

Please check the examination details below before entering your candidate information

Candidate surname

Other names

Centre Number

Candidate Number

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Pearson Edexcel International Advanced Level

Monday 13 May 2024

Morning (Time: 1 hour 30 minutes)

Paper
reference

WCH12/01R

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 ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **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.*
- 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.
- Show all your working in calculations and include units where appropriate.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ►

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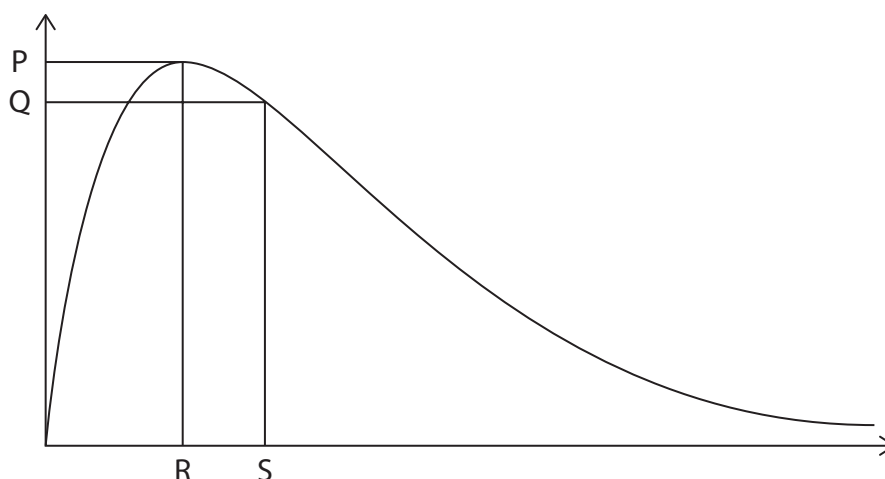
SECTION A

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 A Maxwell-Boltzmann distribution of molecular energies is shown.



- (a) Which letter represents the mean energy of the molecules?

(1)

- A letter P
- B letter Q
- C letter R
- D letter S

- (b) What happens to the curve when the temperature is **decreased**?

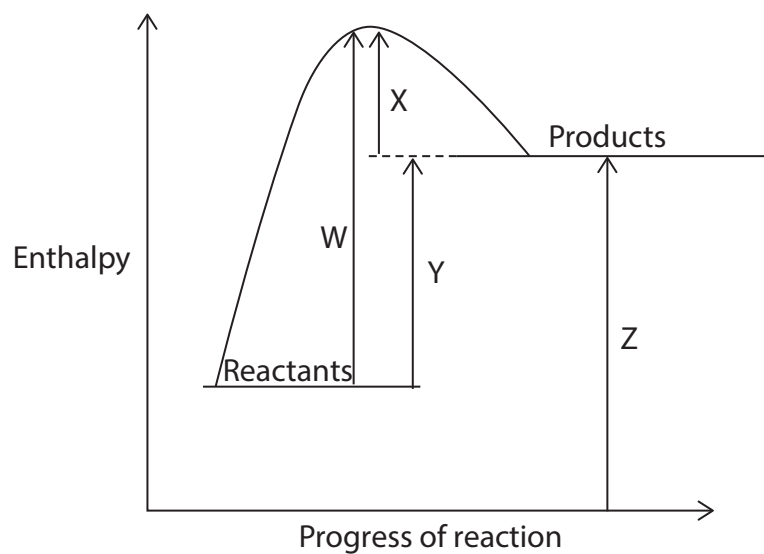
(1)

- A the peak becomes higher and further to the right
- B the peak becomes higher and further to the left
- C the peak becomes lower and further to the right
- D the peak becomes lower and further to the left

(Total for Question 1 = 2 marks)



2 The reaction profile for a reaction is shown.



Which arrow represents the activation energy of the forward reaction?

