Centre Number

Student Number

NSW Education Standards Authority

2025 **HIGHER SCHOOL CERTIFICATE EXAMINATION**

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used
- A formulae sheet, data sheet and Periodic Table are provided at the back of this paper
- Write your Centre Number and Student Number at the top of this page

Total marks: 100

Section I – 20 marks (pages 2–11)

- Attempt Questions 1–20
- Allow about 35 minutes for this section

Section II – 80 marks (pages 13–40)

- Attempt Questions 21–37
- Allow about 2 hours and 25 minutes for this section

Section I

20 marks
Attempt Questions 1–20
Allow about 35 minutes for this section

Use the multiple-choice answer sheet for Questions 1–20.

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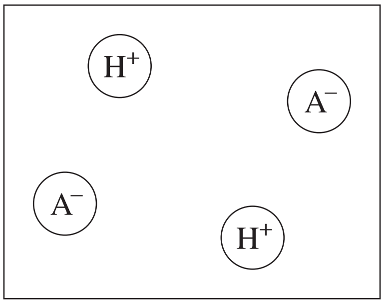
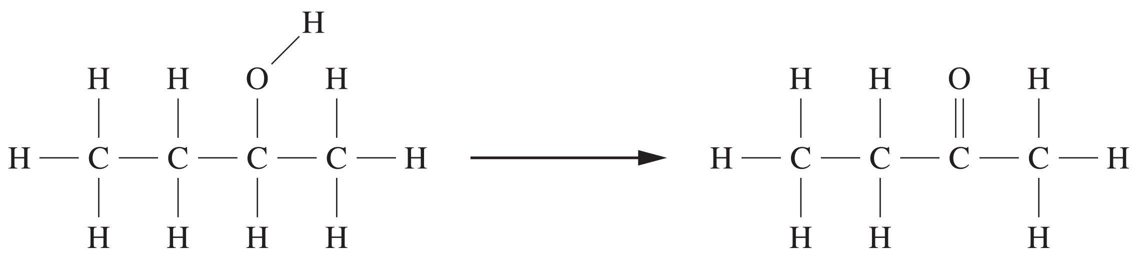
1 An aqueous solution of an unknown acid (HA) is represented below.



Which row of the table best describes this solution?

	Strong	*Concentrated*
A.	✓	✓
B.	✓	✗
C.	✗	✓
D.	✗	✗

2 Consider this reaction.



Which reaction type is shown?

A. Addition

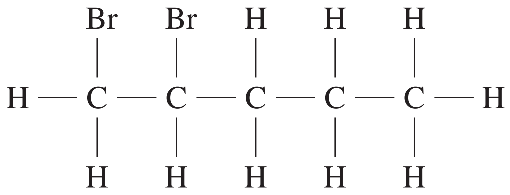
B. Oxidation

C. Reduction

D. Substitution

3 Which of the following structural formulae represents 1,2-dibromopentane?

A.



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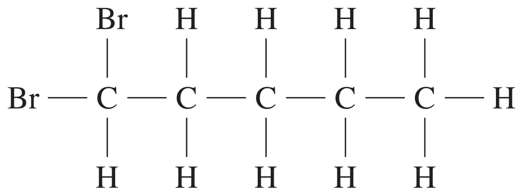

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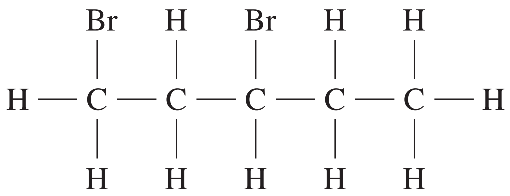

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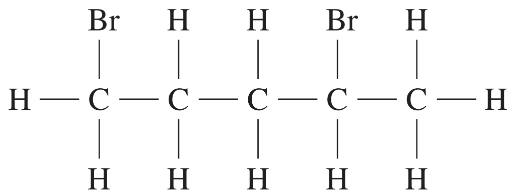


4 A student is presented with two clear colourless solutions. One contains Pb^{2+} and the other Na^{+} ions.

Which ion can be added to the solutions to identify the solutions?

