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ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2023

Centre Number

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Candidate Number

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Chemistry

StemUp Model Solution

Assessment Unit AS 3

assessing

Module 3: Practical Examination

Practical Booklet B (Theory)



[SCH32]

SCH32

THURSDAY 1 JUNE, MORNING

TIME

1 hour 15 minutes.

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 outside the boxed area on each page or on blank pages.

Complete in black ink only. **Do not write with a gel pen or a pencil.**

Answer **all four** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 55.

Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

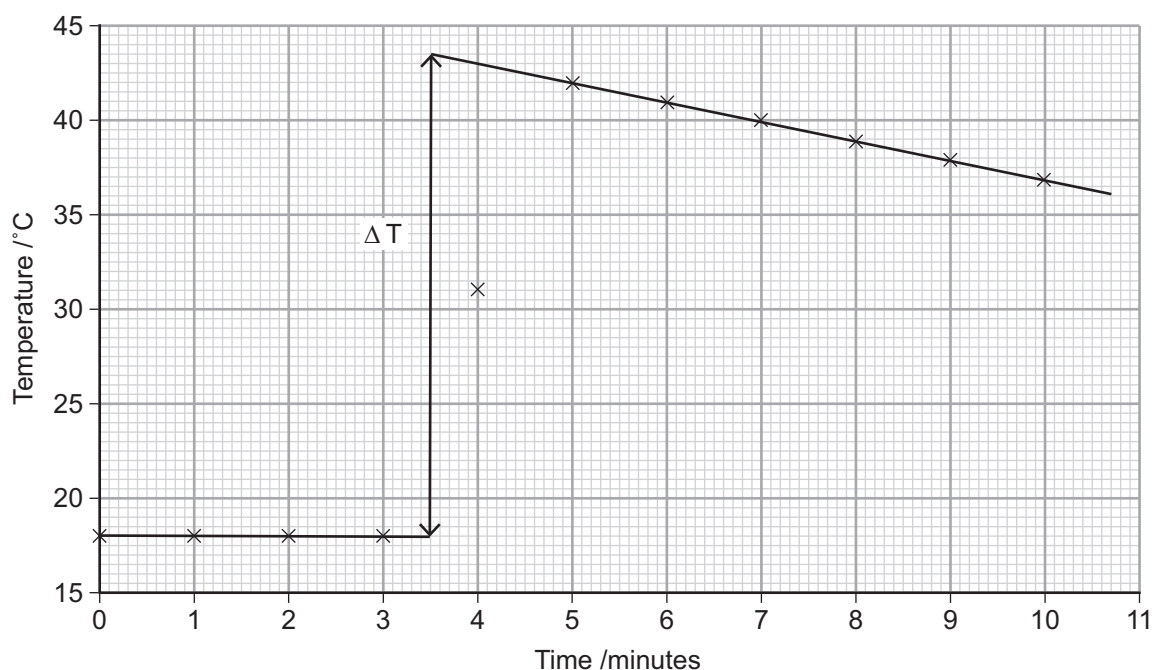
A Periodic Table of Elements (including some data) is provided.



1 The enthalpy change for the reaction between zinc and copper(II) sulfate solution was determined using the method below.

1. Weigh 2.50 g of zinc powder.
2. Measure 25 cm^3 of 0.50 mol dm^{-3} copper(II) sulfate solution using a measuring cylinder and transfer the solution into a polystyrene cup.
3. Stir the solution continuously with a thermometer and record the temperature of the solution at 1 minute intervals up to 3 minutes.
4. At exactly 3.5 minutes add the zinc powder to the copper(II) sulfate solution.
5. Continue to stir the solution and record the temperature each minute from 4 to 10 minutes.

The results obtained are shown on the graph below. Two straight lines of best fit have been drawn on the graph, one from 0.0 to 3.5 minutes and the other from 5.0 to 10.0 minutes extrapolating back to 3.5 minutes.



- (a) Use the lines of best fit to determine the temperature change, ΔT , at 3.5 minutes.

$$\Delta T = 43.5 - 18.0 = 25.5 \text{ }^{\circ}\text{C}$$

Answer 25.5 $^{\circ}\text{C}$ [2]

- (b) (i) Use the answer from (a) to calculate the heat produced in the reaction in kJ. Give your answer to 2 decimal places.

$$\begin{aligned}\text{heat} &= m c \Delta T = 25 \times 4.2 \times 25.5 \\ &= 2677.5 \text{ J} \\ &= 2.6775 \text{ kJ}\end{aligned}$$

Answer 2.68 kJ [2]

- (ii) State two assumptions you made when carrying out the calculation in (b)(i).

