Rewarding Learning

ADVANCED
General Certificate of Education
2025

Centre Number

Candidate Number

Chemistry

Assessment Unit A2 3
assessing
Further Practical Chemistry
Practical Booklet B (Theory)

ACH32

[ACH32]
FRIDAY 20 JUNE, MORNING

TIME

1 hour 15 minutes.

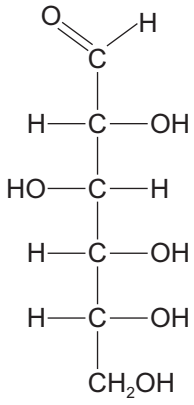
INSTRUCTIONS TO CANDIDATES

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 questions in black ink and use a dark HB pencil for drawings and graphs.
Do not write with a gel pen.
Answer **all four** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 60.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
You may use a scientific calculator.
A Data Leaflet, which includes a Periodic Table of the Elements, is included in this question paper.

1 Glucose, $C_6H_{12}O_6$, and other simple sugars are the monomers which form carbohydrates such as starch. The structure of glucose is shown below.



glucose

(a) Explain why glucose is soluble in water but insoluble in hexane.

_____

_____

_____

_____ [2]

(b) On heating in a boiling tube, glucose decomposes to form a black solid and droplets of a colourless liquid which are visible on the sides of the boiling tube.

(i) Suggest a name for the colourless liquid.

_____ [1]

(ii) Suggest a name for the black solid.

_____ [1]

(c) Two experiments were carried out using an aqueous solution of glucose. The methods and observations for the two experiments are shown in the table below.

Experiment	Method	Observations
1	Add glucose solution to acidified potassium dichromate(VI) solution and heat the reaction mixture under reflux	orange solution changes to green
2	Add Tollens' reagent to glucose solution in a boiling tube and warm the contents of the boiling tube in a water bath	colourless solution changes to form a silver mirror

(i) Draw a labelled diagram of the assembled apparatus required to heat the reaction mixture under reflux in Experiment 1.

[3]

[Turn over

(ii) The half-equation below represents one of the possible oxidation reactions of glucose in Experiment 1.

$$C_6H_{12}O_6 + 2H_2O \rightarrow C_6H_{10}O_8 + 6H^+ + 6e^-$$

Using the half-equation above, write a redox equation for the reaction occurring when glucose reacts with acidified dichromate(VI) ions.

[2]

(iii) Draw the structure of the oxidation product, $C_6H_{10}O_8$, formed in **(c)(ii)**.

[2]

(iv) Which functional group in glucose causes it to react with Tollens' reagent in Experiment 2?

[1]

(v) What would be observed if the glucose solution was mixed with Fehling's solution and warmed in a water bath?

_____

_____ [2]

(d) Starch solution is used as an indicator in iodine-thiosulfate titrations.

(i) State the colour change observed at the end point when starch indicator is used in an iodine-thiosulfate titration.

From _____ to _____ [1]

(ii) Write an equation for the reaction of sodium thiosulfate with iodine.

_____ [2]

[Turn over

2 Phenylamine (density 1.02 g cm^{-3}) reacts with ethanoyl chloride (density 1.10 g cm^{-3}) to form the solid N-phenylethanamide. The equation for the reaction is given below.

$$2C_6H_5NH_2 + CH_3COCl \rightarrow \underset{\text{N-phenylethanamide}}{CH_3CONHC_6H_5} + C_6H_5NH_3Cl$$

(a) Draw the skeletal formula of N-phenylethanamide.

[1]

(b) A 3.5 cm^3 sample of phenylamine was mixed with a 1.5 cm^3 sample of ethanoyl chloride.

(i) Calculate the number of moles of phenylamine in the 3.5 cm^3 sample.

Answer _____ [2]

(ii) Calculate the number of moles of ethanoyl chloride present in the 1.5 cm^3 sample.

Answer _____ [2]

(iii) Calculate the maximum mass of solid N-phenylethanamide which may be formed from 3.5 cm^3 of phenylamine and 1.5 cm^3 of ethanoyl chloride. Give your answer to 2 significant figures.

Answer _____ [2]

(c) (i) Describe, giving practical details, how the solid N-phenylethanamide could be separated from the reaction mixture and purified.

