GCSE

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 plus your additional time allowance

Surname _____

First name(s) _____

Centre Number _____

Candidate Number 0 _____

ADDITIONAL MATERIALS

In addition to this paper you will require a calculator and a ruler.

ITEMS INCLUDED WITH QUESTION PAPER

A separate Data Booklet.

A separate Diagram Booklet.

The Diagram Booklet MUST be handed in to the invigilators and sent for marking.

INSTRUCTIONS TO CANDIDATES

Use black ink, black ball-point pen or your usual method.

Write your name, centre number and candidate number in the spaces provided on the front cover.

Answer ALL questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional pages 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 and the formulae for some common ions are printed in the separate Data Booklet.

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**	

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 in TABLE 1.1 in the separate diagram booklet.

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

_____

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

_____

(iii) Drain cleaner contains sodium hydroxide.

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

NaO NAOH NaOH NaOh

1 (b) **The student carried out some reactions using hydrochloric acid. She recorded the observations in TABLE 1.2 in the separate diagram booklet.**

(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 marks]**

Letter _____

Observation

_____

_____

1 (b)(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 marks]

Test

_____

_____

Observation

_____

_____

(b)(iii) Give the LETTER of the reaction which was the LEAST exothermic. Give the reason for your answer. [2 marks]

Letter _____

Reason

_____

_____

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C3H8 + 5O2
3CO2 +
H2O

2 (a) **DIAGRAM 2.1 in the separate diagram booklet shows a fire triangle. Two sides of the fire triangle have been labelled.**

(i) **COMPLETE THE FIRE TRIANGLE by labelling the third side. [1 mark]**

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

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 on the opposite page. [1 mark]**

2	**3**	**4**	**8**

2 (c) **A class used the apparatus shown in DIAGRAM 2.2 in the separate diagram booklet 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.**

TABLE 2.3 in the separate diagram booklet shows the increase in temperature of the water for each alcohol.

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

Final temperature = _____ °C

2 (c)(ii)

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

- ☐ **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?**

2 (d) **Methanol has the chemical formula CH_3OH.**

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

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

M_r = _____

8

3 (a) **Ethanol can be produced by fermentation using the apparatus shown in DIAGRAM 3.1 in the separate diagram booklet.**

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

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 marks]

Name of solution Y

_____

What is seen

_____

_____

3 (a)(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 mark]

☐ **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 in DIAGRAM 3.2 in the separate diagram booklet, the volume of carbon dioxide produced at 35 °C was measured and recorded every 10 minutes for 60 minutes. The results are shown in TABLE 3.3 in the separate diagram booklet.

(i) Plot the data on GRAPH 3.4 in the separate diagram booklet and draw a suitable line.

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

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

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 mark]

Time = _____ minutes

9

4 (a) **Aluminium metal is produced from aluminium oxide in a process called electrolysis.**

DIAGRAM 4.1 in the separate diagram booklet shows a cell used in electrolysis.

(i) **<u>UNDERLINE</u> the correct word in the brackets to complete each sentence. [4 marks]**

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).

4 (a) (ii)

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

Give the formula of aluminium oxide. [1 mark]

(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 mark]

- ☐ **carbon is more reactive than aluminium**
- ☐ **iron is more reactive than aluminium**
- ☐ **aluminium is more reactive than carbon**

4 (b) **DIAGRAM 4.2 in the separate diagram booklet shows 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 marks QER]

continue answer on the next page (Turn over)

12

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.

CHART 5.1 in the separate diagram booklet shows the relative populations of world continents in 2016.

GRAPH 5.2 shows the relative world consumption of ammonia in 2016.

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

- ☐ 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

5 (a)(ii) State whether the information in CHART 5.1 and GRAPH 5.2 shows a link between the number of people living on each continent and the amount of ammonia used. Give reasons for your answer. [2 marks]

(b) The label on a bag of fertiliser in DIAGRAM 5.3 in the separate diagram booklet shows the formula of the nitrogen compound that the fertiliser contains.

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

5 (b)(ii)

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

- ☐ **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 marks]**

Mass = _____ **g**

5 (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 mark]**

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

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

5 (c)(iii)

A catalyst is used in the Haber process.

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

_____

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

_____

_____

12

6 (a) TABLE 6.1 in the separate diagram booklet shows some information about substances A-E.

(i) Give the LETTERS of the TWO substances which are metals. [1 mark]

_____ and _____

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

_____

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

_____

(b) In DIAGRAM 6.2 in the separate diagram booklet, 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 marks]

6 (c) **DIAGRAM 6.3 in the separate diagram booklet 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 marks]**

V _____

Y _____

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

V_2Y VY VY_2 V_2Y_2

6 (c)(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 marks]

A_r(K) = 39

Percentage = _____ %

10

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 mark]**

7 (a)(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 marks]

_____

_____

_____

_____

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

$$CuO + H_2SO_4 \longrightarrow \_\_\_\_\_ + \_\_\_\_\_$$

7 (b) **DIAGRAM 7.1 in the separate diagram booklet shows an energy profile for a reaction.**

(i) **In TABLE 7.2 in the separate diagram booklet, give the LETTER that represents each part of the energy profile. [2 marks]**

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

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

9

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. This process is shown in DIAGRAM 8.1 in the separate diagram booklet.**

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

X _____

Y _____

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

_____

_____

_____

_____

_____

_____

8 (a)(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 marks]

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

Energy = _____ J

8 (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 mark]

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

(ii) State the TWO conditions used for cracking. [1 mark]

_____

_____

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

Give the meaning of the term unsaturated. [1 mark]

_____

_____

_____

8 (b)(iv)

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

octane / C_8H_{18}

ethene / C_2H_4

11

END OF PAPER

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

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MONDAY, 22 MAY 2023 – MORNING

CHEMISTRY – Unit 2:

Chemical Bonding, Application of Chemical Reactions and Organic Chemistry

FOUNDATION TIER

1 hour 45 minutes plus your additional time allowance

DIAGRAM BOOKLET

This Diagram Booklet MUST be handed in to the invigilators and sent for marking.

