Rewarding Learning

Centre Number

Candidate Number

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2018

Chemistry

Assessment Unit AS 2
assessing
Further Physical and Inorganic Chemistry and
an Introduction to Organic Chemistry

MV18

[SCH22]

FRIDAY 25 MAY, MORNING

Time

1 hour 30 minutes, plus your additional time allowance.

Instructions to Candidates

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all fourteen** 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 four** questions in **Section B**. **You must answer the questions in the spaces provided.**
Do not write on blank pages.
Complete in black ink only.

Information for Candidates

The total mark for this paper is 90.
Quality of written communication will be assessed in Question **14(a)(ii)**.
In Section A all questions carry equal marks, i.e. **one** mark for each question.
In Section B the figures in brackets printed at the end of each question 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 Carbon monoxide reacts with steam as follows:

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g) \quad -40.0\,kJ\,mol^{-1}$$

Which change will shift the position of equilibrium to the right-hand side of the equation?

A Decrease in pressure

B Decrease in temperature

C Increase in pressure

D Increase in temperature

2 Which compound has the highest boiling point?

A Butan-1-ol

B Butan-2-ol

C 2-methylpropan-2-ol

D Pentane

3 Which of the following molecules can show a strong absorption peak at 1750 cm^{-1} in an infrared spectrum?

A C_4H_8

B C_4H_{10}

C C_4H_8O

D $C_4H_{10}O$

4 Neutralisation of 25.0 cm^3 of 2.0 mol dm^{-3} sodium hydroxide by 50.0 cm^3 of 1.0 mol dm^{-3} hydrochloric acid resulted in an 8.0 °C increase in temperature.

The enthalpy of neutralisation for this reaction is

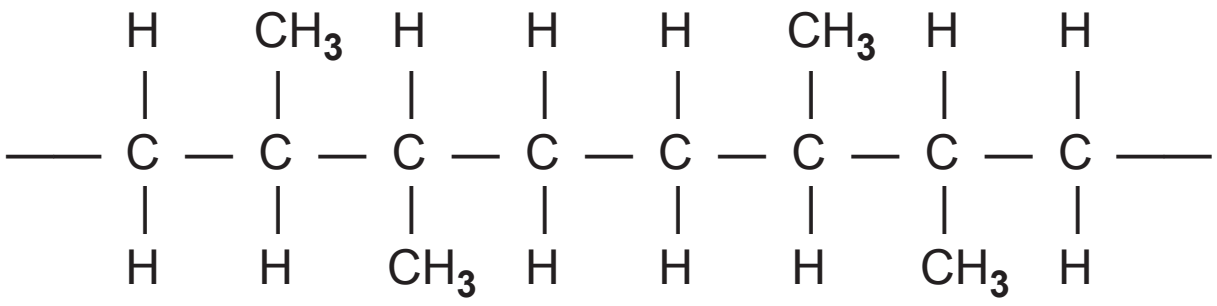
A -16.8 kJ mol^{-1}.

B -25.2 kJ mol^{-1}.

C -33.6 kJ mol^{-1}.

D -50.4 kJ mol^{-1}.

5 Part of a polymer chain is shown below.



Which monomer produces this polymer?

A But-1-ene

B But-2-ene

C Methylpropene

D Propene

6 Sulfur trioxide is produced by the reversible reaction between sulfur dioxide and oxygen.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

What are the units of the equilibrium constant, K_c, for the forward reaction?

A $mol\ dm^{-3}$

B $mol^{-1}\ dm^{3}$

C $mol^{2}\ dm^{-6}$

D $mol^{-2}\ dm^{6}$

7 Ethanoic acid can be produced by the oxidation of butane.

$$2C_4H_{10} + 5O_2 \rightarrow 4CH_3COOH + 2H_2O$$

The atom economy for ethanoic acid is

A 22%.

B 52%.

C 67%.

D 87%.

8 Which statement correctly describes the boiling points of fluoroethane and iodoethane?

A Fluoroethane has a higher boiling point because it forms hydrogen bonds.

B Fluoroethane has a higher boiling point because the C-F bond is stronger than the C-I bond.

C Fluoroethane has a lower boiling point because it has weaker van der Waals' forces between the molecules.

D Fluoroethane has a lower boiling point because the C-F bond is more polar than the C-I bond.

9 The table shows standard enthalpy changes of formation.

compound	$NH_4NO_3(s)$	$H_2O(g)$	$CO_2(g)$
ΔH_f **/kJ mol^{-1}**	−366	−242	−394

Which is the standard enthalpy change for the following reaction?

$$2NH_4NO_3(s) + C(s) \rightarrow 2N_2(g) + 4H_2O(g) + CO_2(g)$$

A −270 kJ mol^{-1}

B +270 kJ mol^{-1}

C +630 kJ mol^{-1}

D −630 kJ mol^{-1}

10 The first reaction that occurs when a car airbag is set off is:

$$2NaN_3(s) \rightarrow 2Na(l) + 3N_2(g)$$

When 3.25 g of NaN_3 decomposes

A 1.80 dm^3 of nitrogen is formed.

B 2.30 g of sodium is formed.

