Write your name here

Surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

International Advanced Subsidiary/Advanced Level
Unit 2: Energetics, Group Chemistry, Halogenoalkanes and Alcohols

Sample Assessment Materials for first teaching September 2018

Time: 1 hour 30 minutes

Paper Reference **WCH12/01**

You must have:
Data Booklet, scientific calculator, ruler

Total Marks

Instructions

- Use **black** ink or **black** ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*
- **Show all your working in calculations and include units where appropriate**.

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- In questions marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.
- There is a Periodic Table on the back page of this paper.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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S 5 8 3 1 0 A 0 1 2 6

Pearson

SECTION A

Answer ALL the questions in this section.

You should aim to spend no more than 20 minutes on this section.

For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which alkane has the highest boiling temperature?

☒ **A** 2,2-dimethylpropane

☒ **B** 2-methylbutane

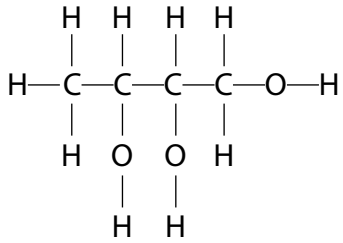
☒ **C** butane

☒ **D** pentane

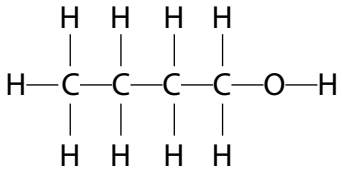
(Total for Question 1 = 1 mark)

2 Which is the order of **increasing** boiling temperature?

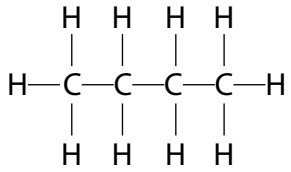
W =



X =



Y =



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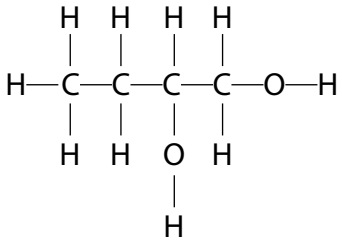

☒ **A** Y Z X W

☒ **B** Y X Z W

☒ **C** W X Z Y

☒ **D** X W Y Z

(Total for Question 2 = 1 mark)

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3 Which statement is **not** explained by hydrogen bonding?

☒ **A** all Group 1 hydroxides are soluble in water

☒ **B** many simple alcohols are soluble in water

☒ **C** the density of ice is less than the density of liquid water at 0 °C

☒ **D** the melting temperature of water is abnormally high

(Total for Question 3 = 1 mark)

4 Which compound is hydrolysed most rapidly?

☒ **A** 1-chloropropane

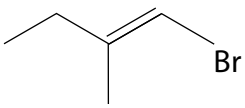
☒ **B** 1-chlorobutane

☒ **C** 2-chloro-2-methylpropane

☒ **D** 2-chlorobutane

(Total for Question 4 = 1 mark)

5 Give the systematic name for the following molecule.



☒ **A** *E*-1-bromo-2-methylbut-2-ene

☒ **B** *E*-2-methyl-1-bromobut-1-ene

☒ **C** *E*-1-bromo-3-methylpent-2-ene

☒ **D** *E*-1-bromo-2-methylbut-1-ene

(Total for Question 5 = 1 mark)

6 1-bromobutane reacts with alkali:

$CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2Br + OH^- \rightarrow CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2OH + Br^-$

The mechanism and type of reaction is:

☒ **A** electrophilic addition

☒ **B** electrophilic substitution

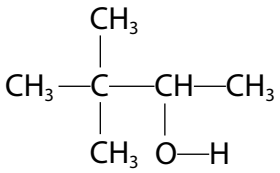
☒ **C** nucleophilic addition

☒ **D** nucleophilic substitution

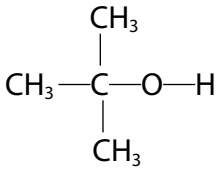
(Total for Question 6 = 1 mark)

7 Which of the following compounds could be oxidised to a carboxylic acid by refluxing with potassium dichromate(VI) and dilute sulfuric acid?

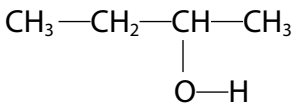
☒ **A**



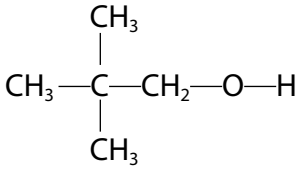
☒ **B**



☒ **C**



☒ **D**



(Total for Question 7 = 1 mark)

8 A student made the following statements about trends going **down** Group 2.
Which statement is correct?

☒ **A** the thermal stability of the nitrates decreases

☒ **B** the thermal stability of the carbonates decreases

☒ **C** the solubility of hydroxides increases

☒ **D** the solubility of sulfates increases

(Total for Question 8 = 1 mark)

9 A colourless solid, Q, was warmed with sodium hydroxide solution. A gas was evolved which turned damp red litmus paper blue. What is solid Q?

