

Pearson Edexcel International Advanced Level

Friday 29 May 2026

Morning (Time: 1 hour 45 minutes)

Paper
reference

WCH14/01A

Chemistry

International Advanced Level

UNIT 4: Rates, Equilibria and Further Organic Chemistry

Question paper

You must have:

Answer Book (sent separately)

Scientific calculator, Data Booklet, ruler

Turn over ►

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SECTION A

Answer ALL the questions in this section in the Answer Book.

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

- 1 A sample of a bromoalkane, RBr, is hydrolysed.



- (a) The rate equation for this hydrolysis is shown.

$$\text{Rate} = k[\text{RBr}]$$

Which compound is **most** likely to be RBr?

(1)

- A 1-bromopentane
- B 1-bromo-2-methylbutane
- C 2-bromo-3-methylbutane
- D 2-bromo-2-methylbutane

- 1 (b) The rate of hydrolysis of RBr, in aqueous silver nitrate, can be determined by measuring the time taken for a precipitate to form.

Which change would **increase** the time for the first appearance of a precipitate?

(1)

- A decreasing the concentration of the aqueous silver nitrate
- B increasing the concentration of RBr
- C increasing the temperature
- D using an iodoalkane, RI, instead of a bromoalkane, RBr

(Total for Question 1 = 2 marks)

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

2 Which would be the most suitable carrier gas in gas chromatography?

- A chlorine
- B hydrogen
- C nitrogen
- D oxygen

(Total for Question 2 = 1 mark)

3 A high performance liquid chromatography (HPLC) system used a column with a non-polar stationary phase and a methanol-water mobile phase.

A mixture of hexane, hexanal and hexan-1-ol was separated using this HPLC column. What is the order of the retention times for these compounds?

	Shortest retention time	Intermediate retention time	Longest retention time
A	hexane	hexanal	hexan-1-ol
B	hexanal	hexan-1-ol	hexane
C	hexan-1-ol	hexanal	hexane
D	hexan-1-ol	hexane	hexanal

(Total for Question 3 = 1 mark)

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

4 Lattice energy is the energy change when one mole of an ionic solid is formed from its gaseous ions.

(a) Which compound has the most exothermic lattice energy?

(1)

- A** MgO
- B** MgS
- C** CaO
- D** CaS

4 (b) Which of these compounds has the greatest difference between the experimental (Born-Haber) lattice energy and the theoretical value obtained using electrostatic theory?

(1)

- A** LiF
- B** LiI
- C** NaF
- D** NaI

(Total for Question 4 = 2 marks)

5 Energy changes are used in the Born-Haber cycle to calculate the lattice energy of sodium oxide, Na₂O.

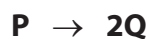
Which of these has a negative value?

- A** enthalpy change of atomisation of sodium
- B** first ionisation energy of sodium
- C** first electron affinity of oxygen
- D** second electron affinity of oxygen

(Total for Question 5 = 1 mark)



6 Substance **P** decomposes as shown.



The reaction is first order with a half-life of 69 s.

In an experiment, the initial amount of P is 1.00 mol and the reaction proceeds for 207 s.

(a) What amount of **Q** is produced?

(1)

A 0.125 mol

B 0.250 mol

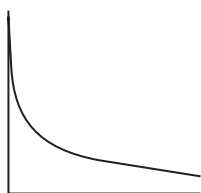
C 0.875 mol

D 1.75 mol

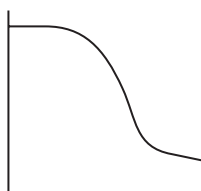
6 (b) Which graph shows the amount of substance **P**, on the vertical axis, against time?

(1)

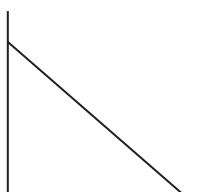
A



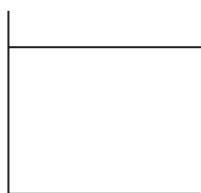
B



C

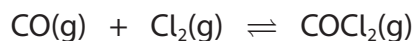


D



(Total for Question 6 = 2 marks)

7 Carbon monoxide and chlorine react to form carbonyl chloride.



- (a) What is the effect on the position of equilibrium and the equilibrium constant, K_p , when the pressure of the system is doubled?

