

Write your name here	
Surname	Other names
<b>Pearson</b>	Centre Number
<b>Edexcel GCE</b>	Candidate Number
<b>Chemistry</b>	
<b>Advanced Subsidiary</b>	
<b>Paper 2: Core Organic and Physical Chemistry</b>	
Friday 9 June 2017 – Afternoon	Paper Reference
<b>Time: 1 hour 30 minutes</b>	<b>8CH0/02</b>
<b>You must have:</b> Data Booklet Scientific calculator	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.*

### 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.*
- You may use a scientific calculator.
- For questions marked with an **asterisk** (\*), marks will be awarded for your ability to structure your answer logically showing the points that you make are related or follow on from each other where appropriate.

### 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.
- Show all your working in calculations and include units where appropriate.

Turn over ►

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**Answer ALL questions.**

**Some questions must be answered with a cross in a box ☒.**  
**If you change your mind about an answer, put a line through the box ☒**  
**and then mark your new answer with a cross ☒.**

**1** Which compound does **not** have hydrogen bonding between its molecules?

	Name of compound	Formula of compound
<input type="checkbox"/> <b>A</b>	fluoromethane	CH <sub>3</sub> F
<input type="checkbox"/> <b>B</b>	hydrogen fluoride	HF
<input type="checkbox"/> <b>C</b>	hydrogen peroxide	H <sub>2</sub> O <sub>2</sub>
<input type="checkbox"/> <b>D</b>	methanol	CH <sub>3</sub> OH

**(Total for Question 1 = 1 mark)**

**2** Which molecule has a linear shape?

- ☐ **A** H<sub>2</sub>S
- ☐ **B** SO<sub>2</sub>
- ☐ **C** CO<sub>2</sub>
- ☐ **D** CH<sub>2</sub>=CH<sub>2</sub>

**(Total for Question 2 = 1 mark)**

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- 3 (a) In an experiment, 1.000 g of a hydrocarbon, **A**, was burned completely in oxygen to produce 3.143 g of carbon dioxide and 1.284 g of water.

In a different experiment, the molar mass of the hydrocarbon, **A**, was found to be  $84.0 \text{ g mol}^{-1}$ .

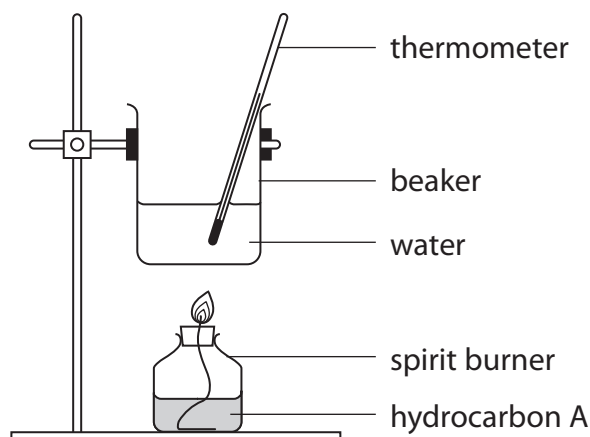
Calculate the empirical formula and the molecular formula of the hydrocarbon, **A**.

(4)



P 4 9 8 5 7 A 0 3 2 4

- (b) A spirit burner was filled with the liquid hydrocarbon, **A**. The burner was weighed, lit and then used to raise the temperature of a quantity of water in a beaker, as shown in the diagram. The burner was then reweighed.



### Results

Mass of spirit burner + hydrocarbon <b>A</b> before use	112.990 g
Mass of spirit burner + hydrocarbon <b>A</b> after use	112.732 g
Volume of water in the beaker	250 cm <sup>3</sup>
Temperature of water before heating	21.3 °C
Temperature of water after heating	29.5 °C

### Other data

Density of water	1.00 g cm <sup>-3</sup>
Specific heat capacity of water	4.18 J g <sup>-1</sup> °C <sup>-1</sup>
Molar mass of hydrocarbon <b>A</b>	84.0 g mol <sup>-1</sup>



- (i) Use these results to calculate the enthalpy change of combustion of hydrocarbon **A** in  $\text{kJ mol}^{-1}$ .

Give your answer to an appropriate number of significant figures and include a sign.  
(3)

- (ii) The beaker used in this experiment was made of copper rather than glass.  
Give a reason for this.