☒ **A** $NaNO_3$

☒ **B** NH_4Cl

☒ **C** NaCl

☒ **D** $Ca(NO_3)_2$

(Total for Question 9 = 1 mark)

10 Which test is used to show that sodium chloride solution contains chloride ions?

☒ **A** damp blue litmus paper turns red

☒ **B** damp blue litmus paper is bleached

☒ **C** dilute hydrochloric acid followed by silver nitrate solution gives a white precipitate

☒ **D** dilute nitric acid followed by silver nitrate solution gives a white precipitate

(Total for Question 10 = 1 mark)

11 Compound X gives a red flame test colour and a white precipitate on addition of dilute hydrochloric acid followed by barium chloride solution. Which compound is X?

☒ **A** calcium chloride

☒ **B** lithium sulfate

☒ **C** potassium sulfate

☒ **D** strontium chloride

(Total for Question 11 = 1 mark)

12 Which process explains the flame colour produced by the compounds of Group 1 elements?

☒ **A** absorption of visible light energy as electrons are promoted to higher energy levels

☒ **B** absorption of visible light energy as electrons are removed from gaseous atoms

☒ **C** emission of visible light energy as electrons return to lower energy levels

☒ **D** emission of visible light energy as electrons are added to gaseous ions

(Total for Question 12 = 1 mark)

13 When chlorine is reacted with hot concentrated potassium hydroxide, the chlorine undergoes disproportionation.

What are the oxidation states of chlorine in the products?

☒ **A** –1 and +3

☒ **B** –1 and +5

☒ **C** +1 and –1

☒ **D** +1 and +5

(Total for Question 13 = 1 mark)

14 What are the gaseous products formed, other than water vapour, when concentrated sulfuric acid is added to potassium bromide?

☒ **A** bromine and sulfur dioxide only

☒ **B** bromine, hydrogen bromide and hydrogen sulfide only

☒ **C** bromine, hydrogen bromide and sulfur dioxide only

☒ **D** bromine, hydrogen bromide, sulfur dioxide and hydrogen sulfide only

(Total for Question 14 = 1 mark)

15 Zinc metal reacts with copper(II) sulfate solution. The equation for the reaction is:

$$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s) \qquad \Delta_r H = -210\,kJ\,mol^{-1}.$$

(a) What is the temperature rise, in °C, when excess zinc powder is added to 50 cm^3 of copper(II) sulfate solution containing 0.0025 mol of copper(II) ions?

[Assume the specific heat capacity of the solution is 4.2 $J\,g^{-1}\,°C^{-1}$].

(1)

☒ **A** 2.5

☒ **B** 10.5

☒ **C** 25.0

☒ **D** 44.1

(b) The reaction of zinc with copper(II) sulfate is best classified as:

(1)

☒ **A** disproportionation

☒ **B** neutralisation

☒ **C** redox

☒ **D** thermal decomposition

(Total for Question 15 = 2 marks)

16 Magnesium metal reacts with hydrochloric acid. Which change in condition would have no effect on the initial rate of this reaction?

☒ **A** an increase in the volume of acid solution

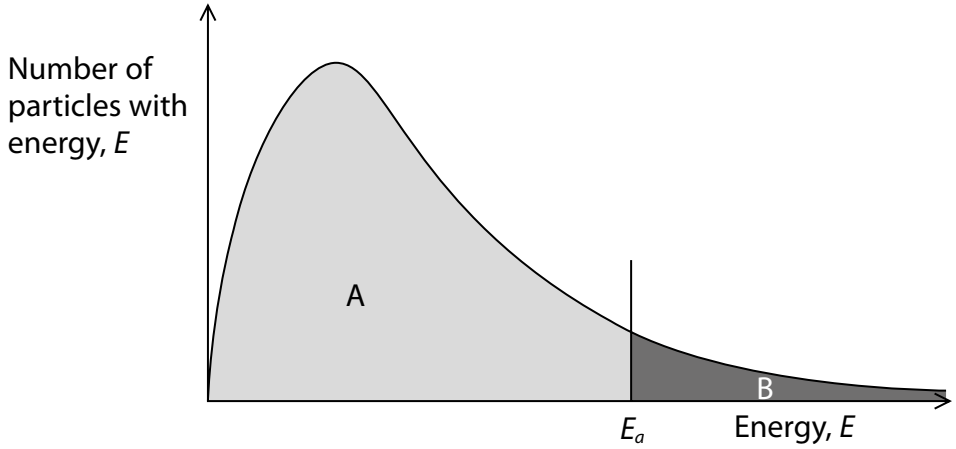
☒ **B** a decrease in the temperature of the acid solution

☒ **C** an increase in the surface area of the magnesium

☒ **D** a decrease in the concentration of the acid solution

(Total for Question 16 = 1 mark)

17 The diagram shows the general shape of a Maxwell-Boltzmann distribution curve for the particles present in a reaction mixture.



