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ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2022

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

WEDNESDAY 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.**

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.

13004



- 1 (a) Barium hydroxide is a Group II hydroxide. A sample of a saturated solution of barium hydroxide formed at 40 °C is heated to constant mass in an evaporating basin using a Bunsen burner.

The following mass measurements were taken:

Mass of evaporating basin = 45.27 g

Mass of evaporating basin and saturated solution = 61.50 g

Mass of evaporating basin and contents after heating to constant mass = 46.28 g

Calculate the solubility of barium hydroxide at 40 °C in g/100 g water based on the results of this experiment. Give your answer to 2 decimal places.

$$\text{mass of water} = 61.50 - 46.28 = 15.22 \text{ g}$$

$$\text{mass of solid Ba(OH)}_2 = 46.28 - 45.27 = 1.01 \text{ g}$$

$$\text{solubility} = 1.01 \div 15.22 \times 100$$

$$= 6.64 \text{ g/100 g water}$$

[3]

- (b) State the trends in the solubility of the Group II hydroxides and sulfates as the group is descended.

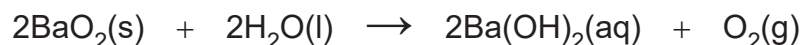
Group II hydroxides: solubility increases down the group

Group II sulfates: solubility decreases down the group

[1]



- (c) Barium hydroxide may be prepared by boiling a mixture of barium peroxide, BaO_2 , and water. The equation for the reaction is:



2.00 g of an impure sample of barium peroxide were boiled with an excess of water and 117 cm^3 of oxygen gas (measured at room temperature and pressure) were collected in a gas syringe.

- (i) State the oxidation number of oxygen in each of the following:

BaO_2 -1

H_2O -2

$\text{Ba}(\text{OH})_2$ -2

O_2 0

[2]

- (ii) Using the volume of oxygen gas collected, calculate the percentage of barium peroxide in the sample. Give your answer to 1 decimal place.

$$\text{moles } \text{O}_2 = 117 \div 24000 = 4.875 \times 10^{-3} \text{ mol}$$

$$\text{moles } \text{BaO}_2 = 2 \times 4.875 \times 10^{-3} = 9.75 \times 10^{-3} \text{ mol}$$

$$\text{mass } \text{BaO}_2 = 9.75 \times 10^{-3} \times 169 = 1.648 \text{ g}$$

$$\% = 1.648 \div 2.00 \times 100 = 82.4\%$$

[3]

- (iii) State the test for oxygen gas.

It relights a glowing splint.

[1]

- (iv) Describe, without experimental detail, how you would test the solution formed for barium ions.

Flame test: barium ions give an apple green flame.

(Or add a sulfate solution: a white precipitate forms.)

[2]

[Turn over]



- 2 Four samples of a **mixture** of dilute ethanoic acid and ethanol were tested as shown in the table below.

(a) Complete the observations column in the table.

Sample	Test	Observations
1	Add a half-spatula measure of solid sodium carbonate to 2 cm ³ of the mixture in a test tube.	effervescence test tube feels cool solid disappears solution remains colourless
2	Add a half-spatula measure of solid phosphorus pentachloride to 2 cm ³ of the mixture in a test tube.	<i>misty (steamy) fumes</i> <i>hissing sound</i> <i>solid disappears</i> <i>test tube warms up</i>
3	Add 2 cm ³ of acidified potassium dichromate(VI) solution to 2 cm ³ of the mixture in a test tube. Warm in a water bath.	<i>solution changes from orange to green</i>
4	Add a 1 cm strip of magnesium ribbon to 5 cm ³ of the mixture in a test tube.	<i>fizzing (effervescence)</i> <i>magnesium disappears</i> <i>test tube warms up</i> <i>solution remains colourless</i>

[5]

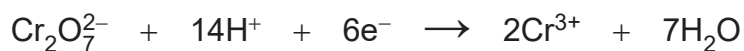


- (b) State the IUPAC name of the organic product of the reaction between phosphorus pentachloride and ethanol.