Surname _____

First name(s) _____

Centre Number _____

Candidate Number 0 _____

TABLE 1.1

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

TABLE 1.2

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

DIAGRAM 2.1

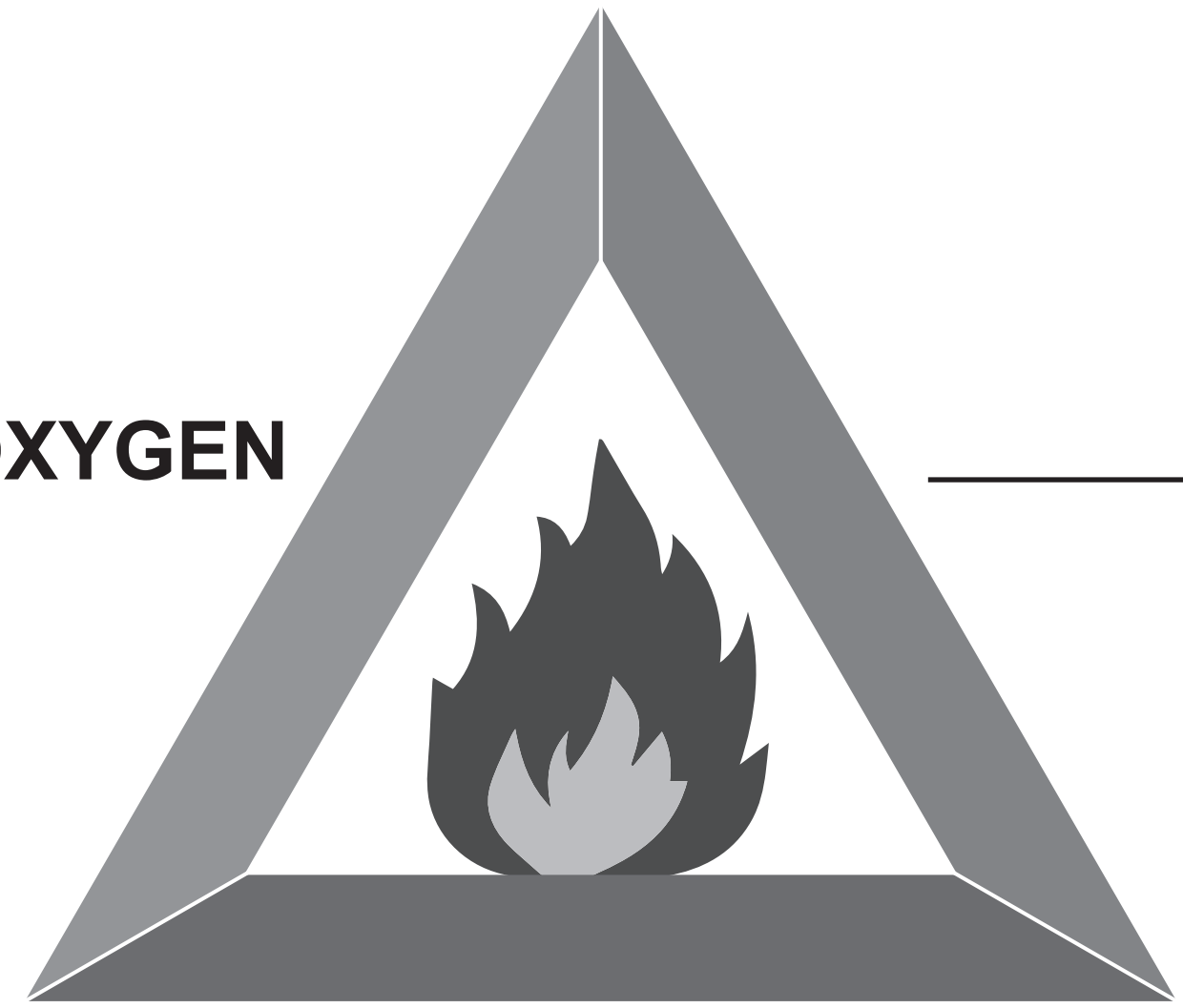


DIAGRAM 2.2

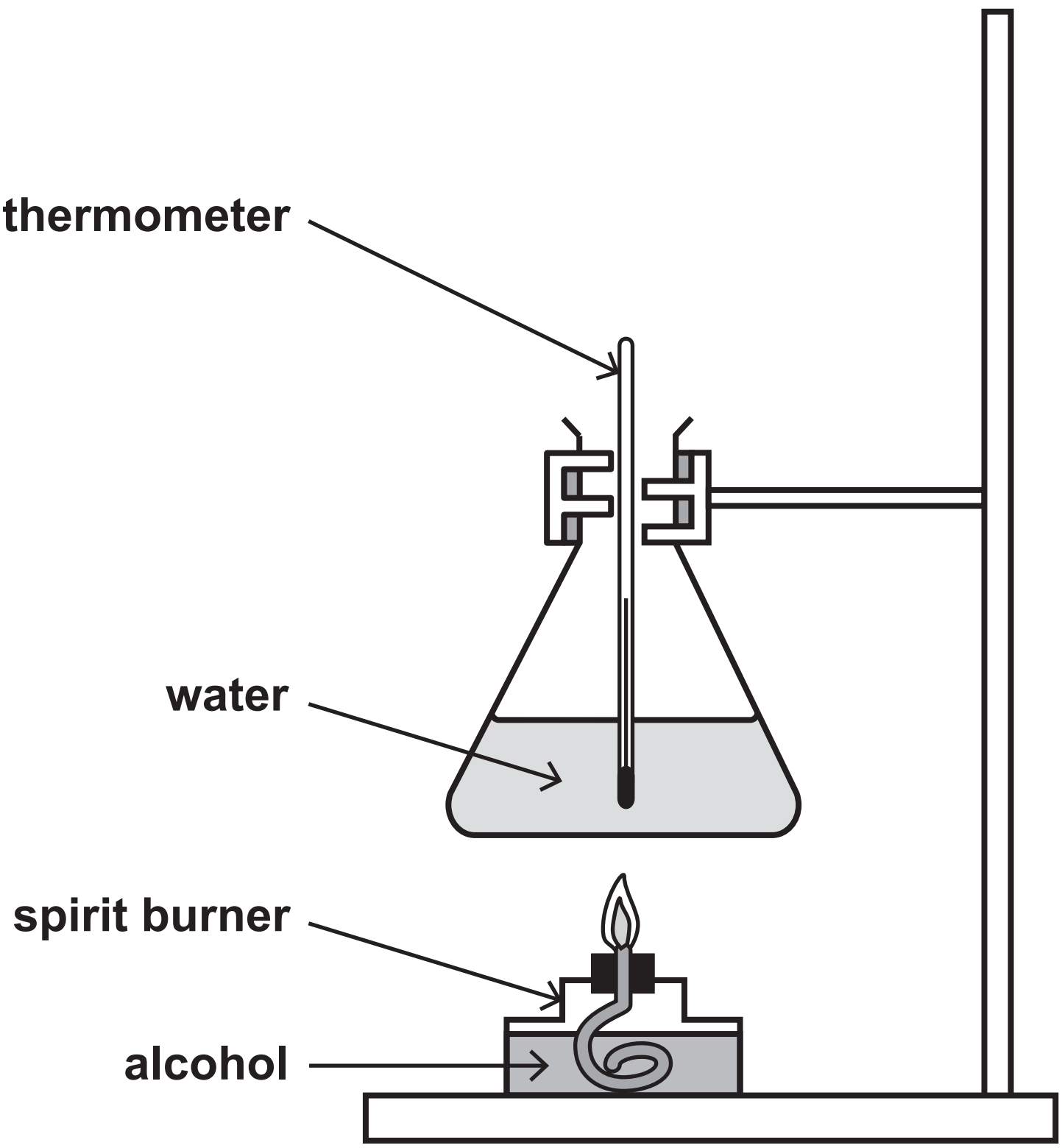
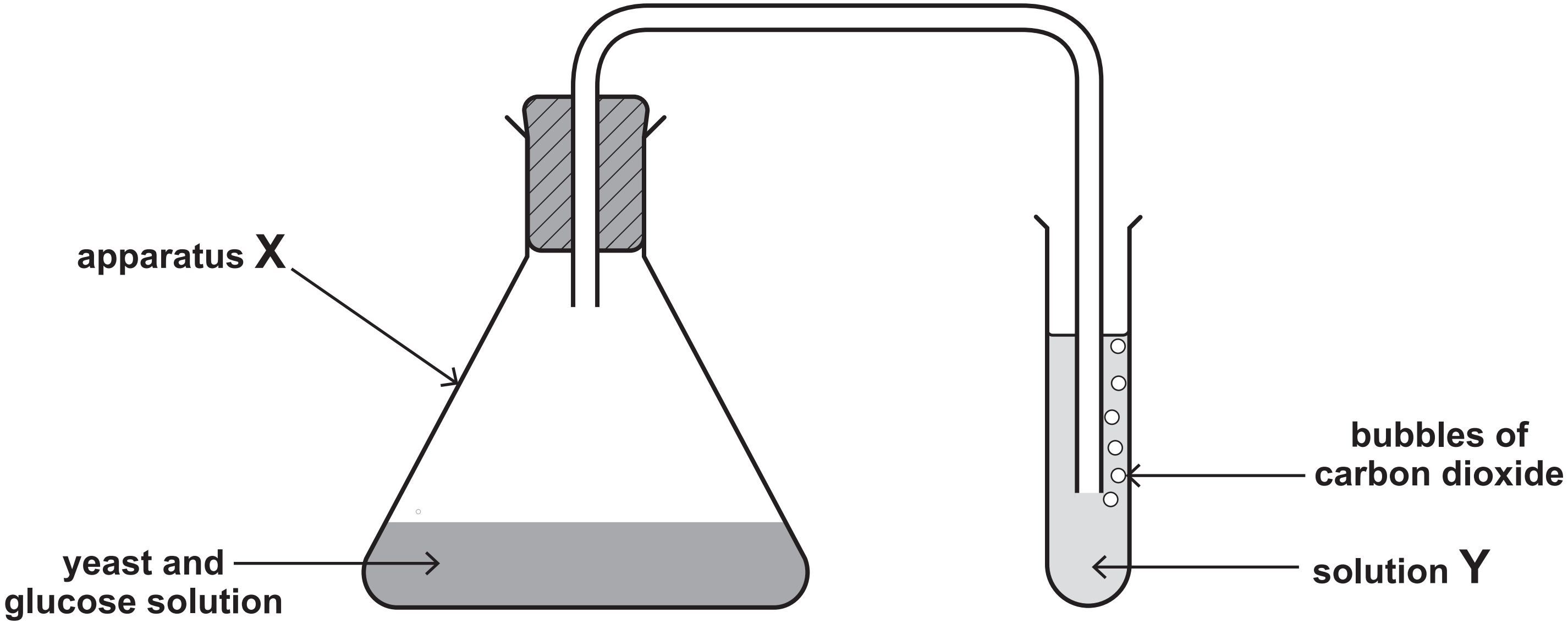


