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 ▶

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

P 5 5 4 4 1 A 0 1 2 4

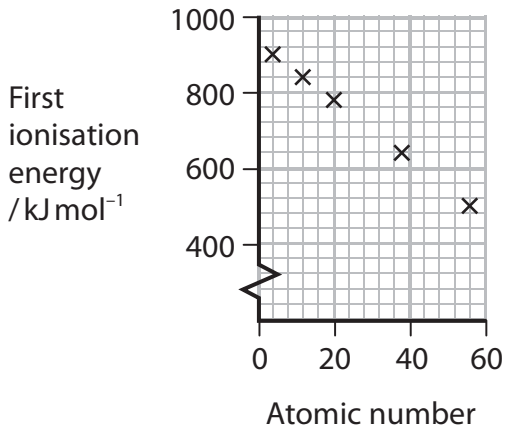
Pearson

SECTION A

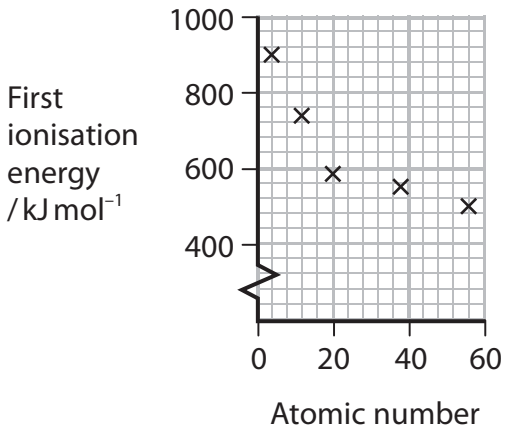
Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

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

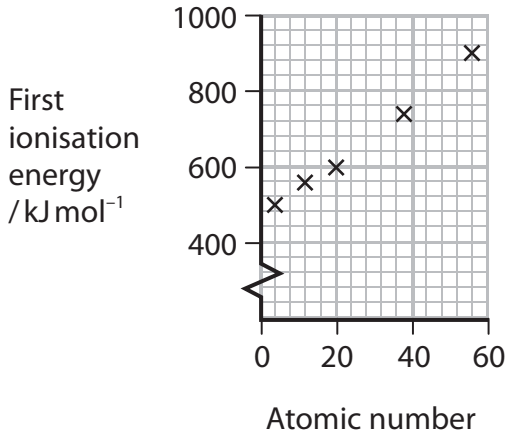
☒ **A**



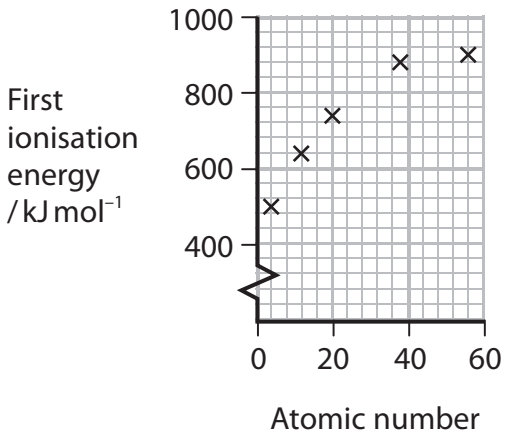
☒ **B**



☒ **C**



☒ **D**



(Total for Question 1 = 1 mark)

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

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

☒ **A** $Ca + H_2O \rightarrow CaO + H_2$

☒ **B** $Ca + 2H_2O \rightarrow CaO + 2H_2$

☒ **C** $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$

☒ **D** $2Ca + 2H_2O \rightarrow 2Ca(OH)_2 + H_2$

(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
☒ **A**	barium	between cation and anion
☒ **B**	barium	between C and O in the anion
☒ **C**	magnesium	between cation and anion
☒ **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 cm^3 of a solution of sodium carbonate, Na_2CO_3, 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
☒ **A**	0.26	0.24
☒ **B**	0.26	0.48
☒ **C**	0.52	0.24
☒ **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

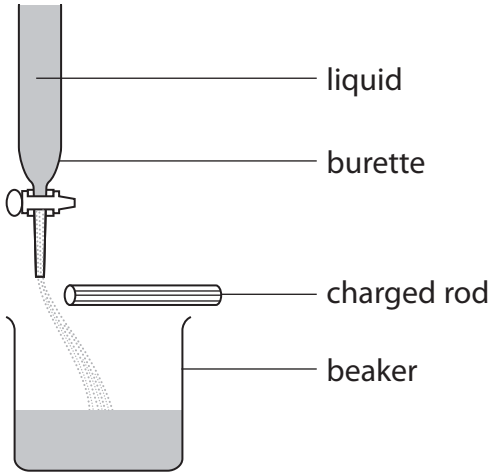
(Total for Question 7 = 1 mark)

