Rewarding Learning

Centre Number

Candidate Number

General Certificate of Secondary Education
2016

GCSE Chemistry

Unit 2
Higher Tier

MV18

[GCH22]

WEDNESDAY 22 JUNE, MORNING

Time

1 hour 45 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.
Complete in blue or black ink only.
Answer **all six** questions.

Information for Candidates

The total mark for this paper is 115.
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 Questions **2(c)(iii)** and **4(a)**.
A Data Leaflet, which includes a Periodic Table of the Elements, is included in this question paper.

1 (a) The first national report examining the impact of water fluoridation on children was published in 2014. The dental health of five year olds and twelve year olds living in fluoridated water and non-fluoridated water areas was measured.

Data from this report is shown in the table below.

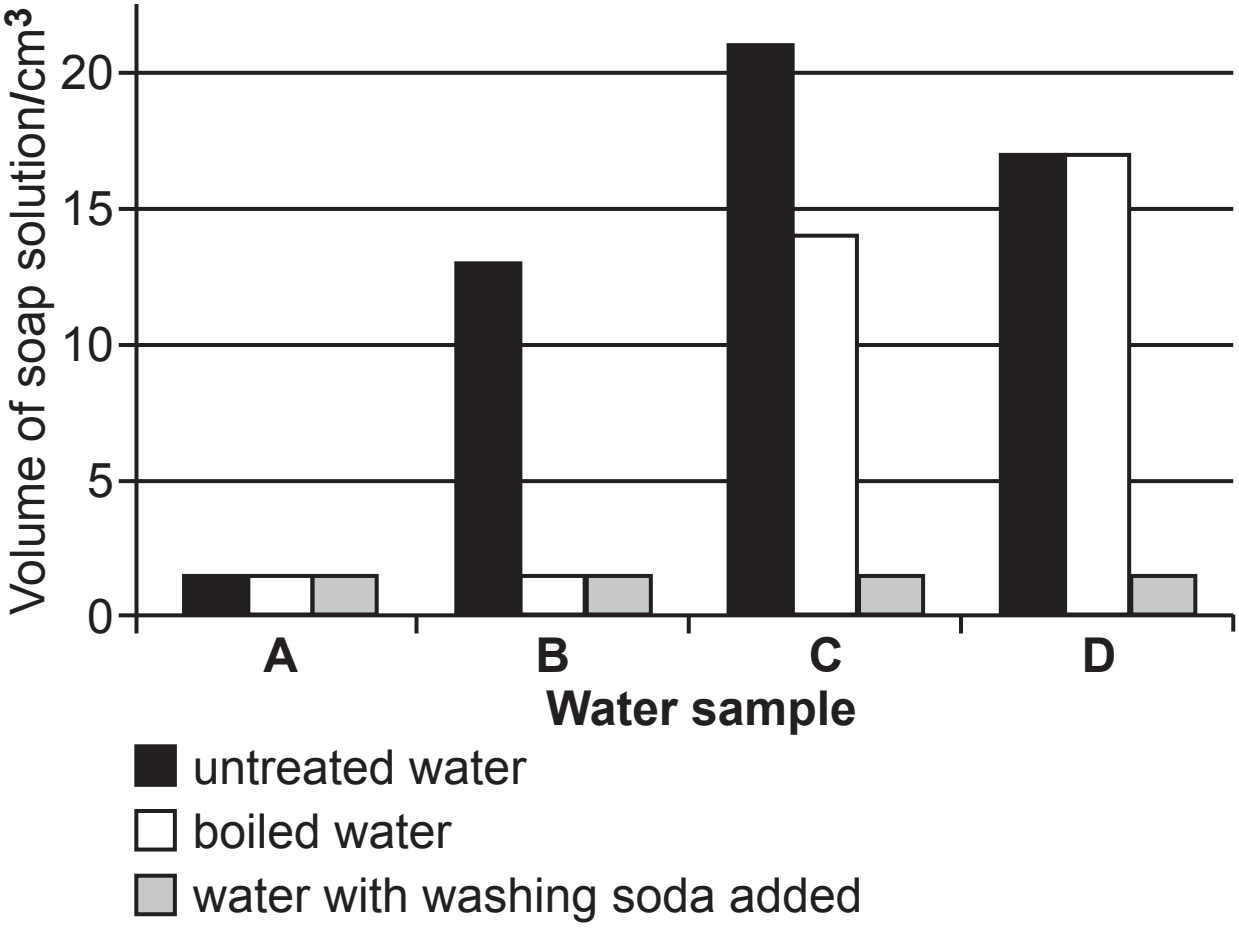
	In fluoridated water areas	In non-fluoridated water areas
% of twelve year olds with tooth decay	22	37
% of five year olds with tooth decay	13	42
% of hospital admissions for children aged 1–4 for tooth decay	2	20

