Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2019

Centre Number

Candidate Number

Chemistry

Assessment Unit AS 2

assessing

Further Physical and Inorganic Chemistry and an Introduction to Organic Chemistry

MV18

[SCH22]

THURSDAY 23 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 **13(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 How many carbon to carbon bonds are there in 3,3-dichloro-2-methylbutan-2-ol?

A 3

B 4

C 5

D 6

2 Which sequence of elements is arranged in order of increasing bond strength?

A F_2 O_2 N_2

B N_2 O_2 F_2

C O_2 F_2 N_2

D O_2 N_2 F_2

3 0.005 mole of a chloride of an element Z was mixed with water and the resulting solution required 25 cm^3 of 0.6 M aqueous silver nitrate for complete precipitation of silver chloride. Element Z is in Group

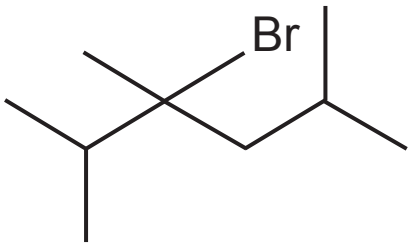
A III.

B IV.

C V.

D VI.

4 The bromoalkane below reacts with ethanolic potassium hydroxide and eliminates hydrogen bromide.



What is the number of alkenes formed and how many pairs of E/Z isomers exist?

	number of alkenes	pairs of E/Z isomers
A	2	1
B	2	2
C	3	1
D	3	2

5 The Williamson synthesis of an ether (ROR′) is summed up by the following two steps:

Step 1 $2ROH + 2Na \rightarrow 2RONa + H_2$

Step 2 $RONa + R'Cl \rightarrow ROR' + NaCl$

Using propan-2-ol and 2-chlorobutane the ether formed is

A $CH_3CH_2CH_2OCH(CH_3)CH_2CH_3$.

B $CH_3CH_2CH_2OCH_2CH_2CH_2CH_3$.

C $CH_3CH(CH_3)OCH_2CH_2CH_2CH_3$.

D $CH_3CH(CH_3)OCH(CH_3)CH_2CH_3$.

6 Which of the following describes a dynamic equilibrium?

	concentration of reactants and products	**forward and reverse reaction rates**
A	constant	equal
B	constant	not equal
C	not constant	equal
D	not constant	not equal

7 A mixture of potassium bromide and potassium carbonate contains 0.6 moles of bromide ion and 0.2 moles of carbonate ion. How many moles of potassium ions are present?

A 0.4

B 0.5

C 0.8

D 1.0

8 The total pressure is increased in each of the following reactions. For which reaction would the yield of product(s) **not** change?

A $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$

B $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$

C $2H_2(g) + O_2(g) \rightleftharpoons 2H_2O(g)$

D $3H_2(g) + CO(g) \rightleftharpoons CH_4(g) + H_2O(g)$

9 One molecule of cuprimine contains one sulfur atom. The percentage, by mass, of sulfur in cuprimine is 21.47**%**. The relative molecular mass of cuprimine is

A 85.

B 101.

C 125.

D 149.

10 The general formula of an alkyl group is

A C_nH_{n+1}

B C_nH_{n-1}

C C_nH_{2n+1}

D C_nH_{2n-1}

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Section B

Answer all **four** questions in this section

11 Group II metal nitrates are formed when either the metal, the metal oxide or the metal carbonate are reacted with nitric acid. Metal nitrates are very soluble in water and all of the reactions proceed normally, apart from magnesium with nitric acid, because nitric acid is an oxidising agent and causes other reactions to take place.

(a) Write equations for the reactions of calcium, calcium oxide and calcium carbonate with dilute nitric acid. [1 mark for each]

(i) calcium:

_____

(ii) calcium oxide:

_____

(iii) calcium carbonate:

_____

(b) Magnesium does not react with most concentrations of nitric acid to give hydrogen. Instead, nitrogen(IV) oxide together with magnesium nitrate and water are produced. Write the equation for the reaction. [1 mark]

_____

(c) Group II metal nitrates increase in thermal stability as the Group is descended.

