Rewarding Learning

General Certificate of Secondary Education
2024

Centre Number

Candidate Number

GCSE Chemistry

Unit 2

Higher Tier

MV18

[GCM22]

FRIDAY 14 JUNE, MORNING

Time

1 hour 30 minutes, plus your additional time allowance.

Instructions to Candidates

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
You must answer the questions in the spaces provided.
Do not write on blank pages.
Complete in black ink only.
Answer **all six** questions.

Information for Candidates

The total mark for this paper is 100.
Figures in brackets printed at the end of each question indicate the marks awarded to each question or part question.
Quality of written communication will be assessed in Question **2(c)**.
A Data Leaflet, which includes a Periodic Table of the Elements, is included in this question paper.

1 The reactions of metals with oxygen in air, with water and with steam differ based on the reactivity of the metal.

(a) Information on the reactions of three metals when heated in air is given below.

Metal 1: Grey solid burns with orange sparks forming a black solid

Metal 2: Red-brown solid glows red when heated and changes to a black solid

Metal 3: Grey solid burns with a brick red flame forming a white solid

(i) Identify the metals. [3 marks]

Metal 1: _____

Metal 2: _____

Metal 3: _____

(ii) Based on your answer to **(a)(i)**, write a balanced symbol equation for the reaction of Metal 3 when heated in air. [3 marks]

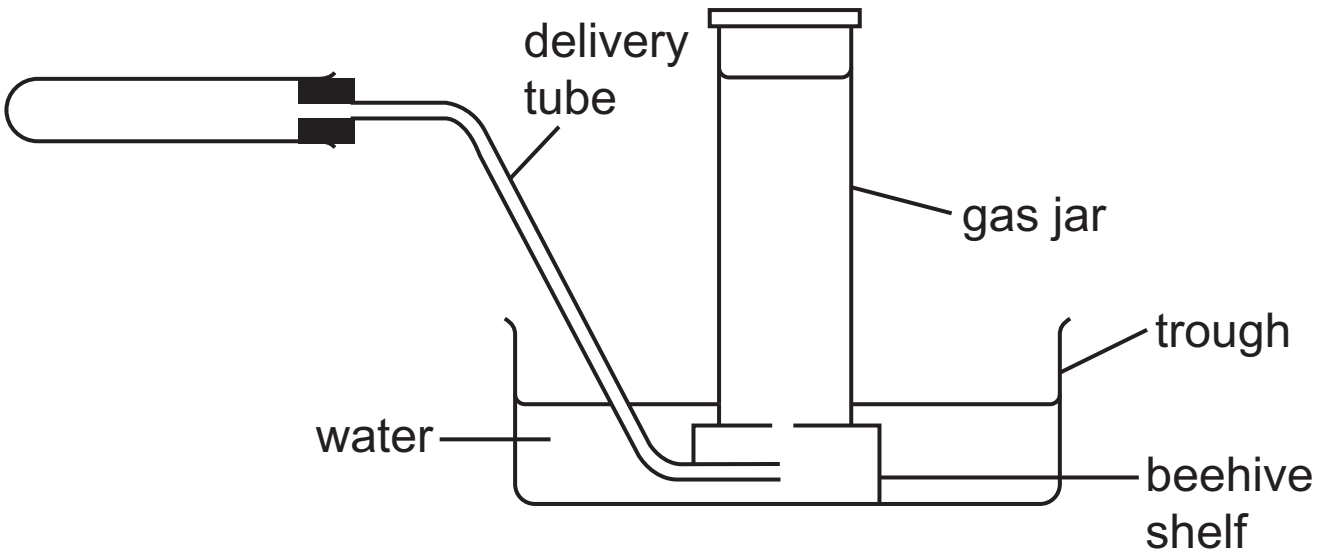
_____

(b) Aluminium metal reacts with steam when heated. The word equation for the reaction is:

aluminium + steam → aluminium oxide + hydrogen

(i) Write a balanced symbol equation for this reaction. Include state symbols. [4 marks]

(ii) The apparatus below was used to react aluminium with steam. A small amount of hydrogen was produced.