A. I^{-}

B. NH_4^{+}

C. NO_3^{-}

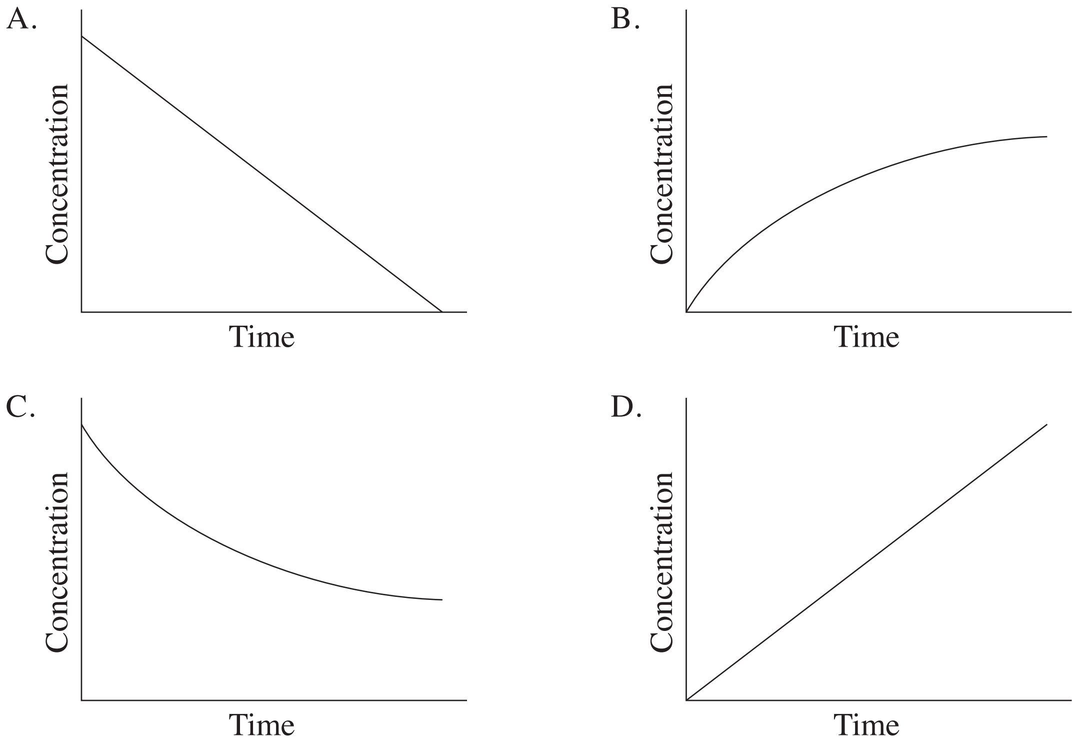
D. CH_3COO^{-}

5 PCl_3 and Cl_2 were introduced to an empty sealed vessel.

PCl_3 reacted with Cl_2 to produce PCl_5.

$$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g)$$

Which graph best represents the changing concentration of Cl_2 as the system approached the equilibrium point?



6 What is the pH of a 0.25 mol L^{-1} solution of hydrochloric acid?

A. −0.60

B. −0.25

C. 0.25

D. 0.60

7 Copper ions can form coloured complexes with water molecules and with chloride ions in dilute aqueous solutions.

Complex ion	*Colour*
$[Cu(H_2O)_6]^{2+}$	Blue
$[CuCl_4]^{2-}$	Green

Which of the following analytical techniques would be most suitable to distinguish between these two complexes?

A. Infrared spectrophotometry

B. Carbon-13 NMR spectroscopy

C. UV-visible spectrophotometry

D. Atomic absorption spectroscopy

8 An alkene X with only one C=C bond undergoes an addition reaction with an unknown substance to produce Y.

$$X + \text{unknown substance} \longrightarrow Y$$

The following table shows the molecular ion peaks for X and Y.

X	Y
70 m/z	90 m/z

Which of the following can be the unknown substance?

A. Water

B. Fluorine

C. Hydrogen

D. Hydrogen fluoride

9 Some Torres Strait Islander Peoples pound the leaves of the vine *Derris uliginosa* to extract a chemical called saponin. Saponin is a relatively large molecule that contains both a water-soluble carbohydrate chain and a fat-soluble side chain.

Which is the most likely use of saponin?

A. As a cleaning agent

B. As a neutraliser of insect bites

C. As a dye for pigmentation and painting

D. As an additive to food for flavouring and tenderising

10 Which of the following options lists ALL the forces that are present between molecules of butanoic acid?

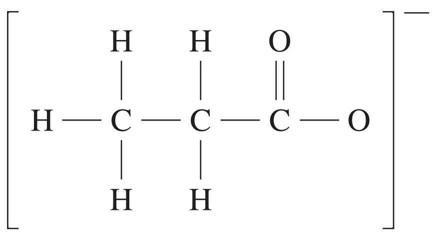
A. Covalent bonding

B. Dispersion and dipole-dipole

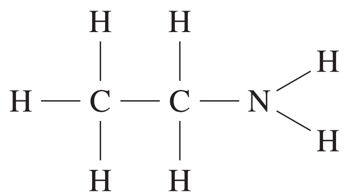
C. Covalent bonding and hydrogen bonding

D. Dispersion, dipole-dipole and hydrogen bonding

11 The structures of two substances, X and Y, are shown.



X



Y

Which row of the table correctly classifies these substances as a Brønsted–Lowry acid or a Brønsted–Lowry base?

	Brønsted–Lowry acid	*Brønsted–Lowry base*
A.	–	X and Y
B.	X and Y	–
C.	Y	X
D.	X	Y

12 Consider the following reaction.

$$3AgNO_3(aq) + FeCl_3(aq) \rightleftharpoons 3AgCl(s) + Fe(NO_3)_3(aq)$$

What is the correct equilibrium expression for this reaction?

A. $\dfrac{[Fe(NO_3)_3]}{[AgNO_3][FeCl_3]}$

B. $\dfrac{[Fe(NO_3)_3]}{[AgNO_3]^3[FeCl_3]}$

C. $\dfrac{[AgNO_3]^3[FeCl_3]}{[AgCl]^3[Fe(NO_3)_3]}$

D. $\dfrac{[AgCl]^3[Fe(NO_3)_3]}{[AgNO_3]^3[FeCl_3]}$

13 Which row of the table correctly shows the expected signs of the enthalpy (ΔH) and entropy (ΔS) changes for the complete combustion of octane above 100°C?

	ΔH	ΔS
A.	> 0	< 0
B.	< 0	< 0
C.	< 0	> 0
D.	> 0	> 0

14 The equation for the decomposition of hydrogen iodide is shown.

$$2HI(g) \rightleftharpoons I_2(g) + H_2(g) \qquad \Delta H = +52 \text{ kJ mol}^{-1}$$

The equilibrium formed during this reaction was investigated in two experiments carried out at different temperatures. The initial and equilibrium concentrations for both experiments are shown in the table, with only the K_{eq} for Experiment 1 shown.

	Initial concentrations (mol L^{-1})			*Equilibrium concentrations* (mol L^{-1})			*Equilibrium constant* (K_{eq})
	$[HI]$	$[H_2]$	$[I_2]$	$[HI]$	$[H_2]$	$[I_2]$	
Experiment 1	0.06	0.00	0.00	0.04	0.01	0.01	6×10^{-2}
Experiment 2	0.00	0.04	0.04	0.04	0.02	0.02	?

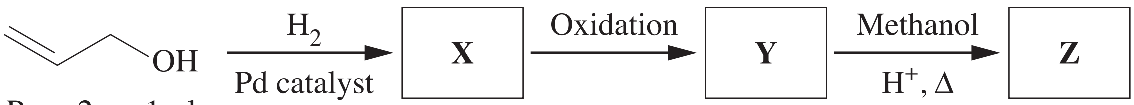
Which row in the table correctly compares features of the two experiments?