(a) How does the peak change when the temperature of the reaction mixture is decreased?

(1)

	Peak position	Peak height
☒ **A**	shifted left	higher
☒ **B**	shifted right	higher
☒ **C**	shifted left	lower
☒ **D**	shifted right	lower

(b) The activation energy of an uncatalysed reaction is represented by the vertical line, E_a, on the horizontal axis. The shaded areas A and B are the areas under the curve on either side of the line E_a.

How do the two shaded areas change, if at all, when a catalyst is added?

(1)

	Area A	Area B
☒ **A**	increases	decreases
☒ **B**	decreases	increases
☒ **C**	no change	no change
☒ **D**	increases	increases

(Total for Question 17 = 2 marks)

18 The equilibrium reaction shown in the equation was studied by placing the components into a sealed glass container.

$$2NO_2(g) \rightleftharpoons N_2O_4(g)$$

At equilibrium, which of the following statements is **not** true?

☒ **A** the concentrations of the $NO_2(g)$ and $N_2O_4(g)$ both remain constant

☒ **B** the total number of molecules is constant

☒ **C** the forward and reverse reactions have both stopped

☒ **D** the rate of the forward reaction is equal to the rate of the reverse reaction

(Total for Question 18 = 1 mark)

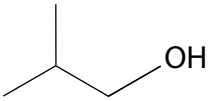
TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions.

Write your answers in the spaces provided.

19 2-methylpropan-1-ol has the skeletal formula:



(a) 2-methylpropan-1-ol can be converted to 1-bromo-2-methylpropane.

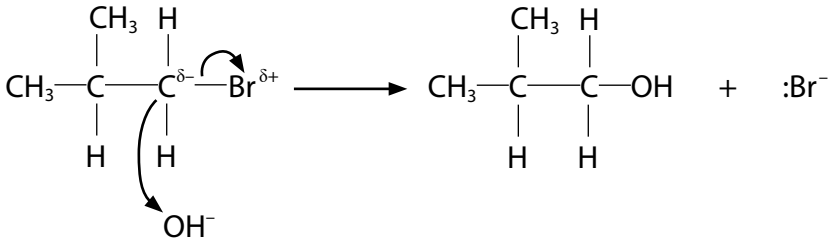
Give the reagents and conditions used for this reaction.

(2)

Reagents .....

Conditions .....

(b) 1-bromo-2-methylpropane can be converted back to 2-methylpropan-1-ol by heating with aqueous alkali. A student suggested the following mechanism for the reaction.



Identify and correct the three mistakes in the mechanism shown.

(3)

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(c) 1-bromo-2-methylpropane can be converted to 2-methylpropene.

Give the reagents and conditions used for this reaction.

(2)

Reagents .....

Conditions .....

(Total for Question 19 = 7 marks)

20 Ethanedioic acid is a solid diprotic acid. A student used ethanedioic acid in a titration to find the concentration of a potassium hydroxide solution.

The equation for the reaction is:

$$2KOH + (COOH)_2 \rightarrow (COOK)_2 + 2H_2O$$

(a) Calculate the mass of ethanedioic acid that should be used to make 1000 cm^3 of a 0.0500 mol dm^{-3} solution in water.

Give your answer to an appropriate number of significant figures.

[Molar mass of ethanedioic acid = 90.0 g mol^{-1}].

(2)

(b) A student decided to check to see if phenolphthalein was a suitable indicator for this titration. The student measured 400 cm^3 of the 0.0500 mol dm^{-3} ethanedioic acid into a beaker and added a few drops of phenolphthalein indicator.

Calculate the minimum mass of solid potassium hydroxide that should be added to produce a colour change.

(2)

*(c) A student used a 0.0500 mol dm^{-3} solution of ethanedioic acid to find an accurate concentration of a potassium hydroxide solution which was known to have an approximate concentration of 0.1 mol dm^{-3}.

Describe a procedure to obtain reliable titration results using standard laboratory equipment.

(6)

(Total for Question 20 = 10 marks)

21 Sodium hydrogencarbonate can be decomposed to sodium carbonate by heating to about 300 °C.

The equation for the reaction is:

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(l)$$

(a) Give a reason why it is **not** possible to measure the enthalpy change for this reaction directly.