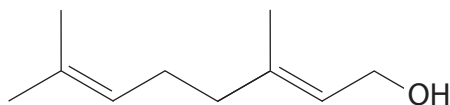
(1)

(Total for Question 3 = 8 marks)



P 4 9 8 5 7 A 0 5 2 4

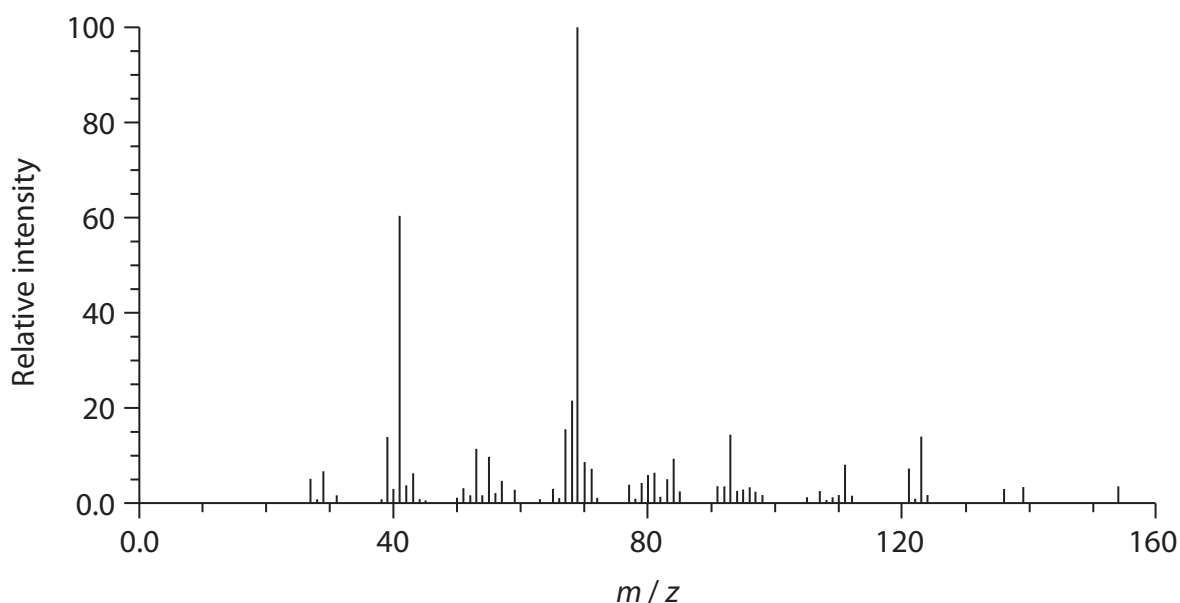
- 4 (a) The characteristic smell of pine wood is due, partly, to the presence of a group of compounds called terpenes. One of the simpler terpenes is a compound called geraniol, which is an oily liquid at room temperature and pressure. The structure of geraniol is



Deduce the molecular formula of geraniol. Use your answer to calculate the molar mass of geraniol in  $\text{g mol}^{-1}$ .

(2)

- (b) The mass spectrum of geraniol is shown.



- (i) Show that this mass spectrum can be used to confirm the molar mass of geraniol.

(1)

- (ii) Identify an ion that could be responsible for the peak at  $m/z = 69$ .

(1)

