

Surname	Centre Number	Candidate Number
First name(s)		0



GCSE

3410U20-1



S23-3410U20-1

MONDAY, 22 MAY 2023 – MORNING

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

1 hour 45 minutes

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.

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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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. [1]
Circle the correct formula of sodium hydroxide.

NaO

NAOH

NaOH

NaOh



- (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

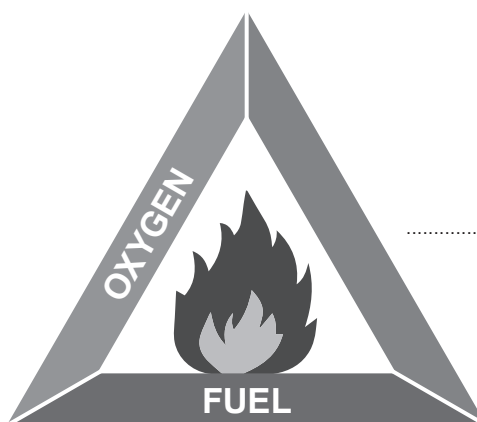
- (iii) Give the **letter** of the reaction which was the **least** exothermic. Give the reason for your answer. [2]

Letter

Reason



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]

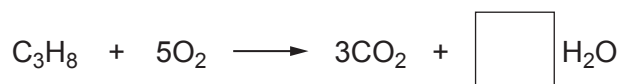
- (ii) Complete the following sentences to explain how a fire is extinguished by the following methods. [2]

Using a fire blanket removes the from the fire triangle.

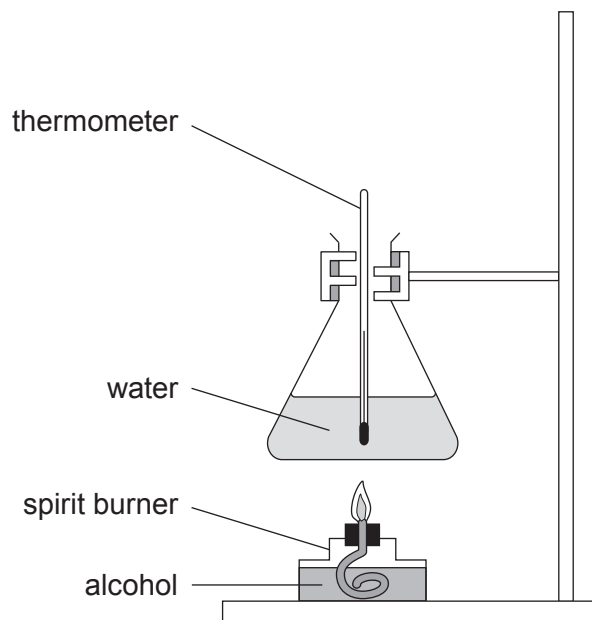
Cutting down trees in a forest fire removes the from the fire triangle.

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

2	3	4	8
---	---	---	---



- (c) 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 ($^{\circ}\text{C}$)
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 = $^{\circ}\text{C}$



(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]