	K_{eq}	*Temperature of experiment*
A.	Lower in 1	Lower in 2
B.	Lower in 1	Higher in 2
C.	Higher in 1	Lower in 2
D.	Higher in 1	Higher in 2

15 Consider the following sequence of reactions.

- Prop-2-en-1-ol was reacted with hydrogen gas to form liquid X.
- X was oxidised, producing liquid Y that formed bubbles of a gas when reacted with aqueous sodium carbonate.
- Y was heated under reflux with methanol and a drop of concentrated sulfuric acid, producing an organic liquid, Z.

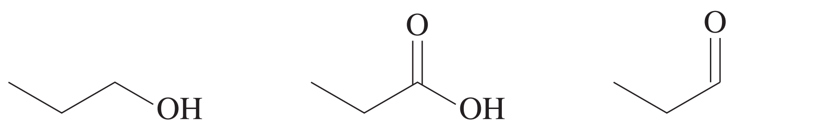
This process has been presented in the flow chart below.



Prop-2-en-1-ol

Which option correctly identifies the structures for X, Y and Z?

X **Y** **Z**

A.


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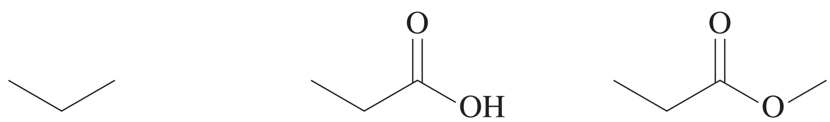

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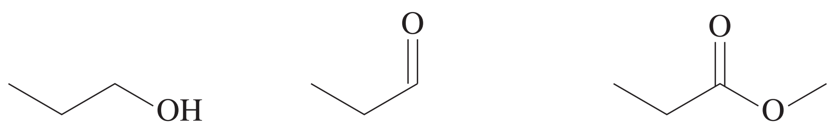

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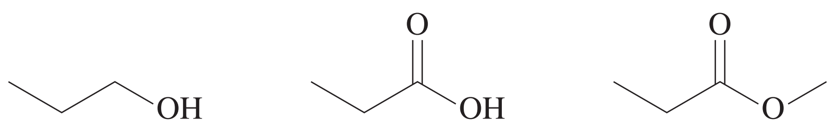


16 A single straight strand of polyester was produced through a condensation reaction of 1000 molecules of 3-hydroxypropanoic acid, $HOCH_2CH_2COOH$.

What is the approximate molar mass of the strand $\left(\text{in g mol}^{-1}\right)$?

A. 72 062

B. 72 080

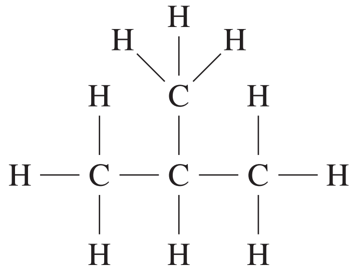
C. 90 060

D. 90 078

17 The chemical environment of an atom depends on the species surrounding that atom within a molecule.

In which of the following compounds does the number of carbon chemical environments equal the number of proton chemical environments?

A.



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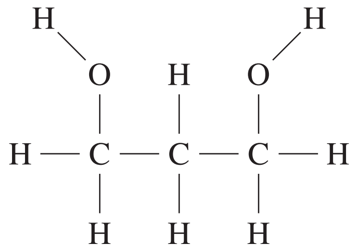

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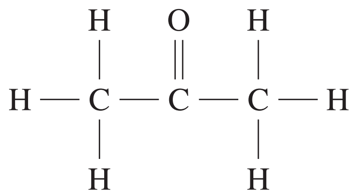
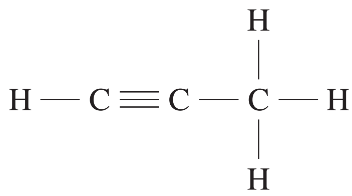


D.



18 The concentration of silver ions in a solution is determined by titrating it with aqueous sodium chloride, using yellow potassium chromate as the indicator.

Which row of the table correctly identifies the colour change at the endpoint and the more soluble salt?

	Colour change at endpoint	*More soluble salt*
A.	Red to yellow	Ag_2CrO_4
B.	Yellow to red	Ag_2CrO_4
C.	Red to yellow	AgCl
D.	Yellow to red	AgCl

19 0.1 mol of solid sodium acetate is dissolved in 500 mL of 0.1 mol L^{-1} HCl in a beaker. This solution has a pH of 4.8.

500 mL of distilled water is then added to the beaker.

What is the pH of the final solution?