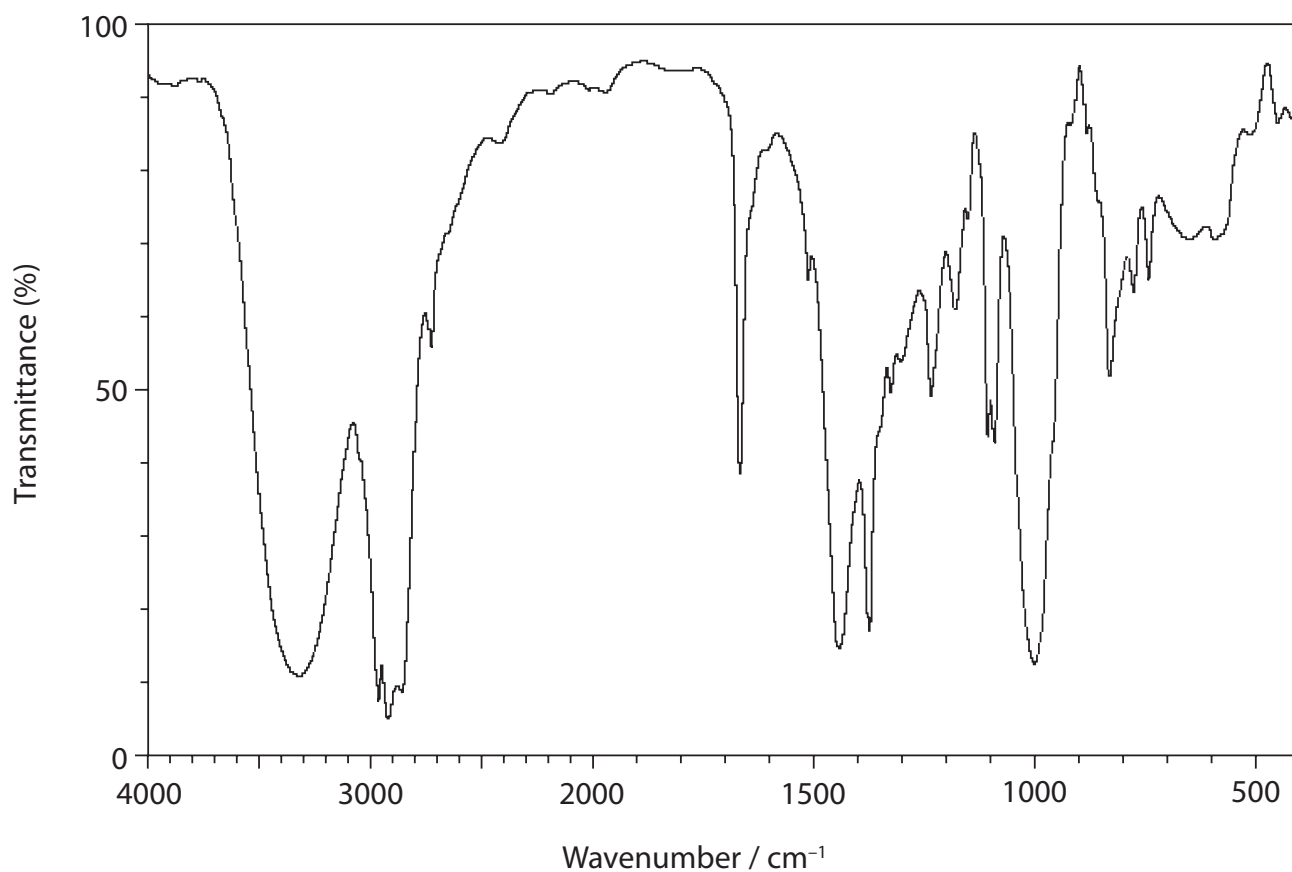
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(c) The infrared spectrum of geraniol is shown.



Using the table of absorptions from the Data Booklet and the infrared spectrum, give the **names** of the two functional groups present in geraniol. To confirm these functional groups, give the wavenumber ranges and their corresponding bonds.

(2)

First functional group .....

.....  
.....  
.....

Second functional group .....

.....  
.....  
.....



- (d) Give **one** chemical test that you could use to confirm the presence of each of the two functional groups suggested in part (c). Predict a result for each test.

(4)

Test and result for first functional group .....

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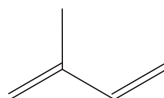
Test and result for second functional group .....

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.....

- (e) Some plants are able to make terpenes by linking together several molecules of 2-methylbuta-1,3-diene, also known as isoprene.  
The skeletal formula of 2-methylbuta-1,3-diene is



Predict the number of isoprene molecules that would be needed to make a single geraniol molecule. Justify your answer.

(2)

.....

.....

.....





- (f) 2-methylbuta-1,3-diene can react with hydrogen bromide.

When 2-methylbuta-1,3-diene reacts with **excess** hydrogen bromide, several isomeric products are possible. Give the structures of **four** isomeric products.

(4)

(Total for Question 4 = 16 marks)



P 4 9 8 5 7 A 0 9 2 4

5 (a) State what is meant by the term **molar volume of a gas**.

(1)

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(b) The following steps were carried out by a student to find the molar mass of a gas. The experiment was carried out at 20 °C and one atmosphere pressure. The dry gas was supplied in a plastic bag fitted with a self-sealing device. The student had a choice of two different gas syringes. The student decided to use a 50 cm<sup>3</sup> syringe.