(1)

- A the position of equilibrium shifts to the right and K_p doubles
- B the position of equilibrium shifts to the left and K_p halves
- C both the position of equilibrium and K_p are unchanged
- D the position of equilibrium shifts to the right and K_p is unchanged

- 7 (b) An equilibrium mixture contained 7 mol of CO, 3 mol of Cl_2 and 5 mol of COCl_2 at a total pressure of 1 atm.

What is the numerical value of the equilibrium constant, K_p ?

(1)

- A 0.24
- B 0.28
- C 3.6
- D 4.2

(Total for Question 7 = 2 marks)

- 8 At 25°C, pure water has a pH of 7.0 but at 90°C it has a pH of 6.1.

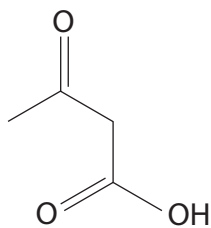
Which pair of options helps to explain why the pH decreases when the temperature increases?

	Dissociation of water	Concentration of hydrogen ions
A	endothermic	lower at 90°C
B	endothermic	higher at 90°C
C	exothermic	lower at 90°C
D	exothermic	higher at 90°C

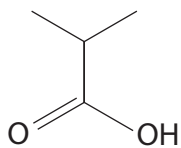
(Total for Question 8 = 1 mark)



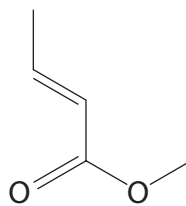
9 The structures of four compounds, **P**, **Q**, **R** and **S**, are shown.



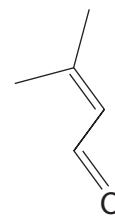
P



Q



R



S

(a) Which compound gives a positive result with Tollens' reagent?

(1)

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

9 (b) Which compound can be hydrolysed?

(1)

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

9 (c) Which compound is reduced by lithium tetrahydridoaluminate(III) to give a compound with a secondary alcohol group?

(1)

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

9 (d) Which compound has the highest boiling temperature?

(1)

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

(Total for Question 9 = 4 marks)

10 Which isomer of C_4H_9Cl has **three** peaks in its ^{13}C NMR spectrum?

- A** 1-chlorobutane
- B** 2-chlorobutane
- C** 1-chloro-2-methylpropane
- D** 2-chloro-2-methylpropane

(Total for Question 10 = 1 mark)

11 Pentan-2-one and pentan-3-one have different fragmentation patterns due to singly charged ions in their mass spectra.

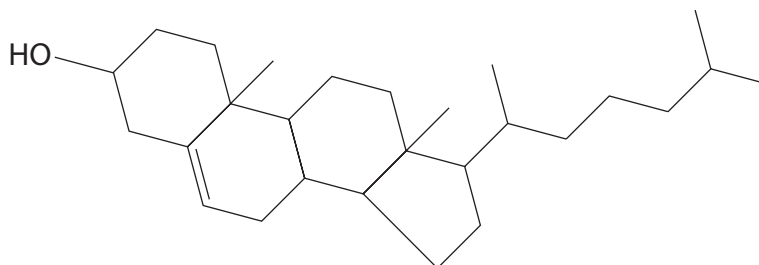
Which m/z peak would be expected to be seen in only one of the spectra?

