Surname	Centre Number	Candidate Number
First name(s)		0

GCSE

S23-3410UB0-1

3410UB0-1

MONDAY, 22 MAY 2023 – MORNING

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

1 hour 45 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**9**	
2.	**11**	
3.	**9**	
4.	**7**	
5.	**11**	
6.	**8**	
7.	**9**	
8.	**10**	
9.	**6**	
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 **6**(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 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]

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(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]

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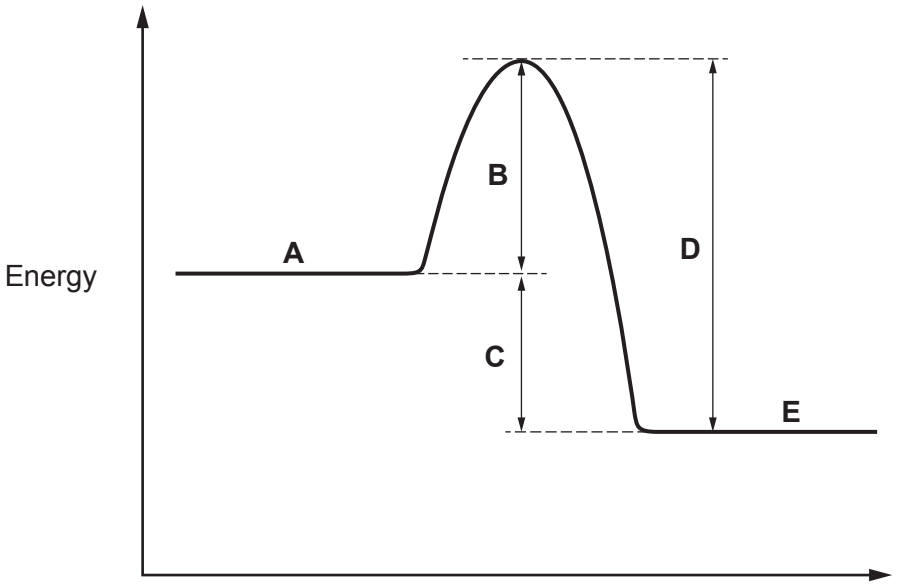
(b) The diagram shows an energy profile for a reaction.



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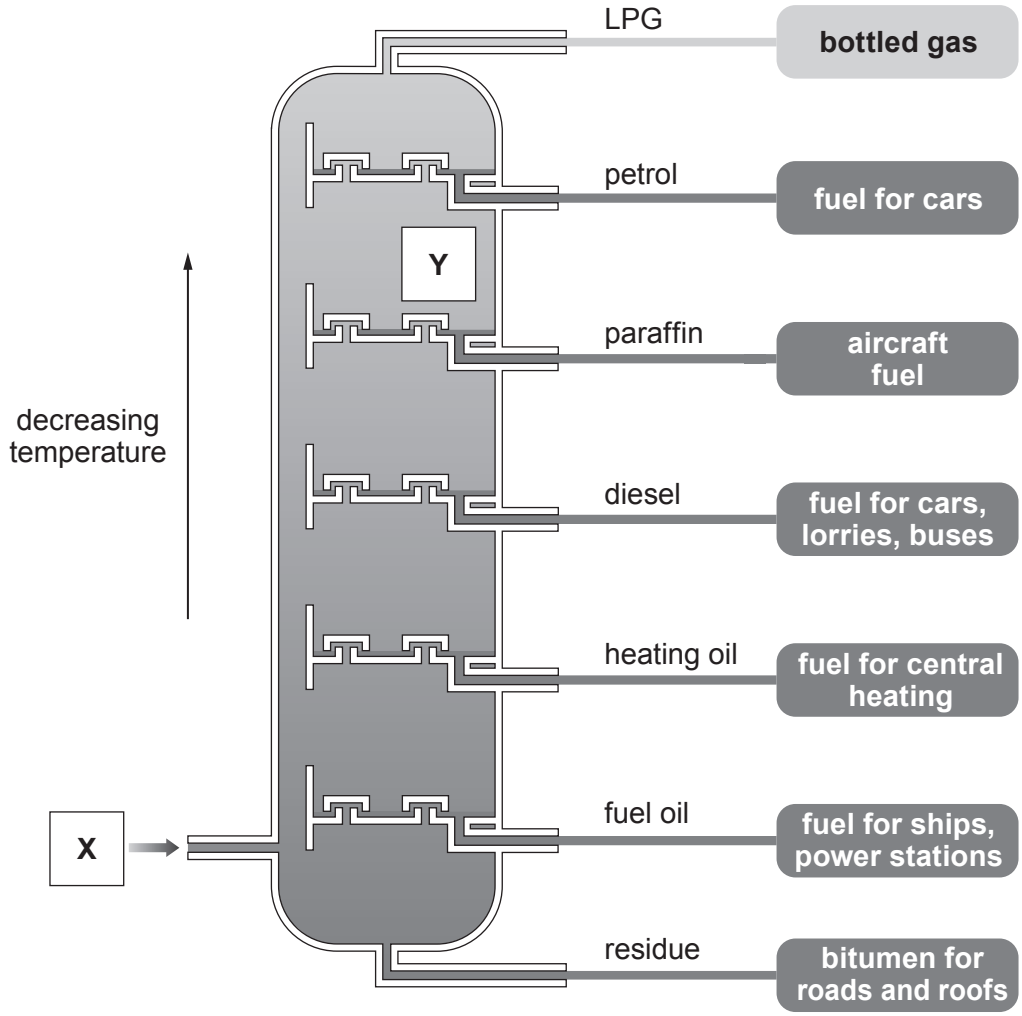
2. (a) Crude oil is separated into mixtures of hydrocarbon compounds in the process of fractional distillation. Many of these fractions are used as fuels.