(i) **Use the data** in the table to deduce the effect, if any, of the presence of fluoride in water on the dental health of children. [2 marks]

(ii) State one reason why some people are against the fluoridation of drinking water. [1 mark]

(b) Four samples of water, A, B, C and D, were tested for hardness. Soap solution was added, with shaking, to each of the four 20.0 cm^3 samples of water. The volume of soap solution required to produce 1 cm height of lather was recorded.

The experiment was repeated, with fresh boiled samples of water and then again with fresh samples of water which had been treated with washing soda. The results of the experiment are shown below.



(i) What is meant by the term hard water? [1 mark]

_____

_____

(ii) Which one of the samples, A, B, C or D is the hardest water? Explain your answer. [2 marks]

Sample: _____

_____

_____

_____

(iii) What type of hardness is present in the following samples? [2 marks]

Sample B _____

Sample D _____

(iv) Name a substance which could cause the hardness in the following samples? [2 marks]

Sample B _____

Sample D _____

(v) What is the chemical name for washing soda? [1 mark]

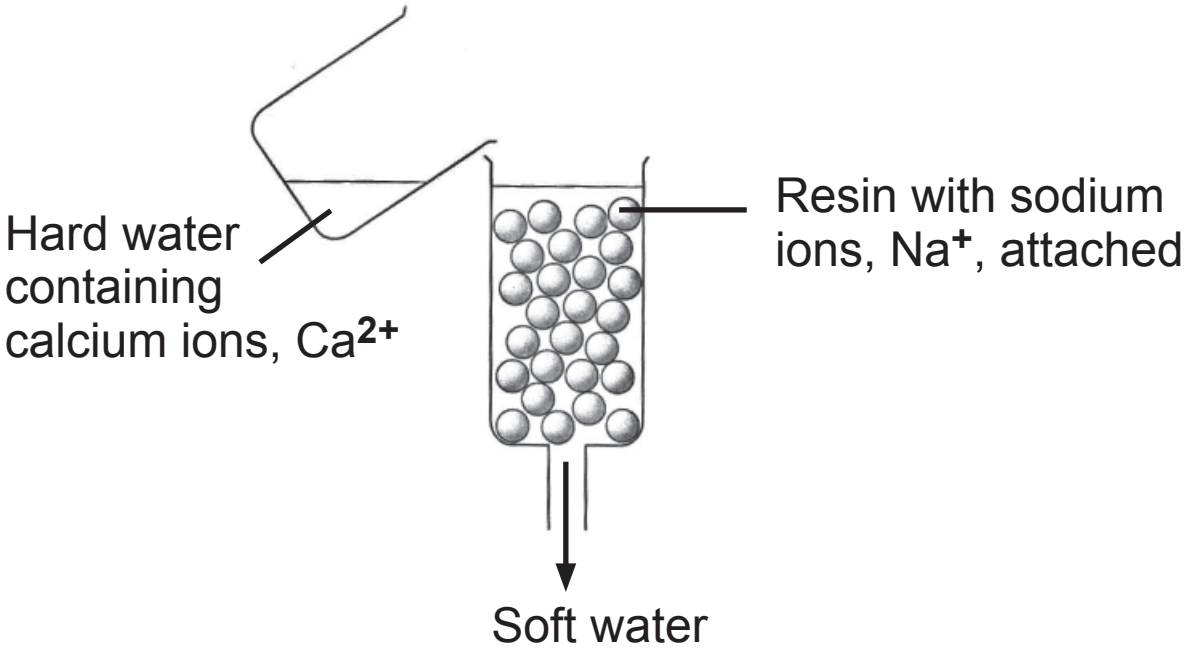
_____

(vi) Explain why hard water is considered to be good for your health. [1 mark]