TABLE 2.3

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

DIAGRAM 3.1


apparatus X
yeast and glucose solution
bubbles of carbon dioxide
solution Y

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TURN OVER

DIAGRAM 3.2

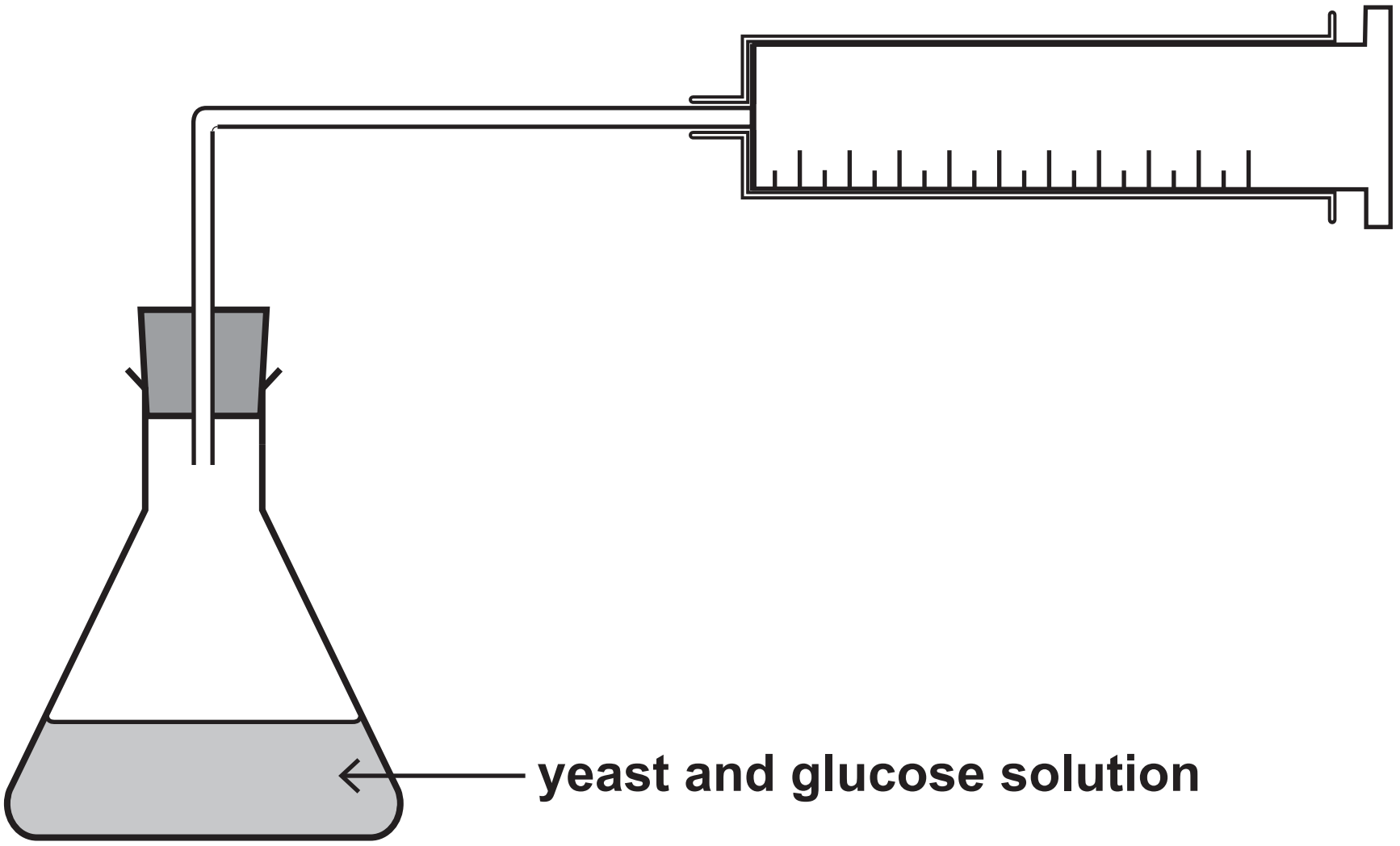


TABLE 3.3

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

GRAPH 3.4

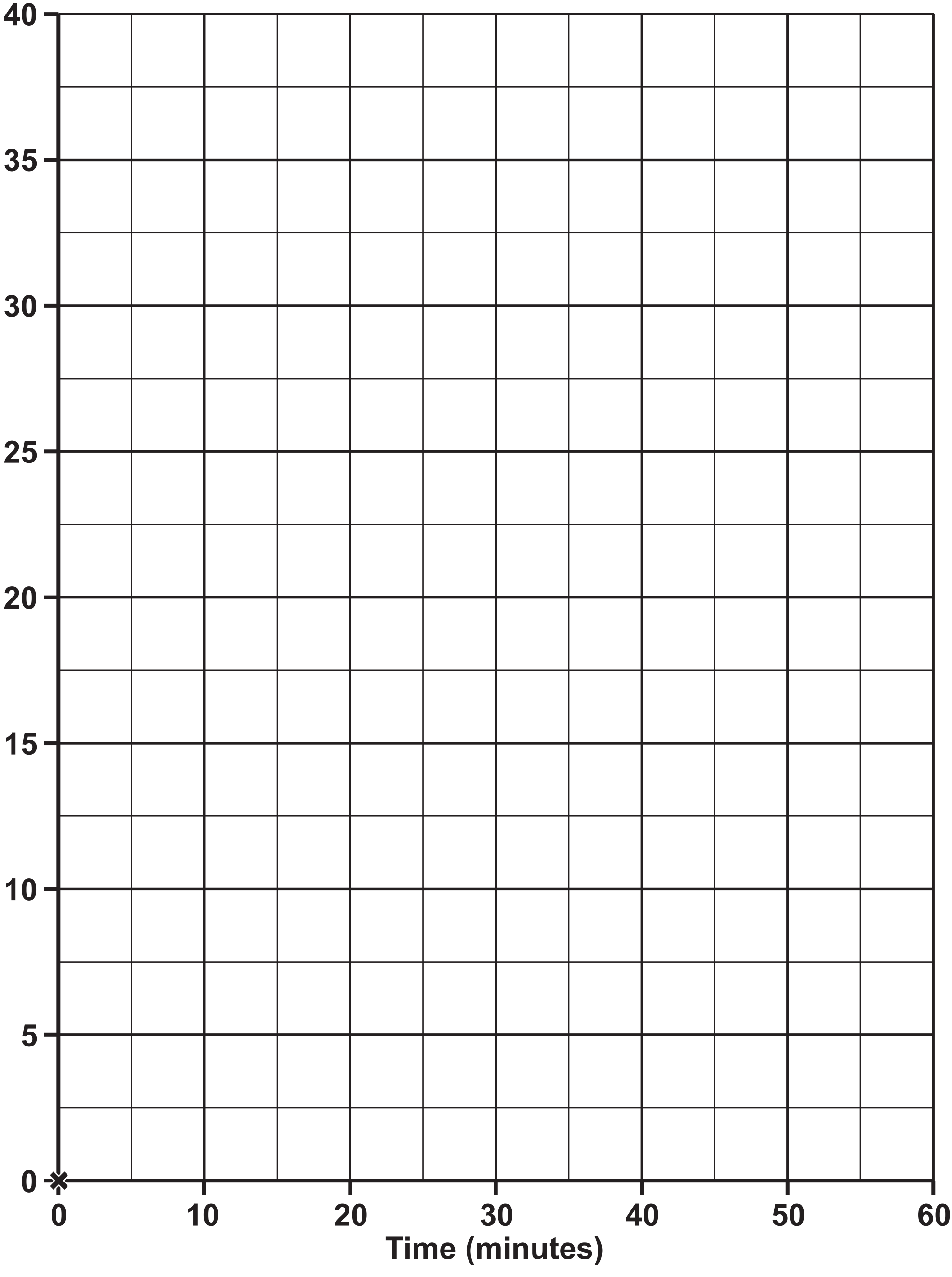

Volume of carbon dioxide produced (cm3)
40
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
Time (minutes)