$$A_r(\text{C}) = 12$$

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

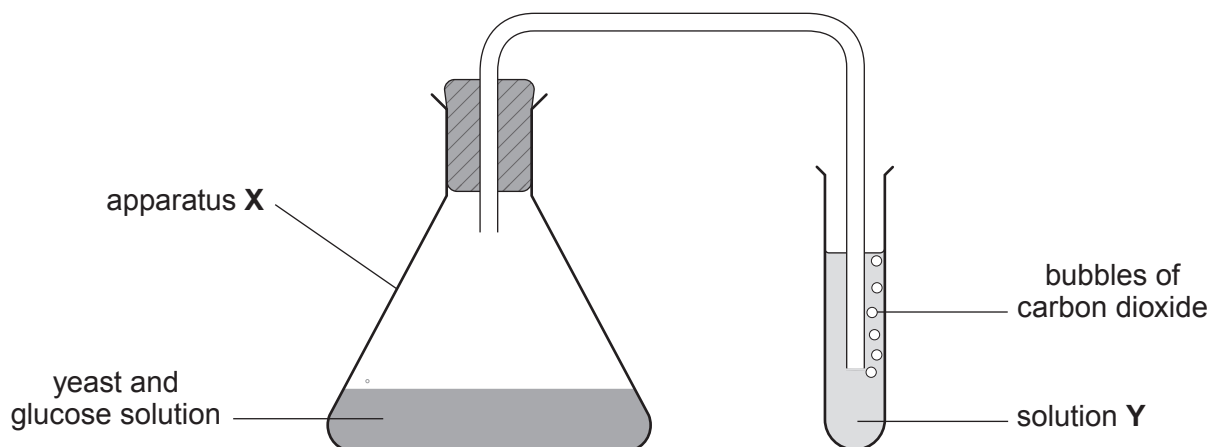
$$A_r(\text{O}) = 16$$

$M_r = \dots\dots\dots$

8



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**

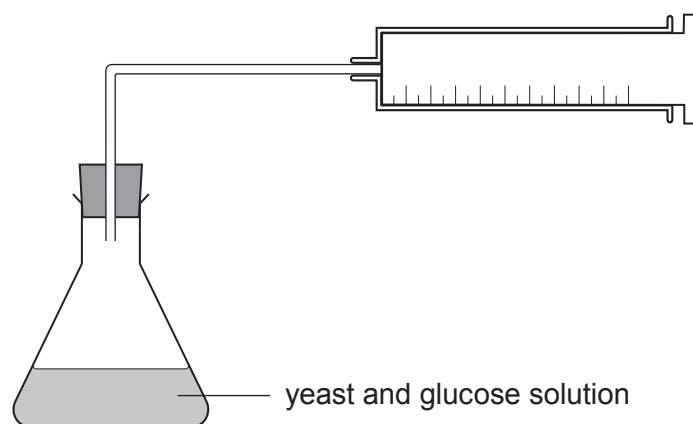
What is seen

- (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	



- (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.