- A letter W
- B letter X
- C letter Y
- D letter Z

(Total for Question 2 = 1 mark)

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



3 The reaction between calcium carbonate and hydrochloric acid is investigated.

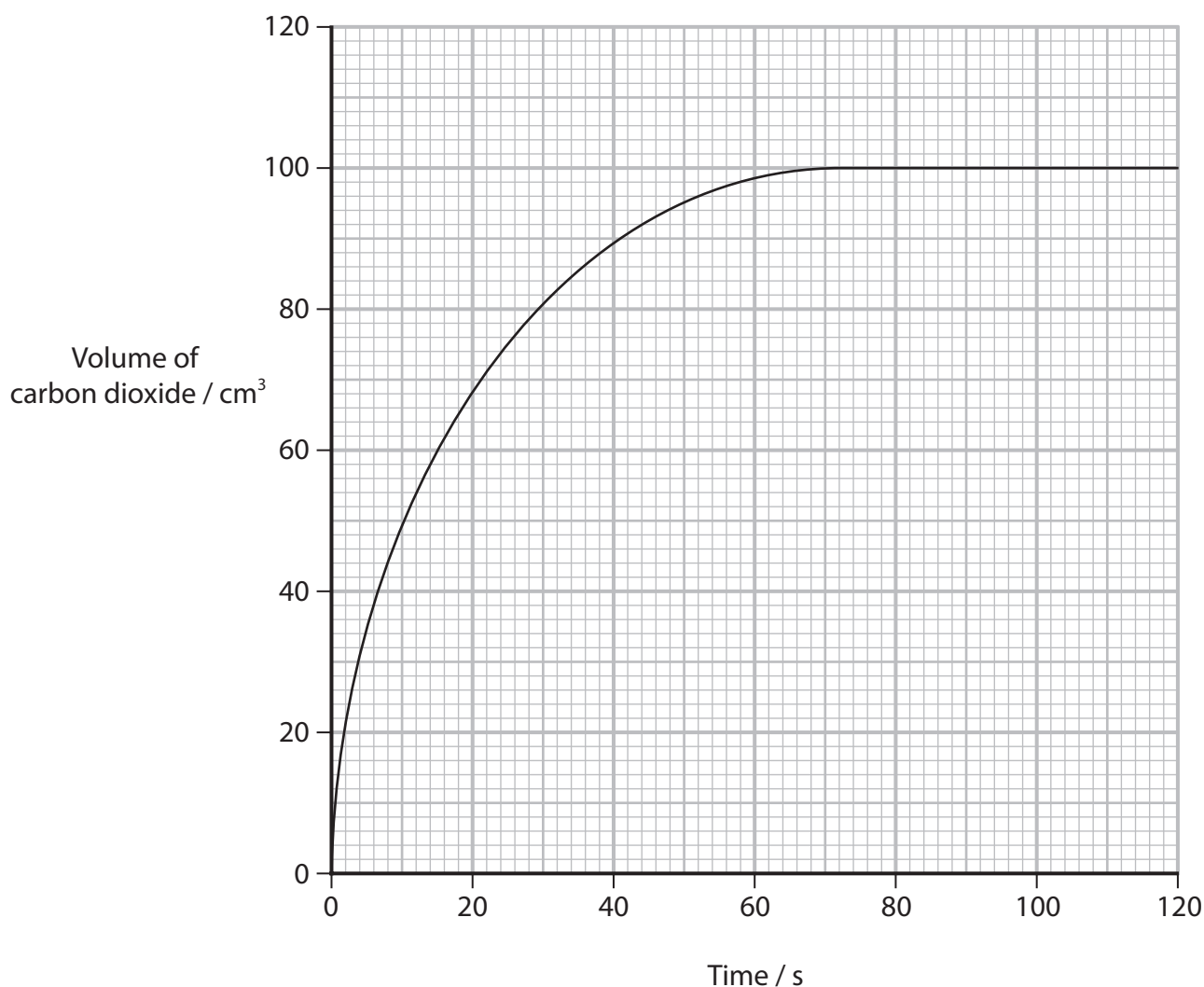


(a) Which change in property will **not** affect the rate of this reaction?