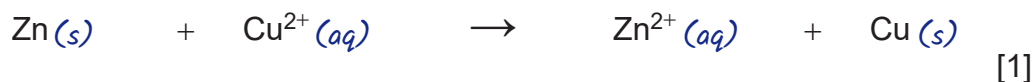
The density of the solution is 1 g cm^{-3} (so 25 cm^3 has a mass of 25 g).

The specific heat capacity of the solution is $4.2 \text{ J g}^{-1} \text{ K}^{-1}$ (the same as water).

[2]

- (c) The 2.50 g of zinc powder is an excess.

- (i) The ionic equation for the reaction is given below. Add state symbols to this ionic equation.



- (ii) Calculate the number of moles of copper(II) sulfate in 25 cm^3 of the solution.

$$\text{moles} = 25 \times 0.50 \div 1000$$

Answer 0.0125 mol [1]

[Turn over]



- (iii) Calculate the minimum mass of zinc powder required to react with the copper(II) sulfate solution.

$$\text{mass Zn} = 0.0125 \times 65$$

Answer 0.8125 g [1]

- (iv) Use your answers to (b)(i) and (c)(ii) to calculate the enthalpy change for the reaction in kJ mol^{-1} . Give your answer to 2 significant figures.

$$\begin{aligned}\Delta H &= - \text{heat} \div \text{moles} = - 2.68 \div 0.0125 \\ &= - 214.4 \text{ kJ mol}^{-1} \\ &= - 210 \text{ kJ mol}^{-1} \text{ (2 s.f.)}\end{aligned}$$

Answer - 210 kJ mol^{-1} [3]

- (v) Describe how the presence of sulfate ions in the solution could be confirmed.

Add a few drops of dilute hydrochloric acid, then barium chloride
solution.

A white precipitate (of barium sulfate) forms, confirming sulfate
ions. [2]

- (d) State the flame test colour for copper(II) ions.

Blue-green [1]





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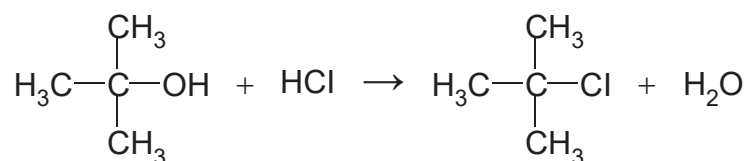
(Questions continue overleaf)

13621.07 R

[Turn over



- 2 The halogenoalkane 2-chloro-2-methylpropane may be prepared by the reaction between 2-methylpropan-2-ol and concentrated hydrochloric acid.



The steps of a method are:

1. Measure approximately 6.5 cm^3 of 2-methylpropan-2-ol using a measuring cylinder. Record the mass of the measuring cylinder and the alcohol.
2. Transfer the alcohol into a separating funnel and record the mass of the measuring cylinder after transfer.

Mass of measuring cylinder and alcohol = 157.55g

Mass of measuring cylinder after transfer = 152.45g

3. Measure approximately 20 cm^3 (an excess) of concentrated hydrochloric acid using a measuring cylinder and gradually add the acid to the 2-methylpropan-2-ol in the separating funnel.
4. Stopper the funnel and shake the mixture periodically over the next 15 minutes.
5. Allow the mixture to stand until two layers appear, remove the stopper and separate the layers. Discard the aqueous layer.
6. Slowly add 10 cm^3 of sodium hydrogencarbonate solution to the crude 2-chloro-2-methylpropane in the separating funnel. Stopper the funnel and shake the contents gently, inverting the funnel and opening the tap periodically.
7. Repeat the washing with sodium hydrogencarbonate solution until no more gas is given off.
8. Allow the layers to separate, run off and discard the aqueous layer and then run the crude 2-chloro-2-methylpropane into a clean conical flask.
9. To the liquid in the flask, add small amounts of anhydrous sodium sulfate and swirl after each addition. Remove the solid sodium sulfate.
10. Transfer the 2-chloro-2-methylpropane into a pear-shaped flask. Distil the 2-chloro-2-methylpropane (boiling point = 51°C) and record the mass of product collected.



- (a) (i) Calculate the mass of 2-methylpropan-2-ol used in the preparation.

$$157.55 - 152.45$$

Answer 5.10 g [1]

- (ii) Suggest why a measuring cylinder is used to measure the volume of concentrated hydrochloric acid rather than a more accurate piece of apparatus.