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^-
☒ **A**	107°	107°
☒ **B**	107°	120°
☒ **C**	120°	107°
☒ **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

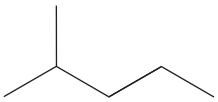
☒ **C** tetrachloromethane

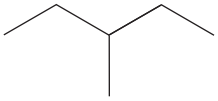
☒ **D** trichloromethane

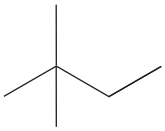
(Total for Question 9 = 1 mark)

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

☒ **A** 

☒ **B** 

☒ **C** 

☒ **D** 

(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** $Br_2 + H_2O \rightarrow HBr + HBrO$

☒ **B** $3ClO^- \rightarrow ClO_3^- + 2Cl^-$

☒ **C** $2F_2 + 2OH^- \rightarrow OF_2 + 2F^- + H_2O$

☒ **D** $3I_2 + 6OH^- \rightarrow IO_3^- + 5I^- + 3H_2O$

(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?

$$2C_3H_7OH + 9O_2 \rightarrow 6CO_2 + 8H_2O$$

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

☒ **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.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l) \quad \Delta H \text{ is negative}$$

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
☒ **A**	doubled	decreased by 10 °C
☒ **B**	doubled	increased by 10 °C
☒ **C**	halved	decreased by 10 °C
☒ **D**	halved	increased by 10 °C

(Total for Question 16 = 1 mark)

17 Methane reacts with steam and an equilibrium is established.

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

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
☒ **A**	decrease	there are more molecules of gas on the right
☒ **B**	decrease	the molecules of gas collide less frequently
☒ **C**	increase	there are more molecules of gas on the right
☒ **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
☒ **A**	non-polar	non-polar only
☒ **B**	polar	non-polar only
☒ **C**	polar	polar only
☒ **D**	polar	non-polar and polar

(Total for Question 20 = 1 mark)

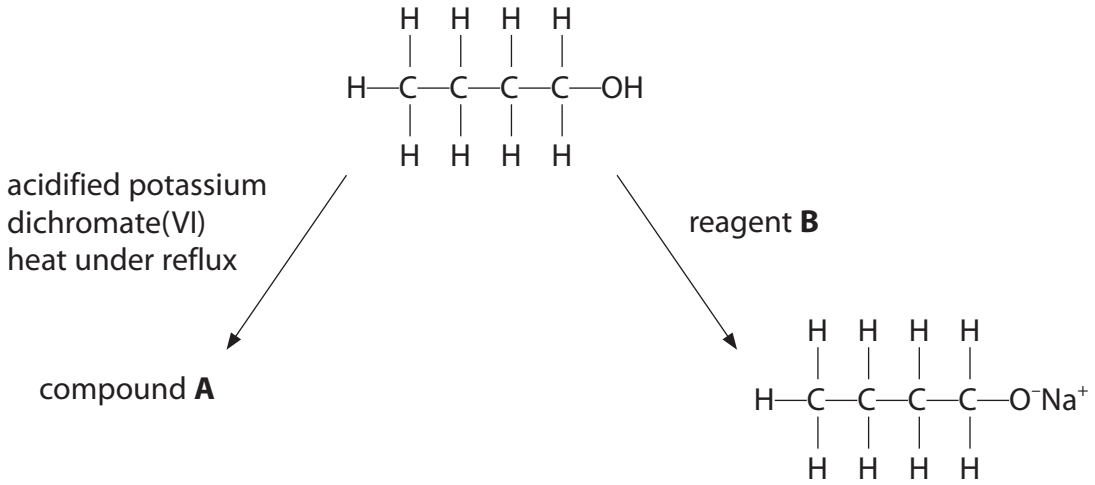
TOTAL FOR SECTION A = 20 MARKS

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)

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

$$CH_3CH_2CH_2CH_2OH \xrightarrow{\text{Step 1}} \text{compound } \mathbf{X} \xrightarrow{\text{Step 2}} CH_3CH_2CH_2CH_2NH_2$$

(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)

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

(1)

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(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)

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

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

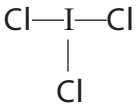
(i) Draw a dot-and-cross diagram of the ICl molecule.
Show outer shell electrons only.

(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 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.

$$2S_2O_3^{2-} + I_2 \rightarrow S_4O_6^{2-} + 2I^-$$

(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)

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 cm^3.

Calculate the percentage yield of propene.