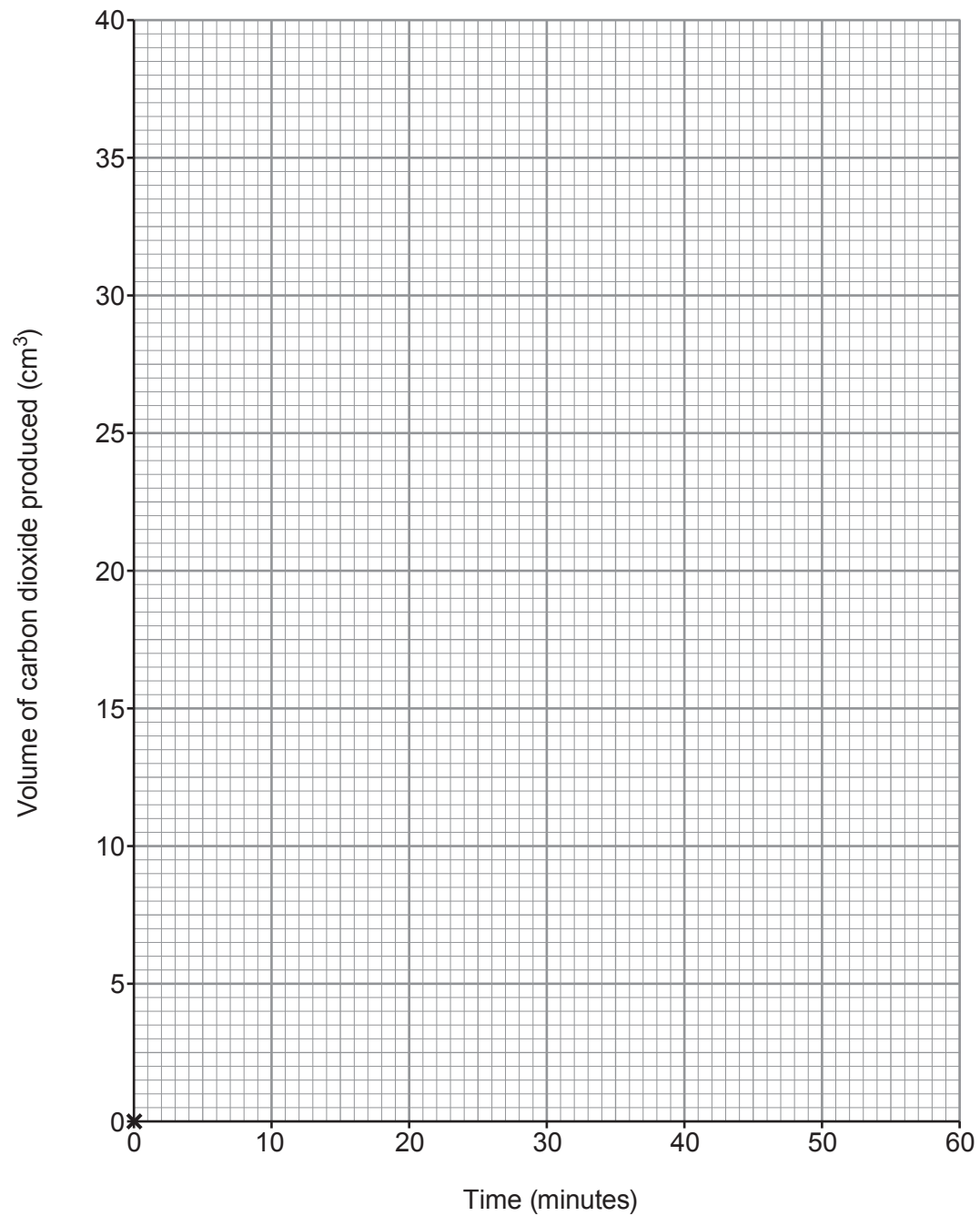
Time (minutes)	Volume of carbon dioxide produced (cm ³)
0	0
10	6
20	12
30	17
40	25
50	30
60	36



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

The first point has been plotted for you.

[3]



- (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

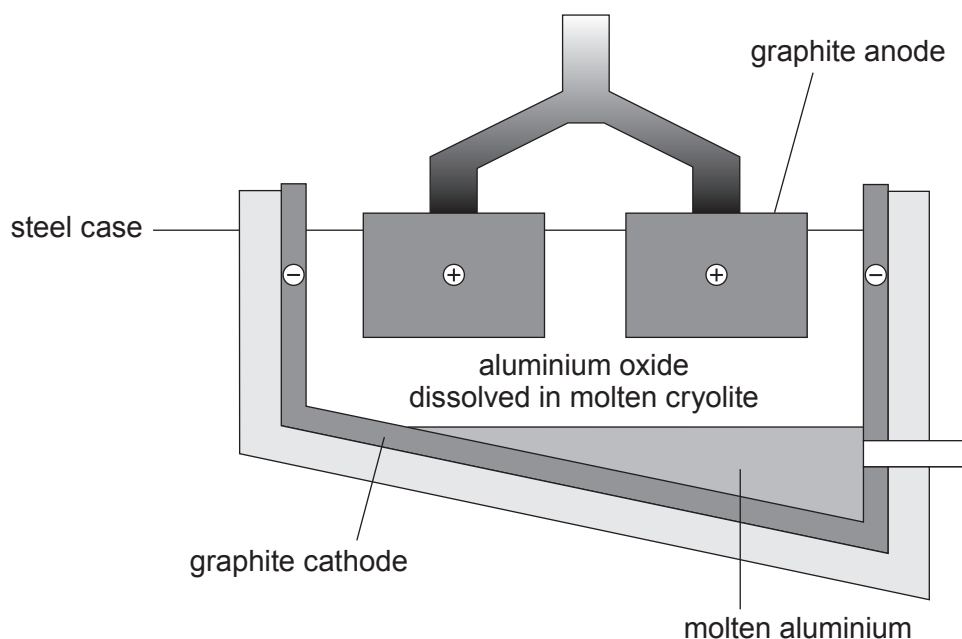


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4. (a) Aluminium metal is produced from aluminium oxide in a process called electrolysis. The diagram shows a cell used in electrolysis.