(1)

- A concentration of hydrochloric acid
- B particle size of calcium carbonate
- C pressure of the system
- D temperature of hydrochloric acid

(b) The graph shows the results of one of the experiments.



What is the **approximate** rate of reaction in $\text{cm}^3 \text{s}^{-1}$ at 20 seconds?

(1)

- A 0.67
- B 0.70
- C 1.50
- D 3.50

(Total for Question 3 = 2 marks)

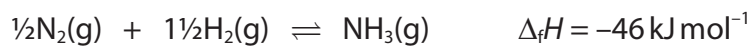
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4 Nitrogen reacts with hydrogen to form ammonia.



Bond	Bond enthalpy / kJ mol^{-1}
H—H	436
N≡N	945

What is the bond enthalpy, in kJ mol^{-1} , of the N—H bond?

- A 360
- B 391
- C 548
- D 1173

(Total for Question 4 = 1 mark)

5 A gas cylinder contains 2.5 kg of butane.

How many molecules of butane are in the cylinder?

[Molar mass of butane = 58.0 g mol^{-1} Avogadro constant, $L = 6.02 \times 10^{23} \text{ mol}^{-1}$]

- A 1.40×10^{22}
- B 2.59×10^{22}
- C 1.40×10^{25}
- D 2.59×10^{25}

(Total for Question 5 = 1 mark)

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



- 6 In an experiment to calculate the enthalpy change of neutralisation, $\Delta_{\text{neut}}H$, 25 cm^3 of 0.1 mol dm^{-3} hydrochloric acid, HCl, was reacted with 25 cm^3 of 0.1 mol dm^{-3} sodium hydroxide solution. The increase in temperature, ΔT , was recorded.

[Assume the density of the solutions = 1.00 g cm^{-3}

Specific heat capacity of solutions = $4.2 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$]

- (a) Which is the correct expression to calculate the enthalpy change of neutralisation for this reaction, in J mol^{-1} ?

(1)

- A $\frac{\Delta T \times 4.2 \times 50}{5.0 \times 10^{-3}}$
- B $\frac{\Delta T \times 4.2 \times 25}{2.5 \times 10^{-3}}$
- C $\frac{-\Delta T \times 4.2 \times 50}{5.0 \times 10^{-3}}$
- D $\frac{-\Delta T \times 4.2 \times 50}{2.5 \times 10^{-3}}$

- (b) The table below shows the measurement uncertainty of some laboratory apparatus.

Apparatus	Measurement uncertainty on each reading / cm^3
burette	+/- 0.05
25 cm^3 measuring cylinder	+/- 0.5
25 cm^3 volumetric flask	+/- 0.1
25 cm^3 pipette	+/- 0.06

Which piece of apparatus would measure 25 cm^3 of hydrochloric acid with the **lowest** percentage uncertainty?

(1)

- A burette
- B measuring cylinder
- C volumetric flask
- D pipette

(Total for Question 6 = 2 marks)



7 Which equation shows the reaction that occurs when the standard enthalpy change of atomisation of iodine is measured?

- A $I_2(s) \rightarrow 2I(g)$
- B $\frac{1}{2}I_2(s) \rightarrow I(g)$
- C $I_2(g) \rightarrow 2I(g)$
- D $\frac{1}{2}I_2(g) \rightarrow I(g)$

(Total for Question 7 = 1 mark)

8 Which statement about the elements in Group 7 is **not correct**?

- A they all exist as diatomic molecules
- B electronegativity decreases down the group
- C reactivity increases up the group
- D they all show variable oxidation states in their compounds

(Total for Question 8 = 1 mark)

9 What are the only products formed when chlorine reacts with **cold** aqueous sodium hydroxide?

- A sodium chloride, sodium chlorate(I) and water
- B sodium chloride, sodium chlorate(V) and water
- C sodium chlorate(I) and water
- D sodium chloride and sodium chlorate(I)

(Total for Question 9 = 1 mark)