[Data: M_r $C_5H_{10}O = 86$]

- A** 29
- B** 43
- C** 57
- D** 71

(Total for Question 11 = 1 mark)

12 The structure of cholesterol is shown.

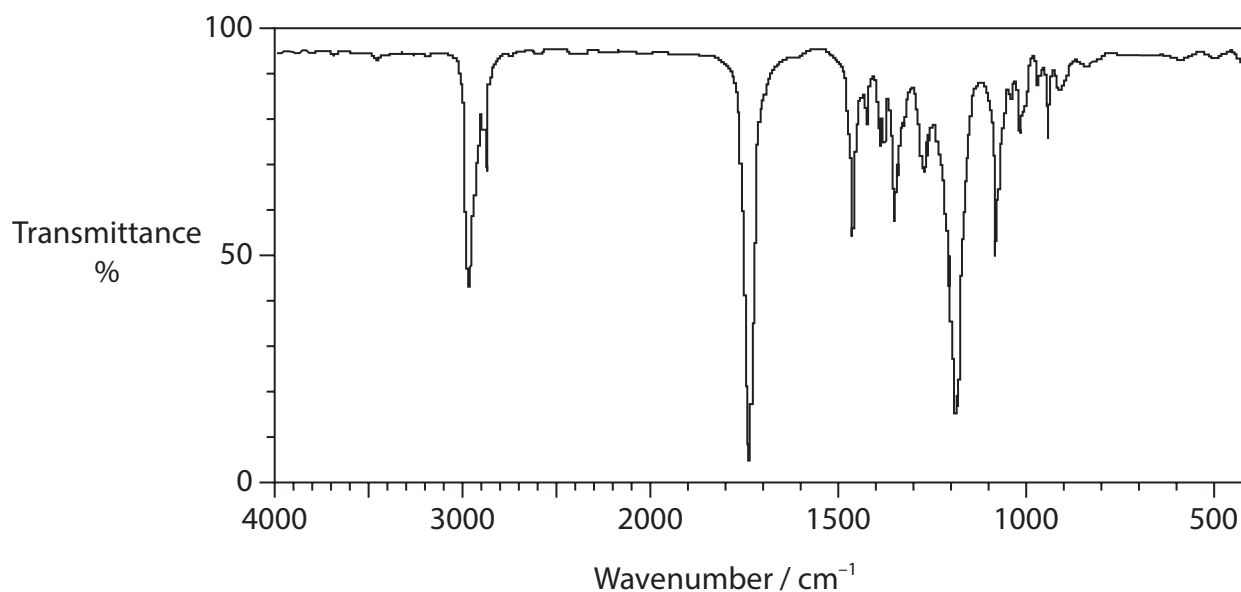


How many chiral centres are there in the cholesterol molecule?

- A** 2
- B** 5
- C** 8
- D** 9

(Total for Question 12 = 1 mark)

13 The infrared spectrum of a compound is shown.



Which of these compounds has this spectrum?
Use your Data Booklet.

- A** propan-1-ol
- B** propanoyl chloride
- C** propyl propanoate
- D** propanoic acid

(Total for Question 13 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL questions in the Answer Book provided.

14 The Ostwald process is used in the manufacture of nitric acid, HNO_3 .

There are three stages:

Stage **1** oxidation of ammonia to nitrogen monoxide, NO , at 1200 K

Stage **2** oxidation of NO to nitrogen dioxide, NO_2

Stage **3** reaction of NO_2 with water to produce HNO_3 .

(a) The equation for the reaction in Stage **1** is shown.

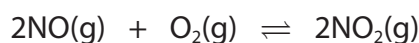


The catalyst only requires heating at the start.

Suggest **one** possible reason for this.

(1)

14 (b) The equation for Stage **2** is shown.



The initial rate of this reaction was determined for different concentrations and the results are shown.

Experiment	Initial concentration / mol dm^{-3}		Initial rate / $\text{mol dm}^{-3} \text{ s}^{-1}$
	$[\text{NO}(\text{g})]$	$[\text{O}_2(\text{g})]$	
1	0.0250	0.0100	5.10×10^{-4}
2	0.0250	0.0200	1.02×10^{-3}
3	0.0500	0.0400	8.16×10^{-3}

14 (b) (i) Deduce the orders of reaction with respect to nitrogen monoxide and oxygen.

Justify your answers.

(3)

14 (b) (ii) Write the rate equation for the reaction in Stage **2**, using your answers to (i).

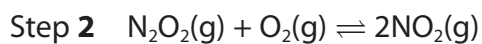
(1)



14 (b)(iii) Calculate the rate constant of this reaction, using values from Experiment 1. Include units in your answer.