A. 2.4

B. 4.5

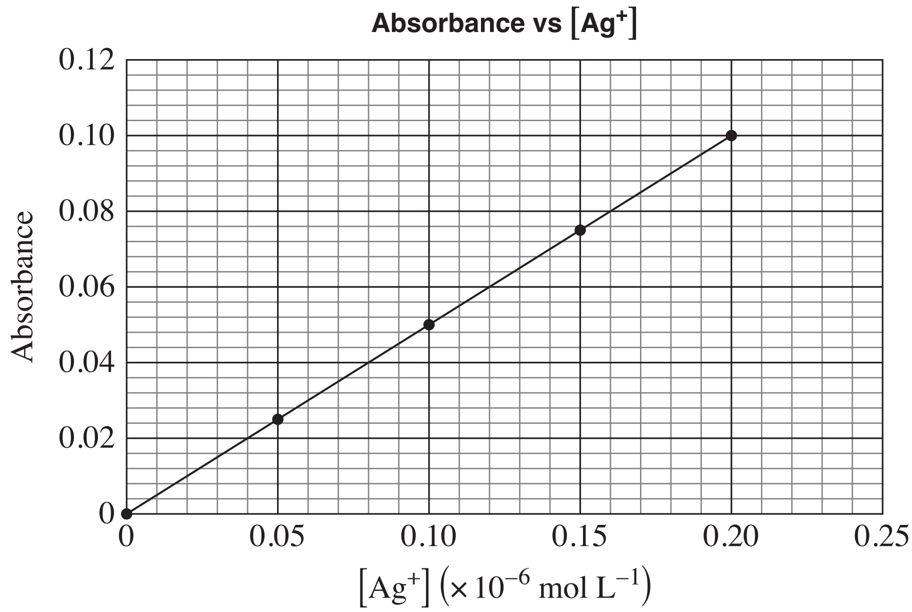
C. 4.8

D. 5.1

20 The solubility constant for silver(I) oxalate $\left(Ag_2C_2O_4\right)$ was determined using the following method.

- 2.0 g of solid $Ag_2C_2O_4$ was added to 100 mL of distilled water.
- A sample of the saturated solution above the undissolved $Ag_2C_2O_4$ was diluted by a factor of 2000, using distilled water.
- This diluted solution was analysed using atomic absorption spectroscopy (AAS).

The calibration curve for the AAS is provided below.



The absorbance of the diluted sample was 0.055.

What is the K_{sp} for silver oxalate?

A. 8.8×10^{-14}

B. 5.3×10^{-12}

C. 1.1×10^{-11}

D. 2.1×10^{-11}

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2025 HIGHER SCHOOL CERTIFICATE EXAMINATION

Centre Number

Student Number

Chemistry

Section II Answer Booklet

80 marks
Attempt Questions 21–37
Allow about 2 hours and 25 minutes for this section

Instructions

- Write your Centre Number and Student Number at the top of this page
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response
- Show all relevant working in questions involving calculations
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering

Please turn over

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Question 21 (2 marks)

Consider the following organic reaction. **2**

$$CH_3CH_2CH_2CH_3 \; + \; Br_2 \xrightarrow{\text{Reaction condition X}} CH_3CH_2\overset{\overset{\displaystyle Br}{|}}{C}HCH_3 \; + \; HBr$$

In the space provided, identify reaction condition X and name the organic product.

Reaction condition X	*IUPAC name of organic product*

Question 22 (2 marks)

Outline why quantitative and qualitative analyses are BOTH important in determining water quality. **2**

Do NOT write in this area.

Question 23 (3 marks)

A student attempted to determine the % w/w of sulfate in a sample of solid fertiliser. They used the procedure described below. **3**

1. Weigh a clean, dry beaker.
2. Add fertiliser to the beaker and weigh again.
3. Add 250 mL of distilled water and stir thoroughly.
4. Add 20 mL of 0.1 mol L^{-1} $BaCl_2$ solution.
5. Filter out the $BaSO_4$ precipitate, using distilled water to ensure all of the solid is transferred from the beaker to the filter paper.
6. Put the filter paper and precipitate onto a weighed watch glass and leave them to dry for 20 minutes in the sun.
7. Weigh the watch glass, the filter paper and the precipitate.
8. Calculate the % w/w.

Justify TWO changes that can be made to the procedure to ensure more accurate results.

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Question 24 (5 marks)

65.0 g of ethyne gas reacts with an excess of gaseous hydrogen chloride to produce chloroethene.

(a) Draw the full structural formula of ethyne and identify the shape of the molecule. **2**

Structural formula	*Shape of molecule*

(b) The molar masses of the compounds in the reaction are provided. **3**

Compound	*Molar mass*
Ethyne	26.04
Hydrogen chloride	36.46
Chloroethene	62.50

Calculate the mass of chloroethene produced, using the molar masses provided. Include a relevant chemical equation in your answer.

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Question 25 (3 marks)

A student produced the ester propyl butanoate in the school laboratory, by refluxing 0.267 mol of propan-1-ol and 0.298 mol of butanoic acid with a catalyst. **3**

Use the data in the table to calculate the percentage yield of the ester.

Product	*Volume produced* (mL)	*Density* $\left(\text{g mL}^{-1}\right)$	*Molar mass* $\left(\text{g mol}^{-1}\right)$
propyl butanoate	12.2	0.873	130.2

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Question 26 (5 marks)

A hydrogen atom on the methyl group of ethanoic acid can be replaced with a single halogen atom. A general formula for these haloethanoic acids is shown.

$$X{-}CH_2COOH \quad (X = F, Cl, Br \text{ or } I)$$

The pK_a values of the four haloethanoic acids are given in the table.

Acid	X	pK_a
Fluoroethanoic acid	F	2.6
Chloroethanoic acid	Cl	2.9
Bromoethanoic acid	Br	2.9
Iodoethanoic acid	I	3.2

Question 26 continues on page 19

Question 26 (continued)

(a) Construct an appropriate graph for the four haloethanoic acids, showing their pK_a values and the identity of the halogen X in each molecule, in the order provided in the table. **3**

$X\left(\text{in } X{-}CH_2COOH\right)$

(b) Describe the trend in the relative strengths of the haloethanoic acids. **2**

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End of Question 26

Question 27 (8 marks)

Mixtures of hydrocarbons can be obtained from crude oil by the process of fractional distillation. Examples include petrol, diesel and natural gas.

(a) Outline an environmental implication for a use of a named hydrocarbon mixture that is obtained from crude oil. **2**

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(b) Ethene is a simple hydrocarbon obtained from crude oil. **3**

Using structural formulae, write the chemical equation for the conversion of ethene to ethanol, including any other necessary reagents.