(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]

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.....

(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 .....

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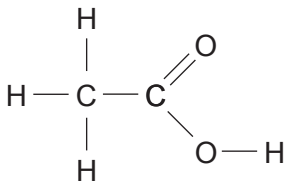
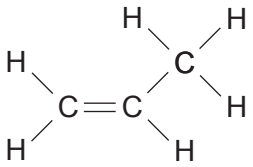
3. (a) The table shows information about some organic compounds.

Name	Molecular formula	Structure	Homologous series
ethanol	C_2H_5OH		alcohols
ethanoic acid	CH_3COOH		.....
.....	C_3H_6		alkenes

(i) **Complete the table.** [3]

(ii) The molecular mass of an alkene is 98. Give the molecular formula of this alkene. [1]

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

Molecular formula .....

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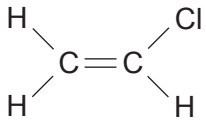
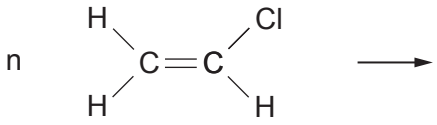
(b) Polyvinyl chloride (PVC) is formed from the following monomer in a polymerisation reaction.

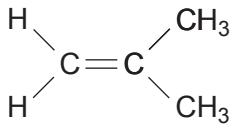


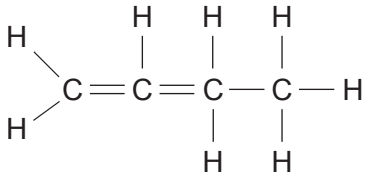
Complete the equation for the polymerisation reaction. [2]

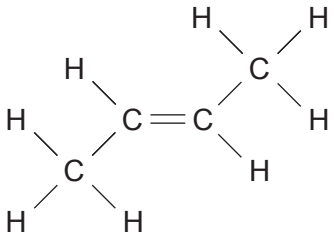


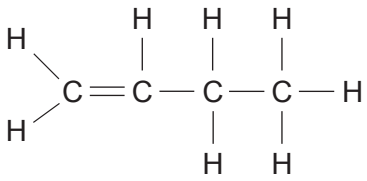
(c) A student was asked to draw structures for isomers with the molecular formula C_4H_8.