Step 1. The 50 cm<sup>3</sup> syringe was fitted with a needle and then emptied of air by pushing in the plunger to zero. The needle was sealed by pushing the needle into a rubber bung and the syringe and bung were then weighed on a balance.

Step 2. The syringe was checked for leaks by pulling the plunger out by about 10 cm<sup>3</sup> for a few seconds before releasing it.

Step 3. The rubber bung was removed from the needle which was then inserted through the self-sealing device in the plastic bag of the dry gas.

Step 4. 50 cm<sup>3</sup> of the dry gas was withdrawn from the plastic bag into the syringe and the needle resealed with the same rubber bung used in step 1.

Step 5. The syringe and rubber bung were then reweighed on the balance.

### Results

volume of gas used	50 cm <sup>3</sup>
initial mass of empty syringe	107.563 g
final mass of syringe + gas	107.655 g

- (i) The gas syringe has a total uncertainty of  $\pm 0.5$  cm<sup>3</sup>.  
Each reading on the balance has an uncertainty of  $\pm 0.0005$  g.

Calculate the percentage uncertainty in the measurement of the volume and mass of gas used in this procedure.

(2)



- (ii) The student repeated the experiment with  $100 \text{ cm}^3$  of the gas using a  $100 \text{ cm}^3$  syringe.

The total uncertainty for this larger syringe was also  $\pm 0.5 \text{ cm}^3$ .

Determine the effect, if any, on the volume and mass uncertainties.

(2)

- (iii) Calculate the molar mass of the gas used in the procedure outlined in part (b).

You may assume that one mole of gas occupies  $24\,000 \text{ cm}^3$  under these conditions.

Give your answer to an appropriate number of significant figures and include units in your answer.

(2)

- (iv) Explain how the student would know if the syringe had a leak in step 2 and what effect this leak would have on the molar mass determined in part (b)(iii).

(2)

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- (c) If the temperature had been less than  $20^{\circ}\text{C}$  and the pressure remained at one atmosphere, deduce the effect, if any, on the molar mass calculated in part (b)(iii).

(2)

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- (d) Give a reason why the gas should be dry.

(1)

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**(Total for Question 5 = 12 marks)**



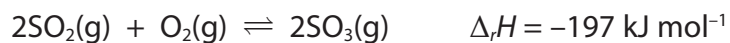
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- \*(a) Evaluate the feasibility of each of these changes in terms of their effect on the rate, yield and economics of the reaction.

(6)

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- (b) (i) On the axes provided, sketch the reaction profiles for the uncatalysed and catalysed reaction.



Label the uncatalysed reaction, **A**, and the reaction catalysed by vanadium(V) oxide, **B**.

(3)

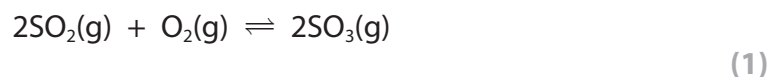


- (ii) On your reaction profile, identify and label both the enthalpy change and the activation energy for the catalysed reaction.

(2)



(c) (i) Write the expression for the equilibrium constant  $K_c$  for this reaction.



(ii) What are the units, if any, of the equilibrium constant,  $K_c$ ?

(1)

- ☐ A  $\text{mol dm}^{-3}$
- ☐ B  $\text{dm}^3 \text{mol}^{-1}$
- ☐ C no units
- ☐ D  $\text{mol}^2 \text{dm}^{-6}$

(Total for Question 6 = 13 marks)

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## 7 This question is about halogenoalkanes.

The tables show some relevant data.

Bond	Bond enthalpy / kJ mol <sup>-1</sup>
C—F	467
C—Cl	346
C—Br	290
C—I	228

Atom	Electronegativity
C	2.5
F	4.0
Cl	3.0
Br	2.8
I	2.5

- (a) In an experiment, 1 cm<sup>3</sup> of ethanol and 5 cm<sup>3</sup> of 0.1 mol dm<sup>-3</sup> silver nitrate were placed in each of three test tubes X, Y and Z. The test tubes and their contents were placed in a water bath at 50 °C for five minutes.

Two drops of 1-chlorobutane were then added to test tube X and the tube was shaken to mix the contents. The time taken for a precipitate to appear was measured.