_____

_____

(c) The diagram below shows a method used to soften hard water.



(i) What is the name for this method of softening hard water? [1 mark]

_____

(ii) Explain how this method softens hard water. [2 marks]

_____

_____

_____

(iii) Explain why this method will stop working after continued use. [1 mark]

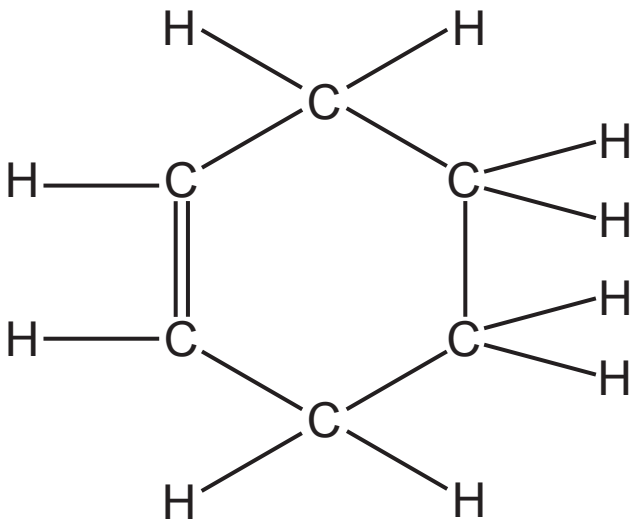
_____

_____

2 Cyclohexene, cyclohexanol and ethanoic acid are colourless liquids at room temperature. Each one belongs to a different homologous series.

(a) What is meant by the term homologous series? [3 marks]

(b) The colourless liquid cyclohexene is a hydrocarbon with the molecular formula C_6H_{10}. The structural formula of cyclohexene is shown below. It undergoes similar reactions to ethene and propene.



(i) What is the functional group in cyclohexene? [1 mark]

(ii) Why is cyclohexene described as a hydrocarbon?
[1 mark]

_____

_____

(iii) Name the two **compounds** formed when cyclohexene is burned in a limited supply of oxygen.
[2 marks]

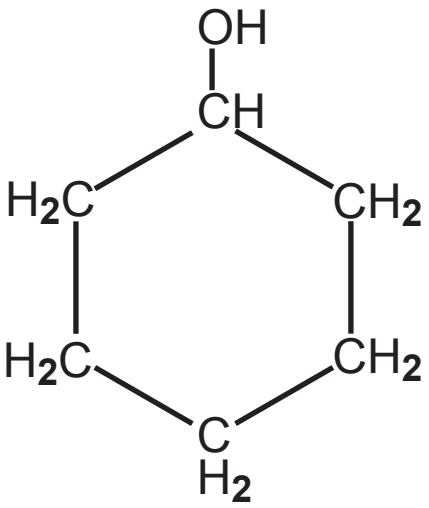
1. _____

2. _____

(iv) What is the empirical formula of cyclohexene?
[1 mark]

_____

(c) The colourless liquid cyclohexanol has the molecular formula $C_6H_{11}OH$ and the structural formula is shown below. It undergoes similar reactions to ethanol and methanol.



(i) What is the functional group in cyclohexanol? [1 mark]

_____

(ii) Write a balanced symbol equation for the complete combustion of cyclohexanol ($C_6H_{11}OH$). [3 marks]

_____

(iii) Describe, giving practical details, the chemical tests you would use to identify cyclohexene and cyclohexanol.

