Rewarding Learning

ADVANCED
General Certificate of Education
2019

Centre Number

Candidate Number

Chemistry

Assessment Unit A2 3

assessing

Further Practical Chemistry

Practical Booklet B (Theory)

ACH32

[ACH32]

WEDNESDAY 19 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 six** questions.

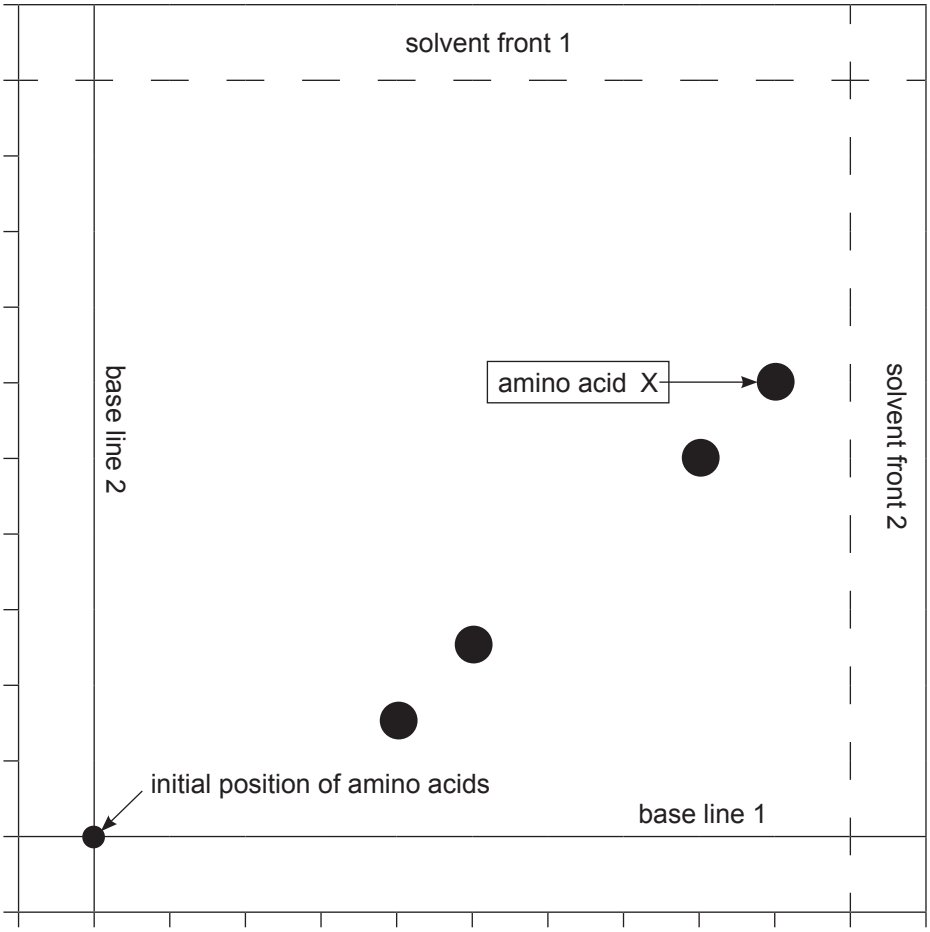
INFORMATION FOR CANDIDATES

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

12318

16ACH3201

1 A mixture of amino acids was analysed using two-way paper chromatography. The first "solvent" used was a solution of butan-1-ol in ethanoic acid. The second "solvent" was a solution of phenol in water. The chromatogram obtained is shown below.



(a) A spot of the mixture was placed on base line 1 using a capillary tube. Describe, giving experimental details, how this chromatogram would be obtained.

_____

_____

_____

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_____

_____ [4]

(b) Calculate the R_f values for the amino acid, X, in solvents 1 and 2. Measure to the middle of the spot.

Solvent 1 _____

Solvent 2 _____ [1]

(c) Without access to R_f data, how would you show that the amino acid leucine was present and the amino acid serine was absent from the mixture?

_____

_____

_____

_____ [2]

(d) Why is two-way paper chromatography a better method for separating amino acids than one-way paper chromatography?

_____

_____ [1]

(e) GLC MS can be used to identify drugs and determine their purity.

(i) How would GLC indicate that a drug was pure?

_____

_____ [1]

(ii) Give **two** ways in which the identity of a drug can be established using GLC MS.

_____

_____ [2]

[Turn over

2 The standard electrode potentials of two half-cells are given below.

$$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s) \qquad E^{\ominus} = -0.76\,V$$

$$Ag^{+}(aq) + e^- \rightleftharpoons Ag(s) \qquad E^{\ominus} = +0.80\,V$$

(a) Define the term **standard electrode potential**.

_____

_____

_____ [2]

(b) **(i)** Draw a labelled diagram to show the cell which you would use to measure the potential difference between these two half-cells under standard conditions. Your diagram should include the concentrations of any ions in solution and the temperature at which the measurement would be made.

[4]

(ii) Calculate the emf of this cell.

_____

_____ [1]

(c) Magnesium is a stronger reducing agent than zinc. The standard electrode potential of the magnesium half-cell can be determined by setting up the following cell:

$$Mg(s) \mid Mg^{2+}(aq) \mid\mid Zn^{2+}(aq) \mid Zn(s)$$

This cell has an emf of +1.61 V. Calculate the standard electrode potential of the magnesium half-cell.

_____

_____ [1]

3 A series of tests was carried out on two organic liquids, **A** and **B**.

(a) Liquid **A** produced an orange solid when reacted with 2,4-dinitrophenylhydrazine and a silver mirror when heated with Tollens' reagent. The mass spectrum of **A** showed a molecular ion peak at 58.

