

Please check the examination details below before entering your candidate information

Candidate surname

Other names

Centre Number

Candidate Number

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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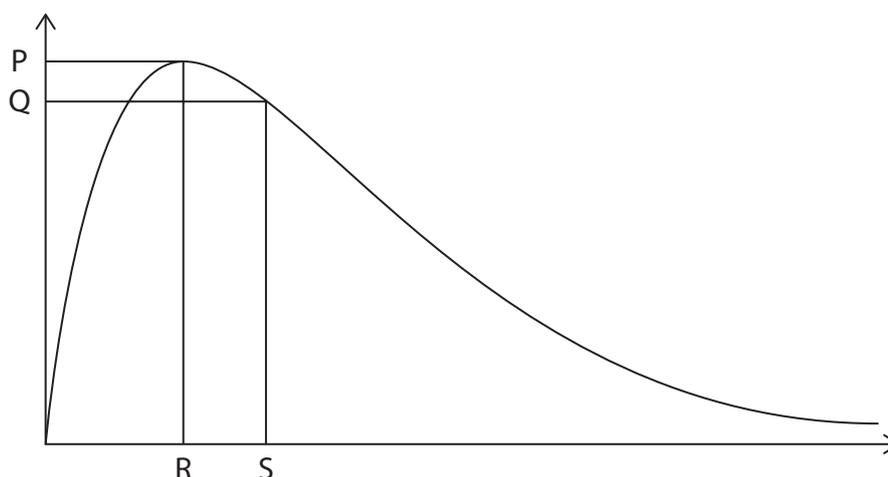
SECTION A

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**?

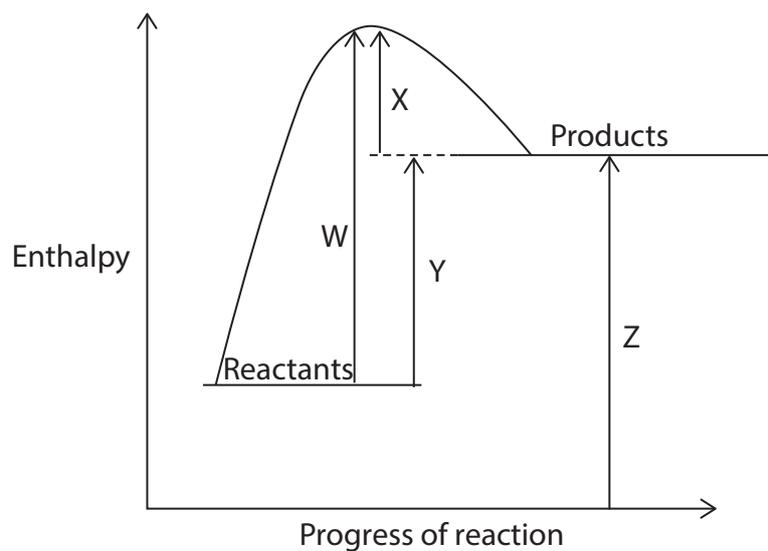
(1)

- 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)