DIAGRAM 4.1

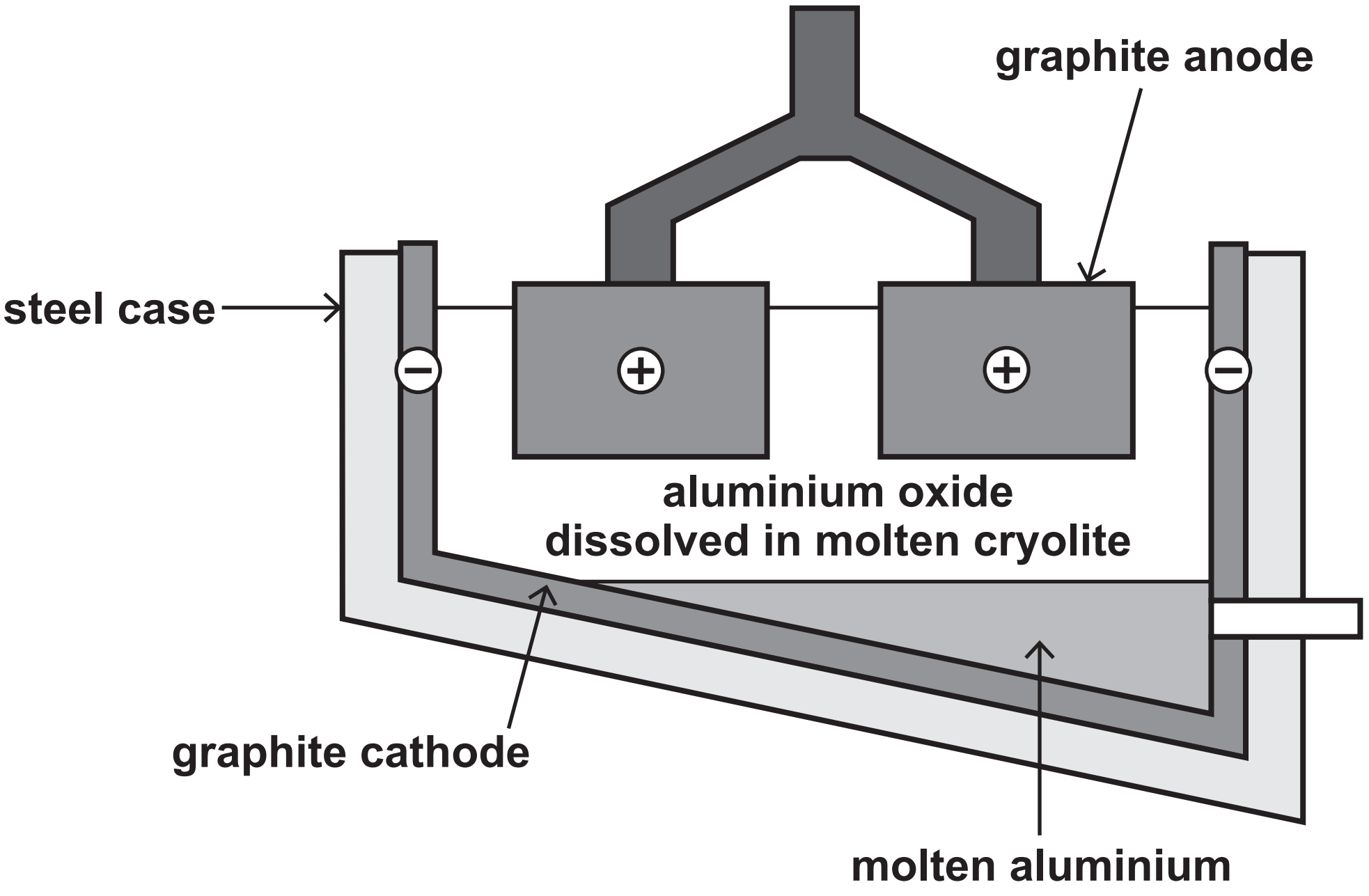

graphite anode
steel case
aluminium oxide
dissolved in molten cryolite
graphite cathode
molten aluminium

DIAGRAM 4.2

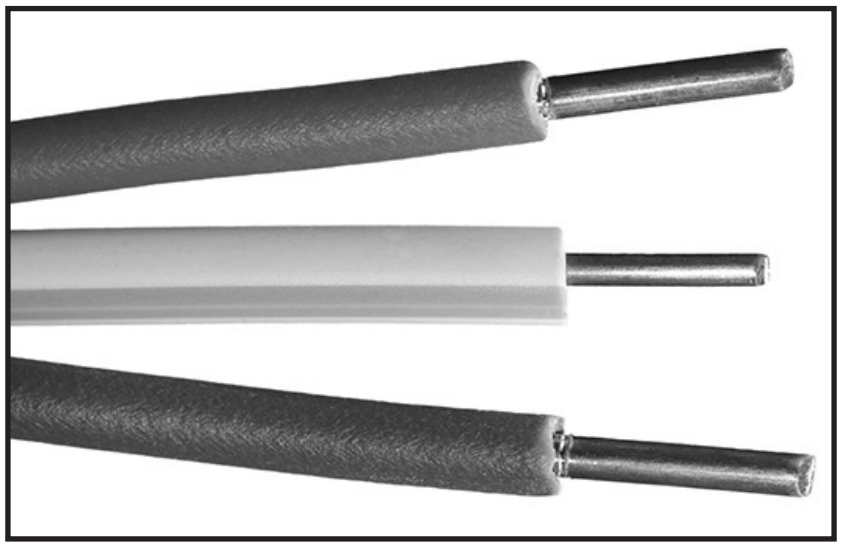
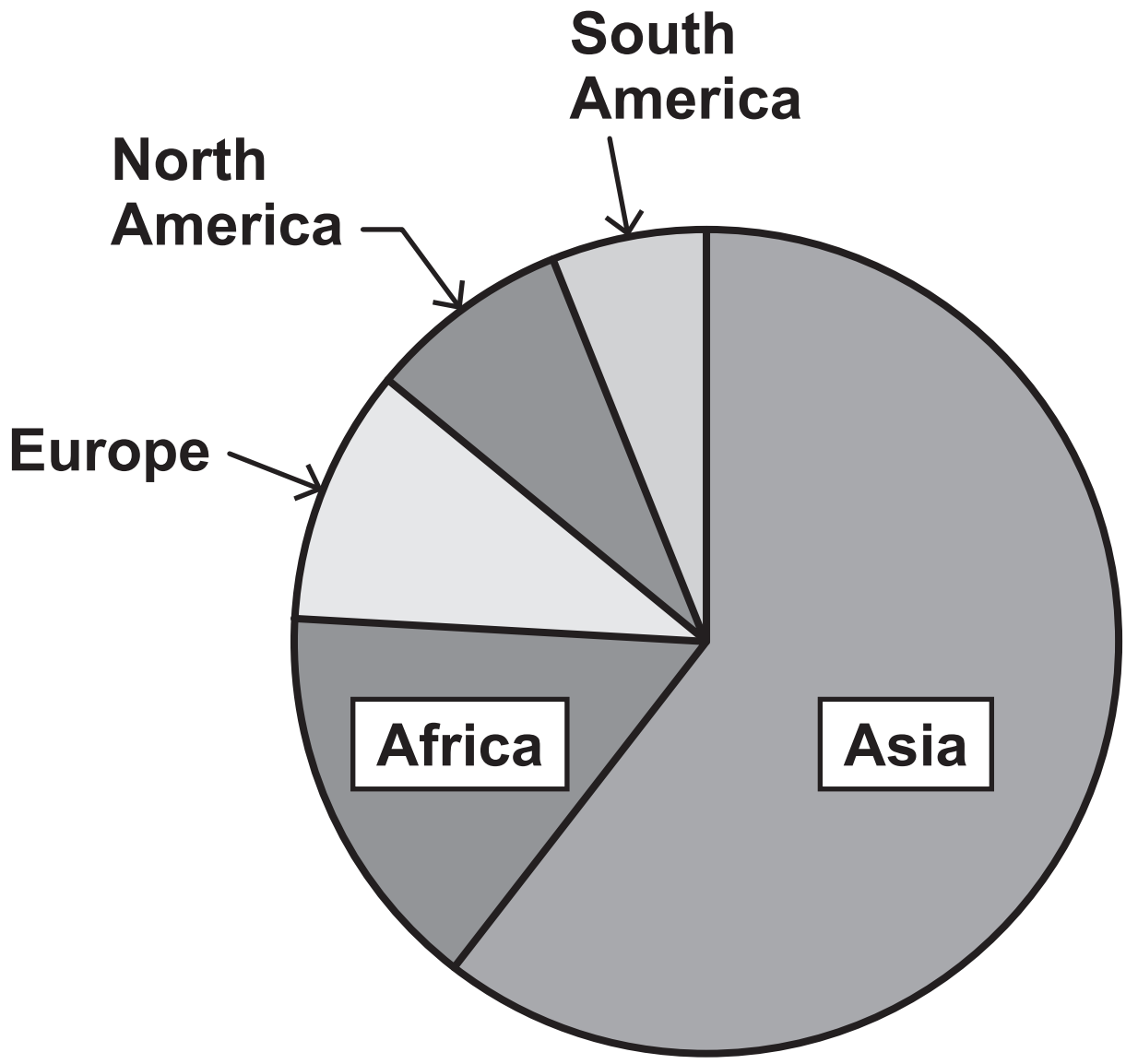