Show the position of the following on the diagram using the letter indicated in the table below. [3 marks]

Letter label	Apparatus/chemicals
A	damp mineral wool
B	aluminium
C	hydrogen

(iii) Explain, in terms of oxygen content, why the reaction of aluminium with steam is described as a redox reaction. [5 marks]

(c) Based on your knowledge of the reactivity of metals, predict which of the following reactions would occur. Place a tick (✓) in the right-hand box for any reactions which would occur. [1 mark]

aluminium + zinc sulfate solution	
copper + steam	
zinc + sodium chloride solution	
magnesium + steam	

(d) The following two half equations represent the processes which occur during a chemical reaction between magnesium and copper(II) ions in solution.

Half equation 1: $Mg \rightarrow Mg^{2+} + 2e^-$

Half equation 2: $Cu^{2+} + 2e^- \rightarrow Cu$

(i) Which half equation represents an oxidation reaction? Explain your answer. [1 mark]

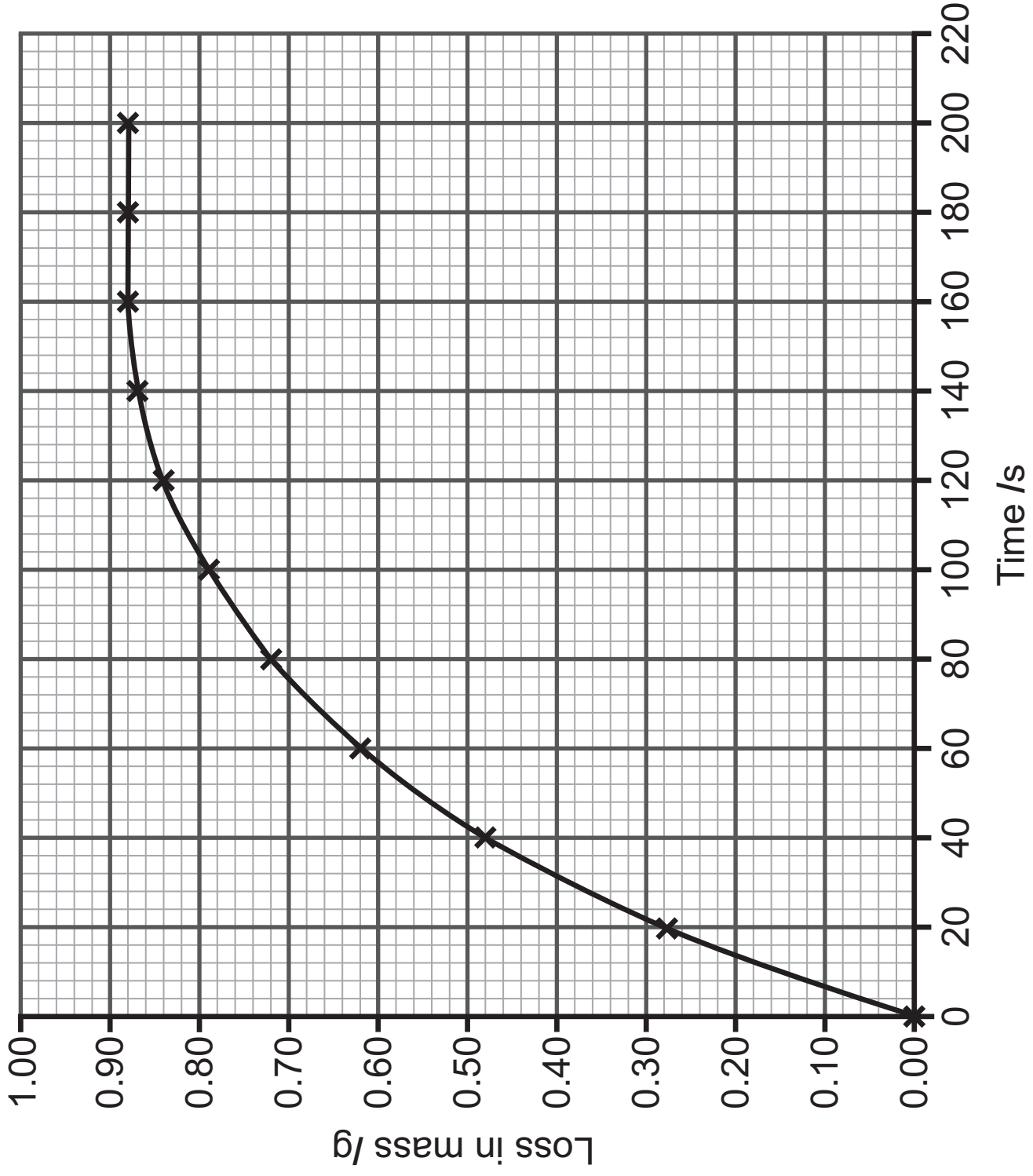
_____

(ii) State the colour change of the solution during this reaction. [2 marks]