(i) Explain what is meant by the term **thermal stability**. [1 mark]

(ii) Explain why thermal stability increases down the Group. [1 mark]

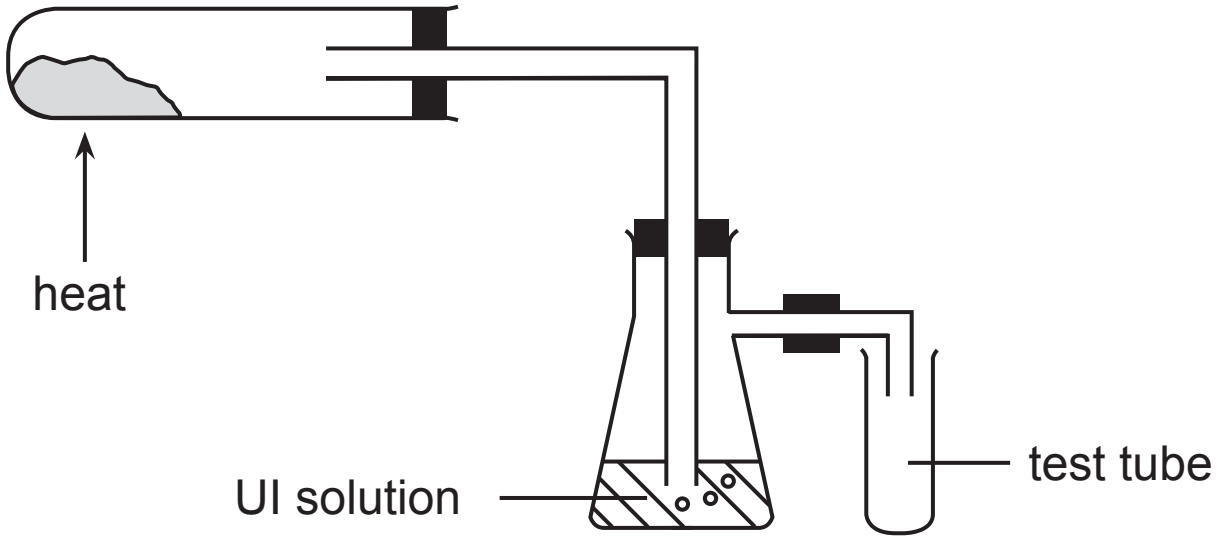
(d) When heated, the Group II nitrates, $M(NO_3)_2$, decompose according to the following equation:

$$2M(NO_3)_2 \rightarrow 2MO + 4NO_2 + O_2$$

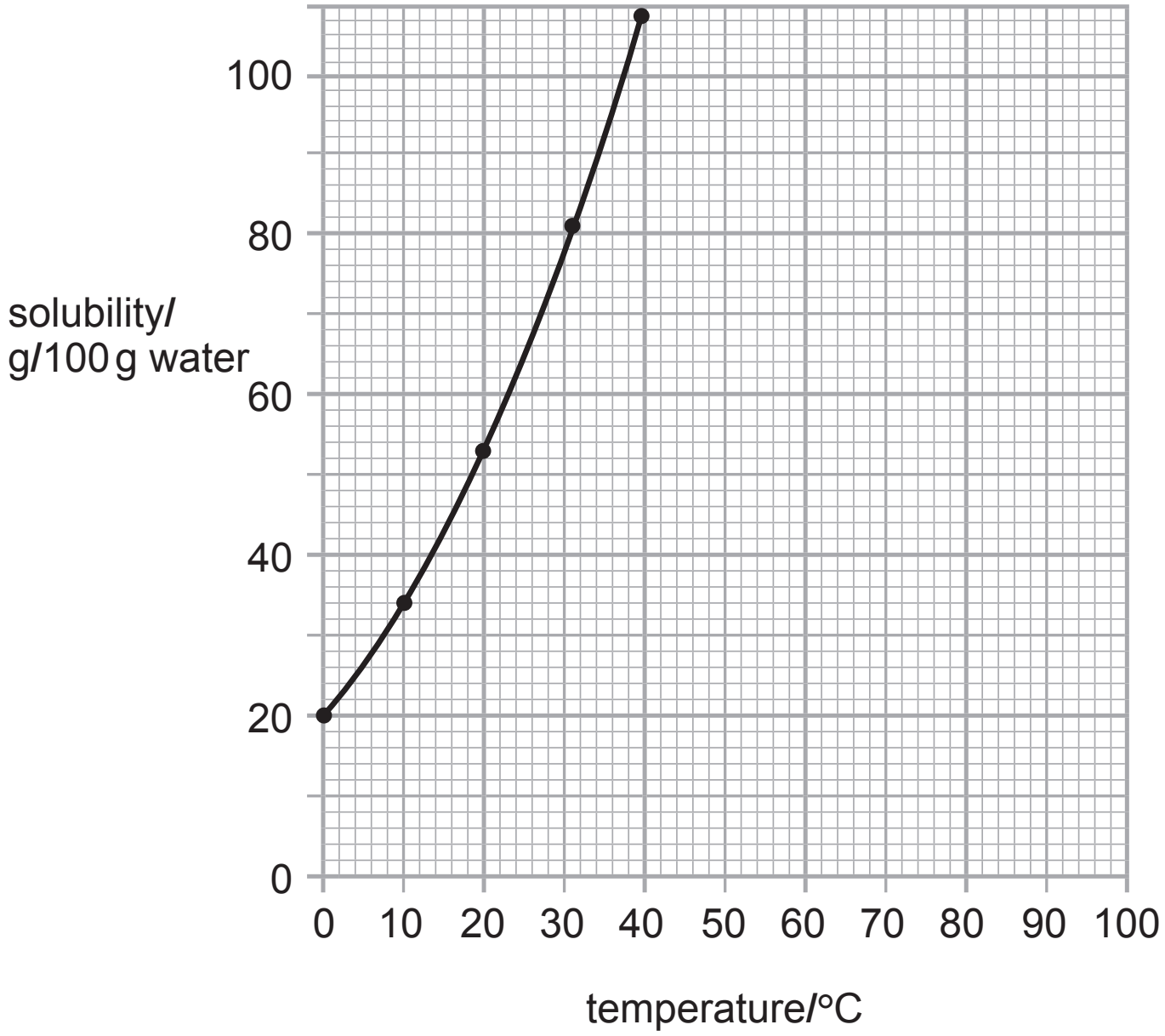
(i) Explain why the residue left after the reaction gives an alkaline solution when dissolved in water. [1 mark]