(1)

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(b) (i) State what is meant by the standard enthalpy change of formation.

(2)

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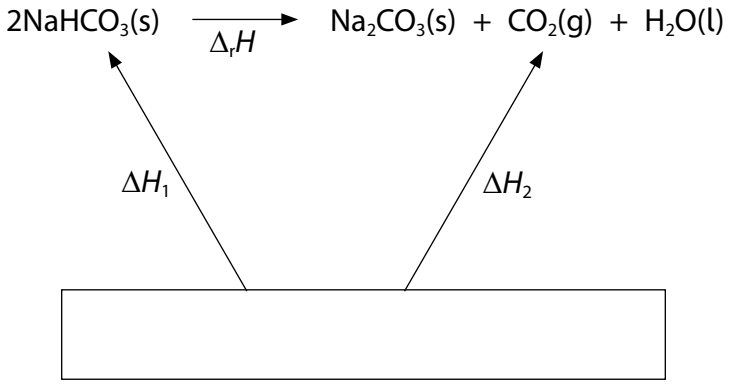
(ii) Complete the Hess cycle that you would use to determine the enthalpy change for this reaction from the standard enthalpy changes of formation.

(2)



(iii) Calculate the standard enthalpy change for the thermal decomposition of sodium hydrogencarbonate, using the information in the table and your completed cycle. Include a sign and units in your answer.

(4)

Compound	Standard enthalpy change of formation, $\Delta_f H^{\ominus}$ / kJ mol^{-1}
$NaHCO_3(s)$	–950.8
$Na_2CO_3(s)$	–1130.7
$CO_2(g)$	–393.5
$H_2O(l)$	–285.8

(iv) Use your answer to (b)(iii) to draw an enthalpy level diagram for this reaction, labelling the axes provided.

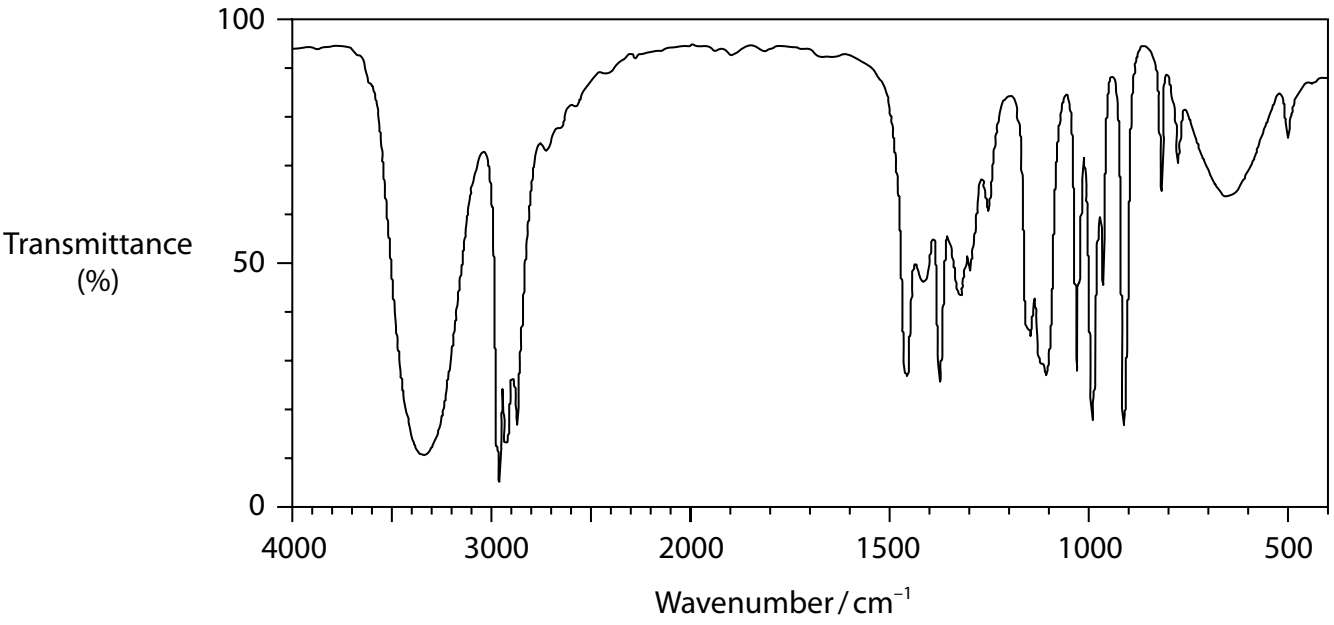
(2)

(Total for Question 21 = 11 marks)