From _____

to _____

2 In an experiment, 2.0 g of marble chips (calcium carbonate) and 25 cm^3 of 2.0 mol/dm^3 hydrochloric acid (an excess) were reacted in a conical flask at room temperature.
The mass of the reaction mixture was recorded and, from the data obtained, a graph of loss in mass against time was drawn. The graph is shown below.



(a) What was the total loss in mass? [1 mark]

_____

(b) At what time did the reaction finish? [1 mark]

_____

(c) Describe how the experiment was carried out to obtain the data needed to draw the graph. Include the apparatus required. [6 marks]

In this question you will be assessed on your written communication skills including the use of specialist scientific terms.

(d) On the axes on page 6, sketch the graph you would expect to obtain if a sample of 2.0 g of marble chips was reacted with 25 cm^3 of 3.0 mol/dm^3 hydrochloric acid at room temperature. [1 mark]

(e) A student analysed the original graph and made the following conclusion:

The rate of the reaction decreases as the reaction proceeds.

(i) Explain how the graph supports the conclusion above. [1 mark]

(ii) Explain, in terms of particles, why the rate of reaction decreases as the reaction proceeds. [3 marks]

3 Organic compounds are classified into different homologous series. All the compounds in a homologous series have the same general formula. Some homologous series are hydrocarbons.

(a) (i) State one feature which is **similar** for all compounds of a homologous series. [1 mark]

_____

_____

(ii) State one way in which successive members of a homologous series differ from each other. [1 mark]

_____

_____

(iii) What is meant by the term hydrocarbon? [1 mark]

_____

_____

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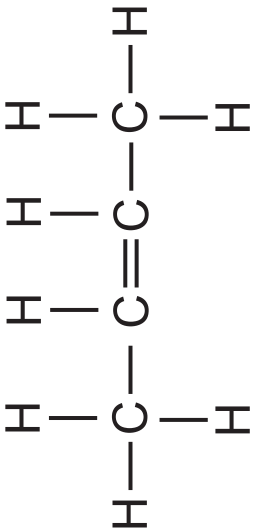
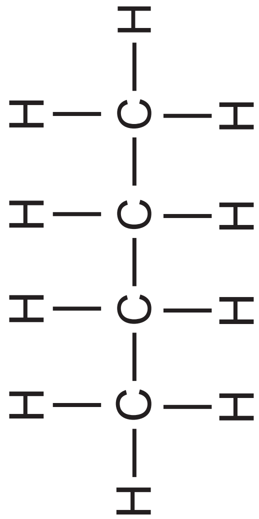
(Questions continue overleaf)

(b) The table below shows some details of four organic compounds, **A**, **B**, **C** and **D**.

	Homologous series	**Number of carbon atoms**	**Name**	**Structural formula**	**Molecular formula**
A	Alkene				
B		3	propan-2-ol		
C			butane		
D	Carboxylic acid	1			

(i) Complete the table. [8 marks]

(ii) Which of the organic compounds in the table (**A**, **B**, **C**, **D**) would react with acidified potassium dichromate solution? State the colour change observed. [2 marks]

_____

_____

(iii) Write a balanced symbol equation for the complete combustion of **A**. [3 marks]

_____

(iv) Name the reagent required to convert **A** into **C**. [1 mark]

_____

(v) Carboxylic acid **D** is a weak acid. What is meant by the term weak acid? [1 mark]

