

Please check the examination details below before entering your candidate information

Candidate surname

Other names

Pearson Edexcel
International
Advanced Level

Centre Number

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Candidate Number

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Thursday 14 January 2021

Afternoon (1 hour 30 minutes)

Paper Reference **WCH12/01****Chemistry****International Advanced Subsidiary / Advanced Level****Unit 2: Energetics, Group Chemistry, Halogenoalkanes
and Alcohols****You must have:**

Scientific calculator, Data booklet, 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 the question 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.
- A Periodic Table is printed on the back cover 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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Pearson

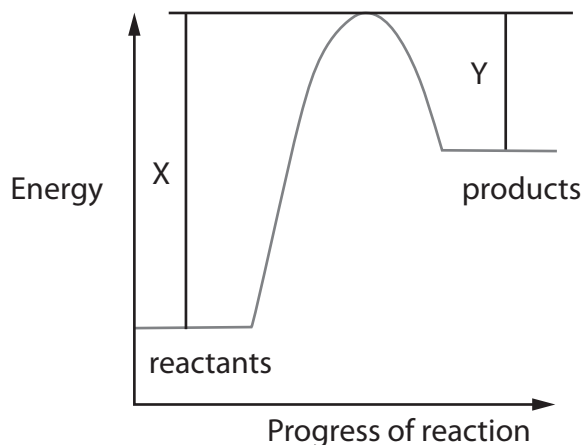
SECTION A

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 The energy profile for a reaction is shown.



What is the minimum energy needed for this reaction to occur?

- ☐ A X
- ☐ B Y
- ☐ C $X - Y$
- ☐ D $X + Y$

(Total for Question 1 = 1 mark)

- 2 Which of these isomers with the formula C_8H_{18} has the lowest boiling temperature?

- ☐ A $CH_3CH(CH_3)CH_2CH_2CH(CH_3)CH_3$
- ☐ B $CH_3CH(CH_3)CH_2CH_2CH_2CH_2CH_3$
- ☐ C $CH_3C(CH_3)_2CH_2CH(CH_3)CH_3$
- ☐ D $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$

(Total for Question 2 = 1 mark)



3 Which of these pure compounds has hydrogen bonding in the liquid state?

- ☐ A 1,1,1-trichloroethane, CH_3CCl_3
- ☐ B trimethylamine, $(\text{CH}_3)_3\text{N}$
- ☐ C hydrogen fluoride, HF
- ☐ D hydrogen sulfide, H_2S

(Total for Question 3 = 1 mark)

4 The hydrogen ion, H^+ , bonds to a water molecule forming an H_3O^+ ion.

For H_3O^+ , what shape and H-O-H bond angle are predicted by the electron-pair repulsion theory?

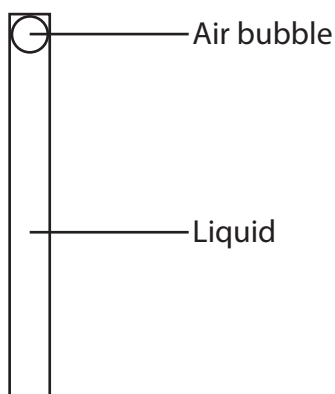
- ☐ A trigonal planar 120°
- ☐ B trigonal planar 117.5°
- ☐ C trigonal pyramidal 107°
- ☐ D trigonal pyramidal 104.5°

(Total for Question 4 = 1 mark)

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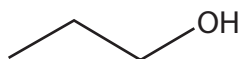
- 5 The viscosities of four liquid organic compounds are compared by placing the liquids in separate identical tubes, each with an air bubble at the top.



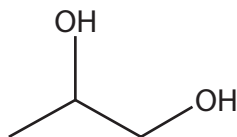
The tubes are inverted, and the times measured for the air bubble to travel the length of the tube.

For which compound does the air bubble take the longest time?

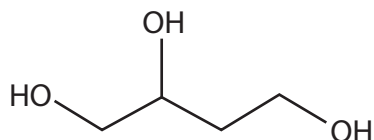
☐ A



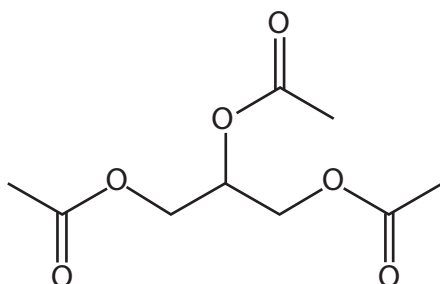
☐ B



☐ C



☐ D



(Total for Question 5 = 1 mark)



6 This question is about the reaction of potassium iodide with concentrated sulfuric acid.

(a) Which of these would **not** be seen?

