New Specification

Rewarding Learning

Centre Number

Candidate Number

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2017

Chemistry

Assessment Unit AS 2

assessing

Further Physical and Inorganic Chemistry and an Introduction to Organic Chemistry

SCH22

[SCH22]

MONDAY 5 JUNE, AFTERNOON

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all seventeen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all seven** questions in **Section B**. **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.**

INFORMATION FOR CANDIDATES

The total mark for this paper is 90.
Quality of written communication will be assessed in Question **14(c)**.
In Section A all questions carry equal marks, i.e. **one** mark for each question.
In Section B the 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, containing some data, is included with this question paper.

Section A – Multiple Choice

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

Each multiple choice question is worth 1 mark.

1 The mechanism for the reaction of halogenoalkanes with ethanolic potassium hydroxide is

A electrophilic addition.

B elimination.

C nucleophilic addition.

D substitution.

2 Which electronic configuration is that of a Group II ion?

A $1s^2 2s^2 2p^2$

B $1s^2 2s^2 2p^6$

C $1s^2 2s^2 2p^6 3s^2$

D $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^2$

3 Which substance occupies the largest volume at 293 K and 1 atmosphere of pressure?

A 4.0 g of ethane

B 4.4 g of propane

C 5.8 g of butane

D 6.4 g of methanol

4 When methane reacts with excess chlorine, in the presence of UV light, the organic product is

A chloromethane.

B dichloromethane.

C trichloromethane.

D tetrachloromethane.

5 What mass of magnesium oxide is required to neutralise 40.0 cm^3 of 1.00 mol dm^{-3} hydrochloric acid?

A 0.80 g

B 1.60 g

C 2.40 g

D 3.20 g

6 Which bromoalkane is a secondary bromoalkane?

A 1-bromobutane

B 1-bromo-2-methylpropane

C 2-bromobutane

D 2-bromo-2-methylpropane

[Turn over

7 The table shows some average bond enthalpies.

	average bond enthalpy/kJ mol^{-1}
C–C	348
C–H	413
O=O	496
C=O	743
O–H	463

What is the enthalpy change for the following reaction?

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$$

A $-1334\,kJ\,mol^{-1}$

B $-1585\,kJ\,mol^{-1}$

C $-1682\,kJ\,mol^{-1}$

D $-1962\,kJ\,mol^{-1}$

8 Assuming a 50.0% yield, what is the minimum mass of butan-1-ol required to produce 13.7 g of 1-bromobutane?

A 6.85 g

B 7.40 g

C 14.8 g

D 68.5 g

9 A radical is

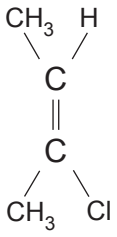
A a particle which acts as an electron pair acceptor.

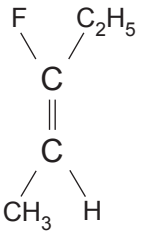
B a particle which acts as an electron pair donor.

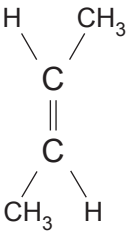
C a particle with a lone pair of electrons.

D a particle with an unpaired electron.

10 Which of the following is a Z isomer?

A 

C 

B 

D 

[Turn over

Section B

Answer all seven questions in the spaces provided.

11 A student carried out a series of activities to investigate the chemistry of Group II elements and compounds.

(a) The student heated magnesium carbonate in a boiling tube and bubbled the gas produced through a suitable reagent to identify the gas.

(i) Draw a diagram of the assembled apparatus and name the reagent used.

[2]

(ii) Write an equation for the thermal decomposition of magnesium carbonate.

_____ [1]

(iii) Explain why magnesium carbonate decomposes much more readily than calcium carbonate when heated.

_____

_____

_____ [2]

(b) The student added a solution of sodium hydroxide to a solution of magnesium nitrate. A white precipitate was formed.

(i) Name the precipitate.

_____ [1]

(ii) Write an ionic equation, without state symbols, for the formation of the precipitate.

_____ [1]

(c) The student added a solution of potassium sulfate to a solution of barium nitrate. A white precipitate was formed.

(i) Name the precipitate.

_____ [1]

(ii) Write an ionic equation, including state symbols, for the formation of the precipitate.

_____ [2]

(d) The student then burnt magnesium using a Bunsen burner.

(i) Give **two** observations.

_____

_____ [2]

(ii) Write an equation for the reaction.