CHART 5.1



GRAPH 5.2

Relative ammonia consumption

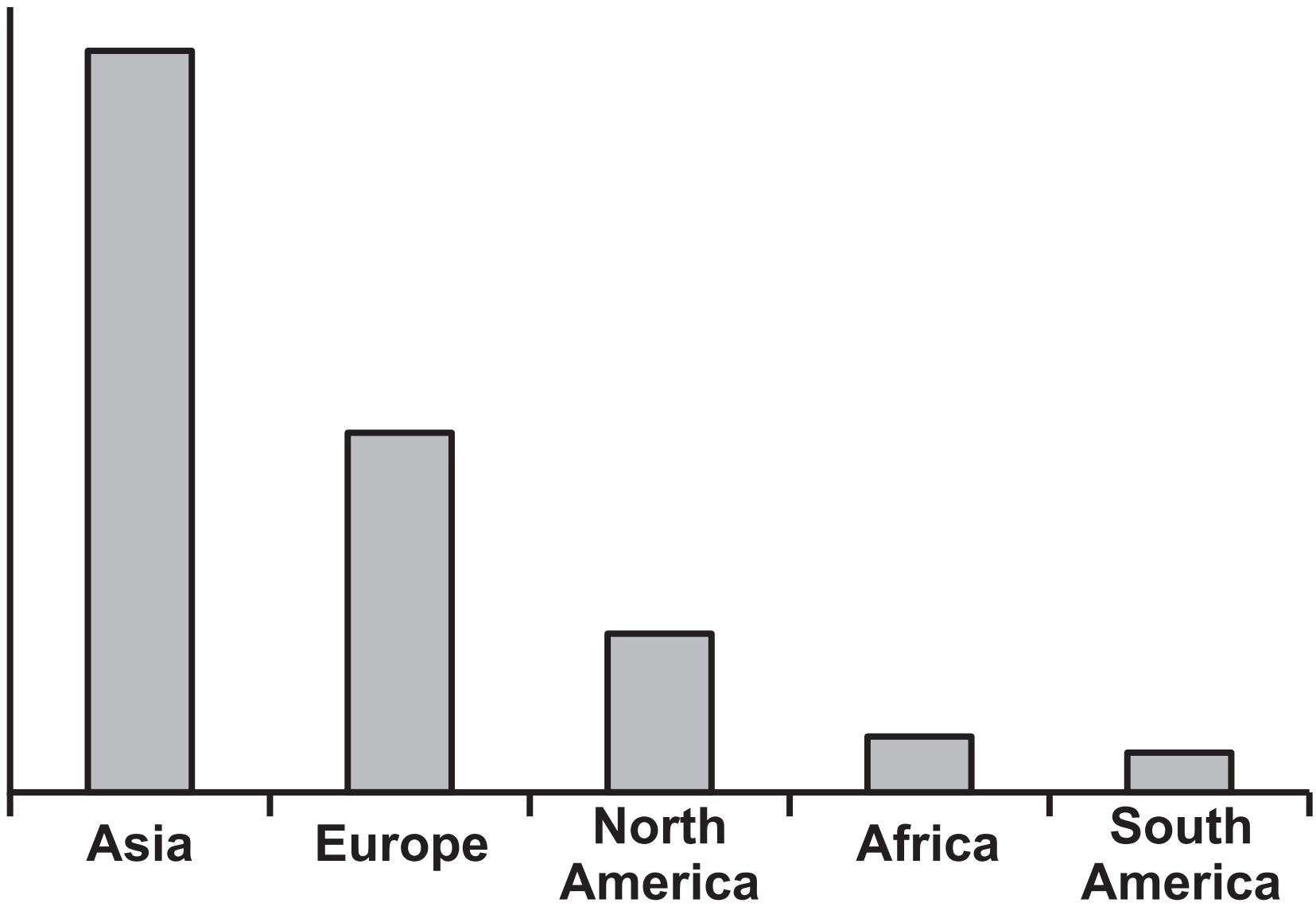


DIAGRAM 5.3

1.5 kg fertiliser

TABLE 6.1

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

DIAGRAM 6.2