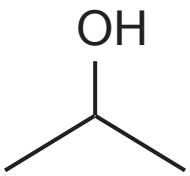
C 3.60 dm^3 of nitrogen is formed.

D 5.35 g of products are formed.

Section B

Answer all **four** questions in this section.

11 Isopropyl alcohol is used as a hand sanitiser and as a cleaning agent for electronic equipment.



isopropyl alcohol

(a) Give the IUPAC name for isopropyl alcohol. [1 mark]

_____

(b) (i) Propan-1-ol is a **structural isomer** of isopropyl alcohol. Explain this term. [2 marks]

_____

_____

_____

(ii) Ethyl methyl ether ($CH_3CH_2OCH_3$) is a structural isomer of isopropyl alcohol.

Explain, using intermolecular forces, why the boiling point of this isomer is lower than isopropyl alcohol. [3 marks]

_____

_____

_____

_____

(c) Isopropyl alcohol can be oxidised using acidified potassium dichromate(VI).

(i) Draw the skeletal formula of the organic product formed. [1 mark]

(ii) Name the type of compound formed. [1 mark]

_____

(iii) Explain how infrared spectroscopy could be used to show that the oxidation reaction was complete. [1 mark]

_____

_____

(d) Oxidation of 1.50 g of isopropyl alcohol gives 1.0 g of the organic product. Calculate the percentage yield of this reaction. [3 marks]

_____

_____

_____

(e) Isopropyl alcohol is completely soluble in water.

(i) Explain why isopropyl alcohol is soluble in water. [2 marks]

(ii) Suggest why the addition of sodium chloride to an aqueous solution of isopropyl alcohol causes the alcohol to become less soluble. [1 mark]

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(Questions continue overleaf)

12 Calcium is present in teeth in the form of calcium phosphate. This salt does not react with water although the element calcium does react forming a gas.

(a) Write the formula of calcium phosphate. [1 mark]

_____

(b) (i) Write an equation for the reaction of calcium with water. [2 marks]

_____

(ii) Explain why, using the same mass of strontium in place of calcium, the volume of gas produced when strontium reacts with water is less under the same conditions. [1 mark]

_____

_____

(iii) Suggest another difference that would be observed in the reaction with water when strontium is used in place of calcium. Explain your answer. [2 marks]

_____

_____

_____

(c) The Group II metal oxides can be formed from the metal hydroxides.

(i) How would you convert calcium hydroxide to calcium oxide? [1 mark]

_____

(ii) State and explain the trend in thermal stability of the Group II hydroxides as the Group is descended. [3 marks]

_____

_____

_____

(d) What chemical property of magnesium oxide makes it suitable for indigestion remedies? [1 mark]

_____

(e) Magnesium sulfate is an important compound in horticulture. Industrially, the sulfates of magnesium and calcium are produced by reacting dolomite rock with excess sulfuric acid.

$$MgCO_3.CaCO_3 + 2H_2SO_4 \rightarrow MgSO_4 + CaSO_4 + 2H_2O + 2CO_2$$

(i) Other than a temperature change, suggest **two** observations during this reaction. [2 marks]

_____

_____

(ii) Compare the solubility of magnesium sulfate with calcium sulfate in water. [1 mark]

(iii) The solubility of magnesium sulfate at two temperatures is given in the table below. In a batch process, a saturated solution of magnesium sulfate at 70 °C contained 100 tonnes of water. Use the table to calculate the mass of solid magnesium sulfate obtained when this solution is cooled to 20 °C. [2 marks]

temperature / °C	**solubility / g per 100 g of water**
20	35.1
70	59.2

(f) 2.50 g of hydrated magnesium sulfate crystals ($MgSO_4.xH_2O$) were heated to constant mass. The anhydrous solid has a mass of 1.22 g. Calculate the value of x and hence deduce the formula for the hydrated salt. [3 marks]

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(Questions continue overleaf)

13 Propene is an important building block for a large number of chemicals. At low temperatures, propene will react with chlorine in an electrophilic addition reaction.

(a) (i) Explain the term **electrophile**. [2 marks]

(ii) Draw a flow scheme to show the mechanism for the reaction between propene and chlorine using curly arrows. [4 marks]

(b) At 500 °C in the presence of ultraviolet light, propene will react with chlorine in a similar way to the reaction of propane with chlorine radicals. The product formed is allyl chloride ($CH_2{=}CHCH_2Cl$).