10 Which statement about the reaction between concentrated sulfuric acid and potassium bromide is correct?

- A bromide ions are reduced
- B hydrogen bromide and hydrogen sulfide are formed
- C sulfuric acid acts as an oxidising agent
- D bromine and hydrogen sulfide are formed

(Total for Question 10 = 1 mark)



11 Which statement is correct about the solubilities of Group 2 compounds as the group is descended?

- A the solubility of the hydroxides and sulfates increases for both
- B the solubility of the hydroxides and sulfates decreases for both
- C the solubility of the hydroxides increases and the solubility of the sulfates decreases
- D the solubility of the hydroxides decreases and the solubility of the sulfates increases

(Total for Question 11 = 1 mark)

12 Which nitrate does **not** produce brown fumes when heated?

- A LiNO_3
- B KNO_3
- C $\text{Ca}(\text{NO}_3)_2$
- D $\text{Ba}(\text{NO}_3)_2$

(Total for Question 12 = 1 mark)

13 Compound **X** gives a red flame test and a solution of **X** produces a white precipitate when added to nitric acid and silver nitrate solution.

Which could be compound **X**?

- A LiCl
- B NaCl
- C NaBr
- D RbBr

(Total for Question 13 = 1 mark)

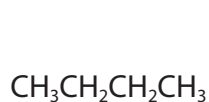
14 Which species contains an element with an oxidation number of +4?

- A CrO_4^{2-}
- B MnO_4^{2-}
- C H_2SO_4
- D Na_2CO_3

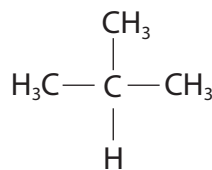
(Total for Question 14 = 1 mark)



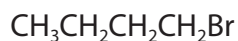
15 The compounds **W**, **X**, **Y** and **Z** have different boiling temperatures.



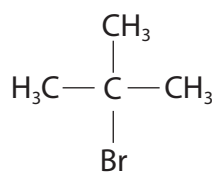
Compound W



Compound X



Compound Y



Compound Z

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

- A** $X < W < Z < Y$
- B** $X < Z < W < Y$
- C** $W < X < Y < Z$
- D** $X < W < Y < Z$

(Total for Question 15 = 1 mark)

16 How many **structural** isomers are there with the molecular formula $\text{C}_3\text{H}_6\text{BrI}$?

- A** 4
- B** 5
- C** 6
- D** 7

(Total for Question 16 = 1 mark)

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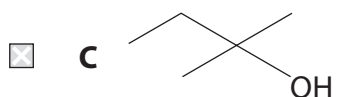
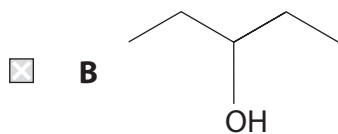
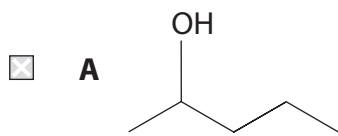


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17 Which alcohol can be oxidised to a carboxylic acid by acidified potassium dichromate(VI)?



(Total for Question 17 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS



SECTION B

Answer ALL the questions in this section.

Write your answers in the spaces provided.

18 This question is about Group 2 carbonates.

Group 2 carbonates decompose on heating to form the corresponding metal oxide and carbon dioxide. The general equation is shown.



- (a) A sample of magnesium carbonate was heated for 4 minutes.
The mass of the sample decreased from 4.17 g to 2.35 g.

Calculate the percentage of magnesium carbonate that has decomposed.

[Molar mass of magnesium carbonate = 84.3 g mol^{-1}]

(3)

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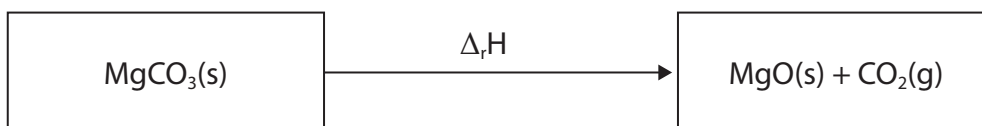


- (b) The enthalpy change, $\Delta_r H$, for the thermal decomposition of magnesium carbonate, MgCO_3 , can be calculated using the data in the table.