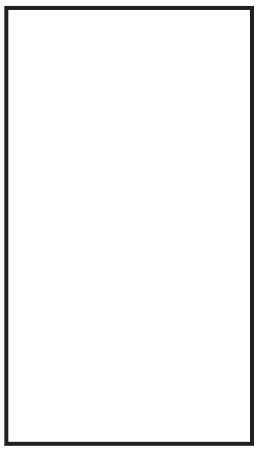
_____

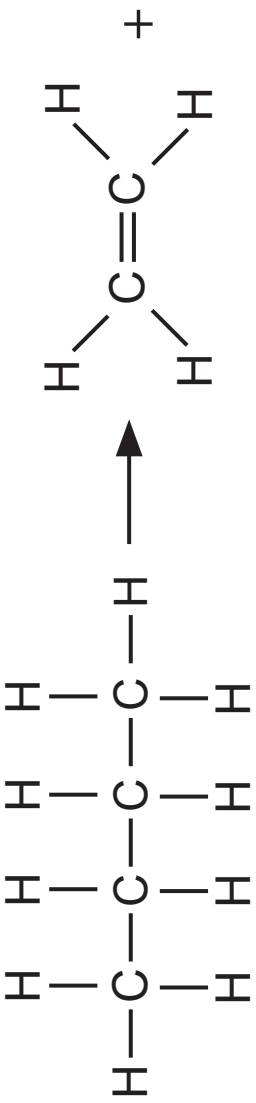
(vi) **A** can undergo polymerisation. State the type of polymerisation. [1 mark]

_____

(c) Butane can undergo cracking to form two gaseous products, one of which is unsaturated.

(i) Complete the equation for this cracking reaction by drawing the structure of the second product in the box. [1 mark]

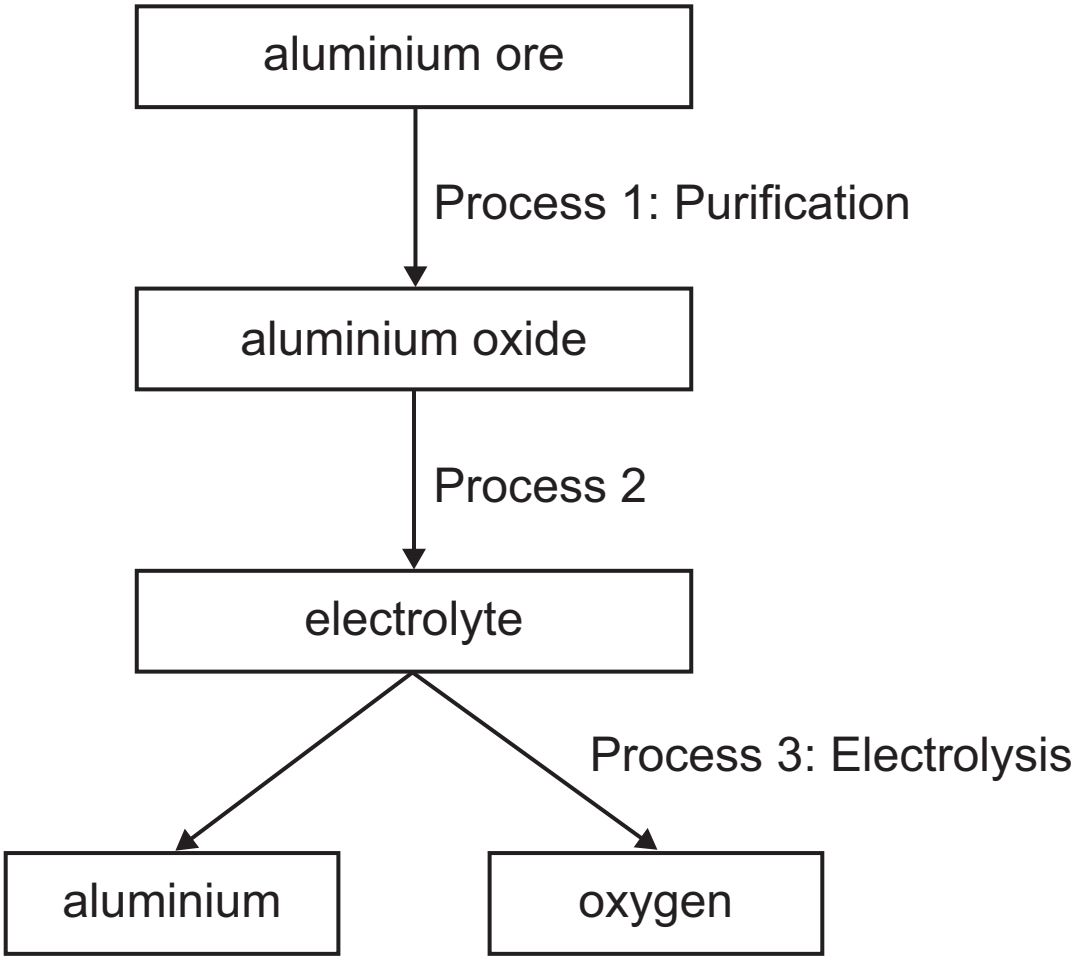




(ii) Describe how you would test for the presence of the unsaturated product. [2 marks]