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

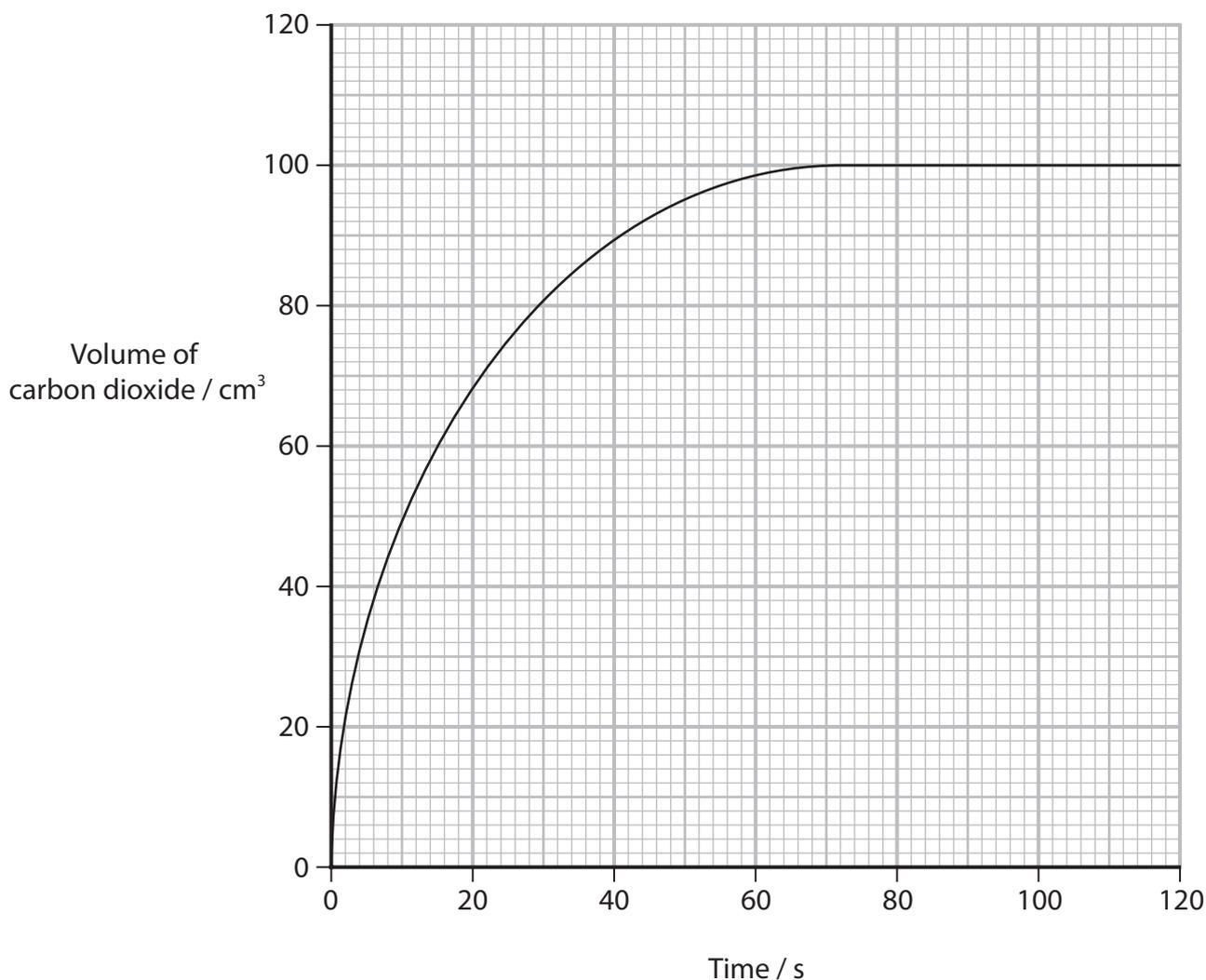


(a) Which change in property will **not** affect the rate of this reaction?

(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)

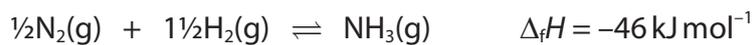
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4 Nitrogen reacts with hydrogen to form ammonia.



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)

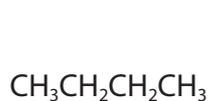
14 Which species contains an element with an oxidation number of +4?

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

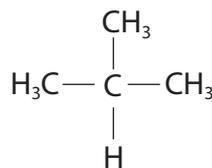
(Total for Question 14 = 1 mark)



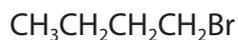
15 The compounds **W**, **X**, **Y** and **Z** have different boiling temperatures.



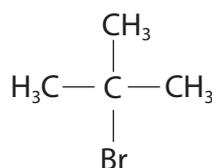
Compound W



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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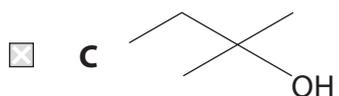
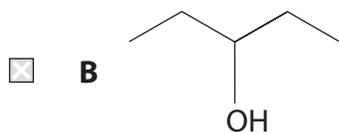
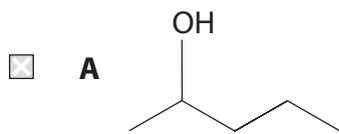


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17 Which alcohol can be oxidised to a carboxylic acid by acidified potassium dichromate(VI)?



(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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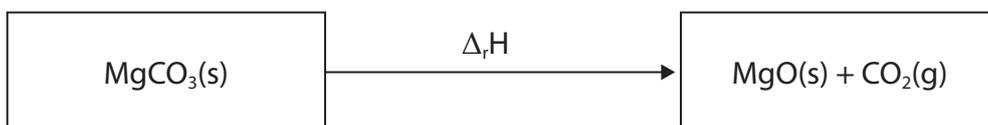


- (b) The enthalpy change, $\Delta_r H$, for the thermal decomposition of magnesium carbonate, MgCO_3 , can be calculated using the data in the table.