Substance	Enthalpy change of formation / kJ mol^{-1}
MgCO_3	-1095.8
MgO	-601.7
CO_2	-393.5

- (i) Complete the Hess cycle with two arrows and correct species and state symbols in the box.

(2)



- (ii) Calculate the enthalpy change for the thermal decomposition of magnesium carbonate, $\Delta_r H$. Include a sign and units in your answer.

(2)



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(c) Explain how the enthalpy change for the thermal decomposition of calcium carbonate, CaCO_3 , compares to that for magnesium carbonate in (b)(ii).

(3)

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(Total for Question 18 = 10 marks)



19 This question is about ozone, O₃.

Ozone is formed by the action of ultraviolet radiation on oxygen molecules.



Ozone is a pale blue gas and oxygen gas is colourless.

A mixture of oxygen and ozone was placed in a sealed container and left to reach equilibrium.

(a) (i) Explain what you would **see** on heating the mixture.

(2)

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(ii) Explain what you would **see** on increasing the pressure.

(2)

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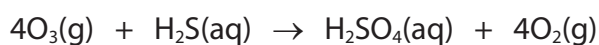
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- (b) Ozone can be used in the treatment of drinking water. As well as killing bacteria and viruses, ozone also removes other dissolved impurities such as hydrogen sulfide, H_2S . Hydrogen sulfide reacts with ozone to produce sulfuric acid.



State the role of the ozone in this redox reaction.
Justify your answer using oxidation numbers.

(3)

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- (c) Ozone can also be used in the treatment of water in swimming pools. A swimming pool has a volume of $375\,000\text{ dm}^3$ and contains 15 g of ozone. Calculate the concentration of ozone in the pool in parts per million (ppm).

[Assume the density of water in the swimming pool = 1.00 g cm^{-3}]

(2)

(Total for Question 19 = 9 marks)



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20 An organic compound, acetoin, is one of the compounds that gives butter its characteristic flavour.

- (a) Acetoin contains 54.5 % by mass of carbon and 9.1 % by mass of hydrogen. The remainder is oxygen.
- (i) Calculate the empirical formula of acetoin.
You must show all your working.

(3)

- (ii) The molar mass of acetoin is 88.0 g mol^{-1} .

Use this information to calculate the molecular formula of acetoin.

(1)



(b) Acetoin contains **two** functional groups.

- (i) Some chemical tests were carried out on acetoin. These tests identify **one** of the two functional groups.

Acetoin produced steamy fumes when reacted with PCl_5 .

Acetoin did **not** react with sodium hydrogencarbonate solution.

Acetoin turned hot acidified potassium dichromate(VI) solution from orange to green.

State what can be deduced from each of these three tests and hence identify this functional group.

(3)

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- (ii) Acetoin also contains the carbonyl group $\text{C}=\text{O}$, in the form of a ketone **not** an aldehyde.

Use page 5 of your Data Booklet to show how infrared spectra data could be used to prove that acetoin contains a ketone not an aldehyde.