(ii) If 3.6 g of strontium nitrate is heated and completely decomposes, what is the total volume of gases collected at 20 °C and a pressure of one atmosphere? [3 marks]

(iii) The diagram below shows the gases from the decomposition of a nitrate passing through Universal Indicator (UI) solution and one gas being collected in a test tube. Explain why the UI solution goes red and name the gas collected in the test tube. [2 marks]



(e) Group II metal nitrates are soluble in water. The solubility curve for the Group I nitrate, rubidium nitrate, is shown below.



The following data refers to the solubility of strontium nitrate with temperature.

Solubility/g/ 100 g water	40	55	71	88	91	93	94	97	99	101
Temperature/°C	0	10	20	30	40	50	60	70	80	90

(i) Plot the solubility curve for strontium nitrate on the axes opposite. [1 mark]

(ii) Determine the temperature at which rubidium nitrate and strontium nitrate have the same solubility. [1 mark]

_____

_____

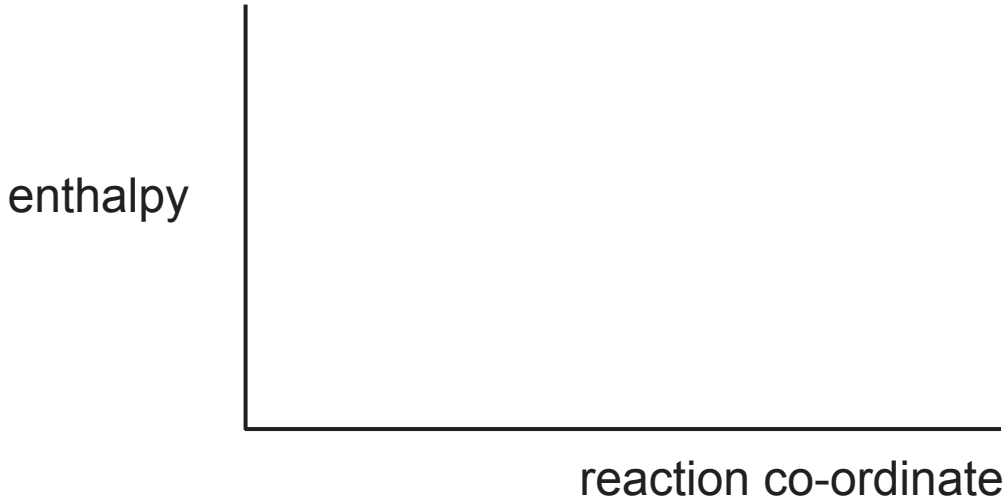
12 Hypochlorous acid has the formula HOCl. It adds to alkenes to form chlorohydrins.