Outline the mechanism of the reaction between propene and chlorine giving equations for the initiation, propagation and termination steps. [4 marks]

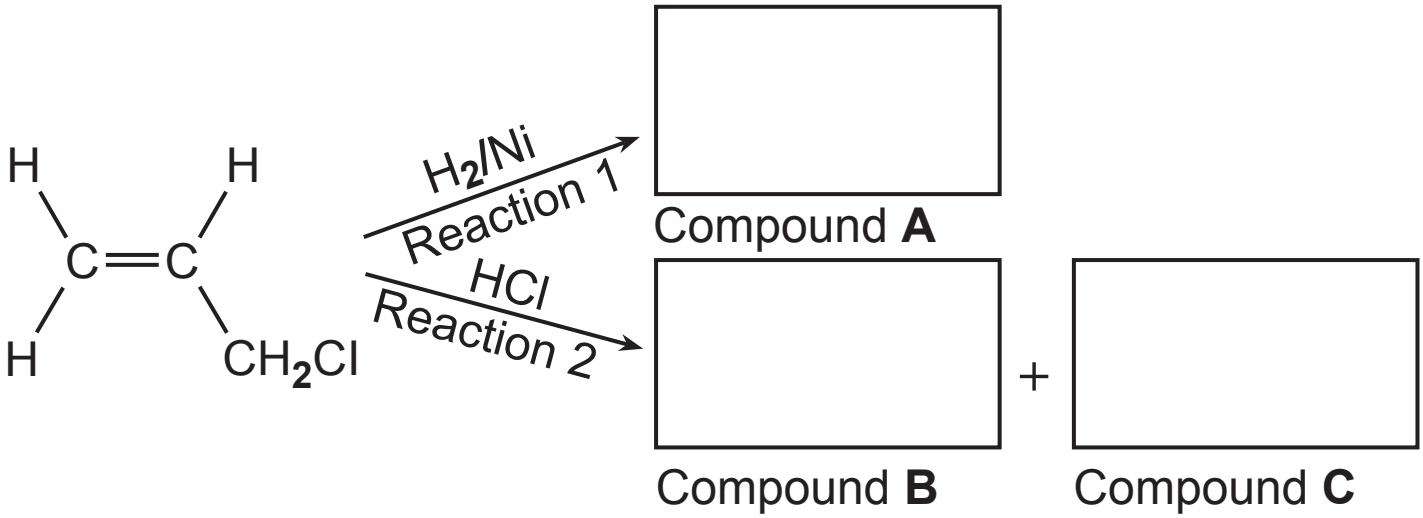
Initiation equation _____

Propagation equations _____

_____

Termination equation _____

(c) (i) Two reactions of allyl chloride are shown. Fill in the structures of Compounds **A**, **B** and **C**. More of compound **B** is formed than compound **C**. [3 marks]



(ii) Explain why compounds **B** and **C** are not formed in equal amounts. [2 marks]

(iii) Compound **B** reacts slowly in humid conditions to form compound **D** which contains the following percentage masses: C, 40.0%; H, 7.0%; O, 53.0%. The relative formula mass of the compound is 90. Deduce the molecular formula of compound **D**. [3 marks]

(d) Allyl chloride will undergo an hydrolysis reaction with aqueous sodium hydroxide similar to halogenoalkanes.

(i) Draw the structural formula of the organic product formed in this reaction.Show **all** the bonds present. [2 marks]

(ii) Name the inorganic product formed during this hydrolysis reaction. [1 mark]

_____

(e) Allyl chloride has a structural isomer which exists as geometrical isomers.
Draw and label these geometrical isomers. [3 marks]

(f) Allyl chloride is highly flammable. When it burns, one of the products formed is a corrosive gas.

(i) Define the term **molar gas volume**. [1 mark]

_____

(ii) 1.50 g of this corrosive gas occupies a volume of 0.986 dm^3 at 293 K and 1 atmosphere pressure. Use this information to calculate the relative molecular mass of the gas and suggest its identity.
[3 marks]

_____

_____

_____

_____

14 Two million tonnes of ethanol are produced each year by the direct hydration of ethene using a phosphoric acid catalyst at 300 °C and 6000 kPa.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \quad -45\,kJ\,mol^{-1}$$

(a) (i) Describe how a catalyst increases the rate of a reaction. [2 marks]

(ii) State and explain the **general** conditions of temperature and pressure required to give a high yield of ethanol. Explain how a compromise between equilibrium yield and the reaction rate may influence the conditions of temperature and pressure used. [6 marks]

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

(b) Ethanol is a liquid at room temperature. It is increasingly used as a fuel.

(i) Give the equation, including state symbols, for the standard molar enthalpy of formation of ethanol. [2 marks]

(ii) Suggest why this standard enthalpy change cannot be measured directly. [1 mark]

(iii) Using the enthalpy changes below, calculate the enthalpy change of formation of gaseous ethanol. [3 marks]

$C_2H_4(g) + H_2O(g) \rightarrow C_2H_5OH(g)$ $-45.0\,kJ\,mol^{-1}$

$2C(s) + 2H_2(g) \rightarrow C_2H_4(g)$ $+52.3\,kJ\,mol^{-1}$

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(g)$ $-242.0\,kJ\,mol^{-1}$

(c) (i) Give the equation for the standard enthalpy of combustion of ethanol. [2 marks]

(ii) Using bond enthalpies explain why enthalpy changes of combustion are negative. [2 marks]

THIS IS THE END OF THE QUESTION PAPER

For Examiner's use only	
Question Number	**Marks**
Section A	
1–10	
Section B	
11	
12	
13	
14	
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
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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

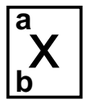
For first teaching from September 2016
For first award of AS Level in Summer 2017
For first award of A Level in Summer 2018
Subject Code: 1110

THE PERIODIC TABLE OF ELEMENTS

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