(i) To which homologous series does **A** belong? Explain how the results of the chemical tests are consistent with your conclusion.

_____

_____

_____

_____ [3]

(ii) Name **A** and identify the molecular ion.

_____ [1]

(b) Liquid **B** reacted vigorously with phosphorus pentachloride, and an aqueous solution of **B** gave effervescence on addition of sodium carbonate. The high resolution nmr spectrum of **B** contains a singlet, a quartet and a triplet.

(i) To which homologous series does **B** belong? Explain how the results of the chemical tests are consistent with your conclusion.

_____

_____

_____

_____ [3]

(ii) Give the structure of **B** and circle the hydrogen(s) responsible for the singlet. Suggest a chemical shift value for the position of the singlet.

_____ [2]

(iii) Explain how the spin-spin splitting in the nmr spectrum is consistent with the structure given in **(ii)**.

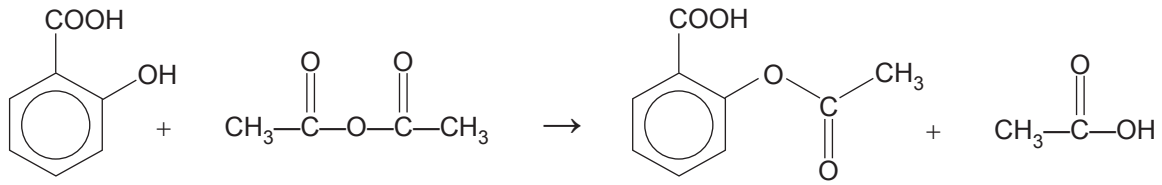
_____

_____

_____

_____ [2]

4 In the presence of concentrated phosphoric acid, salicylic acid reacts with ethanoic anhydride to form aspirin and ethanoic acid.



Addition of cold water causes the crude product to precipitate as a white solid which is filtered off and recrystallised. The purity of the final product is confirmed by carrying out a melting point determination.

(a) Assuming a 40% yield, calculate the minimum mass of salicylic acid required to form 18.0 g of aspirin.

_____

_____

_____

_____

_____ [3]

(b) Describe the purification of aspirin by recrystallisation.

_____

_____

_____

_____

_____

_____ [4]

(c) Describe the melting point determination and explain how the result can be used to confirm the purity of the product.

_____

_____

_____

_____

_____ [5]

(d) Volumetric analysis of a solution containing aspirin can be carried out by adding an excess of sodium hydroxide solution, warming the mixture to hydrolyse the ester group and then titrating the excess sodium hydroxide with a standard solution of hydrochloric acid.

Write an equation for the reaction of aspirin with excess sodium hydroxide.

[1]

[Turn over

5 Iodine reacts with propanone, in the presence of an acid catalyst, according to the following equation:

$$CH_3COCH_3 + I_2 \xrightarrow{H^+} CH_2ICOCH_3 + HI$$

The order of reaction with respect to iodine can be determined by mixing iodine with a large excess of both propanone and hydrochloric acid, starting a stopclock and then monitoring how the concentration of iodine changes with respect to time.

(a) How could you determine the concentration of iodine at regular time intervals using colorimetry?

_____

_____

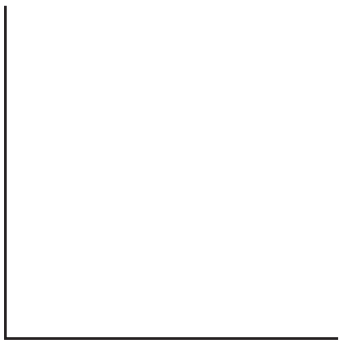
_____

_____

_____ [4]

(b) A graph of iodine concentration against time can be used to show that the reaction is zero order with respect to iodine.

(i) Sketch the graph and label the axes.



[2]

(ii) How can the graph be used to determine the rate of the reaction?

_____

_____ [1]

(c) Suggest why a large excess of propanone and hydrochloric acid is used.

_____

_____ [1]

[Turn over

6 A solution containing iron(II) ions was left exposed to the air for several days. Some of the iron(II) ions were oxidised to iron(III) ions.

(a) The number of moles of iron(II) ions present in the solution can be determined by titrating with acidified manganate(VII) solution.

$$5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$$

(i) Why is no indicator required in this titration?

_____

_____ [1]

(ii) Give the colour change at the end point.

_____ [2]

(b) A 25.0 cm^3 aliquot of the solution, which had been partially oxidised, was transferred into a conical flask. The solution was acidified and then titrated with 0.020 mol dm^{-3} potassium manganate(VII). 18.0 cm^3 was required. Calculate the number of moles of iron(II) ions present in this aliquot.

_____

_____ [2]

(c) Another portion of the solution, which had been partially oxidised, was treated with an excess of zinc. The unreacted zinc was then removed by filtration and 25.0 cm^3 of the filtrate was transferred into a conical flask. The solution was acidified and then titrated with 0.020 mol dm^{-3} potassium manganate(VII) of which 30.0 cm^3 was required.

(i) Use an equation to explain the purpose of the zinc.

_____

_____

_____ [2]

(ii) Calculate the percentage of the iron(II) ions which had been oxidised in this solution.

_____

_____ [2]

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Question Number	Examiner Mark	Remark
1		
2		
3		
4		
5		
6		
Total Marks		

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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 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

For first teaching from September 2016
For first award of AS Level in Summer 2017
For first award of A Level in Summer 2018
Subject Code: 1110

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

$^{a}_{b}X$

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