4 Many useful materials, such as aluminium, iron and plastics, are produced from the Earth's natural resources.

(a) The flow scheme below shows the main processes involved in the production of aluminium from its ore.



(i) Name the ore from which aluminium is extracted. [1 mark]

_____

(ii) What name is used for the purified aluminium oxide formed in Process 1? [1 mark]

_____

(iii) How is the electrolyte made in Process 2?
[1 mark]

_____

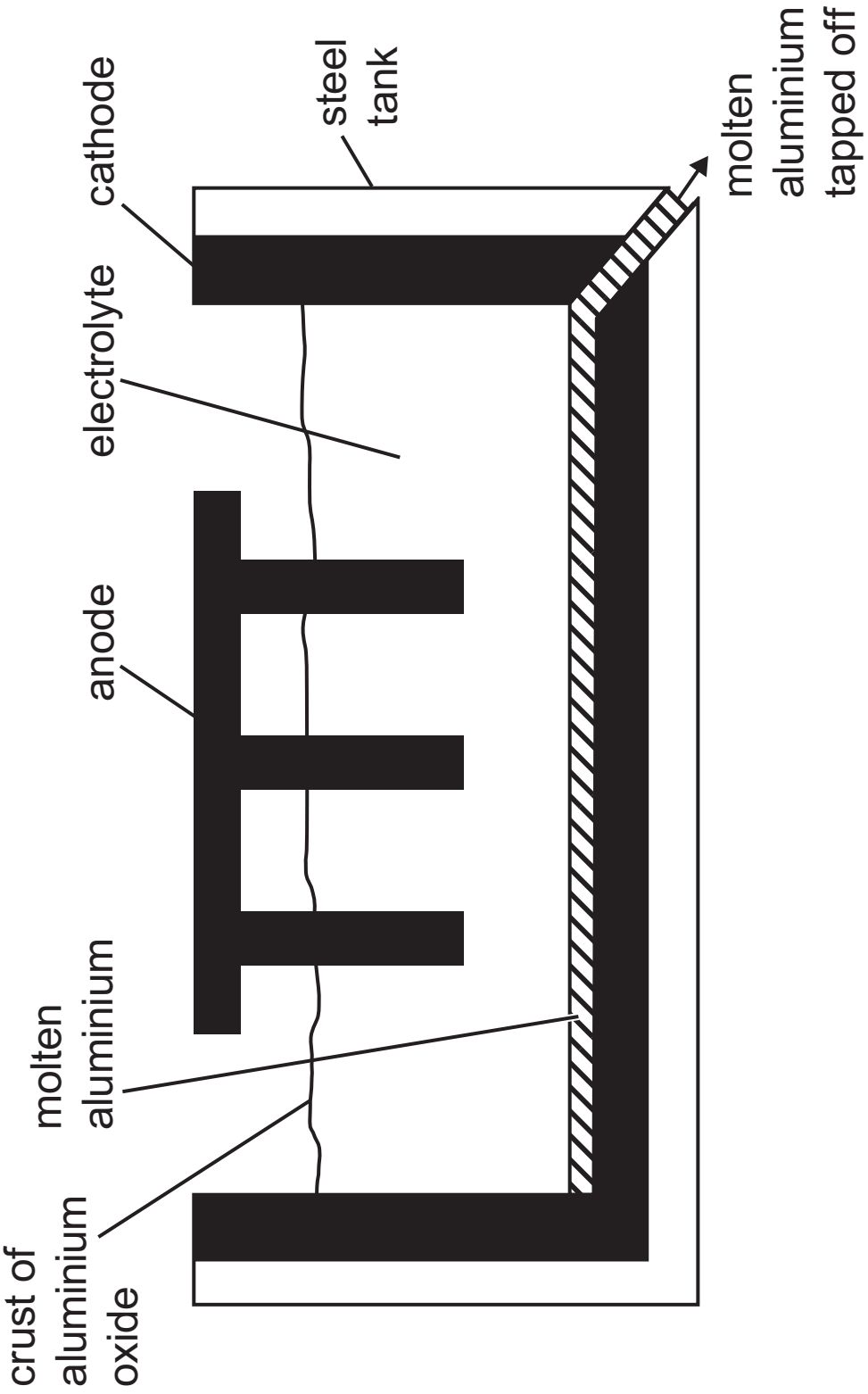
_____

(iv) What is meant by the term electrolyte? [1 mark]

_____

_____

(b) The diagram below shows the industrial apparatus used to extract aluminium from the electrolyte. Aluminium is produced at the cathode and oxygen gas is produced at the anode. The anode and cathode are made of graphite.



(i) State one function of the crust of aluminium oxide. [1 mark]

_____

(ii) What is the operating temperature of this process? [1 mark]

_____

(iii) State two reasons why the electrodes are made of graphite. [2 marks]

1. _____

_____

2. _____

_____

(iv) Describe one problem which occurs due to the use of graphite for the electrodes. [1 mark]

_____

_____

(v) Write half equations for the production of aluminium at the cathode and the production of oxygen at the anode. [6 marks]

Cathode: _____

Anode: _____

5 **(a)** In an experiment, a sample of 0.325 g of **impure** zinc metal was reacted with 25.0 cm^3 of 2.0 mol/dm^3 hydrochloric acid in a conical flask. The volume of hydrogen gas produced was measured using a gas syringe.

The equation for the reaction is:

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$

The total volume of hydrogen gas collected was 90 cm^3.