(2)

14 (c) A two-step mechanism for the reaction in Stage 2 has been proposed.



Deduce which is more likely to be the rate determining step, using your answer to (b)(ii).

(2)

14 (d) In Stage 3, NO_2 reacts with water.

(i) When NO_2 is added to water, a mixture of nitric acid and nitrous acid is formed.

Write an equation for this reaction.

(1)

14 (d) (ii) State the type of reaction.

Justify your answer by referring to changes in oxidation number.

(2)

(Total for Question 14 = 12 marks)

15 This question is about weak Brønsted-Lowry acids such as propanoic acid, $\text{CH}_3\text{CH}_2\text{COOH}$.

(a) (i) State what is meant by the term 'weak Brønsted-Lowry acid'. (2)

15 (a) (ii) Calculate the pH of a $0.250 \text{ mol dm}^{-3}$ solution of propanoic acid at 25°C .

[Data: $K_a = 1.30 \times 10^{-5} \text{ mol dm}^{-3}$ at 25°C] (3)

15 (b) A 10.0 cm^3 portion of $0.250 \text{ mol dm}^{-3}$ propanoic acid is titrated with $0.100 \text{ mol dm}^{-3}$ aqueous sodium hydroxide.

15 (b) (i) Calculate the pH of the solution after 12.50 cm^3 of the alkali has been added. (2)

15 (b) (ii) There is no significant change in the pH of the solution when a further small amount of the alkali is added.

Explain this observation by referring to the relevant equation. (3)

15 (c) An aqueous solution of a different weak acid, RCOOH , with a concentration of $0.250 \text{ mol dm}^{-3}$, has a pH of 2.50.
 10.0 cm^3 of this RCOOH solution is titrated with 30.0 cm^3 of $0.100 \text{ mol dm}^{-3}$ sodium hydroxide solution.

15 (c) (i) Sketch the titration curve on the grid in the Answer Book. (3)

15 (c) (ii) Explain whether bromophenol blue is a suitable indicator for a titration of RCOOH solution with sodium hydroxide solution.
Use your Data Booklet. (2)

(Total for Question 15 = 15 marks)

***16** Ethyl propanoate can be prepared in the laboratory using Reaction 1 or Reaction 2.

Reaction 1 uses ethanol and propanoic acid.

Reaction 2 uses ethanol and propanoyl chloride.

Comment on the differences between these reactions.

Include an equation for each reaction.

(Total for Question 16 = 6 marks)

17 This question is about the solubility of ionic compounds in water.

(a) State the meaning of the term 'enthalpy change of solution, $\Delta_{\text{sol}}H'$.

(1)

17 (b) Some energy change values for the dissolving of sodium chloride in water are shown.

[Data: $LE(\text{NaCl(s)}) = -771 \text{ kJ mol}^{-1}$;

$\Delta_{\text{hyd}}H(\text{Na}^+(\text{g})) = -406 \text{ kJ mol}^{-1}$;

$\Delta_{\text{hyd}}H(\text{Cl}^-(\text{g})) = -364 \text{ kJ mol}^{-1}$]

17 (b) (i) Calculate the enthalpy change of solution of sodium chloride, using the data shown.

(2)

17 (b) (ii) Complete the enthalpy level diagram in the Answer Book to show the relationship between these energy changes.

(2)

17 (c) When ammonium nitrate dissolves in water the enthalpy change of solution is $+25.8 \text{ kJ mol}^{-1}$.

Explain, with reference to the relevant entropy changes, why ammonium nitrate dissolves in water.

No calculations are required.

(4)

(Total for Question 17 = 9 marks)

18 This question is about different structural isomers of $C_5H_{10}O_3$.

Four isomers are shown.