(1)

- ☐ **A** misty fumes
- ☐ **B** black solid
- ☐ **C** yellow solid
- ☐ **D** dense white smoke

(b) One of the reaction products is the gas H_2S .

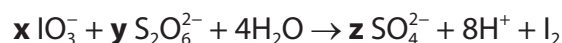
What is the **change** in oxidation number of sulfur as H_2S forms?

(1)

- ☐ **A** -8
- ☐ **B** -6
- ☐ **C** -2
- ☐ **D** +6

(Total for Question 6 = 2 marks)

7 Iodate(V) ions, IO_3^- , oxidise dithionate ions, $\text{S}_2\text{O}_6^{2-}$, according to the equation



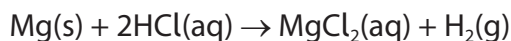
What are the balancing numbers **x**, **y** and **z**?

	x	y	z
☐ A	2	1	2
☐ B	2	2	4
☐ C	2	5	5
☐ D	2	5	10

(Total for Question 7 = 1 mark)



8 Magnesium reacts with hydrochloric acid.



Which statement about this reaction is correct?

- ☐ A magnesium atoms act as oxidising agents
- ☐ B hydrogen molecules act as reducing agents
- ☐ C hydrogen ions act as oxidising agents
- ☐ D chloride ions act as oxidising agents

(Total for Question 8 = 1 mark)

9 Which of these compounds does **not** produce a colour in a flame test, and produces an alkaline gas when warmed with sodium hydroxide solution?

- ☐ A Ca(OH)_2
- ☐ B Mg(OH)_2
- ☐ C NH_4Cl
- ☐ D BeCl_2

(Total for Question 9 = 1 mark)

10 Which of these **increases** as Group 7 is descended?

- ☐ A oxidising ability of the molecular halogens
- ☐ B reducing ability of the halide ions
- ☐ C electrostatic attraction between the nucleus and outer shell of electrons
- ☐ D electronegativity of the halogen atoms

(Total for Question 10 = 1 mark)

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- 11 The table shows the amount of energy released per gram when some alkanes are burned in excess oxygen under standard conditions.

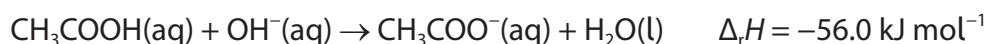
Alkane	Energy released / kJ g^{-1}
methane	55.6
ethane	52.0
propane	50.4
butane	49.6

Which alkane has a standard enthalpy change of combustion of $-2877 \text{ kJ mol}^{-1}$?

- ☐ A methane
- ☐ B ethane
- ☐ C propane
- ☐ D butane

(Total for Question 11 = 1 mark)

- 12 The enthalpy changes for two reactions are shown.



What is the enthalpy change for the dissociation of $\text{CH}_3\text{COOH}(\text{aq})$ into $\text{CH}_3\text{COO}^-(\text{aq})$ and $\text{H}^+(\text{aq})$ ions, in kJ mol^{-1} ?

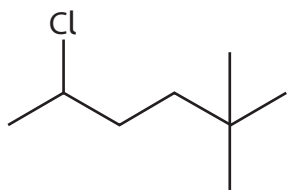
- ☐ A +113.2
- ☐ B +1.2
- ☐ C -1.2
- ☐ D -113.2

(Total for Question 12 = 1 mark)

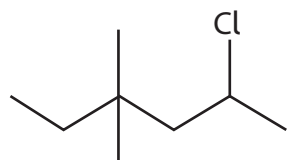


13 What is the skeletal formula of 2-chloro-4,4-dimethylhexane?

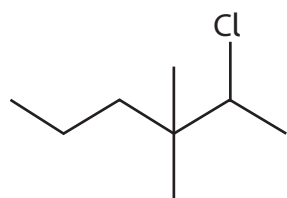
☐ A



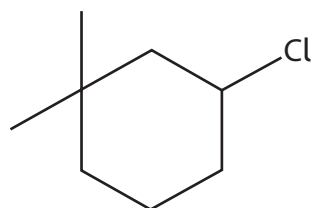
☐ B



☐ C



☐ D



(Total for Question 13 = 1 mark)

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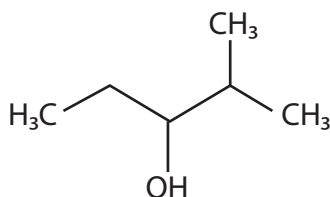


14 Some alcohols react with concentrated phosphoric(V) acid, H_3PO_4 , to form alkenes.

(a) What type of reaction occurs?