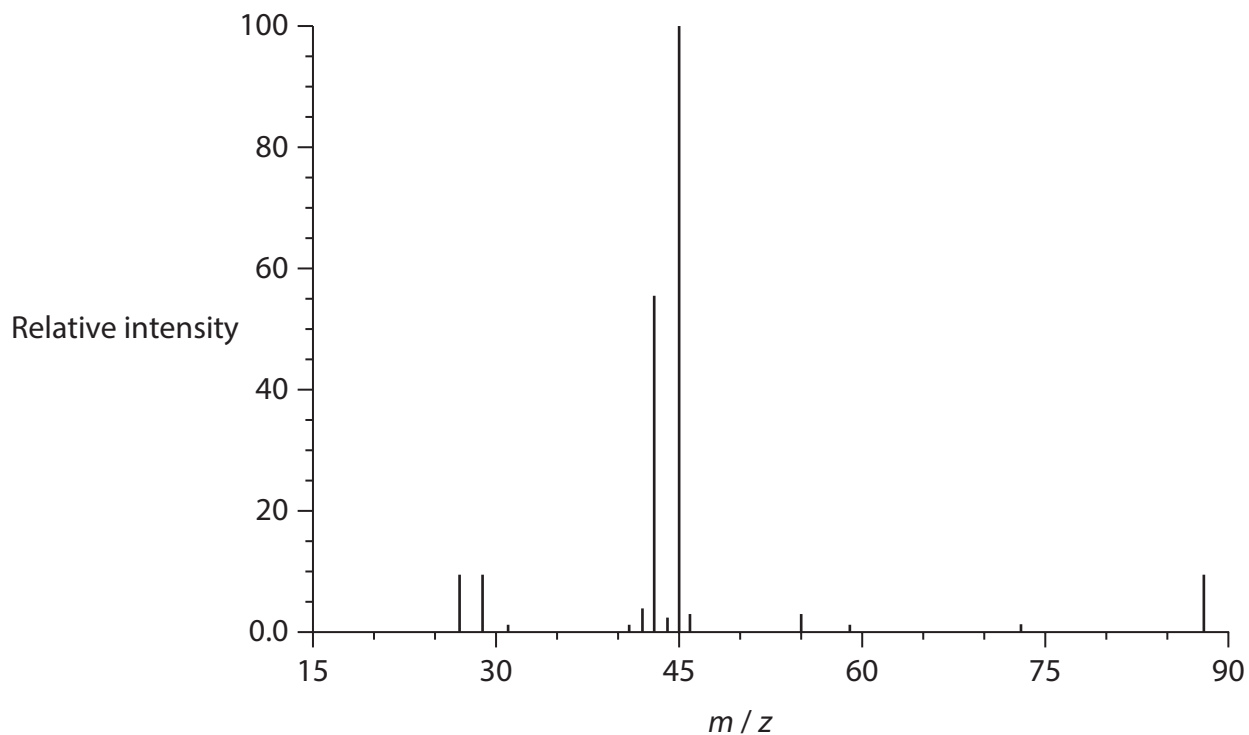
Complete the table.

(3)

	Bond	Wavenumber range / cm^{-1}
Absorption present in acetoin but not in an aldehyde		
One absorption present in an aldehyde but not in acetoin		
Another absorption present in an aldehyde but not in acetoin		



(iii) Part of the mass spectrum of acetoin is shown.



Determine a possible structure of acetoin using your answer to part (b)(i), the information given in (b)(ii) and the mass spectrum.

In your answer, identify the two ions responsible for the two peaks of highest intensity.

(3)

(Total for Question 20 = 13 marks)



P 7 8 3 9 2 A 0 1 9 3 2

21 This question is about halogenoalkanes.

- (a) Complete the table by giving the **displayed** formula and name of each halogenoalkane.

(3)

	A straight chain primary chloroalkane with the molecular formula C_4H_9Cl	A tertiary iodoalkane with the molecular formula C_4H_9I
Displayed formula		
Name		

- (b) The two halogenoalkanes in part (a) react with aqueous potassium hydroxide to produce alcohols.

Give **two** reasons why the rate of reaction of the iodoalkane is faster than that of the chloroalkane.

(2)

Reason 1

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Reason 2

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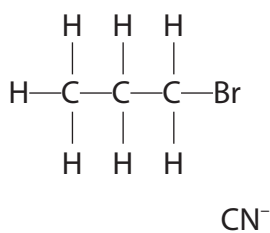


(c) Halogenoalkanes react with cyanide ions, CN^- , in alcoholic solution to form nitriles. The cyanide ions act as nucleophiles.

Complete the mechanism for the formation of butanenitrile, $\text{CH}_3\text{CH}_2\text{CH}_2\text{CN}$.