- (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).



- (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.

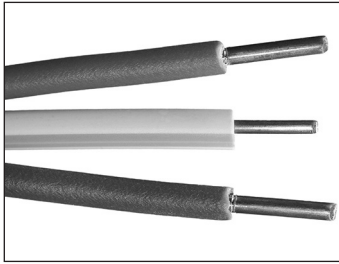
[1]

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



Examiner
only

- (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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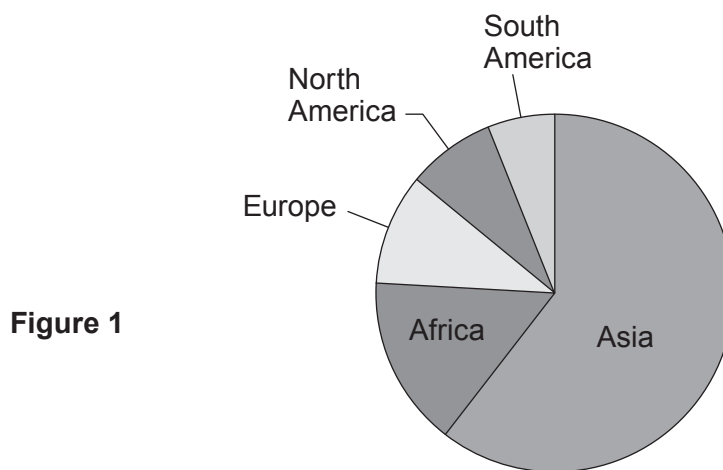
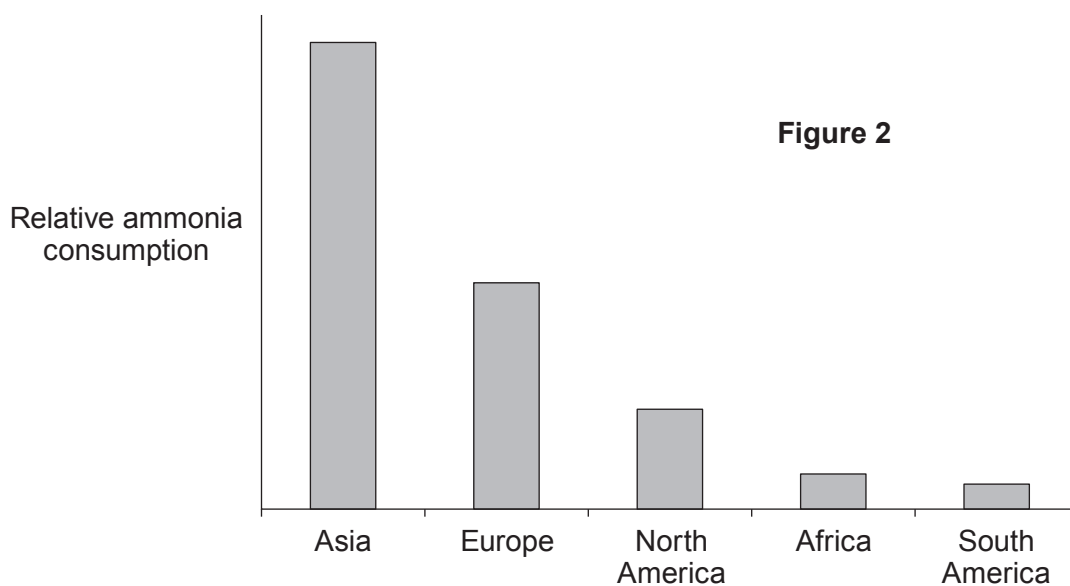


5. Plant and crop growth can be improved using fertilisers containing nitrogen. Fertilisers are substances that are added to the soil in order to increase the supply of nutrients that boost the growth of plants. With the rapid increase in global population, the demand for food has been rising tremendously. 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.