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

(b) The structure of 2-methylpentan-3-ol is shown.



This alcohol reacts with concentrated phosphoric(V) acid.

How many different alkenes can form?

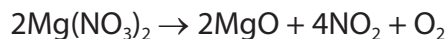
- ☐ **A** one
- ☐ **B** two
- ☐ **C** three
- ☐ **D** four

(Total for Question 14 = 2 marks)

Use this space for any rough working. Anything you write in this space will gain no credit.



15 Magnesium nitrate decomposes on heating.



What is the total volume of gas formed at room temperature and pressure (r.t.p.) when 0.005 mol of magnesium nitrate decomposes completely?

[Molar volume of a gas at r.t.p. = $24\,000\text{ cm}^3\text{ mol}^{-1}$]

- ☐ A 600 cm^3
- ☐ B 300 cm^3
- ☐ C 240 cm^3
- ☐ D 120 cm^3

(Total for Question 15 = 1 mark)

16 How many moles are there in 15.1 cm^3 of liquid propan-1-ol?

[Density of propan-1-ol = 0.80 g cm^{-3} M_r of propan-1-ol = 60]

- ☐ A $(0.80 \times 15.1) \div 60$
- ☐ B $0.80 \div (60 \times 15.1)$
- ☐ C $60 \div (0.80 \times 15.1)$
- ☐ D $(60 \times 15.1) \div 0.80$

(Total for Question 16 = 1 mark)

17 The oxidation of propan-1-ol by acidified potassium dichromate(VI) forms propanoic acid with a yield of 36 % by mass.

What mass of propan-1-ol is needed to form 37.0 g of propanoic acid in this reaction?

[M_r of propanoic acid = 74 M_r of propan-1-ol = 60]

- ☐ A 10.8 g
- ☐ B 36.0 g
- ☐ C 40.8 g
- ☐ D 83.3 g

(Total for Question 17 = 1 mark)



18 Barium chloride solution, $\text{BaCl}_2(\text{aq})$, reacts with gallium sulfate solution, $\text{Ga}_2(\text{SO}_4)_3(\text{aq})$ to form a precipitate of barium sulfate, $\text{BaSO}_4(\text{s})$.

What is the minimum volume of $0.100 \text{ mol dm}^{-3}$ barium chloride needed to precipitate **all** the sulfate ions in 200 cm^3 of 0.05 mol dm^{-3} gallium sulfate?

- ☐ **A** 100 cm^3
- ☐ **B** 200 cm^3
- ☐ **C** 300 cm^3
- ☐ **D** 400 cm^3

(Total for Question 18 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

- 19 Ethanol can be made in industry by the reaction of ethene with steam, using a phosphoric(V) acid catalyst.



The reaction is carried out at 300°C and 60 atm. An initial yield of 5 % is achieved when the ethene and steam first pass through the reactor.

- *(a) Explain the chemical reasons for the conditions used and why such a low initial yield is acceptable in the industrial process.

(6)

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P 6 7 7 4 8 A 0 1 3 2 8

(b) The product of the reaction is a mixture of ethanol and water.

Explain why ethanol and water mix together fully.

You may find it helpful to draw a diagram.

(3)

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(c) Ethanol can be oxidised using a solution of acidified potassium dichromate(VI), $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$.

Ethanoic acid and another organic compound, **Y**, are both possible products.

(i) Draw the structure of **Y**.

(1)

(ii) State the conditions needed to maximise the yield of each product.