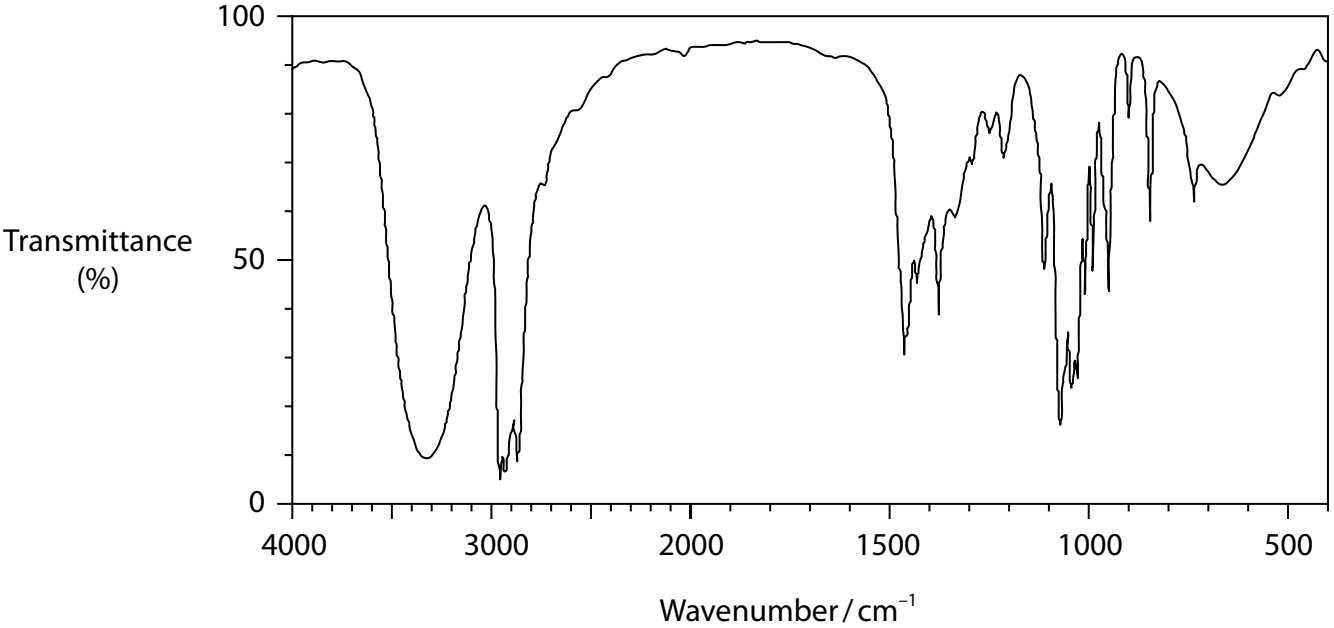
22 Three compounds, A, B and C, each have the same molecular formula $C_4H_{10}O$ and are known to be alcohols.

(a) The infrared spectra of compounds A, B and C are shown.