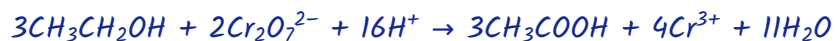
Chloroethane

[1]

- (c) Acidified potassium dichromate(VI) is an oxidising agent. The half equations for the oxidation of ethanol and reduction of dichromate(VI) ions are:



Write the ionic equation for the oxidation of ethanol using acidified dichromate(VI) ions.



[2]

[Turn over]



- 3 250 cm³ of a 7.00 g dm⁻³ solution of a dicarboxylic acid (represented by H₂A) was prepared from the solid acid.

- (a) Describe how 250 cm³ of a solution of the acid was prepared from the solid acid.

Mass needed = 7.00 × 0.250 = 1.75 g. Weigh out accurately 1.75 g

of solid H₂A in a weighing boat.

Dissolve the solid in about 100 cm³ of deionised water in a beaker,

stirring with a glass rod.

Transfer the solution to a 250 cm³ volumetric flask using a funnel.

Rinse the beaker, glass rod and funnel with deionised water, ensuring

all the rinsings go into the flask.

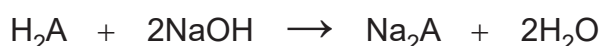
Add deionised water until the bottom of the meniscus is on the

graduation line (dropwise near the line).

Stopper the flask and invert it several times to mix.

[6]

- (b) H₂A reacts with sodium hydroxide solution according to the equation below:



25.0 cm³ portions of the solution of the acid were titrated with 0.145 mol dm⁻³ sodium hydroxide solution. The mean titre was 20.4 cm³.

- (i) State two ways you would ensure the end point of this titration is determined accurately.

1. *Swirl the conical flask throughout the titration.*

2. *Add the NaOH dropwise near the end point (and read from the bottom of the meniscus).*

[2]



(ii) State and explain which indicator is used in this titration.

Phenolphthalein, as it is a weak acid and strong base titration.

[1]

(iii) Calculate the relative formula mass of the acid.

$$\text{moles NaOH} = 20.4 \times 0.145 \div 1000 = 2.958 \times 10^{-3}$$

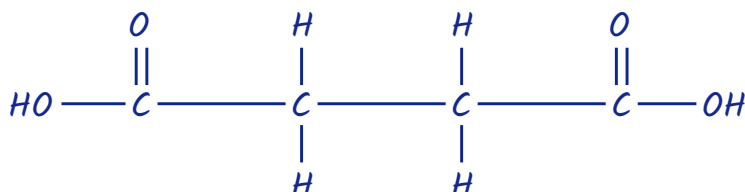
$$\text{moles H}_2\text{A in } 25.0 \text{ cm}^3 = 2.958 \times 10^{-3} \div 2 = 1.479 \times 10^{-3}$$

$$\text{moles H}_2\text{A in } 250 \text{ cm}^3 = 1.479 \times 10^{-3} \times 10 = 0.01479$$

$$M_r = 1.75 \div 0.01479 = 118$$

[4]

(c) H_2A is a dicarboxylic acid as it contains two $-\text{COOH}$ groups. Deduce a structural formula for the acid.



[1]

[Turn over



4 Halogenoalkanes may be hydrolysed.

- (a) The hydrolysis of halogenoalkanes using silver nitrate solution involves heating a mixture of the liquid halogenoalkane with aqueous silver nitrate and ethanol in a water bath at 50 °C. The halogenoalkanes are hydrolysed by the water in aqueous silver nitrate. The mechanism is nucleophilic substitution.

- (i) Suggest why ethanol is added to the mixture.

*It acts as a mutual solvent, dissolving both the halogenoalkane
and the aqueous silver nitrate.*

[1]

- (ii) Write an equation for the hydrolysis of 1-bromobutane with water.



[1]

- (iii) Explain why water can act as a nucleophile.