The hydrochloric acid is in excess, so its volume does not need to be measured accurately.

[1]

- (iii) Suggest why the concentrated hydrochloric acid is added **gradually** to the 2-methylpropan-2-ol in Step 3.

The addition is exothermic, so adding it slowly lets the heat dissipate.

[1]

- (iv) Explain, without reference to density values, how the aqueous layer could be identified from the organic layer in the separating funnel in Step 5.

Add a few cm³ of water to the funnel.

The layer that increases in volume is the aqueous layer.

[2]

- (v) Explain, with an equation, the purpose of adding sodium hydrogencarbonate solution to the crude 2-chloro-2-methylpropane in Step 6.

It removes (neutralises) the excess acid:



[2]

[Turn over]



- (vi) Suggest the purpose of adding anhydrous sodium sulfate in Step 9 and explain how you would know when enough has been added to the crude 2-chloro-2-methylpropane.

It acts as a drying agent (removes water). Enough has been added when the liquid goes clear.

[2]

- (vii) Describe how the solid is removed in Step 9.

Filter (or decant the liquid off the solid).

[1]

- (viii) What should be added to the contents of the pear-shaped flask in Step 10 to promote smooth boiling?

Anti-bumping granules

[1]

- (ix) The pear-shaped flask is heated in a water bath in Step 10. Suggest why the pear-shaped flask is not heated directly.

2-methylpropan-2-ol is flammable.

[1]

- (x) Suggest the effect that any impurities present in the organic product will have on its boiling point.

Increases the boiling point (boils over a wider range).

[1]

- (b) Assuming a 40% yield, use your answer to (a)(i) to calculate the mass of 2-chloro-2-methylpropane obtained.

$$\text{moles 2-methylpropan-2-ol} = 5.10 \div 74 = 0.0689 \text{ mol}$$

$$= \text{moles 2-chloro-2-methylpropane (1 : 1)}$$

$$\text{at 40\% yield: } 0.0689 \times 0.40 = 0.0276 \text{ mol}$$

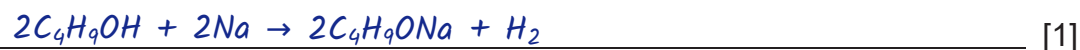
$$\text{mass} = 0.0276 \times 92.5 = 2.55 \text{ g}$$

Answer 2.55 g [3]



(c) 2-methylpropan-2-ol reacts slowly with sodium.

(i) Write an equation for the reaction between 2-methylpropan-2-ol and sodium.



(ii) Describe a test for the gas produced in the reaction in (c)(i).

Hydrogen: it gives a squeaky pop with a burning splint.

 [1]

- 3 The trend in oxidising ability of the halogens can be determined by reacting aqueous solutions of halogens with aqueous solutions of potassium halide salts.

(a) Complete the table.

Aqueous solution	Colour of aqueous solution
Chlorine	<i>pale green</i>
Bromine	<i>orange</i>
Iodine	<i>yellow-brown</i>
Potassium halide	<i>colourless</i>

[2]

- (b) A 1 cm³ portion of each aqueous halogen solution is added separately to 1 cm³ of potassium chloride solution in a test tube and any observations noted. The procedure is repeated using potassium bromide solution and also using potassium iodide solution.

- (i) Complete the following table, using a tick (✓) to indicate that a reaction occurs and a cross (X) to indicate that no reaction occurs.

	Potassium chloride	Potassium bromide	Potassium iodide
Chlorine		✓	✓
Bromine	X		✓
Iodine	X	X	

[1]

- (ii) Write an equation for the reaction of chlorine with potassium iodide.



[1]



- (iii) Some hexane was added to the test tube after the reaction of aqueous chlorine with potassium iodide solution was complete. The test tube was stoppered and shaken for one minute. The contents were allowed to settle. What would be observed?

Two layers form.

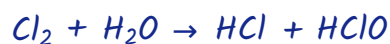
The lower (aqueous) layer is colourless.

The upper (hexane) layer is purple, as the iodine dissolves in it.

[3]

- (c) Chlorine reacts with water and with sodium hydroxide solution.

- (i) Write an equation for the reaction of chlorine with water.



[1]

- (ii) State the conditions required for the reaction between chlorine and sodium hydroxide solution which yield products containing chlorine in the same oxidation states as those in (c)(i).

Cold, dilute sodium hydroxide solution.