The experiment was repeated using two drops of 1-bromobutane in test tube Y and two drops of 1-iodobutane in test tube Z.

- (i) The time taken for a precipitate to appear increases in the order

(1)

- ☐ **A** X, Y, Z
- ☐ **B** Z, Y, X
- ☐ **C** Y, X, Z
- ☐ **D** Z, X, Y

- (ii) Give a reason for the addition of ethanol to each test tube.

(1)

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- (iii) Give a reason why the test tubes were left in the water bath for five minutes before adding the halogenoalkanes.

(1)

- (iv) The precipitates form as a result of reactions between aqueous silver ions and aqueous halide ions.

Explain why halide ions are present in the mixture containing a halogenoalkane which has only covalent bonds.

(2)

- (v) Write the ionic equation, including state symbols, for the reaction involving the silver nitrate in test tube X.

(1)

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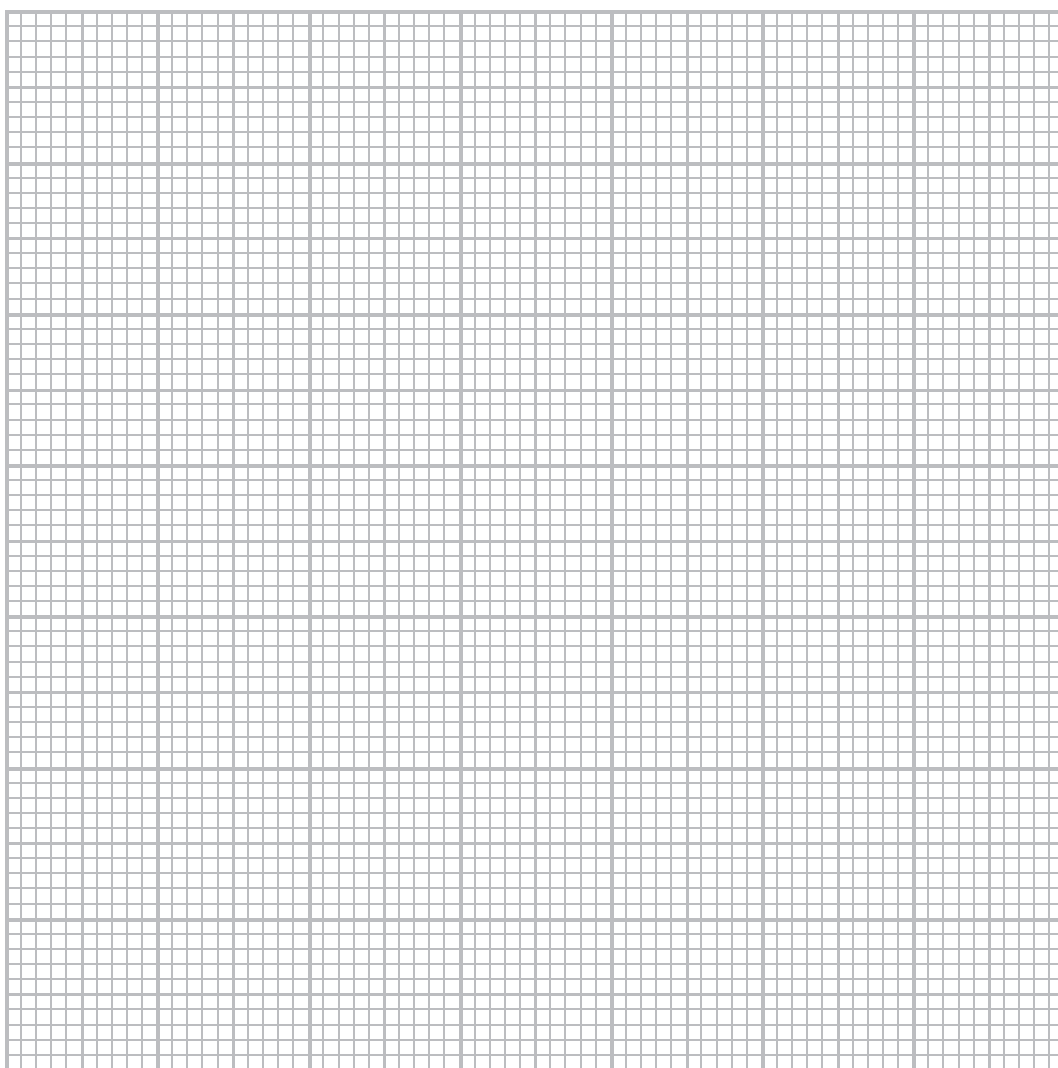
(b) 1-bromo-2-methylpropane was mixed with a large excess of potassium hydroxide solution.

