

Please check the examination details below before entering your candidate information

Candidate surname

Other names

Pearson Edexcel
International
Advanced Level

Centre Number

--	--	--	--	--

Candidate Number

--	--	--	--

Friday 12 October 2018

Morning (Time: 1 hour 30 minutes)

Paper Reference **WCH02/01**

Chemistry
Advanced Subsidiary
Unit 2: Application of Core Principles of Chemistry

You must have: 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.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
– *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Show all your working in calculations and units where appropriate.
- Check your answers if you have time at the end.

Turn over ►

P55441A

©2018 Pearson Education Ltd.

5/2/2/2/2/2/

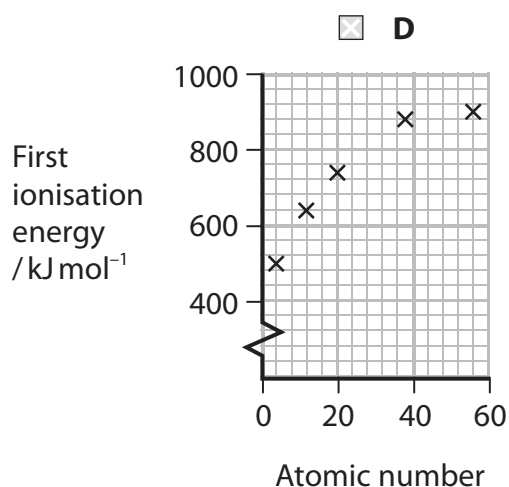
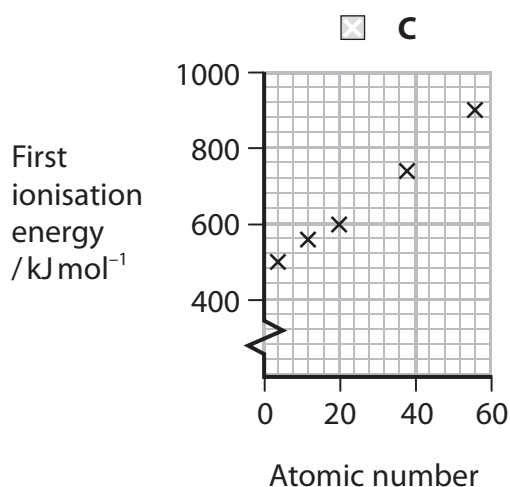
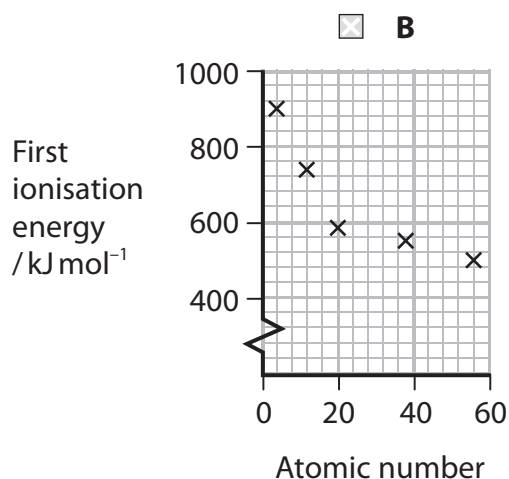
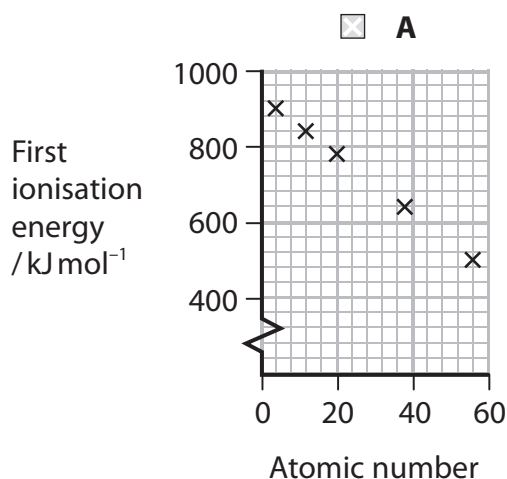


Pearson

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 . If you change your mind, put a line through the box and then mark your new answer with a cross .

- 1 Which diagram shows the trend in first ionisation energy of the Group 2 elements, beryllium to barium?