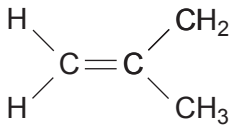
She drew the following diagrams. Circle **all** the **correct** structures. [2]











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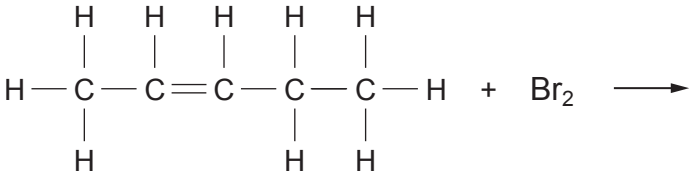
(d) Pent-2-ene reacts with bromine water in a similar manner to ethene.

Complete the equation for the reaction of pent-2-ene with bromine by drawing the structure of the product. [1]



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4. (a) The table shows the results of an experiment in which zinc and lead powders were added separately to solutions of sodium chloride and iron(II) chloride.

	Sodium chloride solution	Iron(II) chloride solution
zinc	no change	colour change
lead	no change	no change

Use the results to place the four metals in order of reactivity. [1]

Most reactive .....

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.....

Least reactive .....

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(b) A student investigated metal reactivity using a different method.

He added 10.0 g of magnesium powder in 2.0 g portions to 50 cm^3 of zinc chloride solution and recorded the temperature of the mixture after each addition. He repeated the experiment with aluminium powder and again with copper powder.

The results for magnesium powder are shown below.

Mass of magnesium powder added (g)	Temperature (°C)
0	21.0
2.0	23.2
4.0	25.1
6.0	27.5
8.0	29.7
10.0	31.6

The results for aluminium and copper have been plotted on the grid opposite.

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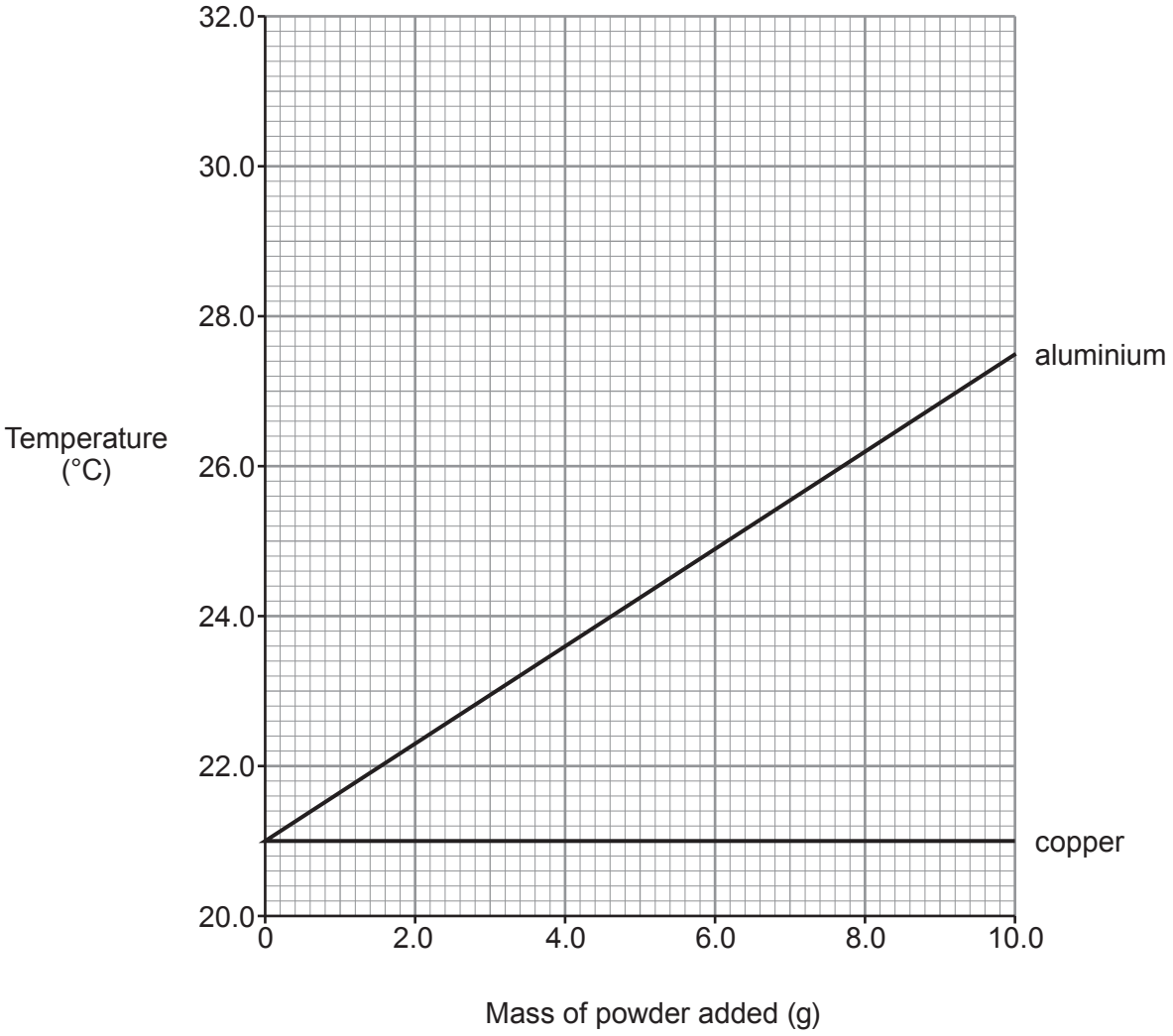
(i) Plot the results for magnesium on the grid. Draw a suitable line. [3]