(2)

Conditions for maximum yield of **Y**

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Conditions for maximum yield of ethanoic acid

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(Total for Question 19 = 12 marks)



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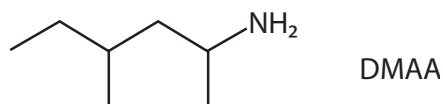
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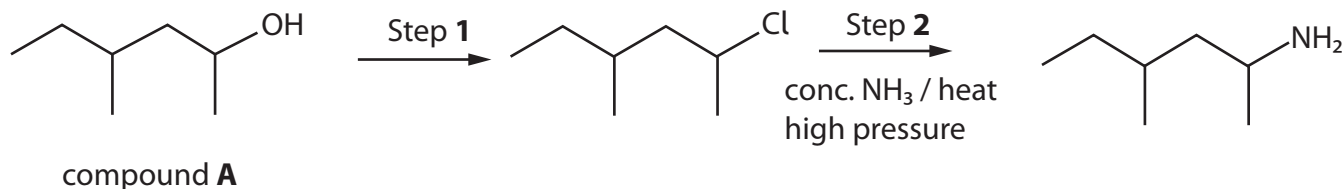
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20 The compound DMAA was originally synthesised as a decongestant.



A suggested synthetic route for DMAA is shown.



(a) (i) Give the systematic name of compound **A**.

(1)

(ii) Identify, by name or formula, a suitable reagent for Step 1.

(1)

(iii) Give the mechanism for the reaction in Step 2.
Include curly arrows, and any relevant dipoles and lone pairs.

(4)

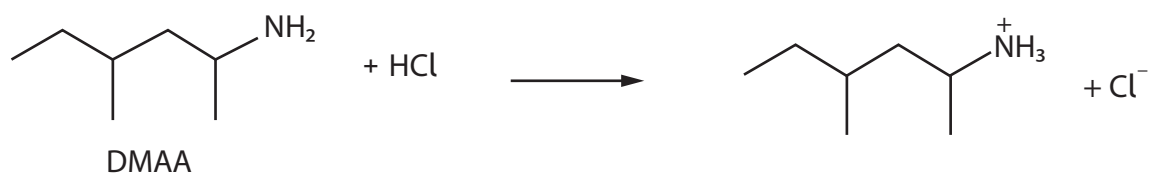
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- (b) DMAA is only slightly soluble in water but dissolves readily in hydrochloric acid to form an aqueous solution.

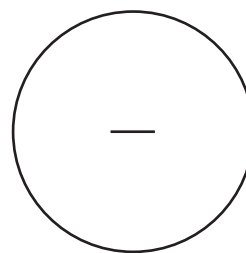
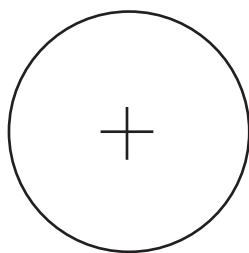


- (i) Explain the type of bonding that occurs between the nitrogen atom and the hydrogen ion, when the positive ion forms.

(3)

- (ii) Complete the diagrams to show how the ions formed in the reaction between DMAA and hydrochloric acid interact with water molecules.

(3)



(Total for Question 20 = 12 marks)



21 This question is about ethanoic acid and some related salts.

- (a) A test to confirm the presence of an aqueous acid is adding a small amount of solid sodium carbonate to the solution.

Describe **two** observations you would **see** in this test.

(2)

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- (b) Sodium ethanoate is a component of reusable hand warmers.
In use, a supersaturated solution of sodium ethanoate recrystallises to form solid hydrated sodium ethanoate, releasing energy.



A hand warmer has a mass of 63.2 g and forms 20.1 g of hydrated sodium ethanoate on recrystallisation.

Calculate the maximum temperature reached by the hand warmer if its initial temperature is 5.0°C.

[Specific heat capacity of the hand warmer = 3.0 J °C⁻¹ g⁻¹]

(5)