Question 27 continues on page 21

Question 27 (continued)

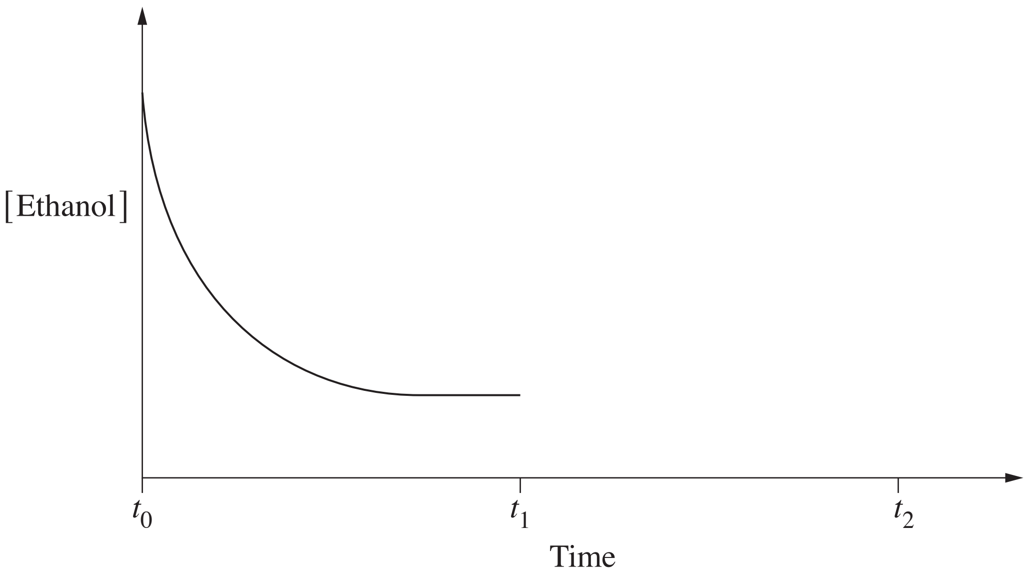
(c) When ethanol is reacted with ethanoic acid, ethyl ethanoate is formed, as shown by the equation. **3**

$$\text{ethanol} + \text{ethanoic acid} \rightleftharpoons \text{ethyl ethanoate} + \text{water}$$

The graph below shows the concentration of ethanol from the start of the reaction, t_0, up to a time t_1.

At time t_1, an additional amount of ethanol is added to the system.

Sketch on the graph the changes that occur in the concentration of ethanol between time t_1, and when the system reaches a new equilibrium before time t_2.

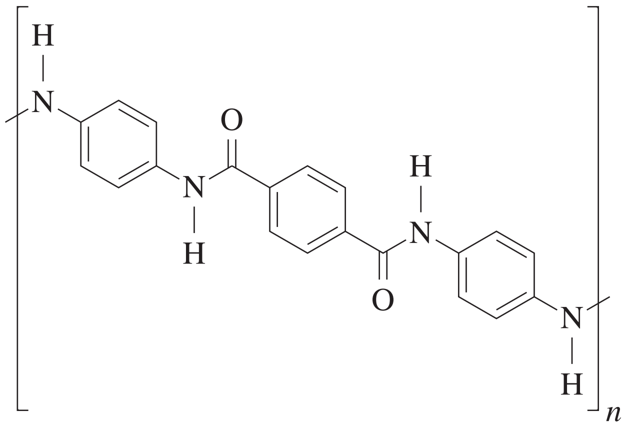


End of Question 27

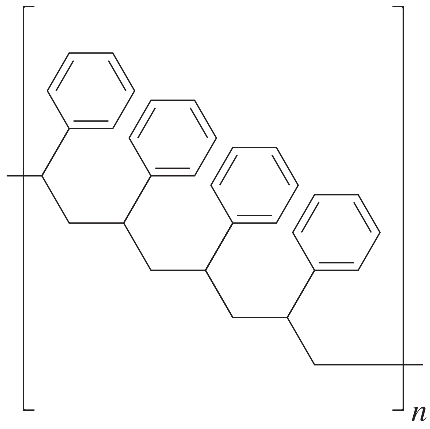
Question 28 (4 marks)

Kevlar and polystyrene are two common polymers.

A section of their structures is shown.

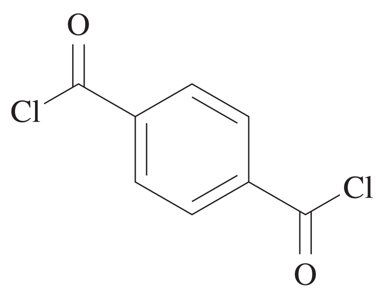


Kevlar



Polystyrene

(a) Kevlar is produced through a reaction of two different monomers, one of which is shown. Draw the missing monomer in the box provided. **1**



Question 28 continues on page 23

(b) Kevlar chains are hard to pull apart, whereas polystyrene chains are not. **3**

With reference to intermolecular forces, explain the difference in the physical properties of the two polymers.

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End of Question 28

Please turn over

Question 29 (4 marks)

Consider the following reaction. **4**

$$2NO_2(g) \rightleftharpoons N_2O_4(g) \qquad \Delta H = -57.2 \text{ kJ mol}^{-1}$$

A sealed reaction vessel of fixed volume contains a mixture of NO_2 and N_2O_4 gases at equilibrium.

Explain the impact of the addition of argon, an inert gas, on the temperature of the system.

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Question 30 (5 marks)

Phosgene is used in industry as a starting material to synthesise useful polymers. Phosgene $\left(Cl_2CO\right)$ is a gas at room temperature and is highly toxic.

(a) Justify a suitable precaution when using phosgene. **2**

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(b) Phosgene is synthesised by the reaction of carbon monoxide (CO) and chlorine $\left(Cl_2\right)$ in the gas phase. **3**

$$Cl_2(g) + CO(g) \rightleftharpoons Cl_2CO(g)$$

Explain why an excess of carbon monoxide and a catalyst are used in the industrial synthesis of phosgene.

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Question 31 (6 marks)

Hydrazine is a compound of hydrogen and nitrogen. The complete combustion of 1.0 L of gaseous hydrazine requires 3.0 L of oxygen, producing 2.0 L of nitrogen dioxide gas and 2.0 L of water vapour. All volumes are measured at 400°C.

(a) Use the chemical equation for the combustion of hydrazine to show that the molecular formula for hydrazine is N_2H_4. **2**

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(b) The relationship between the acid equilibrium constant (K_a) and the corresponding conjugate base equilibrium constant (K_b) is shown. **4**

$$K_a \times K_b = K_w$$

Use a relevant chemical equation to calculate the pH of a 0.20 mol L^{-1} solution of $N_2H_5^+$ using the following data:

- the K_b of hydrazine is 1.7×10^{-6} at 25°C
- $N_2H_5^+$ is the conjugate acid of N_2H_4.