- (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]

.....

.....

.....

.....



- (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 $(\text{NH}_4)_2\text{SO}_4$. [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	

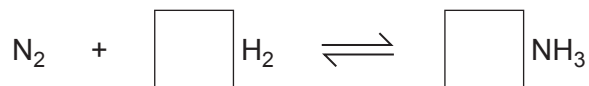
- (iii) 1.5 kg of fertiliser treats an area of 75 m^2 . Calculate the mass needed to treat a lawn with an area of 15 m^2 . Give your answer in **grams**. [2]

Mass = g



- (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]



- (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]

.....



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

Substance	Soluble in water?	Malleable?	Boiling point (°C)	Conducts electricity?
A	no	no	4 200	no
B	yes	no	-79	no
C	yes	no	1 413	only when molten or in solution
D	no	yes	5 555	yes
E	no	yes	2 562	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.

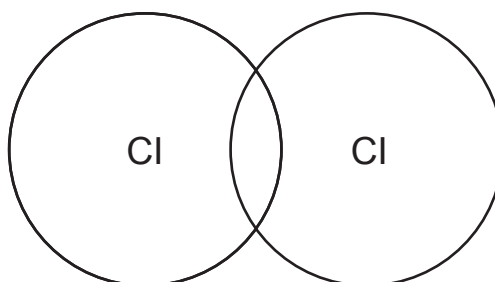
[1]

.....

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

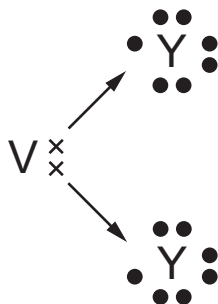
Each atom of chlorine has 7 electrons in its outer shell.

[2]



- (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]



- (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]

$$A_r(\text{K}) = 39$$

Percentage = %



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 cm³ 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]

.....

.....

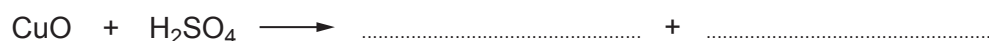
- (ii) Crystals of copper(II) sulfate could also be made using copper(II) oxide powder instead of copper(II) carbonate powder. State and explain how the observations in Stage 2 would be different. [2]

.....

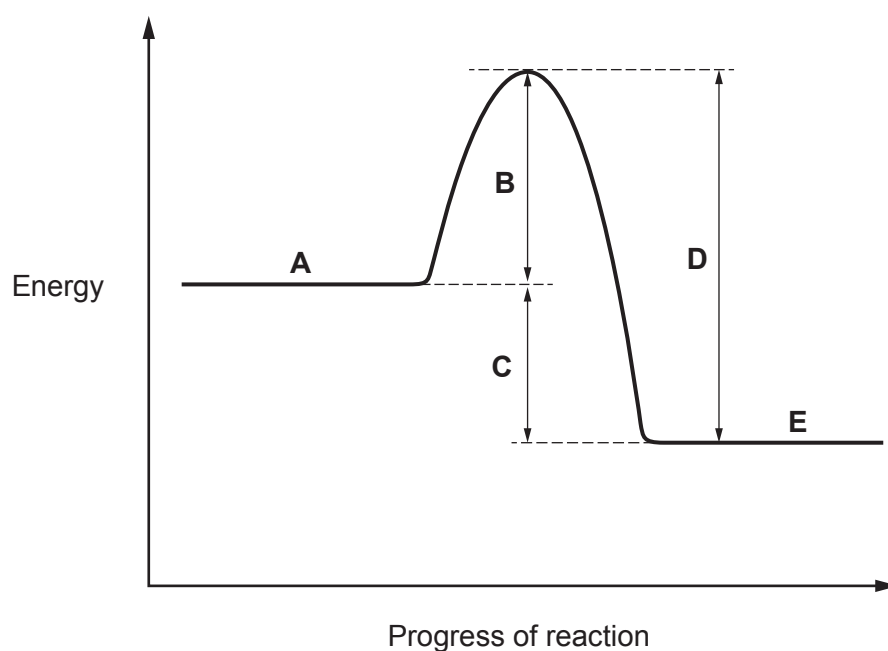
.....