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

$$CH_3CH_2CH_2Br + OH^- \rightarrow CH_3CH{=}CH_2 + H_2O + Br^-$$

(3)

*(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)

(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.

$$CClF_3 \rightarrow {}^{\bullet}CF_3 + Cl^{\bullet}$$

Suggest a reason why fluorine free radicals are not produced.

(1)

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

The overall equation is

$$2O_3 \rightarrow 3O_2$$

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)

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(Total for Question 23 = 16 marks)

TOTAL FOR SECTION B = 38 MARKS

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, N_2, is formed.

$$2NH_3(g) + 3NaClO\,(aq) \rightarrow N_2(g) + 3NaCl(aq) + 3H_2O(l)$$

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

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

The conditions used for this process are:

temperature 350 to 450 °C

pressure 150 to 250 atmospheres

catalyst iron

Nitrogen trichloride, NCl_3, 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.

$$2NH_3(g) + 3NaClO(aq) \rightarrow N_2(g) + 3NaCl(aq) + 3H_2O(l)$$

(3)

(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.

$$2NH_3(g) + 3NaClO(aq) \rightarrow N_2(g) + 3NaCl(aq) + 3H_2O(l)$$

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

(3)

(b) Ammonia is formed in the Haber Process.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta H = -92 \text{ kJ mol}^{-1}$$

(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)

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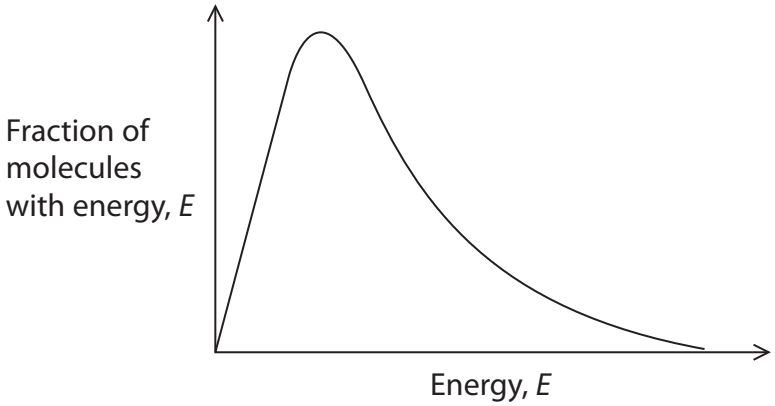
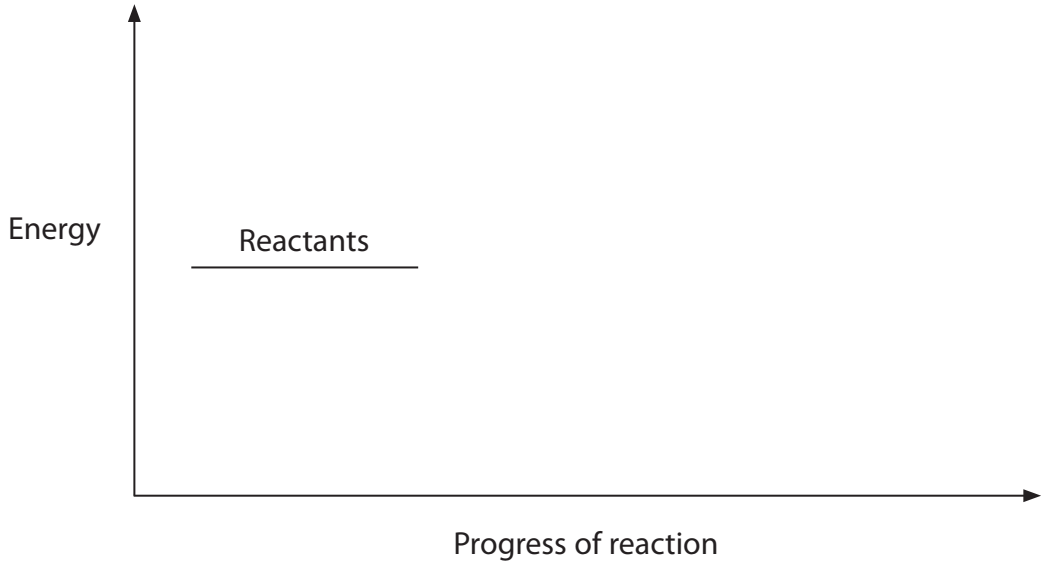
(ii) Use the Maxwell-Boltzmann distribution to explain why the addition of a catalyst increases the rate of this reaction.

(2)



(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)

(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
C_2H_5OH	79

(4)

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(Total for Question 24 = 22 marks)

TOTAL FOR SECTION C = 22 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

* Lanthanide series	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
* Actinide series	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