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Question 32 (5 marks)

The following three solids were added together to 1 litre of water: **5**

- 0.006 mol $Mg(NO_3)_2$
- 0.010 mol NaOH
- 0.002 mol Na_2CO_3.

Which precipitate(s), if any, will form? Justify your answer with appropriate calculations.

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Question 33 (7 marks)

Chalk is predominantly calcium carbonate. Different brands of chalk vary in their calcium carbonate composition. **7**

The table shows the composition of three different brands of chalk.

	Brand X	*Brand Y*	*Brand Z*
$CaCO_3$ (%)	85.5	83.9	82.4

The following procedure was used to determine the calcium carbonate composition of a chalk sample.

- A sample of chalk was crushed in a mortar and pestle.
- A 3.00 g sample of the crushed chalk was placed in a conical flask.
- 100.0 mL of 0.550 mol L^{-1} $HCl(aq)$ was added to the sample and left to react completely, resulting in a clear solution.
- Four 20 mL aliquots of this mixture were then titrated with 0.10 mol L^{-1} KOH.

The results of the titrations are recorded.

Burette volume (mL)	*Trial 1*	*Trial 2*	*Trial 3*	*Trial 4*
Final	7.80	14.90	22.10	29.25
Initial	0.00	7.80	14.90	22.10
Total used	7.80	7.10	7.20	7.15

Determine the brand of the chalk sample. Include a relevant chemical equation in your answer.

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Question 33 continues on page 29

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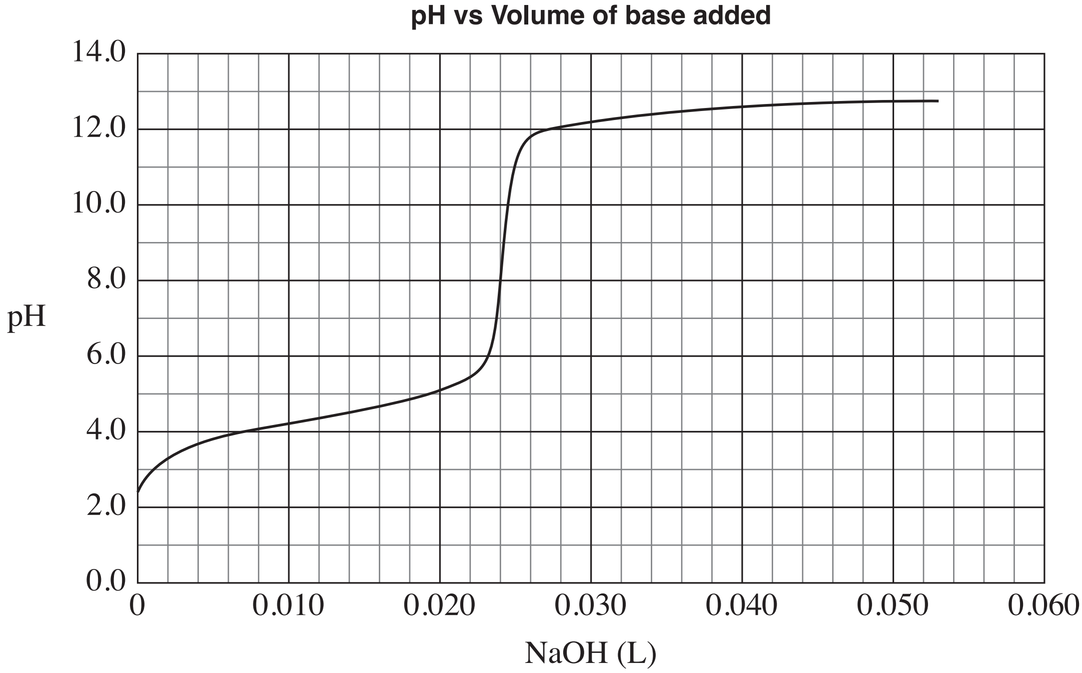
Question 33 (continued)

End of Question 33

Question 34 (5 marks)

A 0.010 L aliquot of an acid was titrated with 0.10 mol L^{-1} NaOH, resulting in the following titration curve.



(a) Calculate the K_a for the acid used. **3**

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Question 34 continues on page 31

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Question 34 (continued)

(b) The concentration of the NaOH was 0.10 mol L^{-1}. **2**

Explain why the pH of the final solution never reached 13.

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End of Question 34

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Question 35 (5 marks)

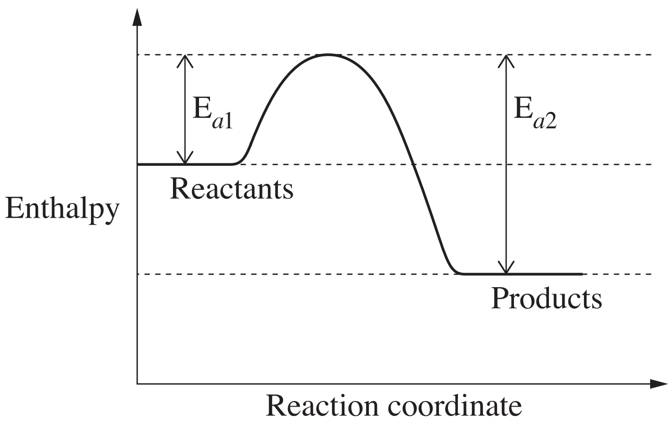
A purple solution at 25°C contains a mixture of two different cobalt(II) complexes which are at equilibrium. **5**

$$\underset{\text{(blue)}}{CoCl_4^{\ 2-}(aq)} + 6H_2O(l) \rightleftharpoons \underset{\text{(pink)}}{Co(H_2O)_6^{\ 2+}(aq)} + 4Cl^-(aq)$$

The results of heating and cooling a sample of this solution are given in the table.