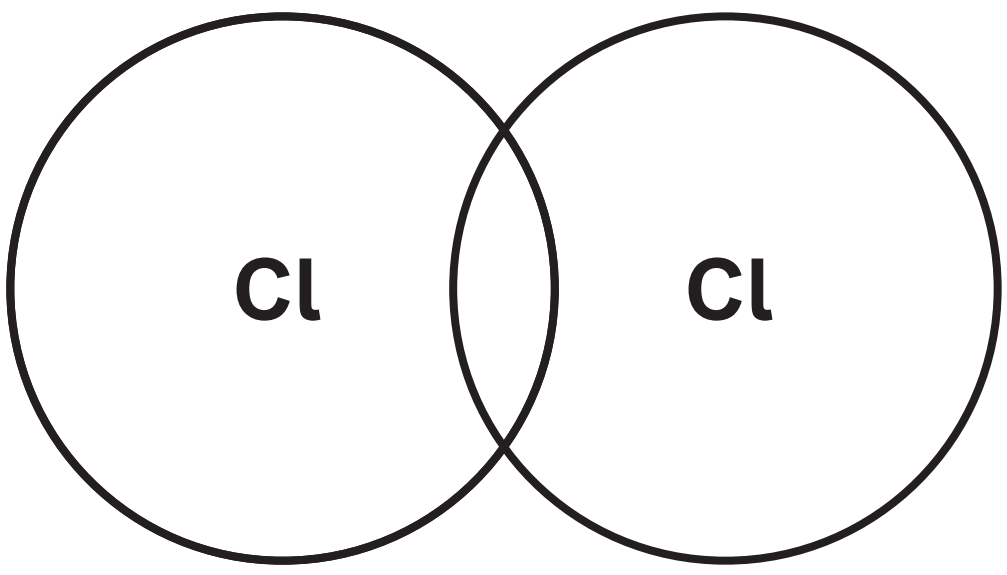


DIAGRAM 6.3

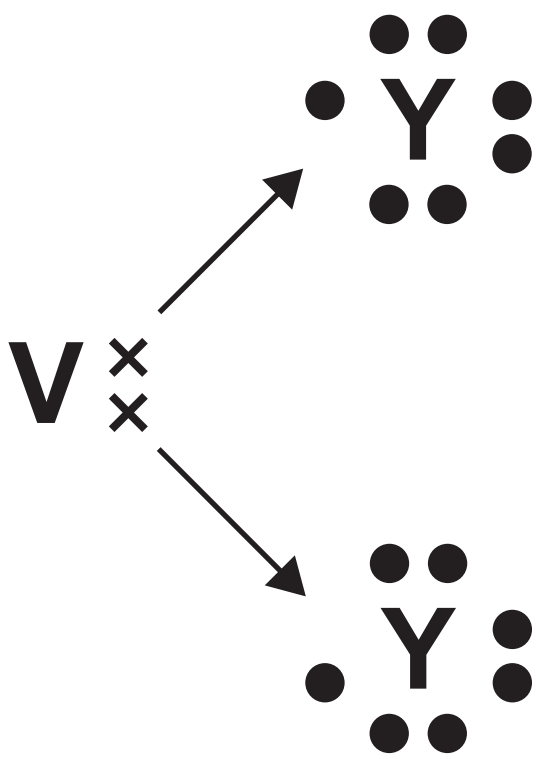


DIAGRAM 7.1

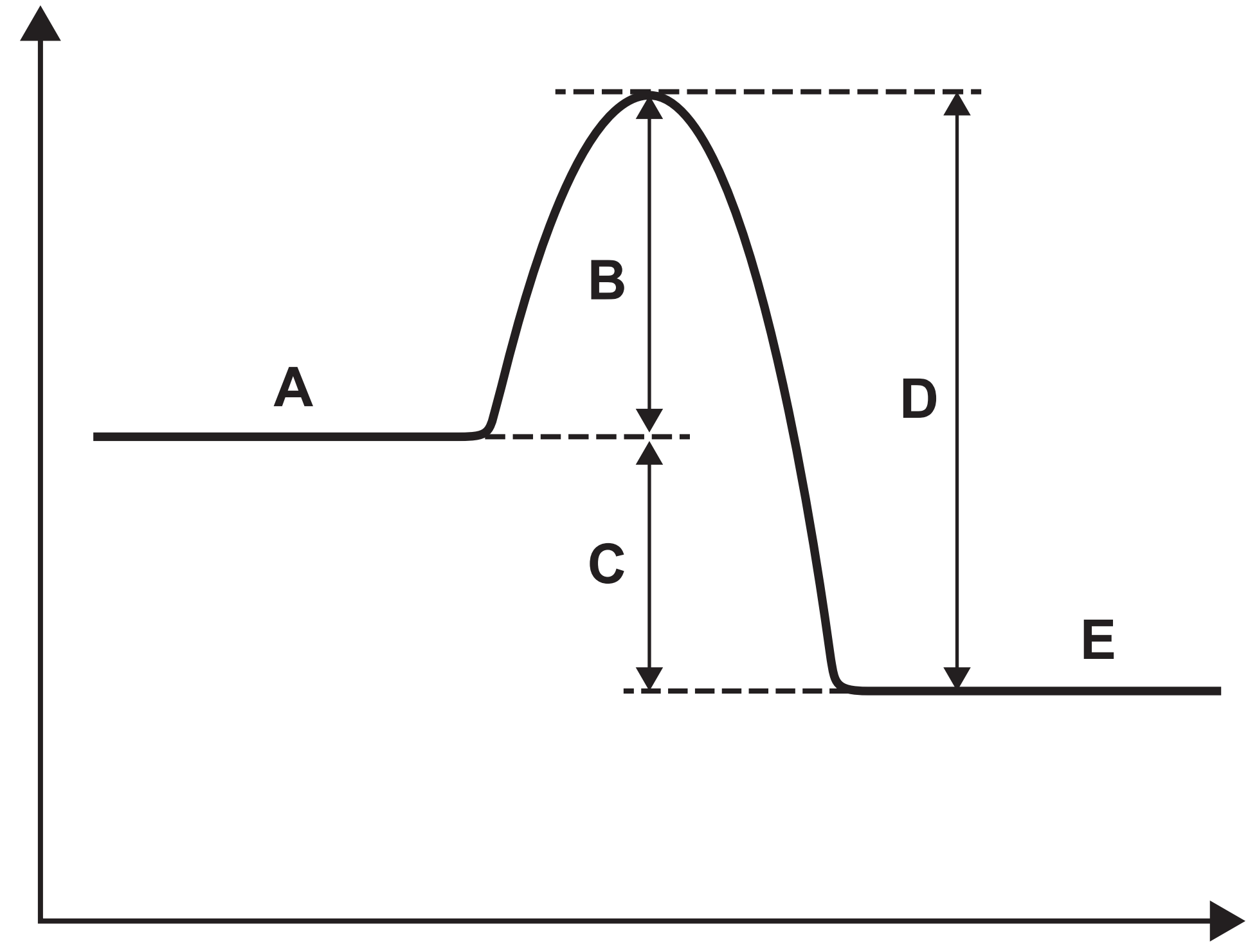
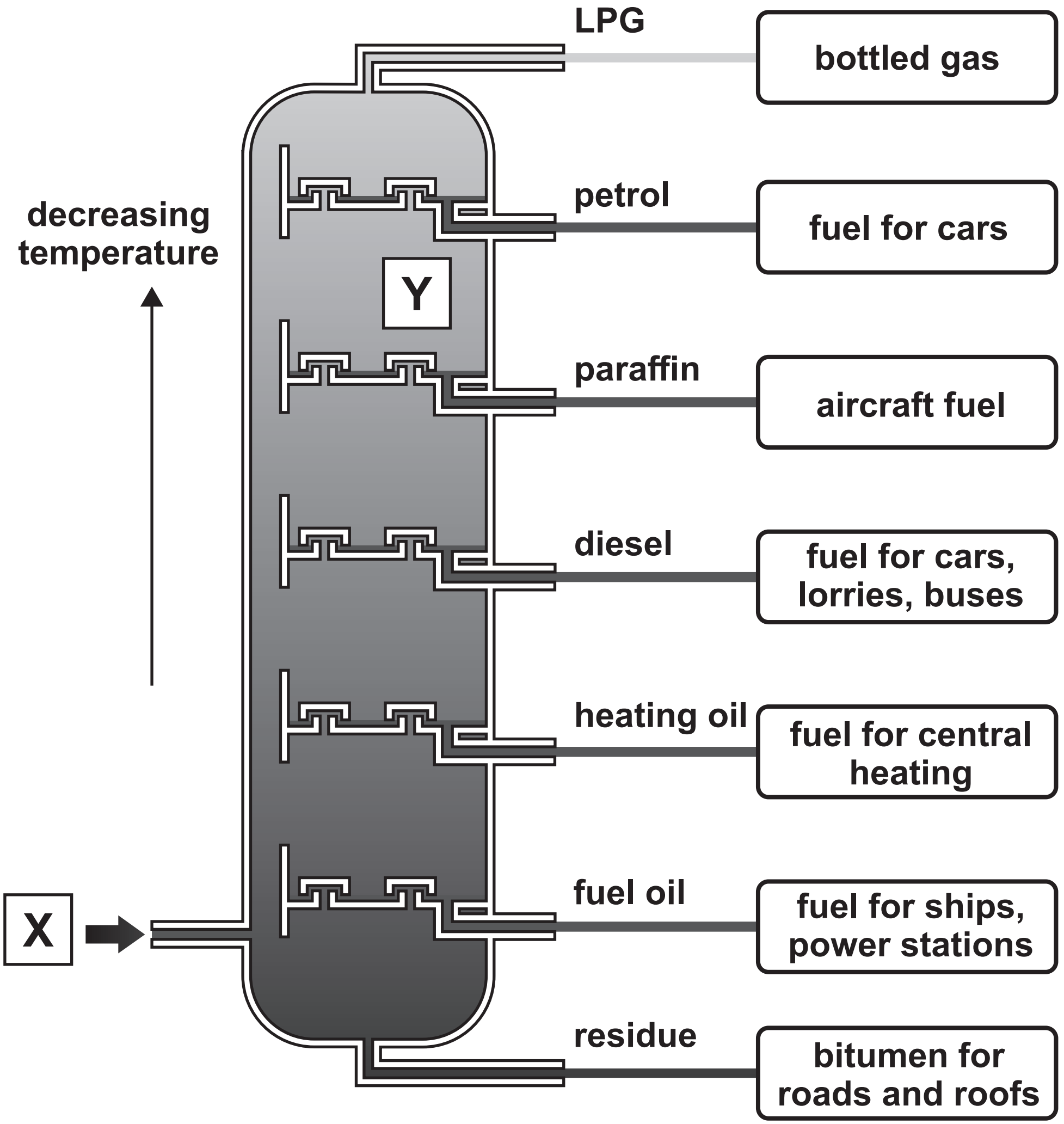