(Total for Question 1 = 1 mark)

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

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



2 Which is the equation for the reaction of calcium with water?

- A $\text{Ca} + \text{H}_2\text{O} \rightarrow \text{CaO} + \text{H}_2$
- B $\text{Ca} + 2\text{H}_2\text{O} \rightarrow \text{CaO} + 2\text{H}_2$
- C $\text{Ca} + 2\text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2 + \text{H}_2$
- D $2\text{Ca} + 2\text{H}_2\text{O} \rightarrow 2\text{Ca(OH)}_2 + \text{H}_2$

(Total for Question 2 = 1 mark)

3 Barium carbonate is more stable to heat than magnesium carbonate.

This is caused by a difference in the polarisation of the carbonate ion and some bonds being weakened.

Which ion causes the greater polarisation of the carbonate ion and which bonds are weakened?

	Ion causing greater polarisation of the carbonate ion	Bonds weakened
<input type="checkbox"/> A	barium	between cation and anion
<input type="checkbox"/> B	barium	between C and O in the anion
<input type="checkbox"/> C	magnesium	between cation and anion
<input type="checkbox"/> D	magnesium	between C and O in the anion

(Total for Question 3 = 1 mark)

4 Group 2 compounds give different colours in a flame test. The **best** explanation is that the cations have different

- A gaps between electron energy levels.
- B ionic radii.
- C numbers of electrons.
- D first and second ionisation energies.

(Total for Question 4 = 1 mark)

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



- 5 25.0 cm³ of a solution of sodium carbonate, Na₂CO₃, contained 2.12 g of solute.

What is the concentration of the solution, in mol dm⁻³?

- A 0.02
 B 0.40
 C 0.80
 D 1.02

(Total for Question 5 = 1 mark)

- 6 Titration was used to find the volume of hydrochloric acid needed to neutralise a solution of sodium hydroxide.

The volumes used and measurement uncertainty for each reading of the burette and pipette are shown.

Apparatus	Volume used / cm ³	Measurement uncertainty for each reading / cm ³
burette	19.40	±0.05
pipette	25.00	±0.06

What are the percentage uncertainties, to two decimal places?

	Total percentage uncertainty on volume measured by burette	Total percentage uncertainty on volume measured by pipette
<input type="checkbox"/> A	0.26	0.24
<input type="checkbox"/> B	0.26	0.48
<input type="checkbox"/> C	0.52	0.24
<input type="checkbox"/> D	0.52	0.48

(Total for Question 6 = 1 mark)

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



7 Which molecule has the shortest distance between the atoms?

- A Cl—Cl
- B I—I
- C O=O
- D N≡N

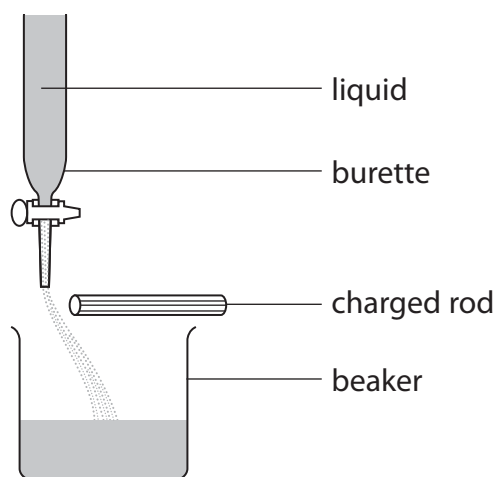
(Total for Question 7 = 1 mark)

8 What are the approximate bond angles in the CH_3^+ and CH_3^- ions?

	Bond angle in CH_3^+	Bond angle in CH_3^-
<input type="checkbox"/> A	107°	107°
<input type="checkbox"/> B	107°	120°
<input type="checkbox"/> C	120°	107°
<input type="checkbox"/> D	120°	120°

(Total for Question 8 = 1 mark)

9 Which liquid will be deflected the most by a charged rod, using the apparatus shown in the diagram?

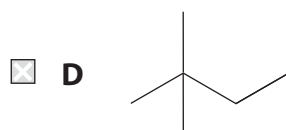
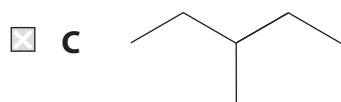
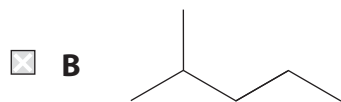
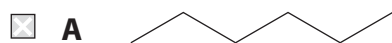