(i) Draw a labelled diagram of the assembled apparatus used to carry out the experiment. [4 marks]

(ii) Calculate the mass of zinc in the impure sample. [3 marks]

mass of zinc = _____ g

(iii) Calculate the percentage of zinc in the impure sample. [1 mark]

percentage = _____ **%**

(b) A sample of 3.72 g of an unknown metal hydroxide, $M(OH)_2$, was dissolved in 250 cm^3 of deionised water in a volumetric flask. 25.0 cm^3 samples of this solution were titrated against 0.25 mol/dm^3 hydrochloric acid using phenolphthalein indicator. The average titre was determined to be 17.4 cm^3.

The equation for the reaction may be represented as:

$$M(OH)_2 + 2HCl \rightarrow MCl_2 + 2H_2O$$

(i) State the colour change at the end point of this titration. [2 marks]

From _____

to _____

(ii) Calculate the number of moles of hydrochloric acid used. [1 mark]

moles of hydrochloric acid = _____

(iii) Calculate the number of moles of $M(OH)_2$ present in 25.0 cm^3. [1 mark]

moles of $M(OH)_2$ = _____

(iv) Calculate the number of moles of $M(OH)_2$ present in 250 cm^3. [1 mark]

moles of $M(OH)_2$ = _____

(v) Using the initial mass of the unknown metal hydroxide and your answer to **(b)(iv)**, calculate the relative formula mass (M_r) of $M(OH)_2$. [1 mark]

relative formula mass (M_r) = _____

(vi) Using your answer to **(b)(v)**, calculate the relative atomic mass (A_r) of M and determine its identity. [2 marks]

relative atomic mass (A_r) = _____

identity of M = _____

6 **(a)** The reaction between methane and water vapour is a reversible reaction producing hydrogen. Carbon dioxide is a waste product.

$$CH_4(g) + 2H_2O(g) \rightleftharpoons CO_2(g) + 4H_2(g)$$

The energy change of the reaction is +150 kJ.