Your answer should include:

- Names of the chemicals used to carry out the tests
- Conditions if appropriate
- Observations for each test.

In this question you will be assessed on your written communication skills including the use of specialist scientific terms. [6 marks]

(d) The colourless liquid ethanoic acid has a sharp smell and is used, in solution, as vinegar to flavour food.

(i) Write the molecular formula of ethanoic acid.
[1 mark]

_____

(ii) Draw the structural formula of ethanoic acid.
[1 mark]

(iii) Why is ethanoic acid described as a weak acid?
[1 mark]

_____

(iv) Write a balanced symbol equation for the reaction of solid sodium carbonate with ethanoic acid.
[3 marks]

_____

(v) State **two** observations which would occur when solid sodium carbonate reacts with ethanoic acid.
[2 marks]

1. _____

2. _____

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3 Hydrogen peroxide decomposes rapidly into water and oxygen in the presence of a catalyst. A catalyst works by lowering the minimum energy required for a reaction to occur.

(a) (i) Write a balanced symbol equation for the decomposition of hydrogen peroxide. [3 marks]

_____

(ii) Name the catalyst used for this reaction in the laboratory. [1 mark]

_____

(iii) What is meant by the term catalyst? [3 marks]

_____

_____

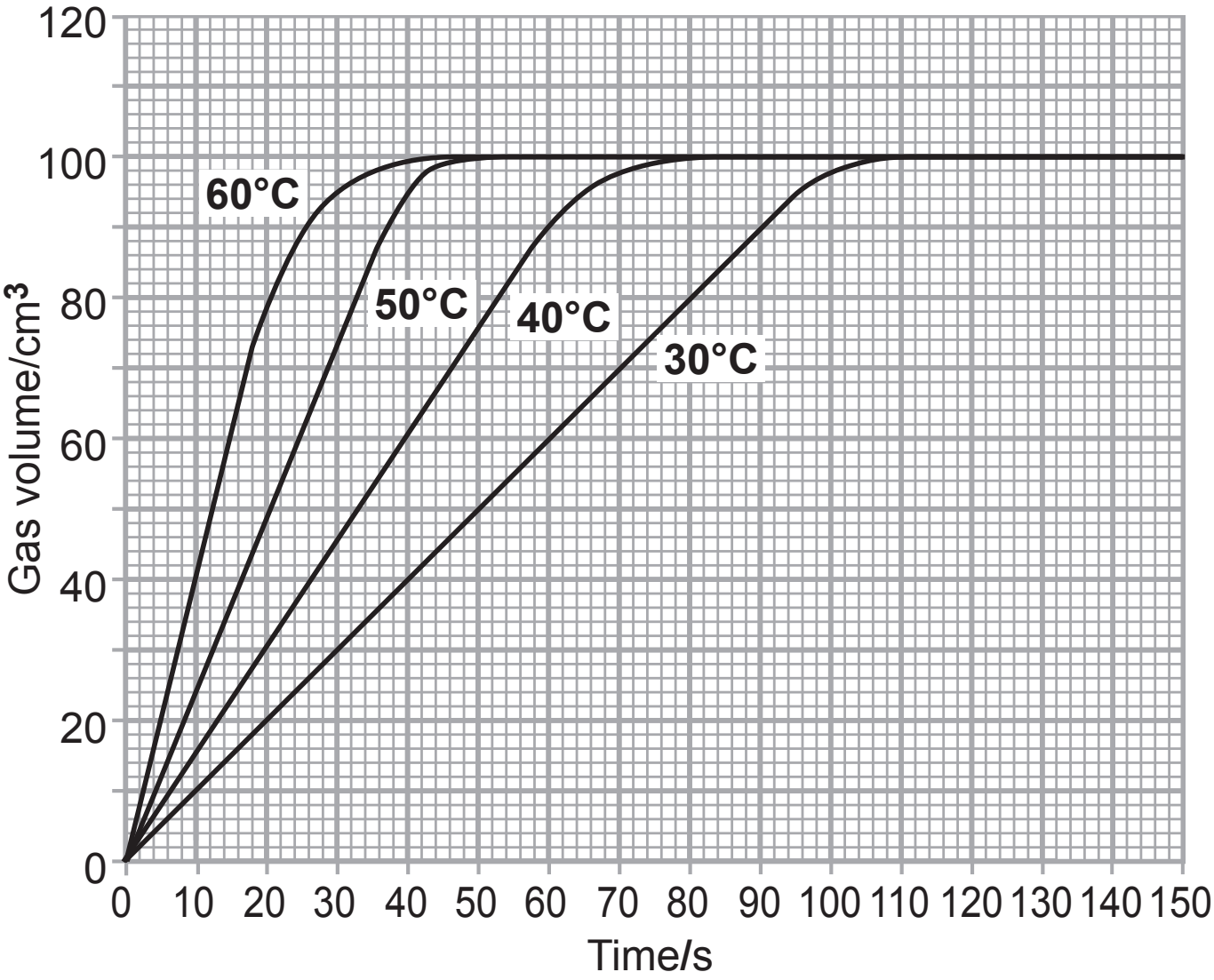
_____

_____

(iv) What is the name given to the minimum energy required for a reaction to occur? [1 mark]

_____

(b) The volume of gas produced by the catalytic decomposition of hydrogen peroxide was measured at four different temperatures. The results were plotted on the graph below.

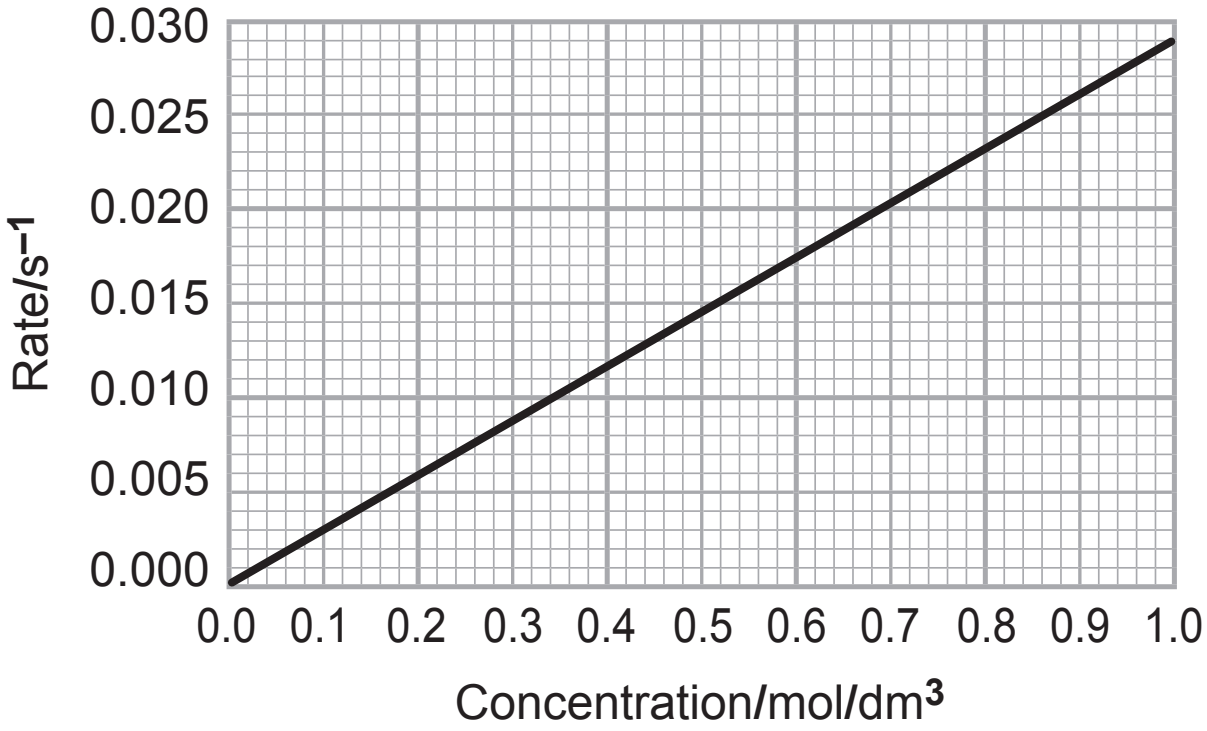


(i) Complete the table below giving the time taken for the reaction to finish at 60 °C. Calculate the rate based on this time. [2 marks]