- A cyclohexane
- B hexane
- C tetrachloromethane
- D trichloromethane

(Total for Question 9 = 1 mark)



10 Which isomer of C_6H_{14} has the **lowest** boiling temperature?



(Total for Question 10 = 1 mark)

11 What is the trend in boiling temperatures for the hydrogen halides from HF to HI?

- A decreases
 B decreases then increases
 C increases
 D increases then decreases

(Total for Question 11 = 1 mark)

12 Which compound is the most soluble in hexane?

- A ethanol
 B octane
 C sodium chloride
 D water

(Total for Question 12 = 1 mark)

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



13 Which of these reactions is **not** disproportionation?

- A $\text{Br}_2 + \text{H}_2\text{O} \rightarrow \text{HBr} + \text{HBrO}$
- B $3\text{ClO}^- \rightarrow \text{ClO}_3^- + 2\text{Cl}^-$
- C $2\text{F}_2 + 2\text{OH}^- \rightarrow \text{OF}_2 + 2\text{F}^- + \text{H}_2\text{O}$
- D $3\text{I}_2 + 6\text{OH}^- \rightarrow \text{IO}_3^- + 5\text{I}^- + 3\text{H}_2\text{O}$

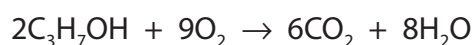
(Total for Question 13 = 1 mark)

14 What is the percentage by mass of carbon in cyclohexane?

- A 83.7%
- B 85.7%
- C 87.8%
- D 92.3%

(Total for Question 14 = 1 mark)

15 What is the maximum volume of carbon dioxide that could be produced at room temperature and pressure when 0.10 mol of propan-1-ol is burned in excess oxygen?



[Molar volume of gas at room temperature and pressure = $24 \text{ dm}^3 \text{ mol}^{-1}$]

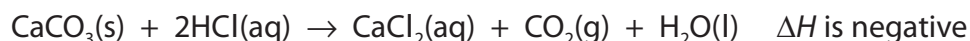
- A 7.2 dm^3
- B 9.6 dm^3
- C 10.8 dm^3
- D 14.4 dm^3

(Total for Question 15 = 1 mark)

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



16 Marble chips react with dilute hydrochloric acid.



An experiment was carried out to measure the initial rate of this reaction at 20°C.

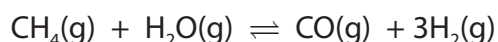
The experiment was repeated keeping the mass of marble chips and the volume and concentration of the hydrochloric acid constant.

Which set of changes will result in the fastest initial rate of reaction?

	Size of solid particles	Temperature
<input type="checkbox"/> A	doubled	decreased by 10°C
<input type="checkbox"/> B	doubled	increased by 10°C
<input type="checkbox"/> C	halved	decreased by 10°C
<input type="checkbox"/> D	halved	increased by 10°C

(Total for Question 16 = 1 mark)

17 Methane reacts with steam and an equilibrium is established.



The pressure is then changed and the equilibrium position shifts to the right to produce more carbon monoxide and hydrogen.

What is the change in pressure and the reason for the change in the equilibrium position?

	Change in pressure	Reason
<input type="checkbox"/> A	decrease	there are more molecules of gas on the right
<input type="checkbox"/> B	decrease	the molecules of gas collide less frequently
<input type="checkbox"/> C	increase	there are more molecules of gas on the right
<input type="checkbox"/> D	increase	the molecules of gas collide more frequently

(Total for Question 17 = 1 mark)

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



18 Which is **always** true for an electrophile?

- A It accepts a pair of electrons to form a covalent bond.
- B It donates a pair of electrons to form a covalent bond.
- C It has a negative charge.
- D It has a positive charge.

(Total for Question 18 = 1 mark)

19 A greenhouse gas allows the Earth to warm up by absorbing energy and slowing the rate at which the energy escapes into space.

The efficiency of a greenhouse gas is determined by its ability to absorb

- A infrared radiation, and how long it remains in the atmosphere.
- B infrared radiation, and how easily it forms free radicals.
- C ultraviolet radiation, and how long it remains in the atmosphere.
- D ultraviolet radiation, and how easily it forms free radicals.