_____ [1]

[Turn over

12 There are five structural isomers with molecular formula C_6H_{14}.

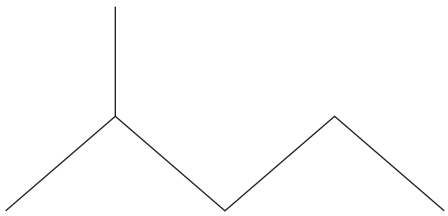
(a) What is meant by the term **structural isomers**?

_____

_____

_____ [2]

(b) Four of the structural isomers are described as having branched structures. Complete the table below.

name of branched isomer	skeletal formula
2-methylpentane	

[3]

(c) Explain why the unbranched isomer, hexane, has a higher boiling point than any of the branched isomers.

_____

_____

_____ [2]

(d) **(i)** Write an equation for the complete combustion of hexane.

_____ [2]

(ii) Write an equation for the incomplete combustion of hexane.

_____ [2]

[Turn over

13 Ammonia is produced by a reversible exothermic reaction between nitrogen and hydrogen:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(a) (i) Write an expression for the equilibrium constant, K_c, and deduce its units.

[2]

(ii) What does a small value of K_c indicate about this equilibrium?

_____

_____ [1]

(b) The Haber process, for the production of ammonia, uses a temperature between 400 °C and 500 °C, a pressure of approximately 200 atm and an iron catalyst.

(i) Explain why the yield improves at a temperature of 300 °C at constant pressure.

_____

_____

_____ [2]

(ii) Explain why the production of ammonia is **not** carried out at 300 °C.

_____

_____

_____ [1]

(iii) Explain why the yield improves when the pressure is 1000 atm at a constant temperature.

_____

_____

_____ [2]

(iv) Explain why the production of ammonia is **not** carried out at 1000 atm.

_____

_____

_____ [1]

[Turn over

14 It is often possible to distinguish between organic molecules by using infrared spectroscopy or simple test tube reactions.

(a) Explain why, without access to a database of infrared spectra, it is difficult to distinguish between butan-2-ol and 2-methylpropan-2-ol using infrared spectroscopy.

[2]

(b) Butan-2-ol and 2-methylpropan-2-ol give the same observations when reacted with phosphorus pentachloride.

(i) Write an equation for the reaction of 2-methylpropan-2-ol with phosphorus pentachloride.

[2]

(ii) Name the organic product.

[1]

(c) Describe how you could use simple test tube reactions to distinguish between butan-2-ol and 2-methylpropan-2-ol. Your answer should include reagents, conditions, observations and an explanation of the chemistry involved.

In this question you will be assessed on using your written communication skills including the use of specialist scientific terms.

[6]

[Turn over

15 Enthalpies of neutralisation can be determined using experimental methods.

(a) What is meant by the term **enthalpy of neutralisation**?

_____

_____

_____ [2]

(b) An enthalpy of neutralisation was determined using the following method.

Add 50 cm^3 of 2.0 mol dm^{-3} hydrochloric acid to a polystyrene cup. Add 50 cm^3 of 2.0 mol dm^{-3} sodium hydroxide solution to a different polystyrene cup. Place thermometers in each solution and leave until both temperatures are equal. Record the temperature. Transfer the alkali into the acid and stir. Record the maximum temperature reached.

The following results were obtained:

initial temperature = 20.0 °C

maximum temperature reached = 33.3 °C

(i) Which piece of apparatus should be used to add 50 cm^3 of 2.0 mol dm^{-3} hydrochloric acid to the polystyrene cup?

_____ [1]

(ii) What is the advantage of using a polystyrene cup?

_____ [1]

(iii) Write an equation for the neutralisation reaction.

_____ [1]

(iv) Assuming that the mass of the solution (in grams) is equal to its volume (in cm^3) and that the heat capacity of the solution is $4.2\,J\,g^{-1}\,K^{-1}$, use the equation $q = mc\Delta T$ to calculate the heat energy released (in Joules).

_____

_____ [2]

(v) Calculate the number of moles of water produced.

_____

_____ [1]

(vi) Calculate the enthalpy of neutralisation in $kJ\,mol^{-1}$.

_____

_____

_____ [3]

(vii) Suggest why the value calculated may be different from the data book value.

_____

_____ [1]

[Turn over

16 A hydrocarbon contains 85.7% carbon by mass.

(a) Calculate the empirical formula of this hydrocarbon using its percentage composition.

_____

_____

_____ [2]

(b) The C=C bond and the four atoms which are attached to the carbon atoms all lie in the same plane.