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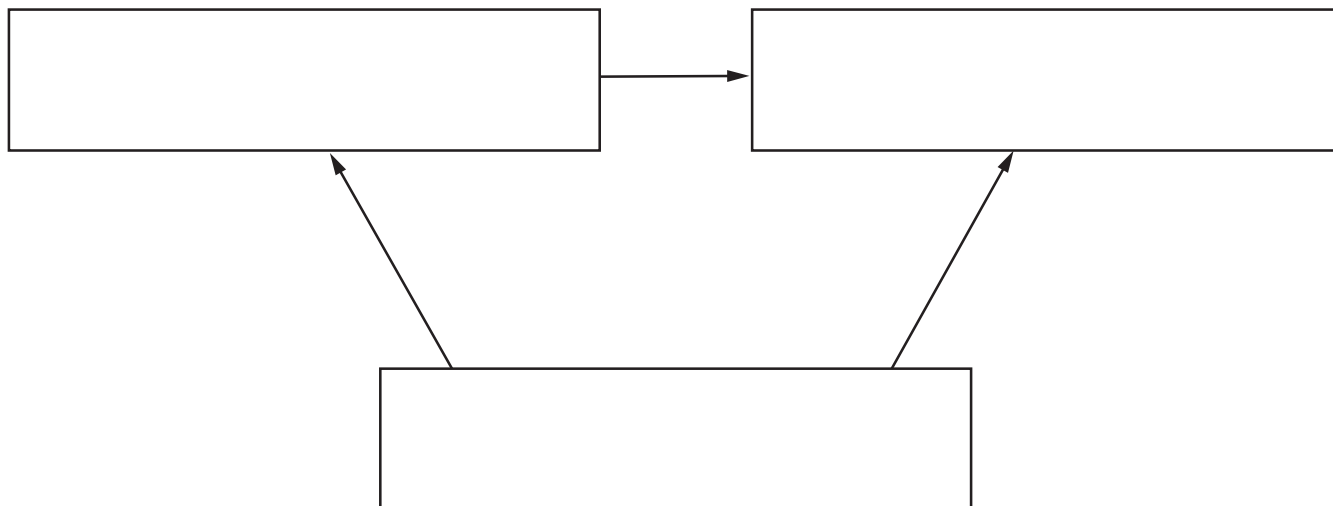
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- (c) Ammonium ethanoate, $\text{CH}_3\text{COONH}_4(\text{s})$, is used to control the pH of foods. It can be formed by the reaction of pure ethanoic acid, $\text{CH}_3\text{COOH}(\text{l})$, with ammonium carbonate, $(\text{NH}_4)_2\text{CO}_3(\text{s})$.

Calculate the standard enthalpy change for this reaction by completing the Hess cycle and using the data shown.

(5)



Compound	Enthalpy change of formation / kJ mol^{-1}
$\text{CH}_3\text{COOH}(\text{l})$	-484.5
$(\text{NH}_4)_2\text{CO}_3(\text{s})$	-939.9
$\text{CH}_3\text{COONH}_4(\text{s})$	-586.3
$\text{CO}_2(\text{g})$	-393.5
$\text{H}_2\text{O}(\text{l})$	-285.8



- (d) Ammonium carbonate, $(\text{NH}_4)_2\text{CO}_3$, is an ingredient in cleaning solutions for camera lenses.

These are aqueous solutions which contain no more than 1.8 g of ammonium carbonate in 100 cm^3 of solution.

Calculate the maximum concentration, in mol dm^{-3} , of ammonium carbonate in such a solution.

(2)

(Total for Question 21 = 14 marks)

TOTAL FOR SECTION B = 38 MARKS



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SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

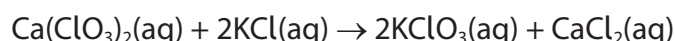
22 Potassium chlorate(V), KClO_3 , is a crystalline solid used in fireworks.

It is produced by the Liebig Process in two stages.

Stage **1** Chlorine gas is passed through hot calcium hydroxide solution forming calcium chlorate(V), $\text{Ca}(\text{ClO}_3)_2$.



Stage **2** Potassium chloride solution is then added to form potassium chlorate(V).



The solution is heated to reduce its volume and then allowed to crystallise.

The crystals are filtered off.

The remaining filtrate is evaporated further to obtain more crystals.

(a) (i) Write the **overall** equation for the Liebig Process.

State symbols are not required.

(1)

(ii) Calculate the **overall** atom economy by mass for the production of potassium chlorate(V), KClO_3 , using your equation in (a)(i).

(3)

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- (b) Explain the type of reaction that takes place in Stage 1 of the Liebig Process, using oxidation numbers.



(3)

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- (c) The crystals of potassium chlorate(V) formed also contain some halide ion impurities.

- (i) Describe a chemical test on a solution of these crystals to **confirm** that the impurities present are chloride ions rather than bromide ions. Include the expected results.

(3)

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- (ii) 1.52 g of impure potassium chlorate(V), formed in the Liebig Process, was heated until the mass of solid remaining was constant at 1.02 g.

The reaction that occurred was



The impurities present did not decompose on heating.

Calculate the percentage purity of the sample.

Give your answer to an appropriate number of significant figures.

(5)

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- (d) In fireworks, potassium chlorate(V) decomposes. This thermal decomposition takes place in two stages with a solid catalyst.



- (i) Give the systematic name of KClO_4 .