(Total for Question 19 = 1 mark)

20 Which types of bonds and molecules absorb infrared radiation?

	Type of bond	Type(s) of molecule
<input type="checkbox"/> A	non-polar	non-polar only
<input type="checkbox"/> B	polar	non-polar only
<input type="checkbox"/> C	polar	polar only
<input type="checkbox"/> D	polar	non-polar and polar

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS



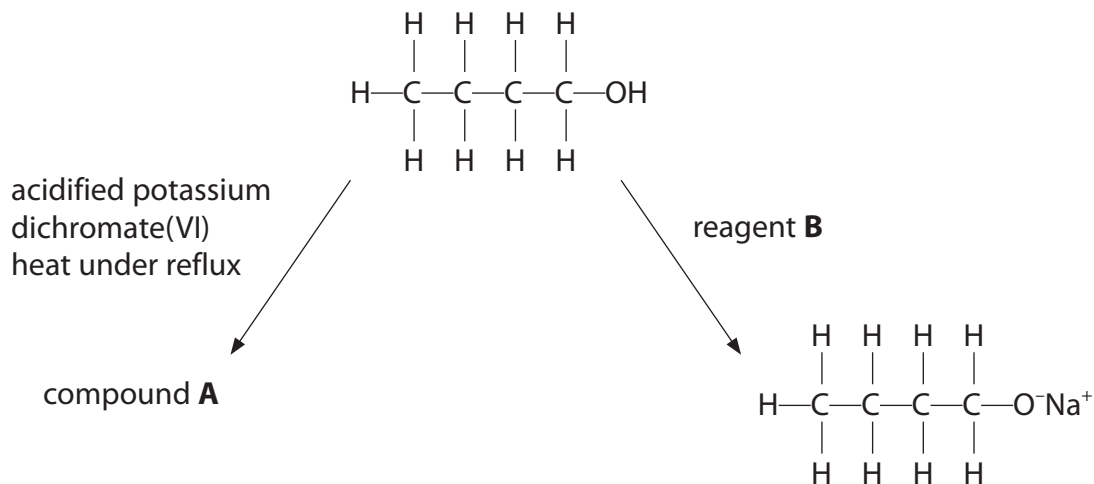
SECTION B

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

21 There are four structural isomers with molecular formula $C_4H_{10}O$ that are alcohols.

(a) Butan-1-ol is one of the structural isomers.

Two reactions of butan-1-ol are shown.



(i) Give the **displayed formula** of organic compound **A**.

(1)

(ii) Identify reagent **B**, by name or formula.

(1)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(b) Butan-1-ol can be converted into 1-aminobutane in two steps.



(i) Identify, by name or formula, a possible reagent or reagents for Step 1. (1)

(ii) Give the structural formula of compound X. (1)

(iii) Identify, by name or formula, the reagent for Step 2. (1)

(iv) Suggest why the reaction in Step 2 is carried out by heating in a sealed tube instead of heating under reflux. (1)



- (c) As well as butan-1-ol, there are three other structural isomers with molecular formula $C_4H_{10}O$ that are alcohols.

Draw the **displayed formulae** of these three structural isomers.

(2)

- (d) Alcohol **Y** has molecular formula $C_4H_{10}O$ and is **not** butan-1-ol.

- (i) The mass spectrum of alcohol **Y** has a major peak at $m/e = 43$. This peak is formed from the fragment produced when **one** bond in the alcohol is broken.

Draw the **displayed formula** of the species that could give this peak.

(2)

- (ii) Draw the **displayed formula** of alcohol **Y** and label the bond that is broken when the fragment producing the peak at $m/e = 43$ is formed.

(2)

(Total for Question 21 = 12 marks)



DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

22 This question is about the halogens and some of their compounds.

(a) Iodine monochloride, ICl , and iodine trichloride, ICl_3 , are interhalogen compounds.

(i) Draw a dot-and-cross diagram of the ICl molecule.
Show outer shell electrons only.

(1)

* (ii) Suggest how the electrons in the outer shell of iodine rearrange to form iodine trichloride, ICl_3 .

(2)

.....

.....

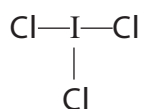
.....

.....

.....

.....

(iii) The iodine trichloride molecule is 'T-shaped'.



State whether the I-Cl bonds are polar and whether ICl_3 is a polar molecule.
Justify your answers.

(2)

.....

.....

.....

.....

.....

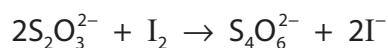
.....