$CH_2{=}CH_2 + HOCl \rightarrow CH_2ClCH_2OH$

(a) (i) Calculate the enthalpy change for the reaction between ethene and hypochlorous acid using the following average bond enthalpies. [3 marks]

bond	**enthalpy/ kJ mol^{-1}**
C═C	612
C—C	347
Cl—O	272
C—Cl	346
C—O	358

(ii) Construct a simple labelled enthalpy level diagram for the reaction between ethene and hypochlorous acid. Insert the enthalpy value calculated in part **(i)** onto the diagram. [2 marks]



(b) Hypochlorous acid adds to alkenes because it has a polar bond, HO—Cl.

(i) Explain what is meant by the term **polar bond**. [2 marks]

(ii) Draw the polarity of a hypochlorous acid molecule. [1 mark]

(iii) Draw the mechanism, using curly arrows, for the reaction of hypochlorous acid with propene to form $CH_2ClCHOHCH_3$. [4 marks]

(iv) Name the compound $CH_2ClCHOHCH_3$. [2 marks]

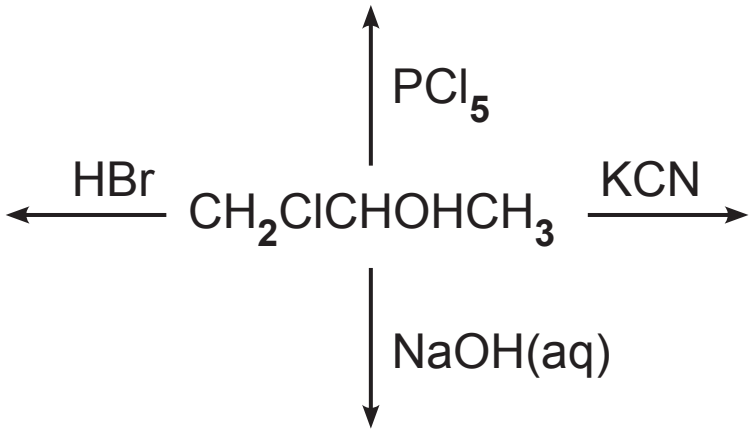
(v) The compound $CH_2ClCHOHCH_3$ is the major product. Draw the structure of the minor product and explain why it is the minor product. [2 marks]

(vi) If the reaction in part **(iii)** is carried out in the presence of sodium nitrite, $NaNO_2$, some $CH_2ClCHNO_2CH_3$ is formed. Suggest how this compound is formed. [1 mark]

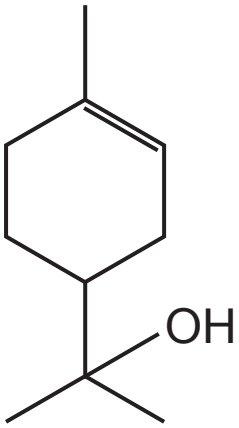
(c) Chlorohydrins are useful in synthetic chemistry because they are bifunctional.

(i) Suggest the meaning of the term **bifunctional**. [1 mark]

(ii) Complete the following reaction scheme for $CH_2ClCHOHCH_3$ by drawing the organic products. [4 marks]



13 α-Terpineol is a terpene which is the main ingredient in pine oil.