$\begin{array}{c} \text{CH}_3 \\ \\ \text{HOOC}-\text{C}-\text{CH}_2-\text{CH}_3 \\ \\ \text{OH} \end{array}$ Isomer 1	$\begin{array}{c} \text{CH}_3 \\ \\ \text{HOOC}-\text{C}-\text{CH}_2-\text{OH} \\ \\ \text{CH}_3 \end{array}$ Isomer 2
$\begin{array}{c} \text{H} \quad \text{CH}_3 \\ \quad \\ \text{HOOC}-\text{C}-\text{C}-\text{CH}_3 \\ \quad \\ \text{OH} \quad \text{H} \end{array}$ Isomer 3	$\begin{array}{c} \text{H} \quad \text{OH} \\ \quad \\ \text{HOOC}-\text{C}-\text{C}-\text{CH}_3 \\ \quad \\ \text{CH}_3 \quad \text{H} \end{array}$ Isomer 4

(a) Name Isomer **1** according to IUPAC rules.

(1)

18 (b) Five drops of acidified sodium dichromate(VI) solution are added to a sample of each isomer and the mixture warmed.

Explain which isomer could be identified by the results of this test.

(2)

18 (c) The high resolution proton NMR spectrum of one of these isomers has a doublet at 1.1 ppm, with a relative peak area of 6.

Explain which isomer is most likely to produce this peak.

(2)

18 (d) When tested with iodine in alkaline solution, only one of these isomers is oxidised and forms a yellow precipitate.

Explain which isomer is most likely to give this reaction.

(2)

18 (e) Draw the structure of the polymer formed from Isomer **4**, showing **two** repeat units.

(2)

(Total for Question 18 = 9 marks)

TOTAL FOR SECTION B = 51 MARKS

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SECTION C

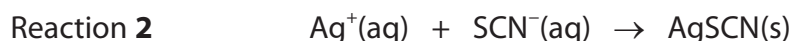
Answer ALL the questions. Write your answers in the Answer Book provided.

- 19** Iron(II) ions and silver(I) ions react to form an equilibrium mixture.
The equation for this reaction is shown.



The concentration of silver ions in the equilibrium mixture is determined by titration with potassium thiocyanate solution, KSCN.

During the titration, a white precipitate of AgSCN is formed.



When all the silver ions have reacted, iron(III) thiocyanate ions, $[\text{Fe}(\text{SCN})]^{2+}$, are formed, which are a blood-red colour.

- (a) This titration is used to determine the concentration of the silver ions in the equilibrium mixture. This concentration is then used to determine the value of the equilibrium constant, K_c .

Explain the effect on the value of the equilibrium constant obtained if the rate of Reaction 1 is similar to that of Reaction 2.

(3)

- 19 (b)** In an experiment, 100.0 cm^3 of $0.0950 \text{ mol dm}^{-3}$ silver nitrate solution was mixed with 100.0 cm^3 of $0.0950 \text{ mol dm}^{-3}$ iron(II) sulfate solution.
The mixture was allowed to stand overnight in an air-tight container.

25.0 cm^3 samples of the mixture were then titrated with $0.0200 \text{ mol dm}^{-3}$ potassium thiocyanate solution.
The mean titre was 15.60 cm^3 .

- 19 (b) (i)** Write the expression for the equilibrium constant, K_c , for Reaction 1.

(1)

- 19 (b) (ii)** Calculate the value of K_c for Reaction 1.

Give your answer to an appropriate number of significant figures.
Include units.

(7)



- 19 (c) (i)** The equilibrium constant is related to the total entropy change according to the expression shown.

$$\Delta S_{\text{total}} = R \ln K$$

Calculate the **total** entropy change for Reaction **1**, using your answer to (b)(ii).

Use the numerical value of 165 for the equilibrium constant if you have not obtained an answer.

[Data: $R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$]

(1)

- 19 (c) (ii)** For Reaction **1**, $\Delta S_{\text{system}}^{\ominus}$ is $-208 \text{ J K}^{-1} \text{ mol}^{-1}$.

Explain why this value is negative.

(2)

- 19 (c) (iii)** Calculate the entropy change of the surroundings, $\Delta S_{\text{surroundings}}^{\ominus}$, at 298 K, using your answer from (i) and the value for $\Delta S_{\text{system}}^{\ominus}$ given in (ii).

Include a sign and units in your answer.