- (b) Thallium exists in more than one oxidation state.
Thallium(III) ions, Tl^{3+} , oxidise iodide ions, I^- , to iodine.

In an experiment, 25.0 cm^3 of a $0.0464\text{ mol dm}^{-3}$ solution of Tl^{3+} was added to excess potassium iodide solution. The iodine produced was titrated with 0.100 mol dm^{-3} sodium thiosulfate solution.

The titration was repeated and the mean titre was 23.20 cm^3 .



- (i) This titration was carried out **without** an indicator.

Give the colour change at the end point.

(1)

From to

- * (ii) Calculate the ratio of moles of I^- to moles of Tl^{3+} and hence deduce the final oxidation number of thallium.

(4)

(Total for Question 22 = 10 marks)



DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

23 This question is about halogenoalkanes.

(a) Bromoalkanes react with aqueous potassium hydroxide.

(i) Draw the mechanism for the reaction between 1-bromopropane and aqueous potassium hydroxide.

Include curly arrows, and relevant lone pairs and dipoles.

(4)

(ii) State the type and mechanism of this reaction.

(2)

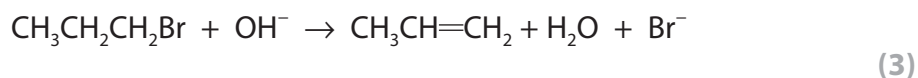


(b) 0.50 g of 1-bromopropane reacted with potassium hydroxide in ethanol.

The volume of propene formed at room temperature and pressure was 18 cm³.

Calculate the percentage yield of propene.

[Molar volume of gas at room temperature and pressure = 24 000 cm³ mol⁻¹]



*(c) An experiment was carried out to compare the rates of reaction when 1-chloropropane, 1-bromopropane and 1-iodopropane react separately with the water present in aqueous silver nitrate.

Identify the halogenoalkane with the fastest rate of reaction.

Justify your answer.

(2)

.....

.....

.....

.....

.....

.....

.....

.....

.....



DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(d) Chlorofluorocarbons, CFCs, have been used as aerosol propellants.

(i) Draw the displayed formula of the CFC 1,1,2-trichloro-1,2,2-trifluoroethane. (1)

(ii) Chlorotrifluoromethane, CClF_3 , breaks down in the ozone layer to form free radicals.



Suggest a reason why fluorine free radicals are not produced. (1)

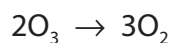
.....

.....

.....

(iii) Chlorine free radicals, $\text{Cl}\cdot$, react with ozone, O_3 .

The overall equation is



Write the two propagation steps for this chain reaction.

Curly arrows are **not** required. (2)



(iv) Butane is now used as a propellant in some aerosols as it does not form free radicals in the ozone layer.

Give a disadvantage of using butane as an aerosol propellant.

(1)

.....

.....

.....

.....

(Total for Question 23 = 16 marks)

TOTAL FOR SECTION B = 38 MARKS

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



SECTION C

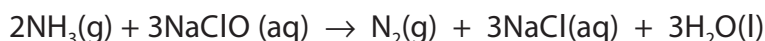
Answer ALL the questions. Write your answers in the spaces provided.

24

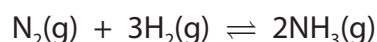
Nitrogen chemistry

Nitrogen is an unreactive gas that makes up about 78% of the atmosphere.

When ammonia reacts with sodium chlorate(I), nitrogen, N₂, is formed.



Nitrogen reacts with hydrogen in the Haber Process to produce ammonia.



The conditions used for this process are:

temperature 350 to 450 °C

pressure 150 to 250 atmospheres

catalyst iron

Nitrogen trichloride, NCl₃, is a yellow liquid that is formed when ammonium salts react with chlorine. It is also formed in small amounts when chlorine reacts with urea in swimming pools and is responsible for the 'chlorine' smell.

- (a) (i) Explain, in terms of the oxidation numbers of nitrogen and chlorine, why the reaction between ammonia and sodium chlorate(I) is a redox reaction.



(3)

.....

.....

.....

.....

.....

.....

.....

.....

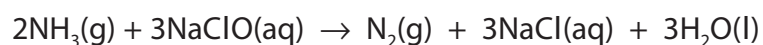
.....

.....