TABLE 7.2

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

DIAGRAM 8.1


LPG
bottled gas
petrol
fuel for cars
decreasing temperature
Y
paraffin
aircraft fuel
diesel
fuel for cars, lorries, buses
heating oil
fuel for central heating
X
fuel oil
fuel for ships, power stations
residue
bitumen for roads and roofs

GCSE

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MONDAY, 22 MAY 2023 – MORNING

CHEMISTRY – Unit 2:

Chemical Bonding, Application of Chemical Reactions and Organic Chemistry

FOUNDATION TIER

Data Booklet

FORMULAE FOR SOME COMMON IONS

POSITIVE IONS	
Name	Formula
aluminium	Al^{3+}
ammonium	NH_4^+
barium	Ba^{2+}
calcium	Ca^{2+}
copper(II)	Cu^{2+}
hydrogen	H^+
iron(II)	Fe^{2+}
iron(III)	Fe^{3+}
lithium	Li^+
magnesium	Mg^{2+}
nickel	Ni^{2+}
potassium	K^+
silver	Ag^+
sodium	Na^+
zinc	Zn^{2+}

NEGATIVE IONS	
Name	Formula
bromide	Br^-
carbonate	CO_3^{2-}
chloride	Cl^-
fluoride	F^-
hydroxide	OH^-
iodide	I^-
nitrate	NO_3^-
oxide	O^{2-}
sulfate	SO_4^{2-}

THE PERIODIC TABLE

KEY

A_r	relative atomic mass
Sym	symbol
Z	atomic number

1	2	GROUP										3	4	5	6	7	0
								1 H 1									4 He 2
7 Li 3	9 Be 4											11 B 5	12 C 6	14 N 7	16 O 8	19 F 9	20 Ne 10
23 Na 11	24 Mg 12											27 Al 13	28 Si 14	31 P 15	32 S 16	35.5 Cl 17	40 Ar 18
39 K 19	40 Ca 20	45 Sc 21	48 Ti 22	51 V 23	52 Cr 24	55 Mn 25	56 Fe 26	59 Co 27	59 Ni 28	63.5 Cu 29	65 Zn 30	70 Ga 31	73 Ge 32	75 As 33	79 Se 34	80 Br 35	84 Kr 36
86 Rb 37	88 Sr 38	89 Y 39	91 Zr 40	93 Nb 41	96 Mo 42	99 Tc 43	101 Ru 44	103 Rh 45	106 Pd 46	108 Ag 47	112 Cd 48	115 In 49	119 Sn 50	122 Sb 51	128 Te 52	127 I 53	131 Xe 54
133 Cs 55	137 Ba 56	139 La 57	179 Hf 72	181 Ta 73	184 W 74	186 Re 75	190 Os 76	192 Ir 77	195 Pt 78	197 Au 79	201 Hg 80	204 Tl 81	207 Pb 82	209 Bi 83	210 Po 84	210 At 85	222 Rn 86
223 Fr 87	226 Ra 88	227 Ac 89															

THE PERIODIC TABLE

PERIODIC TABLE – KEY
ATOMIC NUMBER – SYMBOL – NAME

1	H – Hydrogen
2	He – Helium
3	Li – Lithium
4	Be – Beryllium
5	B – Boron
6	C – Carbon
7	N – Nitrogen
8	O – Oxygen
9	F – Fluorine
10	Ne – Neon
11	Na – Sodium
12	Mg – Magnesium
13	Al – Aluminium
14	Si – Silicon
15	P – Phosphorus
16	S – Sulfur
17	Cl – Chlorine
18	Ar – Argon
19	K – Potassium
20	Ca – Calcium
21	Sc – Scandium
22	Ti – Titanium
23	V – Vanadium
24	Cr – Chromium
25	Mn – Manganese
26	Fe – Iron
27	Co – Cobalt
28	Ni – Nickel
29	Cu – Copper
30	Zn – Zinc
31	Ga – Gallium
32	Ge – Germanium
33	As – Arsenic

34	Se – Selenium
35	Br – Bromine
36	Kr – Krypton
37	Rb – Rubidium
38	Sr – Strontium
39	Y – Yttrium
40	Zr – Zirconium
41	Nb – Niobium
42	Mo – Molybdenum
43	Tc – Technetium
44	Ru – Ruthenium
45	Rh – Rhodium
46	Pd – Palladium
47	Ag – Silver
48	Cd – Cadmium
49	In – Indium
50	Sn – Tin
51	Sb – Antimony
52	Te – Tellurium
53	I – Iodine
54	Xe – Xenon
55	Cs – Caesium
56	Ba – Barium
57	La – Lanthanum
72	Hf – Hafnium
73	Ta – Tantalum
74	W – Tungsten
75	Re – Rhenium
76	Os – Osmium
77	Ir – Iridium
78	Pt – Platinum
79	Au – Gold
80	Hg – Mercury

81	Tl – Thallium
82	Pb – Lead
83	Bi – Bismuth
84	Po – Polonium
85	At – Astatine
86	Rn – Radon
87	Fr – Francium
88	Ra – Radium
89	Ac – Actinium