(1)

- (ii) A student investigated the role of the catalyst in this reaction.

Procedure

Step 1 Heat a sample of KClO_3 , in a test tube, with a known mass of insoluble catalyst until the mass remains constant.

Step 2 Mix the contents of the test tube with water.

Step 3 Filter the mixture and rinse with deionised water.

Step 4 Dry the remaining solid.

Step 5 Measure the mass of the dry solid.

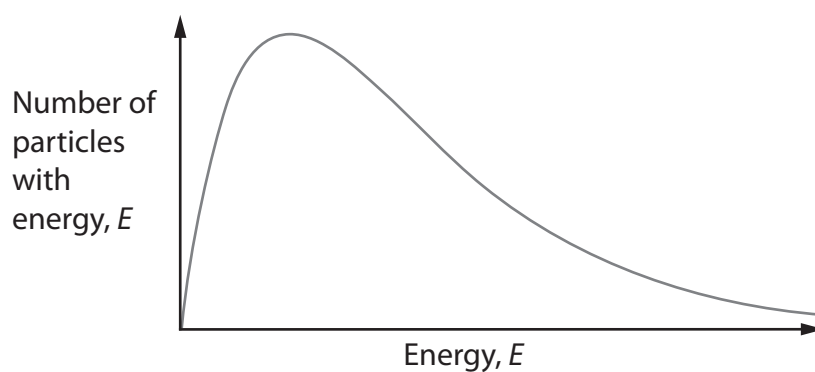
Explain how each of the steps in this procedure is needed to show that the catalyst is **not** used up in this reaction.

(4)



(e) Explain, using the diagram, how a catalyst speeds up a chemical reaction.

(2)



(Total for Question 22 = 22 marks)

TOTAL FOR SECTION C = 22 MARKS

TOTAL FOR PAPER = 80 MARKS



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The Periodic Table of Elements