(i) Complete the diagram below to show the formation of the pi bond from two p-orbitals.

before after

[1]

(ii) Explain why the presence of the pi bond makes an alkene more reactive than an alkane.

_____

_____ [2]

(c) Detailed analysis proved that the hydrocarbon is 2-methylbut-1-ene, $CH_2=C(CH_3)CH_2CH_3$, which reacts with hydrogen bromide to form two organic products.

(i) Show the polarity of the hydrogen bromide molecule.

H–Br

[1]

(ii) Name the mechanism for the reaction of 2-methylbut-1-ene with hydrogen bromide.

_____ [2]

(iii) Name the major organic product.

_____ [1]

(iv) Using curly arrows to show the movement of electron pairs, draw the mechanism for the reaction of 2-methylbut-1-ene with hydrogen bromide to form the major organic product.

[4]

(v) Explain why the mechanism given in part **(iv)** produces the major organic product.

_____

_____

_____

_____ [2]

[Turn over

17 When 1-bromopropane is heated with aqueous potassium hydroxide, the hydroxide ions behave as nucleophiles.

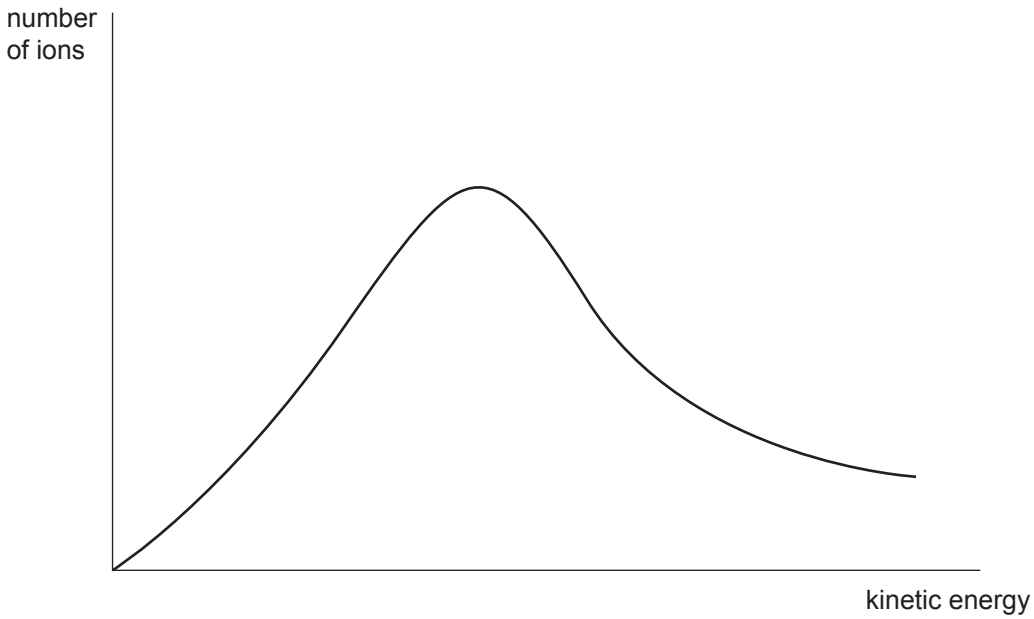
(a) What is meant by the term **nucleophile**?

_____

_____

_____ [2]

(b) Most collisions between hydroxide ions and 1-bromopropane molecules do not result in a reaction. The following diagram shows the kinetic energy distribution of hydroxide ions in the reaction mixture:



(i) On the x-axis above, show a possible position for the activation energy. [1]

(ii) On the same axes, show the kinetic energy distribution of hydroxide ions at a lower temperature. [2]

(iii) Use the two distribution curves to explain how the rate of reaction is affected by lowering the temperature.

_____

_____

_____ [2]

(c) Explain how the rate of the reaction between 1-iodopropane with aqueous potassium hydroxide compares with that of 1-bromopropane.

_____

_____

_____

_____ [2]

THIS IS THE END OF THE QUESTION PAPER

DO NOT WRITE ON THIS PAGE

For Examiner's use only	
Question Number	**Marks**
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
16	
17	
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	$-C_6H_5$	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.

New Specification

Rewarding Learning

GCE

CHEMISTRY DATA SHEET

GCE A/AS EXAMINATIONS

CHEMISTRY

Including the Periodic Table of the Elements

For the use of candidates taking
Advanced Subsidiary and Advanced Level
Chemistry 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.

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

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