[1]

- (iii) Suggest why ozone is often preferred to chlorine in water treatment.

Ozone is more effective at killing bacteria and it breaks down to

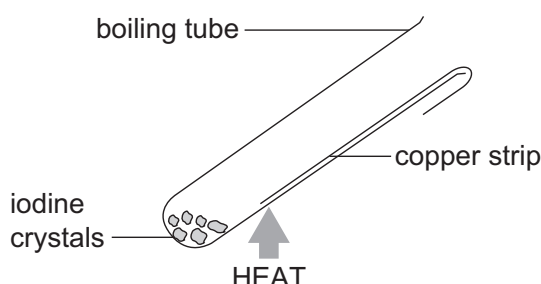
oxygen, leaving no residual chemicals or taste.

[1]

[Turn over]



- 4 The empirical formula of copper iodide may be determined using the apparatus below.



A small quantity of iodine crystals is added to the boiling tube. A clean copper strip is placed into the boiling tube and bent at one end so that it fits over the mouth of the boiling tube.

The part of the copper strip nearest the iodine crystals is heated gently in a fume cupboard until no more purple vapour is observed. Once the boiling tube is cool, the copper strip is carefully removed and reweighed. The yellow coating of copper iodide is scraped from the surface of the copper strip and the copper strip reweighed. The following results are obtained.

	Mass /g
Initial mass of copper strip	2.94
Mass of copper strip and copper iodide	3.28
Final mass of copper strip	2.77

- (a) Explain why the iodine crystals are not heated directly.

The iodine would sublime and the vapour would escape from the tube, so less iodine would react with the copper.

[1]

- (b) Suggest why the procedure is carried out in a fume cupboard.

Iodine (vapour) is toxic.

[1]



(c) Calculate the mass of iodine that reacted.

$$3.28 - 2.94$$

Answer 0.34 g [1]

(d) Calculate the mass of copper that reacted.

$$2.94 - 2.77$$

Answer 0.17 g [1]

(e) Calculate the empirical formula of the copper iodide formed.

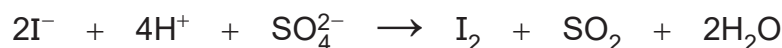
	<i>Cu</i>	<i>I</i>
<i>mass /g</i>	<i>0.17</i>	<i>0.34</i>
<i>moles</i>	$0.17 \div 64$ $= 0.00266$	$0.34 \div 127$ $= 0.00268$
<i>ratio</i>	<i>1</i>	<i>1</i>

Answer *CuI* [3]



(f) Some of the copper iodide formed was removed and placed in a test tube. A few drops of concentrated sulfuric acid were added.

(i) The ionic equation for one reaction which occurs when concentrated sulfuric acid is added to the sample of copper iodide is:



Explain, using oxidation numbers, why this is a redox reaction.

Iodine: the oxidation number changes from -1 in I^- to 0 in I_2 , an

increase, so iodide is oxidised.

Sulfur: the oxidation number changes from $+6$ in SO_4^{2-} to $+4$ in

SO_2 , a decrease, so sulfur is reduced.

Oxidation and reduction occur in the same reaction, so it is a

redox reaction.

[3]

(ii) Describe how you would test for the presence of iodine.

Add a few drops of starch solution.

A blue-black colour shows iodine is present.

[2]

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Question Number	Marks
1	
2	
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Total Marks	

Examiner Number

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General Information

1 tonne = 10^6 g

1 metre = 10^9 nm

One mole of any gas at 293 K and a pressure of 1 atmosphere (10^5 Pa) occupies a volume of 24 dm³

Avogadro Constant = 6.02×10^{23} mol⁻¹

Planck Constant = 6.63×10^{-34} Js

Specific Heat Capacity of water = $4.2 \text{ J g}^{-1} \text{ K}^{-1}$

Speed of Light = $3 \times 10^8 \text{ m s}^{-1}$



Characteristic absorptions in IR spectroscopy

Wavenumber/cm ⁻¹	Bond	Compound
550–850	C–X (X = Cl, Br, I)	Haloalkanes
750–1100	C–C	Alkanes, alkyl groups
1000–1300	C–O	Alcohols, esters, carboxylic acids
1450–1650	C=C	Arenes
1600–1700	C=C	Alkenes
1650–1800	C=O	Carboxylic acids, esters, aldehydes, ketones, amides, acyl chlorides
2200–2300	C≡N	Nitriles
2500–3200	O–H	Carboxylic acids
2750–2850	C–H	Aldehydes
2850–3000	C–H	Alkanes, alkyl groups, alkenes, arenes
3200–3600	O–H	Alcohols
3300–3500	N–H	Amines, amides