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)



(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)

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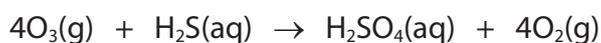
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- (b) Ozone can be used in the treatment of drinking water. As well as killing bacteria and viruses, ozone also removes other dissolved impurities such as hydrogen sulfide, H_2S . Hydrogen sulfide reacts with ozone to produce sulfuric acid.



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.

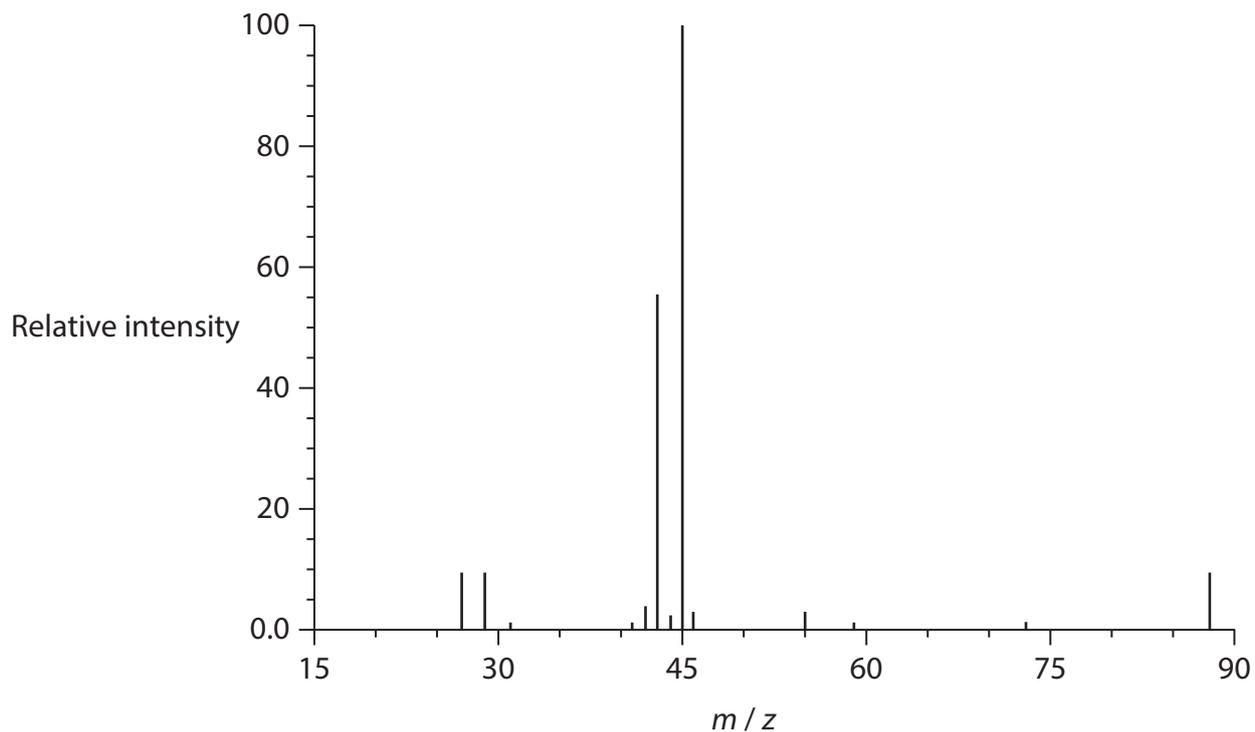
Complete the table.

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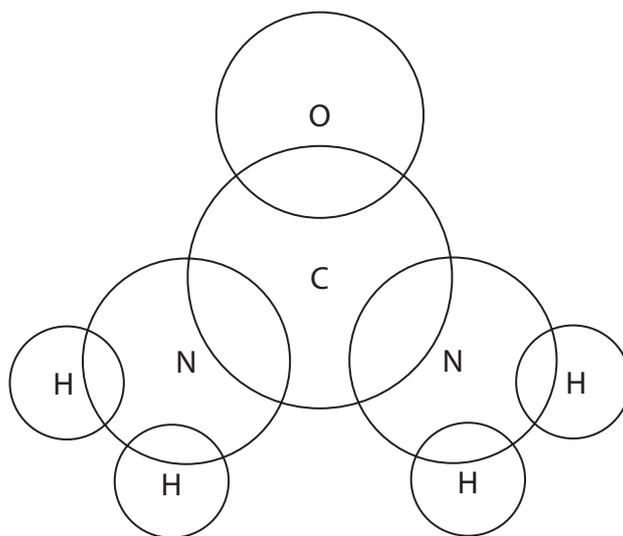
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(d) Urea, NH_2CONH_2 , can also be made from ammonia.