*The oxygen atom has lone pairs of electrons which it can donate
to the δ^+ carbon.*

[1]

- (b) The table below shows the time taken for a precipitate to form in the hydrolysis of the liquid halogenoalkanes using silver nitrate solution.

Halogenoalkane	Time for a precipitate to form / s
1-chlorobutane	565
1-bromobutane	86
1-iodobutane	46
2-bromobutane	32
2-bromo-2-methylpropane	4

- (i) What is meant by the term **hydrolysis**?

Breaking up molecules (breaking a bond) by reaction with water.

[1]



- (ii) State the colour of the precipitate formed when 2-bromo-2-methylpropane is hydrolysed using silver nitrate solution.

Cream [1]

- (iii) Identify the precipitate formed when 1-chlorobutane is hydrolysed using silver nitrate solution.

Silver chloride, AgCl [1]

- (iv) State and explain the trend in the relative rates of hydrolysis of the primary halogenoalkanes.

Rate: 1-iodobutane > 1-bromobutane > 1-chlorobutane.

The C-I bond is weaker than C-Br, which is weaker than C-Cl,
so it breaks more easily. [2]

- (v) Compare the relative rates of hydrolysis of primary, secondary and tertiary halogenoalkanes.

Tertiary is faster than secondary, which is faster than primary.

[1]

[Turn over]



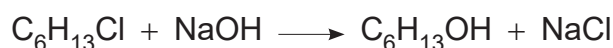
- (c) The following method may be used to hydrolyse 1-chlorohexane using sodium hydroxide solution.

10 cm³ of 1-chlorohexane were placed in a pear-shaped flask. 5 cm³ of 6.0 mol dm⁻³ sodium hydroxide solution (an excess) were added slowly whilst the flask was immersed in ice cold water. The mixture was heated under reflux for 20 minutes. The impure product, hexan-1-ol, was collected by fractional distillation between 150°C and 162°C. 4.4 cm³ of liquid were collected between these temperatures.

The table below gives the densities and boiling points of the organic reactant and product.

Substance	Density /g cm ⁻³	Boiling point /°C
1-chlorohexane	0.88	134
hexan-1-ol	0.82	157

The equation for the hydrolysis reaction is



- (i) Explain why the flask was immersed in ice cold water when the sodium hydroxide solution was being added.

The reaction is exothermic, so cooling dissipates the heat (stops the mixture boiling and losing reactant).

[1]

- (ii) Suggest why an excess of sodium hydroxide was used.

To make sure all the 1-chlorohexane reacts, maximising the yield.

[1]



(iii) Explain what is meant by heated under **reflux**.

Repeated boiling and condensing of the reaction mixture, so no vapour escapes.

[1]

(iv) What should be added to the reaction mixture to promote smooth boiling?

Anti-bumping granules

[1]

(v) Describe four changes which you would make to the apparatus used to heat under reflux, in order to carry out fractional distillation.

Attach a fractionating column to the pear-shaped flask.

Attach a still head (sidearm) to the top of the column.

Insert a thermometer with the bulb level with the sidearm.

Connect the condenser to the sidearm, angled downwards, with a collection vessel at the end.

[4]

(vi) Assuming all of the liquid collected between 150 °C and 162 °C was hexan-1-ol, calculate the percentage yield. Give your answer to 1 decimal place.

moles $C_6H_{13}Cl = 10 \times 0.88 \div 120.5 = 0.07303$

theoretical mass hexan-1-ol = $0.07303 \times 102 = 7.449 \text{ g}$

actual mass = $4.4 \times 0.82 = 3.608 \text{ g}$

% yield = $3.608 \div 7.449 \times 100 = 48.4\%$

[4]

THIS IS THE END OF THE QUESTION PAPER



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Question Number	Marks
1	
2	
3	
4	

Total Marks	
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Examiner Number

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SCH32/5
260990



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

I	II	THE PERIODIC TABLE OF ELEMENTS	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								

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

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

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