecule with the formula C_2H_4 is an unsaturated hydrocarbon.

Give the meaning of the term unsaturated. [1]

.....

.....

(iv) State why there is a high demand for each of the following products of the cracking reaction. [2]

octane / C_8H_{18} .....

ethene / C_2H_4 .....

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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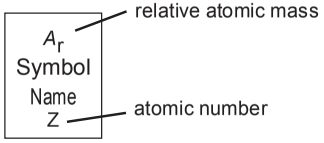
THE PERIODIC TABLE

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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