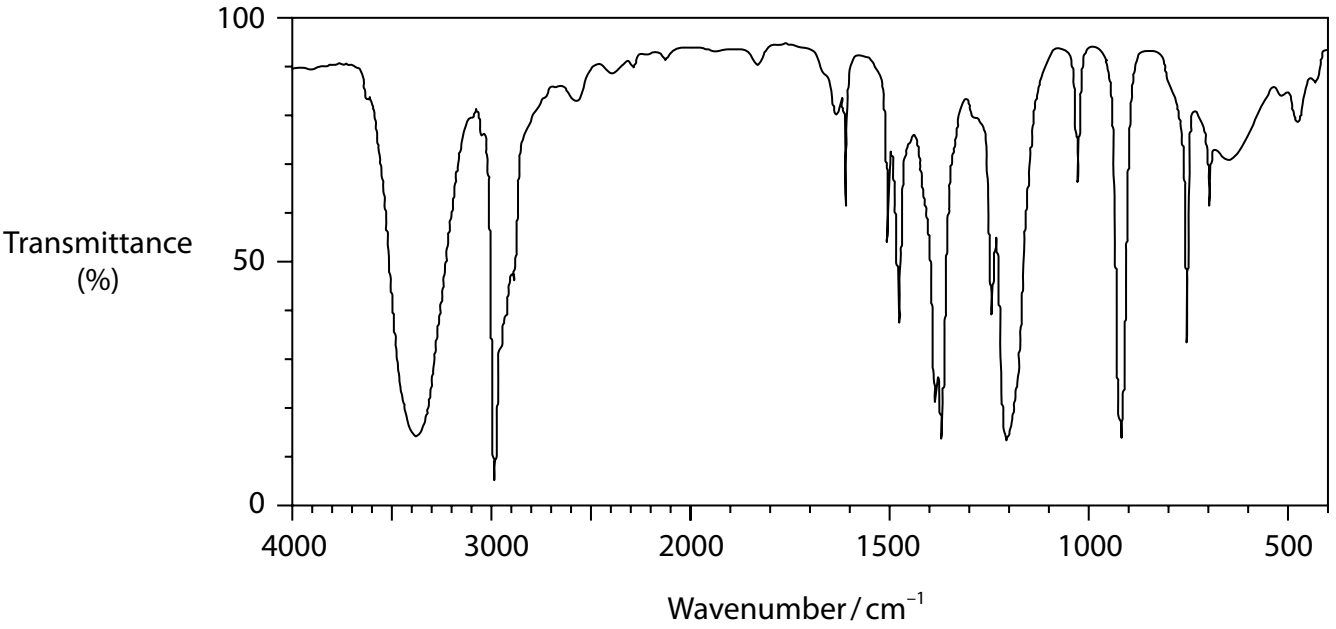
Compound A



Compound B



Compound C



(i) Identify one feature, common to all three infrared spectra, which shows that A, B and C are all alcohols.

(1)

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(ii) State, giving a reason for your answer, if it is possible to identify each of these three alcohols on the basis of the infrared spectra alone.

(1)

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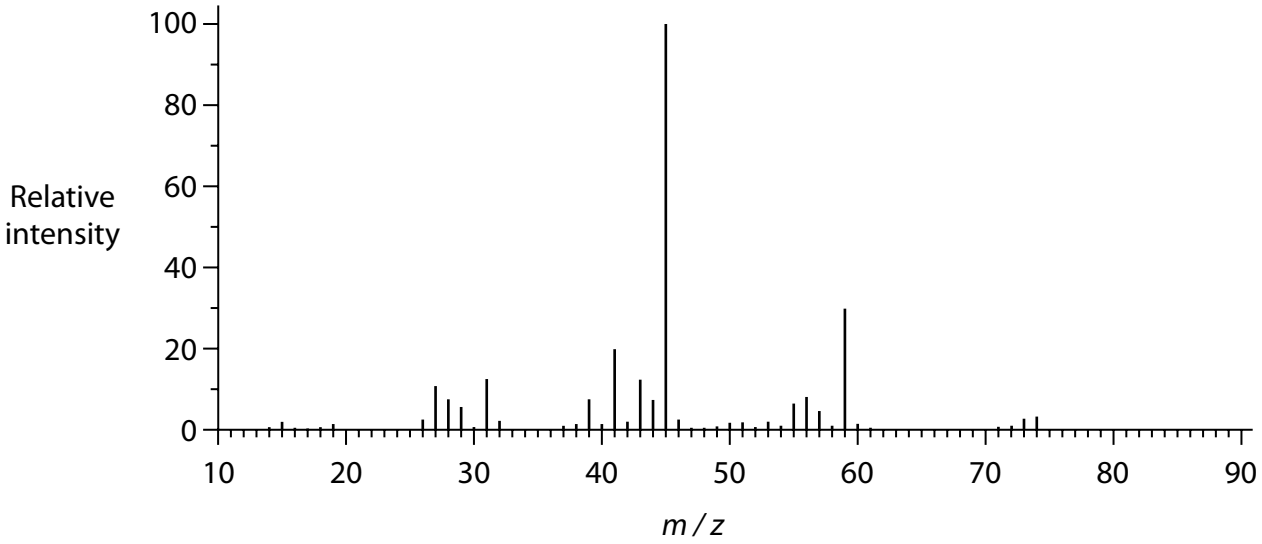
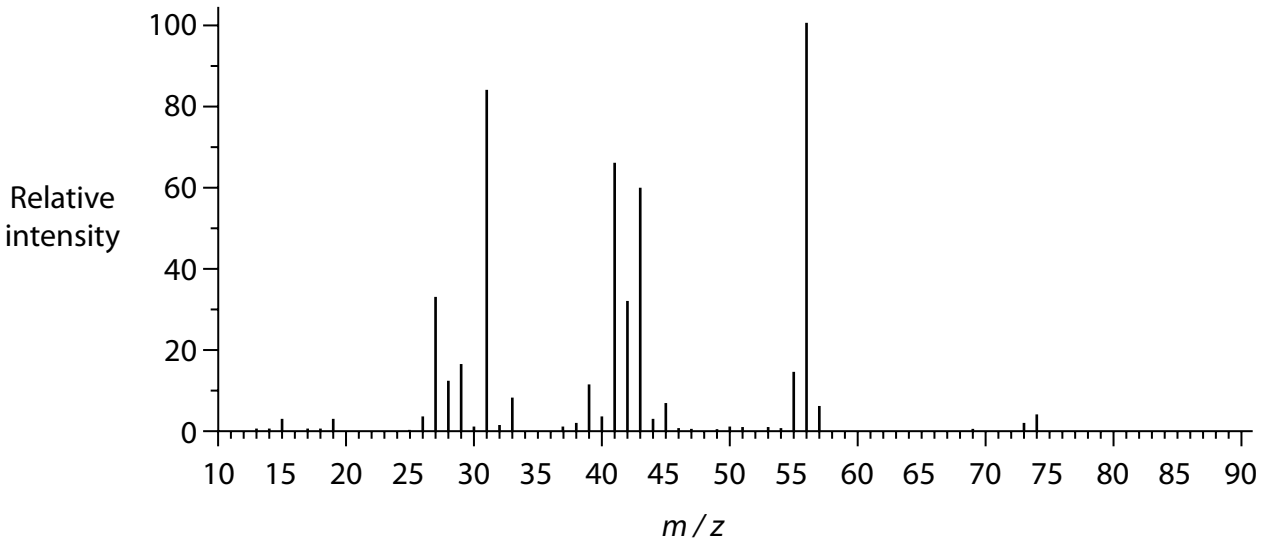
(b) The mass spectra of the compounds A, B and C are shown.