(ii) State the conclusions that can be drawn about the reactivities of magnesium, aluminium, copper and zinc. Give your reasoning. [3]

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5. (a) (i) Draw a dot and cross diagram to show the bonding in a carbon dioxide molecule. [2]

carbon (2,4) oxygen (2,6)

(ii) Explain why carbon dioxide has a low boiling point. [2]

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Examiner only

(b) (i) Draw a diagram to show the electronic changes that take place during the formation of magnesium oxide. Include the charges on the ions formed. [2]

magnesium (2,8,2) oxygen (2,6)

(ii) Explain why magnesium oxide has a higher melting point than sodium chloride. [2]

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Examiner only

(iii) Sodium chloride is produced by the reaction of sodium with chlorine.

$$2Na(s) + Cl_2(g) \longrightarrow 2NaCl(s)$$

In a reaction using 0.080 mol of sodium, 4.12 g of sodium chloride was produced.

Calculate the percentage yield of this reaction. [3]

A_r(Na) = 23 A_r(Cl) = 35.5

Percentage yield = ... %

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6. (a) **X**, **Y** and **Z** are solutions of ethanoic acid, hydrochloric acid and sodium chloride, **but not necessarily in that order**. Reactions of **X**, **Y** and **Z** with magnesium gave the results shown below.

Solution	Reaction with magnesium
X	rapid fizzing, salt formed, temperature increase of 18 °C
Y	no reaction
Z	slow fizzing, salt formed, temperature increase of 11 °C

Use the table to identify **X**, **Y** and **Z**, giving your reasoning. Explain the results recorded and include equations to support your answer. [6 QER]

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(b) State how adding sodium hydroxide solution allows solutions containing iron(II) and iron(III) ions to be identified. Give the observations made for both solutions. [2]

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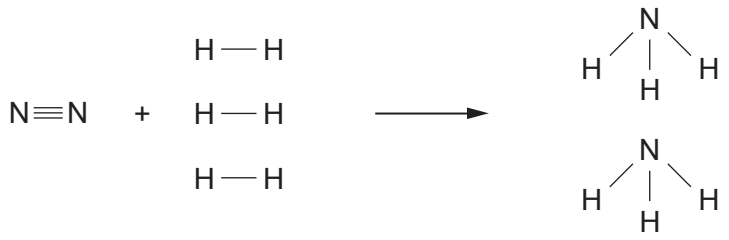
7. (a) The formation of ammonia can be represented by the following equation.