1	2	3	4	5	6	7	0 (8)
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	201.0 Tl thallium 81	204.4 Pb lead 82	207.2 Bi bismuth 83	209 Po polonium 84	210 At astatine 85
Elements with atomic numbers 112-116 have been reported but not fully authenticated							
112 Cd cadmium 48	113 In indium 49	114 Sn tin 50	115 Sb antimony 51	116 Te tellurium 52	117 I iodine 53	118 Xe xenon 54	119 At astatine 85
120 Hf hafnium 72	121 Ta tantalum 73	122 W tungsten 74	123 Re rhenium 75	124 Os osmium 76	125 Ir iridium 77	126 Pt platinum 78	127 Au gold 79
128 Pd palladium 46	129 Ag silver 47	130 Cd cadmium 48	131 In indium 49	132 Sn tin 50	133 Sb antimony 51	134 Te tellurium 52	135 I iodine 53
136 Co cobalt 27	137 Ni nickel 28	138 Cu copper 29	139 Zn zinc 30	140 Ga gallium 31	141 Ge germanium 32	142 As arsenic 33	143 Se selenium 34
144 Fe iron 26	145 Mn manganese 25	146 Cr chromium 24	147 V vanadium 23	148 Ti titanium 22	149 Sc scandium 21	150 Y yttrium 39	151 Zr zirconium 40
152 Ru ruthenium 44	153 Rh rhodium 45	154 Pd palladium 46	155 Ag silver 47	156 Cd cadmium 48	157 In indium 49	158 Sn tin 50	159 Sb antimony 51
160 Os osmium 76	161 Ir iridium 77	162 Pt platinum 78	163 Au gold 79	164 Hg mercury 80	165 Tl thallium 81	166 Pb lead 82	167 Bi bismuth 83
168 Re rhenium 75	169 Os osmium 76	170 Ir iridium 77	171 Pt platinum 78	172 Au gold 79	173 Hg mercury 80	174 Tl thallium 81	175 Pb lead 82
176 Mo molybdenum 42	177 Tc technetium 43	178 Ru ruthenium 44	179 Rh rhodium 45	180 Pd palladium 46	181 Ag silver 47	182 Cd cadmium 48	183 In indium 49
184 Co cobalt 27	185 Ni nickel 28	186 Cu copper 29	187 Zn zinc 30	188 Ga gallium 31	189 Ge germanium 32	190 As arsenic 33	191 Se selenium 34
192 Fe iron 26	193 Mn manganese 25	194 Cr chromium 24	195 V vanadium 23	196 Ti titanium 22	197 Sc scandium 21	198 Y yttrium 39	199 Zr zirconium 40
200 Ru ruthenium 44	201 Rh rhodium 45	202 Pd palladium 46	203 Ag silver 47	204 Cd cadmium 48	205 In indium 49	206 Sn tin 50	207 Sb antimony 51
208 Os osmium 76	209 Ir iridium 77	210 Pt platinum 78	211 Au gold 79	212 Hg mercury 80	213 Tl thallium 81	214 Pb lead 82	215 Bi bismuth 83
216 Re rhenium 75	217 Os osmium 76	218 Ir iridium 77	219 Pt platinum 78	220 Au gold 79	221 Hg mercury 80	222 Tl thallium 81	223 Pb lead 82
224 Mo molybdenum 42	225 Tc technetium 43	226 Ru ruthenium 44	227 Rh rhodium 45	228 Pd palladium 46	229 Ag silver 47	230 Cd cadmium 48	231 In indium 49
232 Co cobalt 27	233 Ni nickel 28	234 Cu copper 29	235 Zn zinc 30	236 Ga gallium 31	237 Ge germanium 32	238 As arsenic 33	239 Se selenium 34
240 Fe iron 26	241 Mn manganese 25	242 Cr chromium 24	243 V vanadium 23	244 Ti titanium 22	245 Sc scandium 21	246 Y yttrium 39	247 Zr zirconium 40
248 Ru ruthenium 44	249 Rh rhodium 45	250 Pd palladium 46	251 Ag silver 47	252 Cd cadmium 48	253 In indium 49	254 Sn tin 50	255 Sb antimony 51
256 Os osmium 76	257 Ir iridium 77	258 Pt platinum 78	259 Au gold 79	260 Hg mercury 80	261 Tl thallium 81	262 Pb lead 82	263 Bi bismuth 83
264 Re rhenium 75	265 Os osmium 76	266 Ir iridium 77	267 Pt platinum 78	268 Au gold 79	269 Hg mercury 80	270 Tl thallium 81	271 Pb lead 82
272 Mo molybdenum 42	273 Tc technetium 43	274 Ru ruthenium 44	275 Rh rhodium 45	276 Pd palladium 46	277 Ag silver 47	278 Cd cadmium 48	279 In indium 49
280 Co cobalt 27	281 Ni nickel 28	282 Cu copper 29	283 Zn zinc 30	284 Ga gallium 31	285 Ge germanium 32	286 As arsenic 33	287 Se selenium 34
288 Fe iron 26	289 Mn manganese 25	290 Cr chromium 24	291 V vanadium 23	292 Ti titanium 22	293 Sc scandium 21	294 Y yttrium 39	295 Zr zirconium 40
296 Ru ruthenium 44	297 Rh rhodium 45	298 Pd palladium 46	299 Ag silver 47	300 Cd cadmium 48	301 In indium 49	302 Sn tin 50	303 Sb antimony 51
304 Os osmium 76	305 Ir iridium 77	306 Pt platinum 78	307 Au gold 79	308 Hg mercury 80	309 Tl thallium 81	310 Pb lead 82	311 Bi bismuth 83
312 Re rhenium 75	313 Os osmium 76	314 Ir iridium 77	315 Pt platinum 78	316 Au gold 79	317 Hg mercury 80	318 Tl thallium 81	319 Pb lead 82
320 Mo molybdenum 42	321 Tc technetium 43	322 Ru ruthenium 44	323 Rh rhodium 45	324 Pd palladium 46	325 Ag silver 47	326 Cd cadmium 48	327 In indium 49
328 Co cobalt 27	329 Ni nickel 28	330 Cu copper 29	331 Zn zinc 30	332 Ga gallium 31	333 Ge germanium 32	334 As arsenic 33	335 Se selenium 34
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456 Re rhenium 75	457 Os osmium 76	458 Ir iridium 77	459 Pt platinum 78	460 Au gold 79	461 Hg mercury 80	462 Tl thallium 81	463 Pb lead 82
464 Mo molybdenum 42	465 Tc technetium 43	466 Ru ruthenium 44	467 Rh rhodium 45	468 Pd palladium 46	469 Ag silver 47	470 Cd cadmium 48	471 In indium 49
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536 Ru ruthenium 44	537 Rh rhodium 45	538 Pd palladium 46	539 Ag silver 47	540 Cd cadmium 48	541 In indium 49	542 Sn tin 50	543 Sb antimony 51
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