Temperature (°C)	Time taken for reaction to finish (s)	Rate = $\frac{1}{\text{time}}$ (s^{-1})
30	108	0.00926
40	79	0.01266
50	48	0.02083
60		

(ii) From the table, state how rate changes as temperature changes. [1 mark]

(c) The graph below shows the relationship between the concentration of hydrogen peroxide solution and the rate of the reaction at 20° C.



(i) What is the rate when the concentration of hydrogen peroxide is 0.34 mol/dm^3? State the units. [1 mark]

_____

(ii) From the graph, state how rate changes as concentration changes. [1 mark]

_____

_____

_____

(iii) On the axes above, sketch the graph you would expect to obtain if the experiment were repeated at 10 °C. [2 marks]

4 (a) Acid rain has been a major environmental problem for decades. Sulfur impurities in fossil fuels contribute to acid rain.

Describe in detail how these sulfur impurities lead to the formation of acid rain. Describe the effects of acid rain and methods used to prevent it.

Your answer should include:

- A description of how sulfur impurities lead to the formation of acid rain. (Include balanced symbol equations.)
- At least two detrimental effects of acid rain on the environment.
- At least two methods used to prevent acid rain.

In this question you will be assessed on your written communication skills including the use of specialist scientific terms. [9 marks]

(b) The presence of nitrogen dioxide, NO_2, in the atmosphere can also cause acid rain. Nitrogen dioxide is formed naturally by the reaction between atmospheric nitrogen and oxygen in an endothermic reaction.

$$N_2 + 2O_2 \rightarrow 2NO_2$$

Explain in terms of bonds why this reaction is endothermic. [5 marks]

5 (a) The reactivity of metals can be studied using displacement reactions. If a displacement reaction occurs there is a temperature rise.

In an experiment the following method was used:

- Pour some copper(II) sulfate solution into a polystyrene cup and record the temperature of the solution.
- Add a known mass of metal and stir.
- Record the maximum temperature of the mixture.
- Repeat the experiment.

The results of this experiment are shown in the table below.

Metal	**Temperature increase (°C)**		**Average temperature rise (°C)**
	Experiment 1	**Experiment 2**	
magnesium	11.5	16.5	14.0
silver	0.0	0.0	0.0
iron	3.0	4.0	3.5
gold	0.0	0.0	0.0
zinc	7.0	8.0	7.5

(i) State two factors which should be kept the same in this experiment to make it a fair test. [2 marks]

1. _____

2. _____

(ii) State and explain which of the metals gave the least reliable temperature rise. [1 mark]

_____

_____

(iii) State and explain which of the metals used in the experiment is the most reactive. [2 marks]

_____

_____

(iv) Explain why there is no temperature rise when silver is added to copper(II) sulfate solution. [1 mark]

_____

(v) Why do the results make it impossible to decide which of the metals is the least reactive? [1 mark]

_____

_____

(vi) Write a balanced symbol equation for the displacement reaction between zinc and copper(II) sulfate solution. [2 marks]

_____

(b) Metals are extracted from their ores using different methods. In the extraction of iron, haematite, coke and limestone are added to the Blast Furnace.

(i) Name the chemical compound present in:
[2 marks]

haematite _____

limestone _____

(ii) The following equations represent reactions which occur in the Blast Furnace.