- The total amount of energy released in making the bonds in the products is 2340 kJ
- The total amount of energy released in making the bonds in the products is 94 kJ **more than** the total energy used in breaking the bonds in the reactants
- The amount of energy used to break the N≡N bond is 941 kJ

Use this information to calculate the energy used to break **one** H—H bond. [3]

Energy = ... kJ

Examiner only

(b) The Haber process used to make ammonia is usually carried out at a temperature of around 400 °C. Explain why this is the optimum temperature. [2]

A higher temperature is not used because .....

.....

A lower temperature is not used because .....

.....

(c) Ammonia is used in the production of fertilisers such as ammonium nitrate.

Give the balanced symbol equation for the reaction between nitric acid and ammonia to form ammonium nitrate. [2]

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(d) Eutrophication is a problem caused by fertilisers being washed into waterways leading to overgrowth of plants. Describe how eutrophication leads to the death of aquatic organisms. [2]

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Examiner only

8. (a) According to the Journal of the British Dental Association, the increase in consumption of fruit juices and other acidic drinks is believed to be one of the leading causes of dental erosion in children and adolescents.

Many fruit juice drinks contain more than one type of acid. Citric acid can be used as a natural preservative and provides a sour taste. Ascorbic acid (vitamin C) is a water-soluble vitamin that must be consumed regularly to ensure proper body function. Citrus fruits, as well as tomatoes and other fresh vegetables, are good sources of vitamin C.

The table below shows information about the content of different fruit juice drinks.

Fruit juice drink	pH	Water (%)	Citric acid (%)	Ascorbic acid (mg / 100 g)	Sugar (%)
lime	2.2	76.4	4.80	29	1.68
lemon	2.4	81.3	4.60	53	1.80
grapefruit	3.0	90.3	1.35	38	2.34
orange	3.6	87.4	0.96	50	4.85
tangerine	3.8	85.7	0.74	31	7.89

(i) Tick (✓) the **two** conclusions that can be drawn from the information. [2]

as pH increases, citric acid content decreases and sugar content increases	
as acidity decreases, ascorbic acid content decreases and water content decreases	
tomatoes are a good source of vitamin C and citric acid	
citrus fruits contain ascorbic acid and a natural preservative	

(ii) **Use information from the table** to suggest why citric acid content has a much greater effect on the pH than ascorbic acid content. [1]

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(b) The concentration of a solution of sodium hydroxide can be determined by titrating with sulfuric acid. The equation for the reaction is shown.

$$H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$$

(i) Give the **ionic** equation for the formation of water in any neutralisation reaction. Include state symbols. [2]

.....

(ii) 21.0 cm^3 of sulfuric acid with a concentration of 0.350 mol/dm^3 neutralised 25.0 cm^3 of the sodium hydroxide solution.

I. Calculate the number of moles of sulfuric acid used in the reaction. [1]

Number of moles = ... mol

II. Calculate the concentration of the sodium hydroxide solution. [2]

Concentration = ... mol/dm^3

Examiner only

(iii) During a similar titration reaction, 0.36 g of water was produced. Calculate the number of **molecules** of water produced in this reaction.

Give your answer in **standard form**. [2]

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

Avogadro's constant = 6.0×10^{23}

Number of molecules = ...

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Question 9 on page 24

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9. Aluminium metal is produced industrially using electrolysis, due to the relatively high stability of aluminium oxide.

The overall equation for the reaction is

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

(a) Describe, in terms of electrons, the reduction and oxidation occurring during the electrolysis. [2]

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Examiner only

(b) (i) Aluminium ore contains 36 % aluminium oxide, Al_2O_3.

Calculate the mass of aluminium oxide in 500 tonnes of the ore. [1]

Mass = ... tonnes

(ii) Calculate the mass of aluminium metal that could be produced from this mass of aluminium oxide. [3]

A_r(Al) = 27 A_r(O) = 16

Mass = ... tonnes

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END OF PAPER

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

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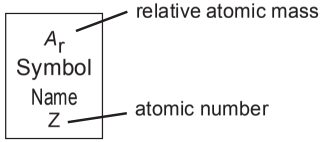
FORMULAE FOR SOME COMMON IONS

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



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