DO NOT WRITE IN THIS AREA



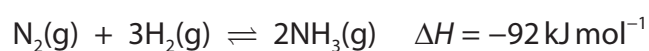
- (ii) Calculate the minimum volume of 0.20 mol dm^{-3} sodium chlorate(I) solution needed to react with 120 cm^3 of ammonia gas at room temperature and pressure.



[Molar volume of gas at room temperature and pressure = $24\,000 \text{ cm}^3 \text{ mol}^{-1}$]

(3)

- (b) Ammonia is formed in the Haber Process.



- (i) Explain the effect, if any, on the position of equilibrium when the temperature increases from 350°C to 450°C at constant pressure.

(2)

.....

.....

.....

.....

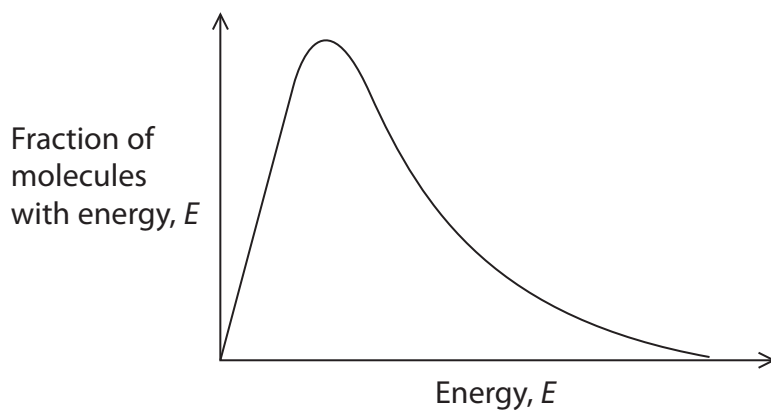
.....

.....



(ii) Use the Maxwell-Boltzmann distribution to explain why the addition of a catalyst increases the rate of this reaction.

(2)



.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

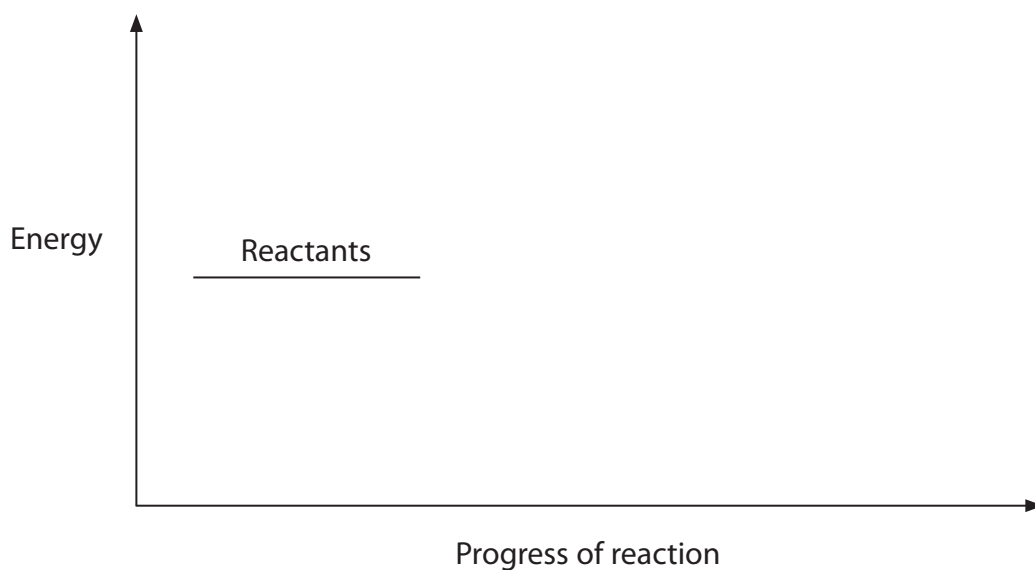
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



(iii) Complete the reaction profile of the **catalysed** reaction for the formation of ammonia. Label the activation energy of the forward reaction, and the enthalpy change. (3)



(c) Ammonium chloride reacts with chlorine to form nitrogen trichloride and hydrogen chloride.

(i) Write the equation for this reaction.

Include state symbols.

(2)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



(ii) Predict the shape of a nitrogen trichloride molecule.

Justify your answer.

(3)

Shape

Justification

.....

.....

.....

.....

.....

(iii) Explain, in terms of intermolecular forces, why nitrogen trichloride has a similar boiling temperature to ethanol.