Include curly arrows, and relevant lone pairs and dipoles.

(3)



(Total for Question 21 = 8 marks)

TOTAL FOR SECTION B = 40 MARKS

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SECTION C**Answer ALL the questions in this section.****Write your answers in the spaces provided.**

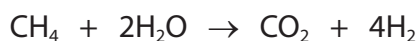
- 22** Ammonia, ammonium nitrate and urea are nitrogen-based fertilisers.
The nitrogen in the fertiliser is taken up by the roots of plants and promotes growth.

Ammonia, NH_3 , is manufactured by the reaction between nitrogen and hydrogen.
The nitrogen is obtained from the air.

Hydrogen can be obtained by two methods.

Method 1

The hydrogen is usually obtained by reacting methane gas with steam.

**Method 2**

Hydrogen can also be obtained using solar power to split water into hydrogen and oxygen.



- (a) Evaluate which of these two methods used to obtain hydrogen is more sustainable.

(3)

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- (b) Ammonia can be used directly as a fertiliser or converted to other compounds such as ammonium nitrate and urea.

Name of fertiliser	ammonia	ammonium nitrate	urea
Formula	NH_3	NH_4NO_3	NH_2CONH_2
% nitrogen by mass	82.4		46.7

- (i) Complete the table by calculating the percentage by mass of nitrogen in ammonium nitrate. (1)

- (ii) Give **one** advantage and **one** disadvantage of applying ammonia directly into the soil as a fertiliser. Use information in the table and your knowledge of ammonia. (2)

Advantage

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Disadvantage

.....

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- (c) Ammonium nitrate, NH_4NO_3 , can be made by reacting ammonia with nitric acid.

- (i) Give the equation for this reaction. State symbols are not required. (1)

- (ii) Name the type of reaction occurring. (1)

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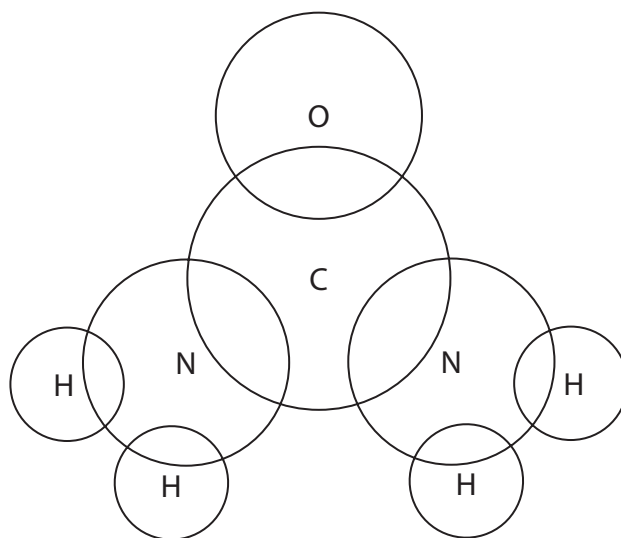
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(d) Urea, NH_2CONH_2 , can also be made from ammonia.

Complete the dot-and-cross diagram for the urea molecule.

(2)



P 7 8 3 9 2 A 0 2 5 3 2

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*(e) Both urea and ammonium nitrate are soluble in water.

Discuss the differences in the interactions of water molecules with both urea and ammonium nitrate.

Include **three** diagrams showing these interactions.

(6)

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Handwriting practice area with 20 horizontal dotted lines.



P 7 8 3 9 2 A 0 2 7 3 2

- (f) A field needs 160 kg of N per hectare to be applied using urea fertiliser.
The field size is 500 m × 640 m.

[1 hectare (ha) = 10 000 m², molar mass of urea = 60 g mol⁻¹]

Urea contains 46.7% N by mass.

Calculate the mass of urea, in tonnes, that needs to be applied to the field.

Give your answer to an appropriate number of significant figures.