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

(2)



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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) (18)

1.0	H
	hydrogen
	1

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

(1) (2)

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

(13)

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

(14)

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

(16)

19.0	F	fluorine	9
35.5	Cl	chlorine	17

(17)

20.2	Ne	neon	10
39.9	Ar	argon	18

(12)

65.4	Zn	zinc	30
63.5	Cu	copper	29
69.7	Ga	gallium	31
72.6	Ge	germanium	32

(11)

112.4	Cd	cadmium	48
107.9	Ag	silver	47
114.8	In	indium	49
118.7	Sn	tin	50

(10)

58.7	Ni	nickel	28
106.4	Pd	palladium	46
107.9	Cd	cadmium	48
197.0	Au	gold	79

(9)

58.9	Co	cobalt	27
102.9	Rh	rhodium	45
192.2	Ir	iridium	77
195.1	Pt	platinum	78

(8)

55.8	Fe	iron	26
101.1	Ru	ruthenium	44
190.2	Os	osmium	76
195.1	Pt	platinum	78

(7)

54.9	Mn	manganese	25
[98]	Tc	technetium	43
186.2	Re	rhenium	75
192.2	Ir	iridium	77

(6)

52.0	Cr	chromium	24
95.9	Mo	molybdenum	42
183.8	W	tungsten	74
192.2	Ir	iridium	77

(5)

50.9	V	vanadium	23
92.9	Nb	niobium	41
180.9	Ta	tantalum	73
192.2	Ir	iridium	77

(4)

47.9	Ti	titanium	22
91.2	Zr	zirconium	40
178.5	Hf	hafnium	72
192.2	Os	osmium	76

(3)

45.0	Sc	scandium	21
88.9	Y	yttrium	39
138.9	La*	lanthanum	57
192.2	Ir	iridium	77

(2)

137.3	Ba	barium	56
173.0	La*	lanthanum	57
226	Ra	radium	88

(1)

132.9	Cs	caesium	55
223	Fr	francium	87

65.4	Zn	zinc	30	112.4	Cd	cadmium	48	200.6	Hg	mercury	80	204.4	Tl	thallium	81	207.2	Pb	lead	82	209.0	Bi	bismuth	83	209.0	Po	polonium	84	210	At	astatine	85	210	Rn	radon	86
63.5	Cu	copper	29	107.9	Ag	silver	47	197.0	Au	gold	79																								
58.7	Ni	nickel	28	106.4	Pd	palladium	46	195.1	Pt	platinum	78																								
58.9	Co	cobalt	27	102.9	Rh	rhodium	45	192.2	Ir	iridium	77																								
55.8	Fe	iron	26	101.1	Ru	ruthenium	44	190.2	Os	osmium	76																								
54.9	Mn	manganese	25	[98]	Tc	technetium	43	186.2	Re	rhenium	75																								
52.0	Cr	chromium	24	95.9	Mo	molybdenum	42	183.8	W	tungsten	74																								
50.9	V	vanadium	23	92.9	Nb	niobium	41	180.9	Ta	tantalum	73																								
47.9	Ti	titanium	22	91.2	Zr	zirconium	40	178.5	Hf	hafnium	72																								
45.0	Sc	scandium	21	88.9	Y	yttrium	39	138.9	La*	lanthanum	57																								
40.1	Ca	calcium	20	87.6	Sr	strontium	38	137.3	Ba	barium	56																								
39.1	K	potassium	19	85.5	Rb	rubidium	37	132.9	Cs	caesium	55																								

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

140	Ce	cerium	58	141	Pr	praseodymium	59	144	Nd	neodymium	60	150	Sm	samarium	62	152	Eu	europium	63	157	Gd	gadolinium	64	163	Dy	dysprosium	66	165	Ho	holmium	67	167	Er	erbium	68	169	Tm	thulium	69	173	Yb	ytterbium	70	175	Lu	lutetium	71				
232	Th	thorium	90	231	Pa	protactinium	91	238	U	uranium	92	238	U	uranium	92	238	U	uranium	92	238	U	uranium	92	238	U	uranium	92	238	U	uranium	92	238	U	uranium	92	238	U	uranium	92	238	U	uranium	92	238	U	uranium	92	238	U	uranium	92
237	Pm	promethium	61	237	Np	neptunium	93	237	U	uranium	92	237	Pu	plutonium	94	237	Am	americium	95	237	Cm	curium	96	237	Cf	californium	98	237	Es	einsteinium	99	237	Fm	fermium	100	237	Md	mendelevium	101	237	No	nobelium	102	237	Lr	lawrencium	103				

* Lanthanide series
* Actinide series



DO NOT WRITE IN THIS AREA