The 1-bromo-2-methylpropane is hydrolysed during the reaction and its concentration decreases as the reaction proceeds. Samples of the reaction mixture were analysed at time intervals to determine the remaining concentration of 1-bromo-2-methylpropane.

Time/s	[1-bromo-2-methylpropane]/mol dm <sup>-3</sup>
0	0.1000
50	0.0500
100	0.0250
200	0.0063
300	0.0016

(i) Draw a graph of [1-bromo-2-methylpropane] against time.

(3)



- (ii) Use your graph to calculate a value for the rate of reaction at 100 s.  
Include units in your answer.

(3)

- (c) (i) Which term best describes the role of the  $\text{OH}^-$  ion in the reaction in (b)?

(1)

- ☐ **A** catalyst
- ☐ **B** electrophile
- ☐ **C** free radical
- ☐ **D** nucleophile

- (ii) Draw a diagram to show the mechanism for the hydrolysis of  
1-bromo-2-methylpropane by the hydroxide ion.  
Include any appropriate lone pairs and dipoles.

(4)

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(iii) The hydrolysis reaction described in part (b) may also be classified as

(1)

- ☐ **A** addition
- ☐ **B** elimination
- ☐ **C** redox
- ☐ **D** substitution

(Total for Question 7 = 18 marks)

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8 This question is about the chemistry of propane-1,3-diol and propanedioic acid.

- (a) Give the structures of propane-1,3-diol and another diol which is an isomer of propane-1,3-diol.

(2)

- (b) Propane-1,3-diol can be oxidised to propanedioic acid in the same way as other primary alcohols.

- (i) Suitable reagents and conditions are

(1)

	Reagents	Conditions
<input type="checkbox"/> A	sodium dichromate(VI) + sulfuric acid	heating under reflux
<input type="checkbox"/> B	sodium dichromate(VI) + hydrochloric acid	heating under reflux
<input type="checkbox"/> C	potassium dichromate(VI) + sulfuric acid	room temperature
<input type="checkbox"/> D	potassium dichromate(VI) + hydrochloric acid	room temperature

- (ii) The colour change in this reaction is

(1)

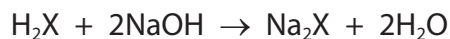
- ☐ A green to orange  
☐ B orange to green  
☐ C orange to colourless  
☐ D colourless to orange



- (c) In an experiment, 15.2 g of propane-1,3-diol was oxidised to propanedioic acid, which is a solid **dibasic** acid. This acid may be represented as  $H_2X$ .

250 cm<sup>3</sup> of a solution was prepared from all of the acid in a volumetric flask.

10.0 cm<sup>3</sup> portions of this solution were then titrated with 0.400 mol dm<sup>-3</sup> sodium hydroxide solution. The mean titre was 18.45 cm<sup>3</sup>.



[Relative formula masses: propane-1,3-diol = 76.0; propanedioic acid = 104.0]

- (i) Calculate the moles of propanedioic acid in 10.0 cm<sup>3</sup> of the acid solution.

(2)

- (ii) Calculate the mass of propanedioic acid in the 250 cm<sup>3</sup> solution.

(2)



(iii) Calculate the percentage yield for the oxidation of propane-1,3-diol to propanedioic acid.

(2)

(iv) Give **one** reason why the yield calculated in (iii) is less than 100%.

(1)