_____

_____

_____

_____

_____

_____

_____

_____

_____ [5]

[Turn over

(ii) Describe, giving practical details, how the melting point of the solid N-phenylethanamide could be determined.

_____

_____

_____

_____

_____ [3]

(iii) State two ways in which the melting point of an impure sample of N-phenylethanamide would differ from the melting point of a pure sample.

1. _____

_____

2. _____

_____ [2]

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(Questions continue overleaf)

[Turn over

3 Solid **X** is a hydrated iron(III) compound.

(a) Solid **X** dissolves in water to form a yellow solution. Write the formula of the hexaaqua complex ion present in the yellow solution.

_____ [1]

(b) On addition of sodium hydroxide solution to an aqueous solution of **X**, a brown precipitate is formed. Write an equation for the reaction that occurs representing the brown precipitate as $[Fe(OH)_3(H_2O)_3]$.

_____ [1]

(c) When acidified silver nitrate solution is added to an aqueous solution of **X**, a white precipitate is formed. The white precipitate dissolves on addition of concentrated ammonia solution.

(i) Name the anion present in the aqueous solution of **X**.

_____ [1]

(ii) The silver ions in the white precipitate react with ammonia solution to form a soluble complex which has a linear shape. Suggest the formula of this complex.

_____ [1]

(d) When a spatula-measure of sodium carbonate is added to an aqueous solution of **X**, bubbles of gas are observed.

Identify the gas produced and suggest what the formation of this gas indicates about the aqueous solution of **X**.

_____

_____

_____ [2]

(e) The addition of a solution containing thiocyanate ions (SCN^-) to an aqueous solution of **X** resulted in the formation of a blood red solution. This is a ligand replacement reaction in which one thiocyanate ion replaces one molecule of water in the hexaaquairon(III) ion. Suggest an equation for the reaction that occurs.

_____ [1]

(f) 1 mole of the hydrated iron(III) compound contains 6 moles of water of crystallisation. The percentage of water of crystallisation in the compound is 39.93%.

(i) Calculate the relative formula mass of the hydrated iron(III) compound. Give your answer to 1 decimal place.

Answer _____ [2]

(ii) Based on your calculation in **(f)(i)** and the information in **(a)** to **(e)**, write the formula of the hydrated iron(III) compound.

_____ [1]

[Turn over

4 A method for a back titration is outlined below.

Step 1: Weigh out approximately 2.5 g of a Group II metal oxide in a beaker.
Step 2: Add 50.0 cm^3 of 2.00 mol dm^{-3} hydrochloric acid to the Group II metal oxide in the beaker.
Step 3: Make up the reaction mixture from **Step 2** to form a 250 cm^3 aqueous solution in a volumetric flask.
Step 4: Titrate 25.0 cm^3 samples of the solution from **Step 3** against 0.100 mol dm^{-3} sodium hydroxide solution using a suitable indicator.

(a) (i) Define the term **back titration**.

[2]

(ii) Describe the practical procedure carried out in **Step 3** of the method.

[4]

(iii) Name a suitable indicator for the titration in **Step 4**. State the colour change at the end point of this titration.

[2]

(b) 2.44 g of a Group II metal oxide were used in the back titration and the results obtained are shown in the table below.

Titration	Initial burette reading /cm^3	Final burette reading /cm^3	Titre /cm^3
1	0.0	13.3	13.3
2	13.3	26.2	12.9
3	26.2	39.0	12.8

(i) Explain why the titre value from **Titration 1** should not be used in the calculation of the mean titre.

_____

_____ [1]

(ii) Calculate the number of moles of hydrochloric acid added to the Group II metal oxide in **Step 2**.

Answer _____ [1]

(iii) Calculate the number of moles of hydrochloric acid neutralised by the 0.100 mol dm^{-3} sodium hydroxide solution in **Step 4**.

Answer _____ [2]

(iv) Using MO to represent the Group II metal oxide, write an equation for the reaction of the metal oxide with hydrochloric acid.

_____ [1]

[Turn over

(v) Calculate the relative formula mass of the Group II metal oxide, MO.
Give your answer to the nearest whole number.

Answer _____ [3]

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

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**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

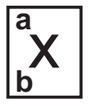
chemistry

THE PERIODIC TABLE OF ELEMENTS

I	II											III	IV	V	VI	VII	0
Group																	
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 = relative atomic mass (approx)
x = atomic symbol
b = atomic number

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