(i) State and explain how the yield of hydrogen would change as temperature increases. [3 marks]

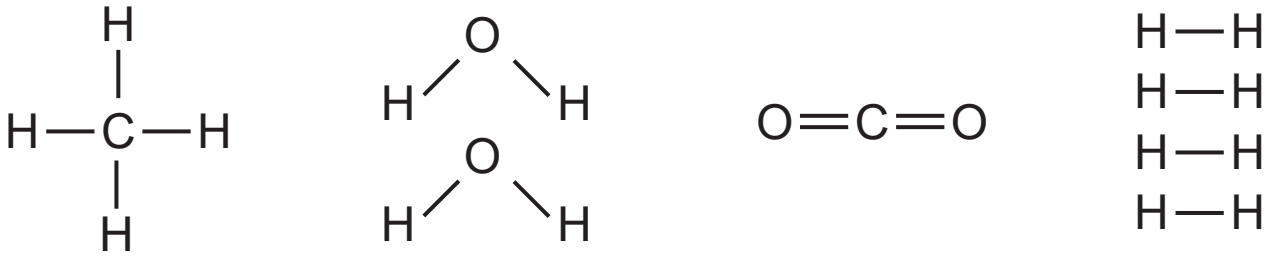
(ii) Explain why the yield of hydrogen decreases as pressure increases. [2 marks]

(iii) Calculate the percentage atom economy of this reaction. Give your answer to 1 decimal place. Show your working out. [3 marks]

percentage atom economy = _____ **%**

(b) The diagram below shows the molecules present in the reactants and products for the reaction in **(a)**.
The energy change of the reaction is +150 kJ.

$CH_4(g) + 2H_2O(g) \rightleftharpoons CO_2(g) + 4H_2(g)$



The table below gives the bond energies of some of the covalent bonds present in the molecules in this reaction.

Bond	**Bond energy /kJ**
C—H	412
O—H	missing value
C=O	803
H—H	436

Using the values in the table and the energy change of the reaction, calculate the O—H bond energy.
[4 marks]

O—H bond energy = _____ kJ

This is the end of the question paper

For Examiner's use only	
Question Number	**Marks**
1	
2	
3	
4	
5	
6	
Total Marks	

Examiner Number

SYMBOLS OF SELECTED IONS

Positive ions

Name	Symbol
Ammonium	NH_4^+
Chromium(III)	Cr^{3+}
Copper(II)	Cu^{2+}
Iron(II)	Fe^{2+}
Iron(III)	Fe^{3+}
Lead(II)	Pb^{2+}
Silver	Ag^+
Zinc	Zn^{2+}

Negative ions

Name	Symbol
Butanoate	$C_3H_7COO^-$
Carbonate	CO_3^{2-}
Dichromate	$Cr_2O_7^{2-}$
Ethanoate	CH_3COO^-
Hydrogencarbonate	HCO_3^-
Hydroxide	OH^-
Methanoate	$HCOO^-$
Nitrate	NO_3^-
Propanoate	$C_2H_5COO^-$
Sulfate	SO_4^{2-}
Sulfite	SO_3^{2-}

SOLUBILITY IN COLD WATER OF COMMON SALTS, HYDROXIDES AND OXIDES

Soluble
All sodium, potassium and ammonium salts
All nitrates
Most chlorides, bromides and iodides EXCEPT silver and lead chlorides, bromides and iodides
Most sulfates EXCEPT lead and barium sulfates Calcium sulfate is slightly soluble

Insoluble
Most carbonates EXCEPT sodium, potassium and ammonium carbonates
Most hydroxides EXCEPT sodium, potassium and ammonium hydroxides
Most oxides EXCEPT sodium, potassium and calcium oxides which react with water

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Data Leaflet

Including the Periodic Table of the Elements

For the use of candidates taking
Science: Chemistry,
Science: Double Award
or Science: Single Award

Copies must be free from notes or additions of any kind. No other type of data booklet or information sheet is authorised for use in the examinations

gcse examinations

chemistry

11984.02

THE PERIODIC TABLE OF ELEMENTS

Group

1	2											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	64 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
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	98 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	178 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	261 Rf Rutherfordium 104	262 Db Dubnium 105	266 Sg Seaborgium 106	264 Bh Bohrium 107	277 Hs Hassium 108	268 Mt Meitnerium 109	271 Ds Darmstadtium 110	272 Rg Roentgenium 111	285 Cn Copernicium 112						

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	145 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	242 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	245 Bk Berkelium 97	251 Cf Californium 98	254 Es Einsteinium 99	253 Fm Fermium 100	256 Md Mendelevium 101	254 No Nobelium 102	257 Lr Lawrencium 103

* 58 – 71 Lanthanum series
† 90 – 103 Actinium series

a
X
b

a = relative atomic mass (approx)
x = atomic symbol
b = atomic number

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