(1)

- 19 (c) (iv)** Calculate the enthalpy change, $\Delta_r H^{\ominus}$, for Reaction **1**, using your answer from (iii).

Include a sign and units in your answer.

(2)

- 19 (c) (v)** State how an increase in temperature affects the total entropy change of the reaction and the equilibrium position.

(2)

(Total for Question 19 = 19 marks)

TOTAL FOR SECTION C = 19 MARKS
TOTAL FOR PAPER = 90 MARKS

Please check the examination details below before entering your candidate information

Candidate surname		Other names	
Centre Number		Candidate Number	

Pearson Edexcel International Advanced Level

Friday 29 May 2026

Morning (Time: 1 hour 45 minutes)

Paper reference **WCH14/01A**

Chemistry

International Advanced Level

UNIT 4: Rates, Equilibria and Further Organic Chemistry

Answer Book

You must have:

Question paper (sent separately)

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 90.
- 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)

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

1 (b)

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(Total for Question 1 = 2 marks)

2

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(Total for Question 2 = 1 mark)

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3☐ **A**☐ **B**☐ **C**☐ **D****(Total for Question 3 = 1 mark)****4 (a)****(1)**☐ **A**☐ **B**☐ **C**☐ **D****4 (b)****(1)**☐ **A**☐ **B**☐ **C**☐ **D****(Total for Question 4 = 2 marks)****5**☐ **A**☐ **B**☐ **C**☐ **D****(Total for Question 5 = 1 mark)**

6 (a)

(1)

- ☐ A
☐ B
☐ C
☐ D

6 (b)

(1)

- ☐ A
☐ B
☐ C
☐ D

(Total for Question 6 = 2 marks)

7 (a)

(1)

- ☐ A
☐ B
☐ C
☐ D

7 (b)

(1)

- ☐ A
☐ B
☐ C
☐ D

(Total for Question 7 = 2 marks)

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8

☐ A☐ B☐ C☐ D

(Total for Question 8 = 1 mark)

9 (a)

(1)

☐ A☐ B☐ C☐ D

9 (b)

(1)

☐ A☐ B☐ C☐ D

9 (c)

(1)

☐ A☐ B☐ C☐ D

9 (d)

(1)

☐ A☐ B☐ C☐ D

(Total for Question 9 = 4 marks)



10

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(Total for Question 10 = 1 mark)

11

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(Total for Question 11 = 1 mark)

12

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(Total for Question 12 = 1 mark)

13

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(Total for Question 13 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS



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SECTION B

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

14 (a)

(1)

14 (b) (i)

(3)

Oxygen

Nitrogen monoxide

14 (b) (ii)

(1)

14 (b) (iii)

(2)

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14 (c)

(2)

14 (d) (i)

(1)

14 (d) (ii)

(2)

(Total for Question 14 = 12 marks)



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15 (a) (i)

(2)

15 (a) (ii)

(3)

15 (b) (i)

(2)



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15 (b) (ii)

(3)