Temperature (°C)	80	0
Colour of solution	blue	pink

The energy profile diagram for this reaction is shown.



How do collision theory and Le Chatelier's principle account for the colour change to pink when the solution is cooled? Refer to the energy profile diagram in your answer.

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Question 35 continues on page 33

Do NOT write in this area.

Question 35 (continued)

End of Question 35

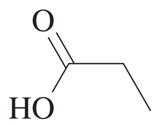
Question 36 (7 marks)

Use the data sheet provided and the information in the table to answer this question. 7

^{1}H NMR chemical shift data

Type of proton	*Common functional groups*	δ (ppm)
$—\mathbf{CH}_3$, $—\mathbf{CH}_2—$, $—\mathbf{CH}—$	hydrocarbons	0.7–2.1
$\mathbf{CH}_3—\mathrm{CO}—$ $\mathbf{CH}_2—\mathrm{CO}—$ $\mathbf{CH}_2—\mathrm{CO}$	aldehydes, ketones, carboxylic acids or esters	2.1–4.5
$—\mathrm{CH}_2—\mathrm{O}\mathbf{H}$ or $—\mathrm{CH}_2—\mathrm{N}\mathbf{H}$	alcohols or amines	0.5–4.8
$—\mathrm{COO}\mathbf{H}$	carboxylic acid	9.0–13.0

Consider the molecule shown.



For each of the following instrumental techniques, predict the expected features of the spectra produced.

Refer to the structural features of the molecule in your answer.

- Infrared (IR) (Ignore any absorptions due to C—C or C—H)
- Carbon-13 NMR
- Proton NMR
- Mass spectroscopy

Question 36 continues on page 35

Do NOT write in this area.

Question 36 (continued)

End of Question 36

Question 37 (4 marks)

Compound A has the molecular formula C_5H_{10}. The information below shows some chemical reactions beginning with this compound. **4**

- Compound A reacts with H^+/H_2O to produce compounds B and C.
- Compound B does not react with $H^+/Cr_2O_7^{2-}$.
- Compound C reacts with $H^+/Cr_2O_7^{2-}$ to produce compound D.
- Compound D does not react with $Na_2CO_3(aq)$.

Determine the structure of compound A. Justify your answer using all the data given.

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Chemistry

FORMULAE SHEET

$n = \dfrac{m}{MM}$	$c = \dfrac{n}{V}$	$PV = nRT$
$q = mc\Delta T$	$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$	$\mathrm{pH} = -\log_{10}\left[\mathrm{H}^+\right]$
$pK_a = -\log_{10}\left[K_a\right]$	$A = \varepsilon lc = \log_{10}\dfrac{I_o}{I}$	

Avogadro constant, N_A .... 6.022×10^{23} mol^{-1}

Volume of 1 mole ideal gas: at 100 kPa and
at 0°C (273.15 K) .... 22.71 L
at 25°C (298.15 K) .... 24.79 L

Gas constant .... 8.314 J mol^{-1} K^{-1}

Ionisation constant for water at 25°C (298.15 K), K_w .... 1.0×10^{-14}

Specific heat capacity of water .... 4.18×10^{3} J kg^{-1} K^{-1}

DATA SHEET

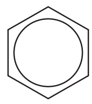
Solubility constants at 25°C

Compound	K_{sp}	*Compound*	K_{sp}
Barium carbonate	2.58×10^{-9}	Lead(II) bromide	6.60×10^{-6}
Barium hydroxide	2.55×10^{-4}	Lead(II) chloride	1.70×10^{-5}
Barium phosphate	1.3×10^{-29}	Lead(II) iodide	9.8×10^{-9}
Barium sulfate	1.08×10^{-10}	Lead(II) carbonate	7.40×10^{-14}
Calcium carbonate	3.36×10^{-9}	Lead(II) hydroxide	1.43×10^{-15}
Calcium hydroxide	5.02×10^{-6}	Lead(II) phosphate	8.0×10^{-43}
Calcium phosphate	2.07×10^{-29}	Lead(II) sulfate	2.53×10^{-8}
Calcium sulfate	4.93×10^{-5}	Magnesium carbonate	6.82×10^{-6}
Copper(II) carbonate	1.4×10^{-10}	Magnesium hydroxide	5.61×10^{-12}
Copper(II) hydroxide	2.2×10^{-20}	Magnesium phosphate	1.04×10^{-24}
Copper(II) phosphate	1.40×10^{-37}	Silver bromide	5.35×10^{-13}
Iron(II) carbonate	3.13×10^{-11}	Silver chloride	1.77×10^{-10}
Iron(II) hydroxide	4.87×10^{-17}	Silver carbonate	8.46×10^{-12}
Iron(III) hydroxide	2.79×10^{-39}	Silver hydroxide	2.0×10^{-8}
Iron(III) phosphate	9.91×10^{-16}	Silver iodide	8.52×10^{-17}
		Silver phosphate	8.89×10^{-17}
		Silver sulfate	1.20×10^{-5}

Infrared absorption data

Bond	Wavenumber/cm^{-1}
N—H (amines)	3300–3500
O—H (alcohols)	3230–3550 (broad)
C—H	2850–3300
O—H (acids)	2500–3000 (very broad)
C≡N	2220–2260
C=O	1680–1750
C=C	1620–1680
C—O	1000–1300
C—C	750–1100

^{13}C NMR chemical shift data

Type of carbon		δ/ppm
—C—C—		5–40
R—C—Cl or Br		10–70
R—C(=O)—C—		20–50
R—C—N<		25–60
—C—O—	alcohols, ethers or esters	50–90
>C=C<		90–150
R—C≡N		110–125
		110–160
R—C(=O)—	esters or acids	160–185
R—C(=O)—	aldehydes or ketones	190–220

UV absorption

(This is not a definitive list and is approximate.)