.....

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



(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]

.....

.....

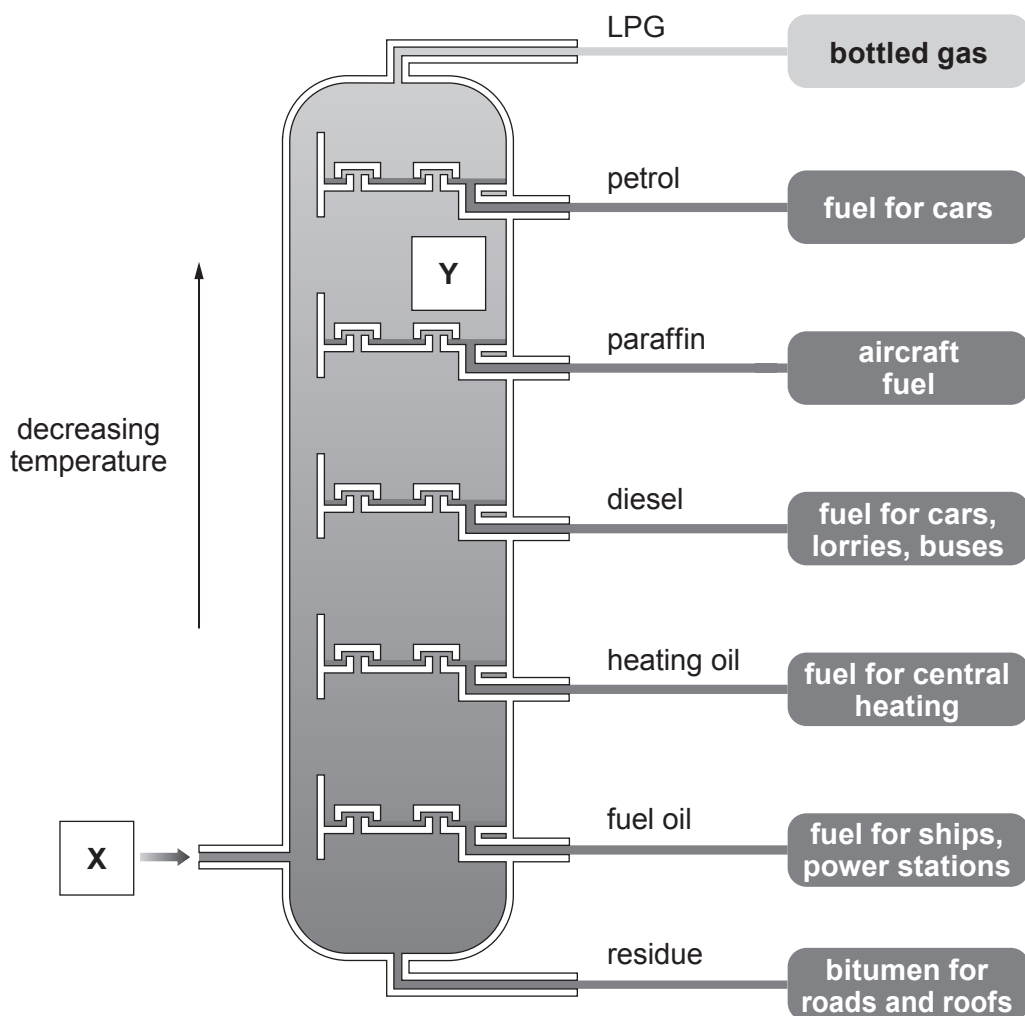
(iii) State how the energy profile shows that this is an exothermic reaction. [1]

.....