α-terpineol

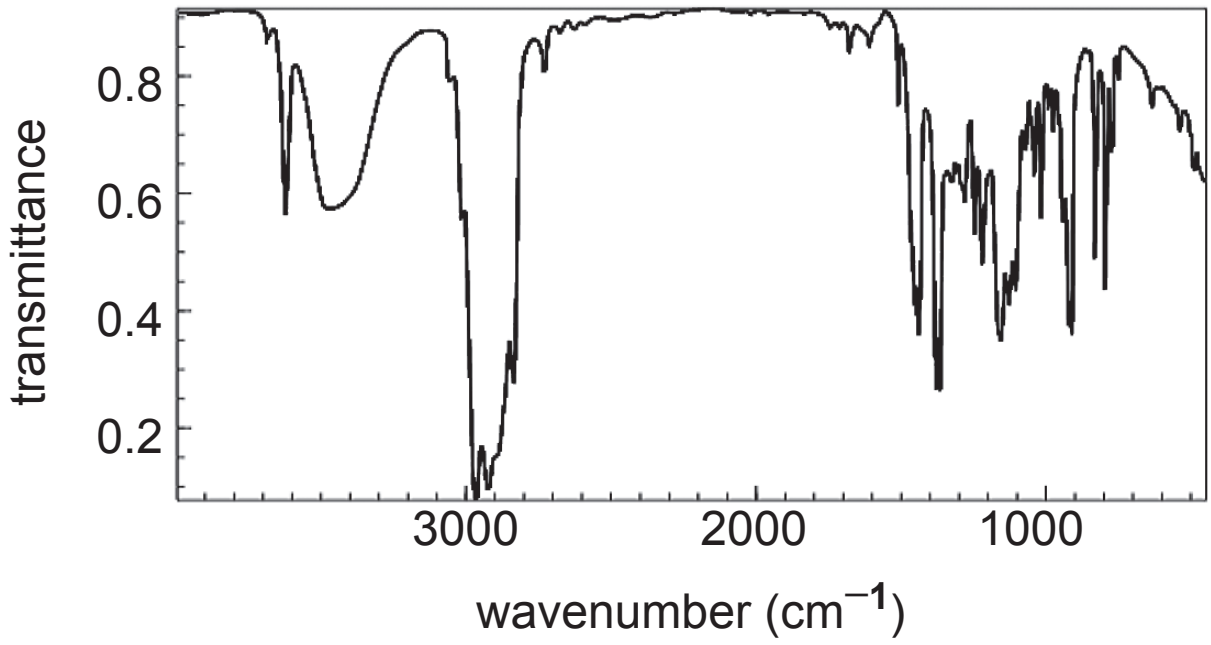
It is a colourless liquid with a smell of violets. The boiling point of α-terpineol is 214–216 °C and its density is 0.93 g cm^{-3}. α-Terpineol is slightly soluble in water; 2.42 g dissolves in 1 dm^3 of water at room temperature.

(a) (i) Describe and explain, using calculated values, what you would observe if you added 1.1 g of α-terpineol to 200 cm^3 of water in a beaker at room temperature and stirred the mixture. [4 marks]

(ii) Explain, with full experimental detail, how you would separate α-terpineol from a mixture of 50 cm^3 of α-terpineol and 10 cm^3 of water. Your method should include separating with a funnel, distillation and drying. [6 marks]

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

(b) The purity of the α-terpineol obtained from part **(a)** may be determined by the infrared spectrum which is shown below.



(i) Explain why molecules absorb infrared radiation producing infrared spectra. [2 marks]

(ii) Identify the peaks, by stating the range of wavenumbers in the spectrum, which correspond to the functional groups in the molecule. [2 marks]

(iii) Explain how you could use infrared spectrometry to determine that a sample of α-terpineol is pure and free from all impurities. [1 mark]

_____

_____

(c) (i) Explain, using the structure of α-terpineol, whether the alcohol is primary, secondary or tertiary. [2 marks]

_____

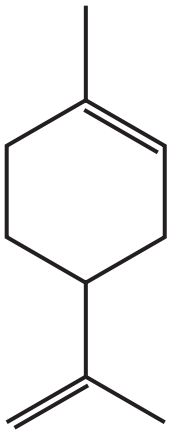
_____

(ii) State what would be observed when a few drops of α-terpineol are added to acidified potassium dichromate(VI) and the mixture is heated. [1 mark]

_____

_____

(d) When α-terpineol is dehydrated it forms a mixture of limonene and δ-terpinene.



limonene

Suggest the structure of δ-terpinene. [1 mark]

(e) Limonene is an unsaturated hydrocarbon which reacts with bromine and hydrogen.