(4)

(Total for Question 22 = 20 marks)

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



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P 7 8 3 9 2 A 0 3 1 3 2

The Periodic Table of Elements

1 2 3 4 5 6 7 0 (8)

1.0	H
	hydrogen
	1

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

(1) (2)

6.9	Li	9.0
	lithium	beryllium
	3	4
23.0	Na	24.3
	sodium	magnesium
	11	12

(13)

10.8	B	12.0
	boron	carbon
	5	6
27.0	Al	28.1
	aluminium	silicon
	13	14

(14)

14.0	N	16.0
	nitrogen	oxygen
	7	8
31.0	P	32.1
	phosphorus	sulfur
	15	16

(15)

14.0	N	16.0
	nitrogen	oxygen
	7	8
31.0	P	32.1
	phosphorus	sulfur
	15	16

(16)

19.0	F	20.2
	fluorine	neon
	9	10
35.5	Cl	39.9
	chlorine	argon
	17	18

(17)

4.0	He	
	helium	
	2	

(18)

4.0	He	
	helium	
	2	

(12)

65.4	Zn	112.4
	zinc	cadmium
	30	48
63.5	Cu	107.9
	copper	silver
	29	47

(11)

65.4	Zn	112.4
	zinc	cadmium
	30	48
63.5	Cu	107.9
	copper	silver
	29	47

(10)

58.7	Ni	106.4
	nickel	palladium
	28	46
106.4	Pd	107.9
	palladium	silver
	46	47

(9)

58.9	Co	102.9
	cobalt	rhodium
	27	45
102.9	Rh	106.4
	rhodium	palladium
	45	46

(8)

55.8	Fe	101.1
	iron	ruthenium
	26	44
101.1	Ru	106.4
	ruthenium	palladium
	44	46

(7)

54.9	Mn	[98]
	manganese	technetium
	25	43
[98]	Tc	106.4
	technetium	palladium
	43	46

(6)

52.0	Cr	95.9
	chromium	molybdenum
	24	42
95.9	Mo	106.4
	molybdenum	palladium
	42	46

(5)

50.9	V	92.9
	vanadium	niobium
	23	41
92.9	Nb	106.4
	niobium	palladium
	41	46

(4)

47.9	Ti	91.2
	titanium	zirconium
	22	40
91.2	Zr	106.4
	zirconium	palladium
	40	46

(3)

45.0	Sc	88.9
	scandium	yttrium
	21	39
88.9	Y	106.4
	yttrium	palladium
	39	46

178.5	Hf	178.5
	hafnium	hafnium
	72	72
178.5	Ta	180.9
	tantalum	tantalum
	73	73

186.2	Re	186.2
	rhenium	rhenium
	75	75
186.2	Os	190.2
	osmium	osmium
	76	76

190.2	Ir	192.2
	iridium	iridium
	77	77
192.2	Pt	195.1
	platinum	platinum
	78	78

195.1	Au	197.0
	gold	gold
	79	79
197.0	Hg	200.6
	mercury	mercury
	80	80

200.6	Hg	200.6
	mercury	mercury
	80	80
204.4	Tl	204.4
	thallium	thallium
	81	81

207.2	Pb	207.2
	lead	lead
	82	82
209.0	Bi	209.0
	bismuth	bismuth
	83	83

212.0	Po	212.0
	polonium	polonium
	84	84
210.0	At	210.0
	astatine	astatine
	85	85

222.0	Rn	222.0
	radon	radon
	86	86

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

140	Ce	141	144	150	152	157	163	165	167	173	175
	cerium	praseodymium	neodymium	samarium	europium	gadolinium	dysprosium	holmium	erbium	ytterbium	lutetium
	58	59	60	62	63	64	66	67	68	70	71
232	Th	231	238	242	243	247	251	254	253	254	257
	thorium	protactinium	uranium	plutonium	americium	curium	californium	einsteinium	fermium	nobelium	lawrencium
	90	91	92	94	95	96	98	99	100	102	103

* Lanthanide series

* Actinide series

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