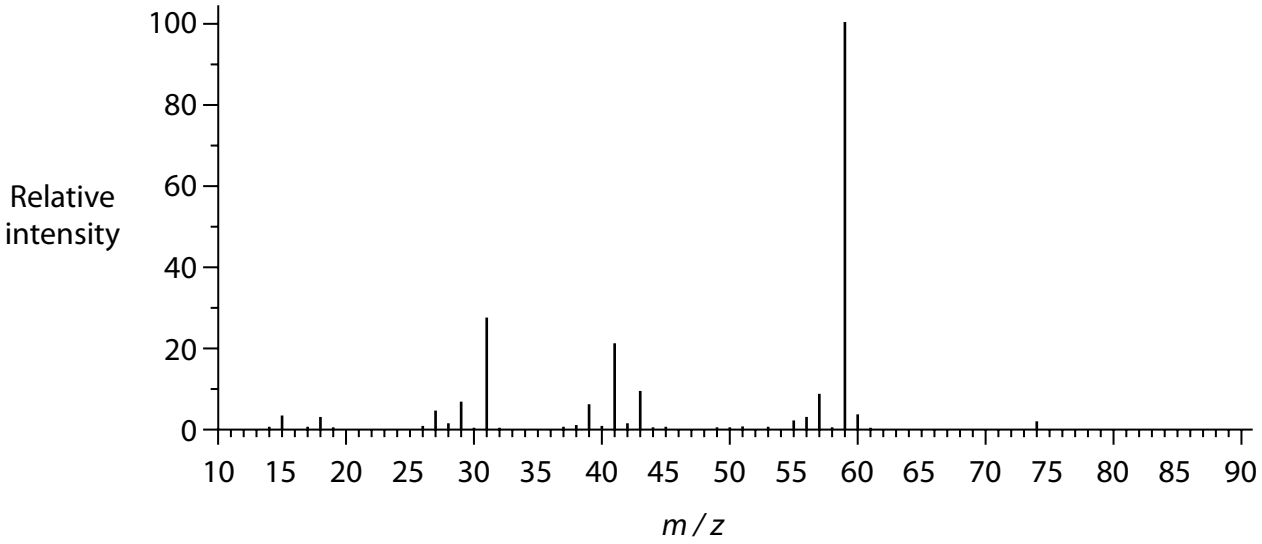
Compound A



Compound B



Compound C



(i) Identify one feature common to the mass spectra of compounds A, B and C which shows that the molecular formula is $C_4H_{10}O$.

(1)

.....

.....

(ii) Using the fragmentation patterns, a student proposed that:

compound A is butan-2-ol
compound B is butan-1-ol
compound C is 2-methylpropan-2-ol

State how the appearance in the spectra of the following peaks supports the student's conclusion.

(3)

the fragment causing the peak at $m/z = 45$ for compound A

.....

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the fragment causing the peak at $m/z = 31$ for compound B

.....

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the fragment causing the peak at $m/z = 59$ for compound C

.....

.....

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(c) To help with the identification of compounds A and B, the student decided to mix each of them with potassium dichromate(VI) and dilute sulfuric acid solutions, and then distil the mixture immediately.

(i) Identify, by name and structural formula, the organic compound present at the conclusion of each of these two oxidation reactions.

(3)

Organic compound used	Name of oxidation product	Structural formula of oxidation product
A, butan-2-ol		
B, butan-1-ol		

(ii) To identify A and B, the student decided that one further chemical test should be used on their oxidation products.