(Total for Question 8 = 11 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							
(1)	(2)	(13)	(14)	(15)	(16)	(17)	(18)
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	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	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	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	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	200.6 Hg mercury 80	112.4 Cd cadmium 48	107.9 Ag silver 47	106.4 Pd palladium 46	105.1 Pt platinum 78	197.0 Au gold 79
[227] Ac* actinium 89	[227] La* lanthanum 57	102.9 Rh rhodium 45	101.1 Ru ruthenium 44	106.4 Ni nickel 28	58.9 Co cobalt 27	55.8 Fe iron 26	54.9 Mn manganese 25
		95.9 Mo molybdenum 42	92.9 Nb niobium 41	52.0 Cr chromium 24	50.9 V vanadium 23	47.9 Ti titanium 22	45.0 Sc scandium 21
		186.2 Re rhenium 75	180.9 Ta tantalum 73	183.8 W tungsten 74	180.9 Ta tantalum 73	178.5 Hf hafnium 72	138.9 La* lanthanum 57
		268 Mt meitnerium 109	264 Bh bohrium 107	266 Sg seaborgium 106	262 Db dubnium 105	261 Rf rutherfordium 104	[227] Ac* actinium 89
		277 Hs hassium 108	276 Ts tennessine 115	271 Ds darmstadtium 110	270 Nh nihonium 113	269 Lv livermorium 116	[222] Rn radon 86
		285 Og oganesson 118	284 Lr lawrencium 103	283 Uub unbibium 120	282 Uuh unbihium 119	281 Uuo ununoctium 118	[222] Rn radon 86
		289 Nh nihonium 113	288 Ds darmstadtium 110	287 Rg roentgenium 111	286 Og oganesson 118	285 Lr lawrencium 103	[222] Rn radon 86
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		324 Uus ununseptium 117	323 Uuo ununoctium 118	322 Uuh unbihium 119	321 Uuo ununoctium 118	320 Uuo ununoctium 118	[222] Rn radon 86
		325 Uus ununseptium 117	324 Uuo ununoctium 118	323 Uuh unbihium 119	322 Uuo ununoctium 118	321 Uuo ununoctium 118	[222] Rn radon 86
		326 Uus ununseptium 117	325 Uuo ununoctium 118	324 Uuh unbihium 119	323 Uuo ununoctium 118	322 Uuo ununoctium 118	[222] Rn radon 86
		327 Uus ununseptium 117	326 Uuo ununoctium 118	325 Uuh unbihium 119	324 Uuo ununoctium 118	323 Uuo ununoctium 118	[222] Rn radon 86
		328 Uus ununseptium 117	327 Uuo ununoctium 118	326 Uuh unbihium 119	325 Uuo ununoctium 118	324 Uuo ununoctium 118	[222] Rn radon 86
		329 Uus ununseptium 117	328 Uuo ununoctium 118	327 Uuh unbihium 119	326 Uuo ununoctium 118	325 Uuo ununoctium 118	[222] Rn radon 86
		330 Uus ununseptium 117	329 Uuo ununoctium 118	328 Uuh unbihium 119	327 Uuo ununoctium 118	326 Uuo ununoctium 118	[222] Rn radon 86
		331 Uus ununseptium 117	330 Uuo ununoctium 118	329 Uuh unbihium 119	328 Uuo ununoctium 118	327 Uuo ununoctium 118	[222] Rn radon 86
		332 Uus ununseptium 117	331 Uuo ununoctium 118	330 Uuh unbihium 119	329 Uuo ununoctium 118	328 Uuo ununoctium 118	[222] Rn radon 86
		333 Uus ununseptium 117	332 Uuo ununoctium 118	331 Uuh unbihium 119	330 Uuo ununoctium 118	329 Uuo ununoctium 118	[222] Rn radon 86
		334 Uus ununseptium 117	333 Uuo ununoctium 118	332 Uuh unbihium 119	331 Uuo ununoctium 118	330 Uuo ununoctium 118	[222] Rn radon 86
		335 Uus ununseptium 117	334 Uuo ununoctium 118	333 Uuh unbihium 119	332 Uuo ununoctium 118	331 Uuo ununoctium 118	[222] Rn radon 86
		336 Uus ununseptium 117	335 Uuo ununoctium 118	334 Uuh unbihium 119	333 Uuo ununoctium 118	332 Uuo ununoctium 118	[222] Rn radon 86