Formula	Boiling temperature / °C
NCl_3	71
$\text{C}_2\text{H}_5\text{OH}$	79

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for Question 24 = 22 marks)

TOTAL FOR SECTION C = 22 MARKS
TOTAL FOR PAPER = 80 MARKS

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



The Periodic Table of Elements

1	2	3	4	5	6	7	0 (8)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
6.9 Li lithium 3	9.0 Be beryllium 4	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
23.0 Na sodium 11	24.3 Mg magnesium 12	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
39.1 K potassium 19	40.1 Ca calcium 20	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	192.2 Os osmium 76
85.5 Rb rubidium 37	87.6 Sr strontium 38	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108
132.9 Cs caesium 55	137.3 Ba barium 56	[226] Ra radium 88	[223] Fr francium 87	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108
10.8 B boron 5	12.0 C carbon 6	107.9 Au gold 79	114.8 In indium 49	112.4 Cd cadmium 48	107.9 Ag silver 47	106.4 Pd palladium 46	102.9 Rh rhodium 45
27.0 Al aluminium 13	28.1 Si silicon 14	200.6 Hg mercury 80	69.7 Ga gallium 31	65.4 Zn zinc 30	63.5 Cu copper 29	58.7 Ni nickel 28	58.9 Co cobalt 27
19.0 F fluorine 9	16.0 O oxygen 8	200.6 Pb lead 82	12.0 C carbon 6	65.4 Zn zinc 30	63.5 Cu copper 29	58.7 Ni nickel 28	58.9 Co cobalt 27
20.2 Ne neon 10	19.0 F fluorine 9	126.9 Te tellurium 52	14.0 N nitrogen 7	112.4 Cd cadmium 48	107.9 Ag silver 47	106.4 Pd palladium 46	102.9 Rh rhodium 45
39.9 Ar argon 18	35.5 Cl chlorine 17	127.6 Te tellurium 52	31.0 P phosphorus 15	107.9 Au gold 79	106.4 Pd palladium 46	106.4 Pd palladium 46	102.9 Rh rhodium 45
		126.9 I iodine 53	32.1 S sulfur 16	114.8 In indium 49	102.9 Rh rhodium 45	102.9 Rh rhodium 45	102.9 Rh rhodium 45
		[222] Rn radon 86	79.9 Br bromine 35	118.7 Sn tin 50	102.9 Rh rhodium 45	102.9 Rh rhodium 45	102.9 Rh rhodium 45
			79.9 Br bromine 35	121.8 Sb antimony 51	102.9 Rh rhodium 45	102.9 Rh rhodium 45	102.9 Rh rhodium 45
				127.6 Te tellurium 52	102.9 Rh rhodium 45	102.9 Rh rhodium 45	102.9 Rh rhodium 45
				126.9 I iodine 53	102.9 Rh rhodium 45	102.9 Rh rhodium 45	102.9 Rh rhodium 45
				[209] Po polonium 84	102.9 Rh rhodium 45	102.9 Rh rhodium 45	102.9 Rh rhodium 45
				209.0 Po polonium 84	102.9 Rh rhodium 45	102.9 Rh rhodium 45	102.9 Rh rhodium 45
				83 Bi bismuth 83	102.9 Rh rhodium 45	102.9 Rh rhodium 45	102.9 Rh rhodium 45
				82 Pb lead 82	102.9 Rh rhodium 45	102.9 Rh rhodium 45	102.9 Rh rhodium 45
				81 Tl thallium 81	102.9 Rh rhodium 45	102.9 Rh rhodium 45	102.9 Rh rhodium 45
				82 Pb lead 82	102.9 Rh rhodium 45	102.9 Rh rhodium 45	102.9 Rh rhodium 45
				83 Bi bismuth 83	102.9 Rh rhodium 45	102.9 Rh rhodium 45	102.9 Rh rhodium 45
				84 Po polonium 84	102.9 Rh rhodium 45	102.9 Rh rhodium 45	102.9 Rh rhodium 45
				85 At astatine 85	102.9 Rh rhodium 45	102.9 Rh rhodium 45	102.9 Rh rhodium 45
				86 Rn radon 86	102.9 Rh rhodium 45	102.9 Rh rhodium 45	102.9 Rh rhodium 45

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

* Lanthanide series
* Actinide series

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



P 5 5 4 4 1 A 0 2 4 2 4