Proton Chemical Shifts in Nuclear Magnetic Resonance Spectroscopy (relative to TMS)

Chemical Shift	Structure	
0.5–2.0	–CH	Saturated alkanes
0.5–5.5	–OH	Alcohols
1.0–3.0	–NH	Amines
2.0–3.0	–CO–CH	Ketones
	–N–CH	Amines
	C ₆ H ₅ –CH	Arene (aliphatic on ring)
2.0–4.0	X–CH	X = Cl or Br (3.0–4.0) X = I (2.0–3.0)
4.5–6.0	–C=CH	Alkenes
5.5–8.5	RCONH	Amides
6.0–8.0	–C ₆ H ₅	Arenes (on ring)
9.0–10.0	–CHO	Aldehydes
10.0–12.0	–COOH	Carboxylic acids

These chemical shifts are concentration and temperature dependent and may be outside the ranges indicated above.

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Data Leaflet

Including the Periodic Table of the Elements

For the use of candidates taking
Advanced Subsidiary and
Advanced Level Examinations

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

gce a/as examinations chemistry

THE PERIODIC TABLE OF ELEMENTS																	
Group																	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen																	4 He Helium
7 Li Lithium	9 Be Beryllium											11 B Boron	12 C Carbon	14 N Nitrogen	16 O Oxygen	19 F Fluorine	20 Ne Neon
23 Na Sodium	24 Mg Magnesium											27 Al Aluminium	28 Si Silicon	31 P Phosphorus	32 S Sulfur	35.5 Cl Chlorine	40 Ar Argon
39 K Potassium	40 Ca Calcium	45 Sc Scandium	48 Ti Titanium	51 V Vanadium	52 Cr Chromium	55 Mn Manganese	56 Fe Iron	59 Co Cobalt	59 Ni Nickel	64 Cu Copper	65 Zn Zinc	70 Ga Gallium	73 Ge Germanium	75 As Arsenic	79 Se Selenium	80 Br Bromine	84 Kr Krypton
85 Rb Rubidium	88 Sr Strontium	89 Y Yttrium	91 Zr Zirconium	93 Nb Niobium	96 Mo Molybdenum	98 Tc Technetium	101 Ru Ruthenium	103 Rh Rhodium	106 Pd Palladium	108 Ag Silver	112 Cd Cadmium	115 In Indium	119 Sn Tin	122 Sb Antimony	128 Te Tellurium	127 I Iodine	131 Xe Xenon
133 Cs Caesium	137 Ba Barium	139 La [*] Lanthanum	178 Hf Hafnium	181 Ta Tantalum	184 W Tungsten	186 Re Rhenium	190 Os Osmium	192 Ir Iridium	195 Pt Platinum	197 Au Gold	201 Hg Mercury	204 Tl Thallium	207 Pb Lead	209 Bi Bismuth	210 Po Polonium	210 At Astatine	222 Rn Radon
223 Fr Francium	226 Ra Radium	227 Ac [†] Actinium	261 Rf Rutherfordium	262 Db Dubnium	266 Sg Seaborgium	264 Bh Bohrium	277 Hs Hassium	268 Mt Meitnerium	271 Ds Darmstadtium	272 Rg Roentgenium	285 Cn Copernicium						
			140 Ce Cerium	141 Pr Praseodymium	144 Nd Neodymium	145 Pm Promethium	150 Sm Samarium	152 Eu Europium	157 Gd Gadolinium	159 Tb Terbium	162 Dy Dysprosium	165 Ho Holmium	167 Er Erbium	169 Tm Thulium	173 Yb Ytterbium	175 Lu Lutetium	
			232 Th Thorium	231 Pa Protactinium	238 U Uranium	237 Np Neptunium	242 Pu Plutonium	243 Am Americium	247 Cm Curium	245 Bk Berkelium	251 Cf Californium	254 Es Einsteinium	253 Fm Fermium	256 Md Mendelevium	254 No Nobelium	257 Lr Lawrencium	
			90	91	92	93	94	95	96	97	98	99	100	101	102	103	

a

X

b

a = relative atomic mass (approx)

x = atomic symbol

b = atomic number

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

$\begin{matrix} a \\ \boxed{X} \\ b \end{matrix}$ a = relative atomic mass (approx)
x = atomic symbol
b = atomic number