Reaction A $C + O_2 \rightarrow CO_2$

Reaction B $CaCO_3 \rightarrow CaO + CO_2$

Reaction C $C + CO_2 \rightarrow 2CO$

Reaction D $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

Reaction E $CaO + SiO_2 \rightarrow CaSiO_3$

Which reaction (A, B, C, D or E) represents a reaction which best matches the descriptions below?

Each letter can be used once, more than once or not at all. [4 marks]

A decomposition reaction _____

A reaction to form the reducing agent _____

A neutralisation reaction _____

A reaction that is used to produce heat _____

(c) Aluminium is extracted from its ore by electrolysis.

(i) Name an ore of aluminium. [1 mark]

_____

(ii) Write a half equation for the production of aluminium at the cathode. [3 marks]

_____

(iii) Write a half equation for the reaction which happens at the anode during this electrolysis. [3 marks]

_____

6 This question is about the experimental reactions of some carbonates.

(a) Ammonium carbonate decomposes on heating to produce ammonia, carbon dioxide and water. Write a balanced symbol equation for this reaction. [3 marks]

_____

(b) Copper(II) carbonate reacts with hydrochloric acid according to the equation:

$$CuCO_3 + 2HCl \rightarrow CuCl_2 + CO_2 + H_2O$$

0.868 g of copper(II) carbonate were reacted with 0.175 mol/dm^3 hydrochloric acid.

(i) Calculate the number of moles of copper(II) carbonate used.
(Relative atomic masses: C = 12; O = 16; Cu = 64.)
[2 marks]

_____

(ii) Calculate the number of moles of hydrochloric acid required to react with all of the copper(II) carbonate. [2 marks]

_____

(iii) Calculate the volume (in cm^3) of 0.175 mol/dm^3 hydrochloric acid required to react with the copper(II) carbonate. [2 marks]

_____ cm^3

(c) A sample of 2.52 g of hydrated sodium carbonate, $Na_2CO_3.xH_2O$, was dissolved in deionised water.

The solution was transferred to a 250 cm^3 volumetric flask and the volume made up to 250 cm^3 using deionised water.

25.0 cm^3 portions of this solution were titrated against 0.175 mol/dm^3 hydrochloric acid using methyl orange indicator. The results of the titration are given below.

The equation for the reaction is:

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O$$

Titration	Initial burette volume (cm^3)	Final burette volume (cm^3)	Titre (cm^3)
Rough	0.0	18.6	18.6
First Accurate Titration	18.6	36.6	18.0
Second Accurate Titration	0.0	18.0	18.0

(i) State the colour change observed at the end point. [2 marks]

From _____ to _____

(ii) Calculate the average titre. [2 marks]

_____ cm^3

(iii) Calcuate the number of moles of hydrochloric acid used. [2 marks]

_____

(iv) Calculate the number of moles of sodium carbonate present in 25.0 cm^3 of the solution. [2 marks]

_____

(v) Calculate the number of moles of sodium carbonate present in 250 cm^3 of the solution. [1 mark]

_____

(vi) Using the initial mass of $Na_2CO_3.xH_2O$ added and the answer to part **(v)**, calculate the relative formula mass (RFM) of $Na_2CO_3.xH_2O$. [2 marks]

_____

(vii) Calculate the value of x.
(Relative atomic masses: H = 1; C = 12; O = 16; Na = 23) [2 marks]

_____

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Question Number	**Marks**
1	
2	
3	
4	
5	
6	
Total Marks	

Examiner Number

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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
Carbonate	CO_3^{2-}
Dichromate	$Cr_2O_7^{2-}$
Ethanoate	CH_3COO^-
Hydrogen carbonate	HCO_3^-
Hydroxide	OH^-
Methanoate	$HCOO^-$
Nitrate	NO_3^-
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

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

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Rewarding Learning

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	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	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	263 Sg Seaborgium 106	262 Bh Bohrium 107	265 Hs Hassium 108	266 Mt Meitnerium 109	269 Ds Darmstadtium 110	272 Rg Roentgenium 111	285 Cn Copernicium 112						

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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
b x

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