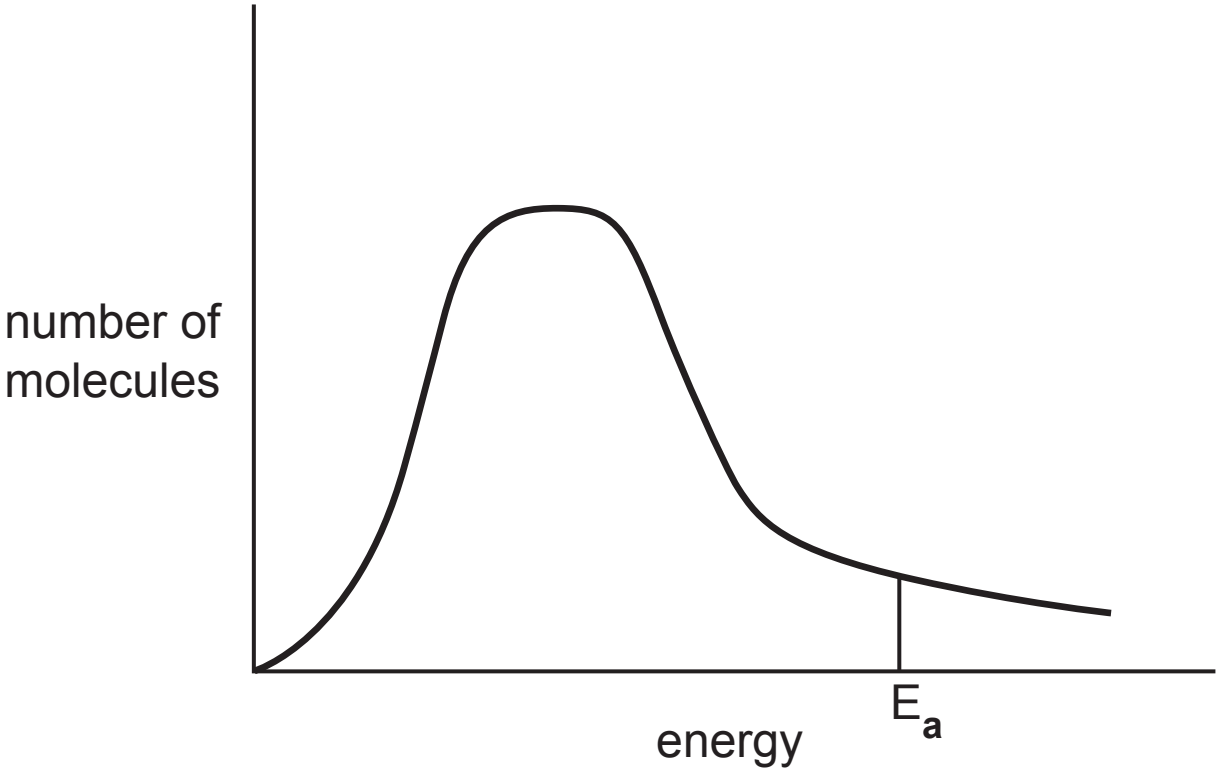
(i) Define the term **unsaturated**. [1 mark]

(ii) Explain, giving experimental detail, how you would use bromine water to test for unsaturation.
[3 marks]

(iii) Explain, naming the catalyst, what is meant by catalytic hydrogenation. [2 marks]

(iv) Cadinene, $C_{15}H_{24}$, reacts with hydrogen and becomes completely saturated. 0.34 g of cadinene reacts with 80 cm^3 of hydrogen at 20 °C and a pressure of one atmosphere. Calculate the number of double bonds in a molecule of cadinene.
[3 marks]

14 The Maxwell–Boltzmann distribution curve below shows the distribution of molecular energies in a mixture of the gases sulfur dioxide and oxygen at 25 °C.



The x-axis can either be labelled as energy or speed. The distribution curve starts at the point 0,0 and at the end approaches the x-axis but does not touch it. The symbol E_a is the activation energy.

(a) Draw, on the axes above, the Maxwell–Boltzmann distribution curve for a mixture of sulfur dioxide and oxygen, at a **lower** temperature. [2 marks]

(b) Explain why the x-axis can either be labelled as energy or speed. [1 mark]

(c) Explain what it means if the distribution curve starts at the point 0,0. [1 mark]

(d) Explain what it would mean if the Maxwell–Boltzmann curve touched the x-axis at a final energy value. [1 mark]

(e) Activation energy varies from reaction to reaction.

(i) Explain the term **activation energy**. [2 marks]

(ii) Comment on the reaction speed between silver ions and chloride ions in aqueous solution and how it relates to activation energy. [2 marks]

(iii) State the effect of a catalyst on the activation energy of a reaction. [1 mark]

(f) The reaction between sulfur dioxide and oxygen is part of the process to manufacture sulfuric acid.

(i) What is the name of this industrial process?
[1 mark]

(ii) Describe and explain the conditions used in this process for the reaction between sulfur dioxide and oxygen referring to temperature, pressure and catalyst.

temperature [2 marks]

pressure [2 marks]

catalyst [1 mark]

This is the end of the question paper

Sources

"Data from NIST Standard Reference Database 69: NIST Chemistry WebBook
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11983.03 **MV18**

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

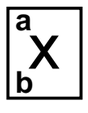
For first teaching from September 2016
For first award of AS Level in Summer 2017
For first award of A Level in Summer 2018
Subject Code: 1110

THE PERIODIC TABLE OF ELEMENTS

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