Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2023

Centre Number

Candidate Number

Chemistry

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.

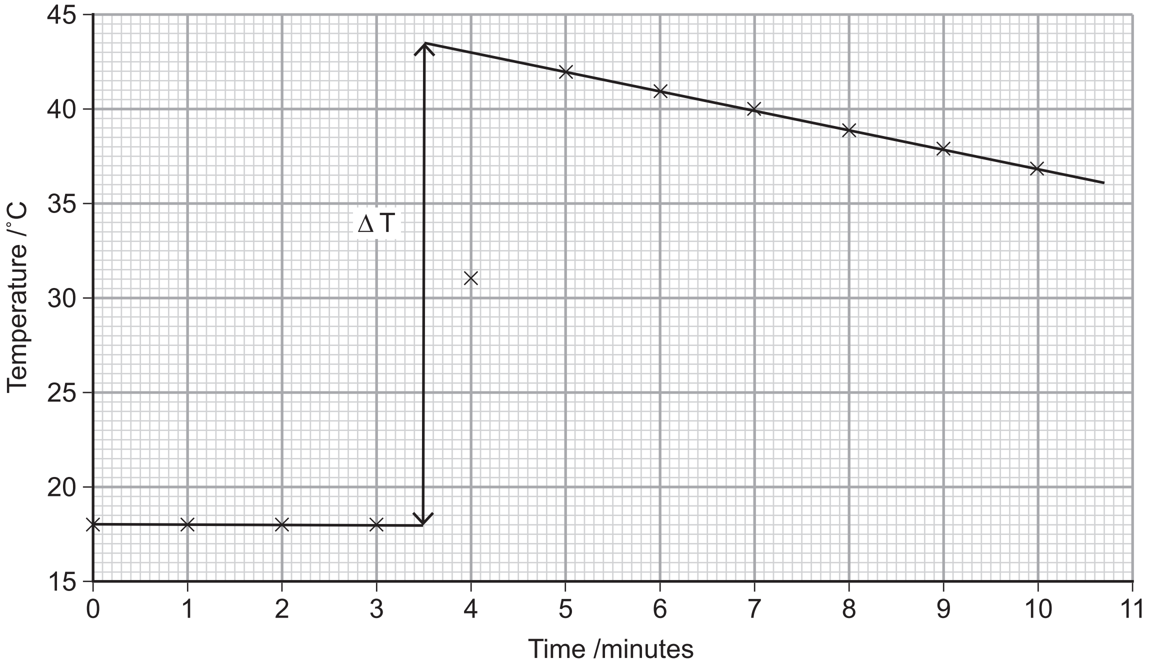
INFORMATION FOR CANDIDATES

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.

Answer ____________________ [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.

Answer ____________________ kJ [2]

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

____

____

____

____ [2]

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

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

$$Zn \quad + \quad Cu^{2+} \quad \longrightarrow \quad Zn^{2+} \quad + \quad Cu$$

[1]

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

Answer ____________________ [1]

[Turn over

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

Answer ____________________ [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.

Answer ____________________ $kJ\,mol^{-1}$ [3]

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

____

____

____

____ [2]

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

____ [1]

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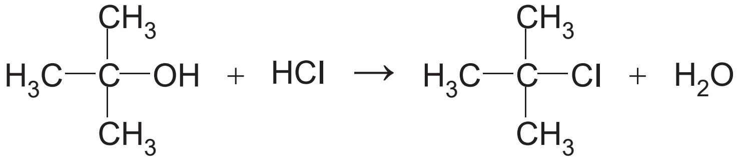
(Questions continue overleaf)

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



$$H_3C{-}\overset{CH_3}{\underset{CH_3}{C}}{-}OH + HCl \longrightarrow H_3C{-}\overset{CH_3}{\underset{CH_3}{C}}{-}Cl + H_2O$$

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 = 157.55 g
   Mass of measuring cylinder after transfer = 152.45 g

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.

Answer ________________ 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.

____

____

____ [1]

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

____

____ [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.

____

____

____ [2]

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

____

____ [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.

____

____ [2]

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

____ [1]

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

____ [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.

____ [1]

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

____ [1]

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

Answer ____________________ 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.

____ [1]

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

____

____ [1]

[Turn over

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	
Bromine	
Iodine	
Potassium halide	

[2]

(b) A 1 cm^3 portion of each aqueous halogen solution is added separately to 1 cm^3 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 (✗) to indicate that no reaction occurs.

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

[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?

[3]

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

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

[1]

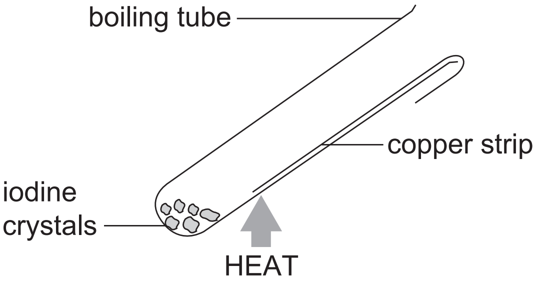
(ii) State the conditions required for the reaction between chlorine and sodium hydroxide solution which yield products containing chlorine in the same oxidation states as those in **(c)(i)**.

[1]

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

[1]

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.

____

____ [1]

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

____ [1]

(c) Calculate the mass of iodine that reacted.

Answer ____________________ g [1]

(d) Calculate the mass of copper that reacted.

Answer ____________________ g [1]

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

Answer ____________________ [3]

[Turn over

(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:

$$2I^- + 4H^+ + SO_4^{2-} \longrightarrow I_2 + SO_2 + 2H_2O$$

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

[3]

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

[2]

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

Total Marks	

Examiner Number ☐

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 dm^3
Avogadro Constant = 6.02×10^{23} mol^{-1}
Planck Constant = 6.63×10^{-34} J s
Specific Heat Capacity of water = 4.2 J g^{-1} K^{-1}
Speed of Light = 3×10^8 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	–C**H**	Saturated alkanes
0.5–5.5	–O**H**	Alcohols
1.0–3.0	–N**H**	Amines
2.0–3.0	–CO–C**H**	Ketones
	–N–C**H**	Amines
	C_6H_5–C**H**	Arene (aliphatic on ring)
2.0–4.0	X–C**H**	X = Cl or Br (3.0–4.0)
		X = I (2.0–3.0)
4.5–6.0	–C=C**H**	Alkenes
5.5–8.5	RCON**H**	Amides
6.0–8.0	$-C_6\mathbf{H}_5$	Arenes (on ring)
9.0–10.0	–C**H**O	Aldehydes
10.0–12.0	–COO**H**	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

I	II											III	IV	V	VI	VII	0
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
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