		337 Uus ununseptium 117	336 Uuo ununoctium 118	335 Uuh unbihium 119	334 Uuo ununoctium 118	333 Uuo ununoctium 118	[222] Rn radon 86
		338 Uus ununseptium 117	337 Uuo ununoctium 118	336 Uuh unbihium 119	335 Uuo ununoctium 118	334 Uuo ununoctium 118	[222] Rn radon 86
		339 Uus ununseptium 117	338 Uuo ununoctium 118	337 Uuh unbihium 119	336 Uuo ununoctium 118	335 Uuo ununoctium 118	[222] Rn radon 86
		340 Uus ununseptium 117	339 Uuo ununoctium 118	338 Uuh unbihium 119	337 Uuo ununoctium 118	336 Uuo ununoctium 118	[222] Rn radon 86
		341 Uus ununseptium 117	340 Uuo ununoctium 118	339 Uuh unbihium 119	338 Uuo ununoctium 118	337 Uuo ununoctium 118	[222] Rn radon 86
		342 Uus ununseptium 117	341 Uuo ununoctium 118	340 Uuh unbihium 119	339 Uuo ununoctium 118	338 Uuo ununoctium 118	[222] Rn radon 86
		343 Uus ununseptium 117	342 Uuo ununoctium 118	341 Uuh unbihium 119	340 Uuo ununoctium 118	339 Uuo ununoctium 118	[222] Rn radon 86
		344 Uus ununseptium 117	343 Uuo ununoctium 118	342 Uuh unbihium 119	341 Uuo ununoctium 118	340 Uuo ununoctium 118	[222] Rn radon 86
		345 Uus ununseptium 117	344 Uuo ununoctium 118	343 Uuh unbihium 119	342 Uuo ununoctium 118	341 Uuo ununoctium 118	[222] Rn radon 86
		346 Uus ununseptium 117	345 Uuo ununoctium 118	344 Uuh unbihium 119	343 Uuo ununoctium 118	342 Uuo ununoctium 118	[222] Rn radon 86
		347 Uus ununseptium 117	346 Uuo ununoctium 118	345 Uuh unbihium 119	344 Uuo ununoctium 118	343 Uuo ununoctium 118	[222] Rn radon 86
		348 Uus ununseptium 117	347 Uuo ununoctium 118	346 Uuh unbihium 119	345 Uuo ununoctium 118	344 Uuo ununoctium 118	[222] Rn radon 86
		349 Uus ununseptium 117	348 Uuo ununoctium 118	347 Uuh unbihium 119	346 Uuo ununoctium 118	345 Uuo ununoctium 118	[222] Rn radon 86
		350 Uus ununseptium 117	349 Uuo ununoctium 118	348 Uuh unbihium 119	347 Uuo ununoctium 118	346 Uuo ununoctium 118	[222] Rn radon 86
		351 Uus ununseptium 117	350 Uuo ununoctium 118	349 Uuh unbihium 119	348 Uuo ununoctium 118	347 Uuo ununoctium 118	[222] Rn radon 86
		352 Uus ununseptium 117	351 Uuo ununoctium 118	350 Uuh unbihium 119	349 Uuo ununoctium 118	348 Uuo ununoctium 118	[222] Rn radon 86
		353 Uus ununseptium 117	352 Uuo ununoctium 118	351 Uuh unbihium 119	350 Uuo ununoctium 118	349 Uuo ununoctium 118	[222] Rn radon 86
		354 Uus ununseptium 117	353 Uuo ununoctium 118	352 Uuh unbihium 119	351 Uuo ununoctium 118	350 Uuo ununoctium 118	[222] Rn radon 86
		355 Uus ununseptium 117	354 Uuo ununoctium 118	353 Uuh unbihium 119	352 Uuo ununoctium 118	351 Uuo ununoctium 118	[222] Rn radon 86
		356 Uus ununseptium 117	355 Uuo ununoctium 118	354 Uuh unbihium 119	353 Uuo ununoctium 118	352 Uuo ununoctium 118	[222] Rn radon 86
		357 Uus ununseptium 117	356 Uuo ununoctium 118	355 Uuh unbihium 119	354 Uuo ununoctium 118	353 Uuo ununoctium 118	[222] Rn radon 86
		358 Uus ununseptium 117	357 Uuo ununoctium 118	356 Uuh unbihium 119	355 Uuo ununoctium 118	354 Uuo ununoctium 118	[222] Rn radon 86
		359 Uus ununseptium 117	358 Uuo ununoctium 118	357 Uuh unbihium 119	356 Uuo ununoctium 118	355 Uuo ununoctium 118	[222] Rn radon 86
		360 Uus ununseptium 117	359 Uuo ununoctium 118	358 Uuh unbihium 119	357 Uuo ununoctium 118	356 Uuo ununoctium 118	[222] Rn radon 86
		361 Uus ununseptium 117	360 Uuo ununoctium 118	359 Uuh unbihium 119	358 Uuo ununo		