.....



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]

.....

.....

.....

.....



- (iii) A hydrocarbon fuel was burned and used to heat 100g 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]

$$\text{energy (J)} = \text{mass of water (g)} \times 4.2 \times \text{temperature rise (}^{\circ}\text{C)}$$

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 $\text{C}_{16}\text{H}_{34}$. [1]



- (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



[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+}		





THE PERIODIC TABLE

Group 1 2 3 4 5 6 7 0

<div>1 H Hydrogen 1</div>													<div>4 He Helium 2</div>																																																																																				
<div>7 Li Lithium 3</div>																		<div>11 B Boron 5</div>					<div>12 C Carbon 6</div>					<div>14 N Nitrogen 7</div>					<div>16 O Oxygen 8</div>					<div>19 F Fluorine 9</div>					<div>20 Ne Neon 10</div>																																																						
<div>23 Na Sodium 11</div>													<div>24 Mg Magnesium 12</div>					<div>27 Al Aluminium 13</div>																		<div>28 Si Silicon 14</div>					<div>31 P Phosphorus 15</div>					<div>32 S Sulfur 16</div>					<div>35.5 Cl Chlorine 17</div>					<div>40 Ar Argon 18</div>																																									
<div>39 K Potassium 19</div>													<div>40 Ca Calcium 20</div>					<div>45 Sc Scandium 21</div>					<div>48 Ti Titanium 22</div>					<div>51 V Vanadium 23</div>					<div>52 Cr Chromium 24</div>					<div>55 Mn Manganese 25</div>					<div>56 Fe Iron 26</div>					<div>59 Co Cobalt 27</div>					<div>59 Ni Nickel 28</div>					<div>63.5 Cu Copper 29</div>					<div>65 Zn Zinc 30</div>					<div>70 Ga Gallium 31</div>					<div>73 Ge Germanium 32</div>					<div>75 As Arsenic 33</div>					<div>79 Se Selenium 34</div>					<div>80 Br Bromine 35</div>					<div>84 Kr Krypton 36</div>				
<div>86 Rb Rubidium 37</div>													<div>88 Sr Strontium 38</div>					<div>89 Y Yttrium 39</div>					<div>91 Zr Zirconium 40</div>					<div>93 Nb Niobium 41</div>					<div>96 Mo Molybdenum 42</div>					<div>99 Tc Technetium 43</div>					<div>101 Ru Ruthenium 44</div>					<div>103 Rh Rhodium 45</div>					<div>106 Pd Palladium 46</div>					<div>108 Ag Silver 47</div>					<div>112 Cd Cadmium 48</div>					<div>115 In Indium 49</div>					<div>119 Sn Tin 50</div>					<div>122 Sb Antimony 51</div>					<div>127 Te Tellurium 52</div>					<div>127 I Iodine 53</div>					<div>131 Xe Xenon 54</div>				
<div>133 Cs Caesium 55</div>													<div>137 Ba Barium 56</div>					<div>139 La Lanthanum 57</div>					<div>179 Hf Hafnium 72</div>					<div>181 Ta Tantalum 73</div>					<div>184 W Tungsten 74</div>					<div>186 Re Rhenium 75</div>					<div>190 Os Osmium 76</div>					<div>192 Ir Iridium 77</div>					<div>195 Pt Platinum 78</div>					<div>197 Au Gold 79</div>					<div>201 Hg Mercury 80</div>					<div>204 Tl Thallium 81</div>					<div>207 Pb Lead 82</div>					<div>209 Bi Bismuth 83</div>					<div>210 Po Polonium 84</div>					<div>210 At Astatine 85</div>					<div>222 Rn Radon 86</div>				
<div>223 Fr Francium 87</div>													<div>226 Ra Radium 88</div>					<div>227 Ac Actinium 89</div>																																																																															

Key

Key

A_r	relative atomic mass
Symbol	
Name	
Z	atomic number