Give a suitable reagent and expected observations that could be used to distinguish between the oxidation products of A and B.

(3)

(Total for Question 22 = 12 marks)

TOTAL FOR SECTION B = 40 MARKS

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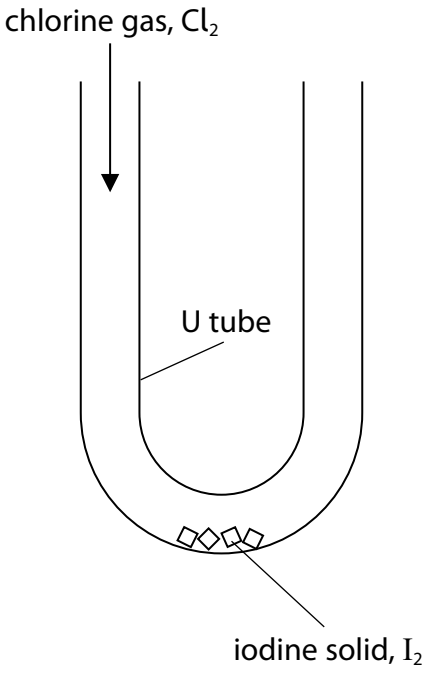
SECTION C

Answer ALL the questions.

Write your answers in the spaces provided.

23 Iodine monochloride, ICl, is a covalent compound produced by the reaction of iodine with chlorine. Iodine monochloride is a dark brown liquid at room temperature.

The equipment shown can be used to pass chlorine over solid iodine to produce iodine monochloride.



When excess chlorine is passed through the U tube, the iodine monochloride reacts to produce iodine trichloride in an equilibrium reaction.

(a) Write a chemical equation for the reaction of iodine with chlorine to produce iodine monochloride. Include state symbols.

(2)

(b) The iodine monochloride molecule has a permanent dipole. Complete the following table using the electronegativity data from your Data Booklet and hence show the dipole on the diagram of the iodine monochloride molecule.

(1)

Element	Electronegativity
Cl	
I	

I — Cl

(c) Iodine monochloride reacts with propene to form two isomeric products. This is an addition reaction that is similar to the reaction of propene with hydrogen halides.

(i) Draw the skeletal formulae of both isomers.

(2)

(ii) Explain which of these isomers is the major product.

(3)

(d) The equation for the reaction between iodine monochloride and chlorine is:

$$\underset{\text{brown liquid}}{ICl(l)} + Cl_2(g) \rightleftharpoons \underset{\text{yellow solid}}{ICl_3(s)}$$

(i) State and justify **one** precaution that must be taken when preparing iodine trichloride.

(2)

.....

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.....

(ii) Give the oxidation number of iodine in both iodine-containing compounds in the equilibrium.

(1)

I in ICl .....

I in ICl_3 .....

(iii) Iodine trichloride can also be made by reacting potassium chlorate(V) with iodine in hydrochloric acid. The equation for the reaction is

$$KClO_3 + I_2 + 6HCl \rightarrow KCl + 2ICl_3 + 3H_2O$$

By considering oxidation numbers for chlorine, explain whether or not this reaction is a disproportionation.

(2)

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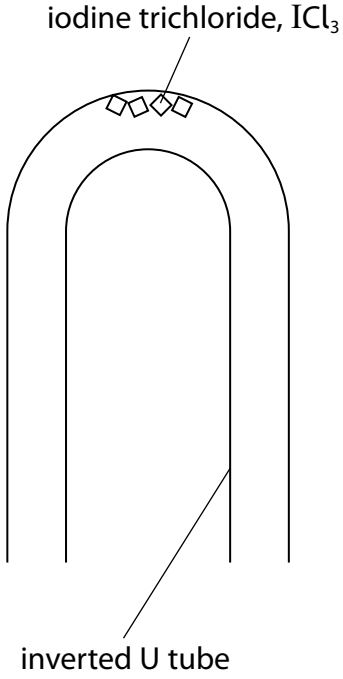
(e) Chlorine gas has a molar volume of 24 000 cm^3 mol^{-1} under the conditions used in this reaction.

(i) Show that the density of chlorine gas is approximately 3 g dm^{-3}.

(2)

(ii) Air has an average density of 1.25 g dm^{-3}. If the U-tube used in 23(d) is inverted, as shown in the diagram, the solid yellow iodine trichloride produced in the equilibrium reaction turns to a brown liquid.



Explain this observation.

(3)

(f) A mass of 0.64 g of iodine reacted with fluorine to form 1.31 g of a fluoride of iodine.

Calculate the empirical formula of this compound of iodine and fluorine.

(2)

(Total for Question 23 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 80 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] 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							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 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

* Lanthanide series

* Actinide series