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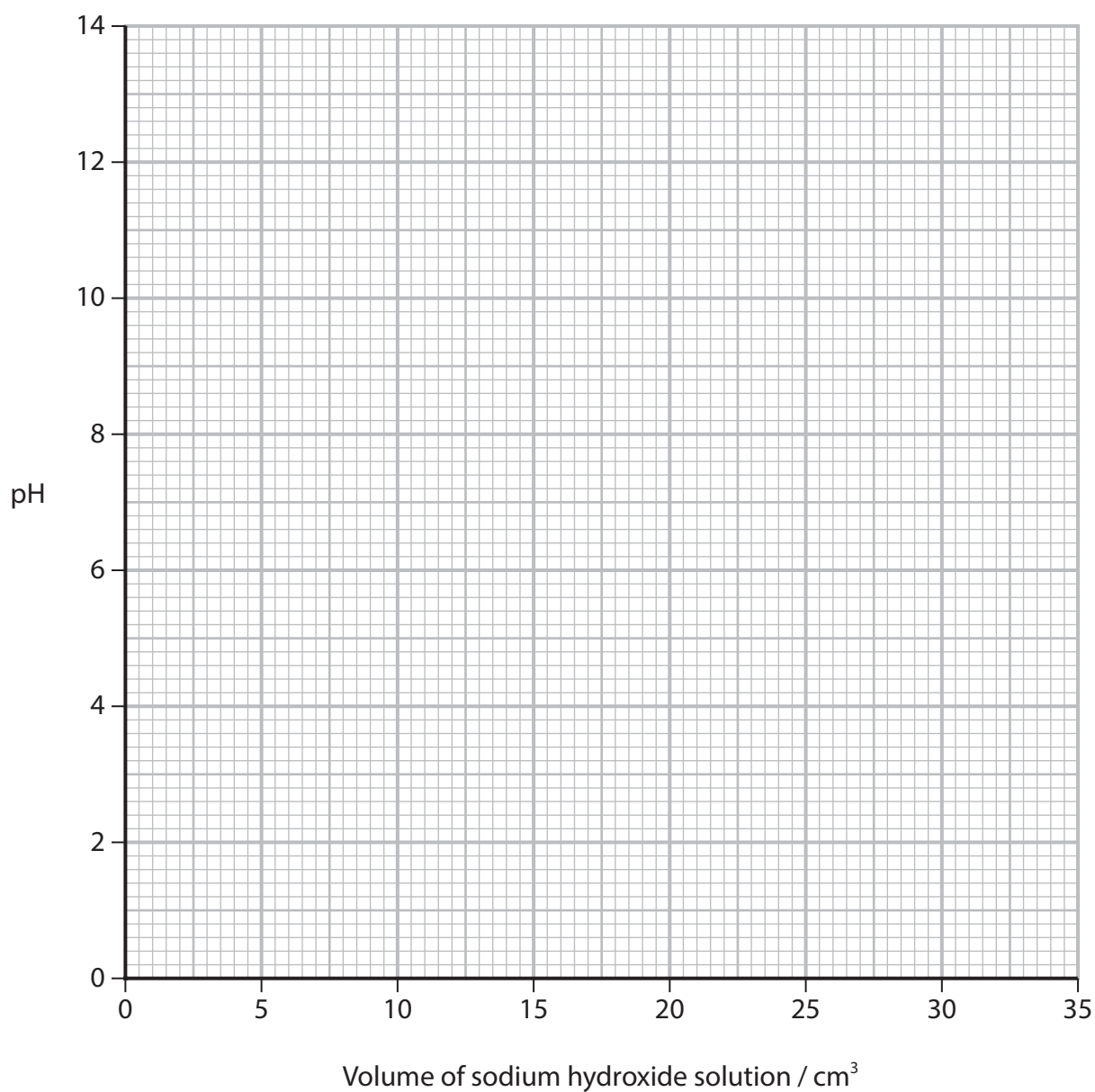
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15 (c) (i)

(3)



15 (c) (ii)

(2)

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.....

(Total for Question 15 = 15 marks)



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Handwriting practice area with 24 horizontal dotted lines.

(Total for Question 16 = 6 marks)



17 (a)

(1)

17 (b) (i)

(2)

17 (b) (ii)

(2)

Enthalpy, $H / \text{kJ mol}^{-1}$



DO NOT WRITE IN THIS AREA



18 (a)

(1)

18 (b)

(2)

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18 (c)

(2)

18 (d)

(2)

18 (e)

(2)

(Total for Question 18 = 9 marks)

TOTAL FOR SECTION B = 51 MARKS



SECTION C

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

19 (a)

(3)

19 (b) (i)

(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

19 (b) (ii)

(7)



19 (c) (i)

(1)

19 (c) (ii)

(2)

19 (c) (iii)

(1)

19 (c) (iv)

(2)



DO NOT WRITE IN THIS AREA

19 (c) (v)

(2)

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(Total for Question 19 = 19 marks)

TOTAL FOR SECTION C = 19 MARKS
TOTAL FOR PAPER = 90 MARKS



24

* Lanthanide series

* Actinide series

DO NOT WRITE IN THIS AREA