Chromophore	λ_{max} (nm)
C—H	122
C—C	135
C=C	162

Chromophore	λ_{max} (nm)
C≡C	173 178 196 222
C—Cl	173
C—Br	208

Some standard potentials

$K^+ + e^-$	$\rightleftharpoons$	$K(s)$	−2.94 V
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	$Ba(s)$	−2.91 V
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	$Ca(s)$	−2.87 V
$Na^+ + e^-$	$\rightleftharpoons$	$Na(s)$	−2.71 V
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	$Mg(s)$	−2.36 V
$Al^{3+} + 3e^-$	$\rightleftharpoons$	$Al(s)$	−1.68 V
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	$Mn(s)$	−1.18 V
$H_2O + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g) + OH^-$	−0.83 V
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	$Zn(s)$	−0.76 V
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	$Fe(s)$	−0.44 V
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	$Ni(s)$	−0.24 V
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	$Sn(s)$	−0.14 V
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	$Pb(s)$	−0.13 V
$H^+ + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g)$	0.00 V
$SO_4^{\ 2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(aq) + 2H_2O$	0.16 V
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	$Cu(s)$	0.34 V
$\frac{1}{2}O_2(g) + H_2O + 2e^-$	$\rightleftharpoons$	$2OH^-$	0.40 V
$Cu^+ + e^-$	$\rightleftharpoons$	$Cu(s)$	0.52 V
$\frac{1}{2}I_2(s) + e^-$	$\rightleftharpoons$	I^-	0.54 V
$\frac{1}{2}I_2(aq) + e^-$	$\rightleftharpoons$	I^-	0.62 V
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	0.77 V
$Ag^+ + e^-$	$\rightleftharpoons$	$Ag(s)$	0.80 V
$\frac{1}{2}Br_2(l) + e^-$	$\rightleftharpoons$	Br^-	1.08 V
$\frac{1}{2}Br_2(aq) + e^-$	$\rightleftharpoons$	Br^-	1.10 V
$\frac{1}{2}O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1.23 V
$\frac{1}{2}Cl_2(g) + e^-$	$\rightleftharpoons$	Cl^-	1.36 V
$\frac{1}{2}Cr_2O_7^{\ 2-} + 7H^+ + 3e^-$	$\rightleftharpoons$	$Cr^{3+} + \frac{7}{2}H_2O$	1.36 V
$\frac{1}{2}Cl_2(aq) + e^-$	$\rightleftharpoons$	Cl^-	1.40 V
$MnO_4^{\ -} + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	1.51 V
$\frac{1}{2}F_2(g) + e^-$	$\rightleftharpoons$	F^-	2.89 V

Aylward and Findlay, *SI Chemical Data* (5th Edition) is the principal source of data for the standard potentials. Some data may have been modified for examination purposes.

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number	79
Symbol	Au
Standard Atomic Weight	197.0
Name	Gold

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.38 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.61 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.96 Molybdenum	43 Tc Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanoids	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.9 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium	89–103 Actinoids	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium	113 Nh Nihonium	114 Fl Flerovium	115 Mc Moscovium	116 Lv Livermorium	117 Ts Tennessine	118 Og Oganesson

Lanthanoids

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.1 Ytterbium	71 Lu 175.0 Lutetium

Actinoids

89 Ac Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium

Standard atomic weights are abridged to four significant figures.

Elements with no reported values in the table have no stable nuclides.

Information on elements with atomic numbers 113 and above is sourced from the International Union of Pure and Applied Chemistry Periodic Table of the Elements (November 2016 version).

The International Union of Pure and Applied Chemistry Periodic Table of the Elements (February 2010 version) is the principal source of all other data. Some data may have been modified.

2025 HSC Chemistry Marking Guidelines

Section I

Multiple-choice Answer Key

Question	Answer
1	B
2	B
3	A
4	A
5	C
6	D
7	C
8	D
9	A
10	D
11	A
12	B
13	C
14	B
15	D
16	B
17	A
18	A
19	C
20	B

Section II

Question 21

Criteria	Marks
• Correctly identifies both the reaction condition AND product	2
• Correctly identifies either the reaction condition OR product	1

Sample answer:

Reaction condition X	*IUPAC name of organic product*
UV light	2-bromobutane

Question 22

Criteria	Marks
• Outlines the need for both analysis types	2
• Provides some relevant information	1

Sample answer:

Qualitative analysis allows the identification of a pollutant present in the water. Quantitative analysis allows for the amount of the pollutant present to be determined.

Question 23

Criteria	Marks
• Justifies TWO appropriate changes with justifications of both related to accuracy	3
• Justifies ONE appropriate change OR • Identifies TWO appropriate changes	2
• Provides some relevant information	1

Sample answer:

Filter out any insoluble components before step 4, or else these will contribute to the mass of the precipitate.

Weigh the filter paper, or else the mass of the precipitate will be inaccurate.

Answers could include:

- Dry to constant mass (step 6) else water will contribute to the mass of precipitate.
- Rinse the precipitate with distilled water during step 5 to prevent soluble salts from crystallising on the precipitate.
- Add more $BaCl_2$ solution to the filtrate after step 5 to ensure all sulfate has precipitated.
- Use finer filter paper and a Buchner funnel, to ensure solid is captured.

Question 24 (a)

Criteria	Marks
• Correctly draws the structural formula AND correctly identifies the shape	2
• Correctly draws the structural formula OR correctly identifies the shape	1

Sample answer:

Structural formula	*Shape of molecule*
$H-C\equiv C-H$	Linear

Question 24 (b)

Criteria	Marks
• Calculates the correct mass of chloroethene AND provides a correct chemical equation	3
• Provides the main steps of the calculation OR • Provides some steps of the calculation AND a correct chemical equation	2
• Provides some relevant information	1

Sample answer:

$C_2H_2 + HCl \longrightarrow C_2H_3Cl$

Moles of $C_2H_2 = \dfrac{65.0}{26.04} = 2.50$ mol

$n\ C_2H_3Cl = nC_2H_2$

$= 2.50$ mol

$m\ C_2H_3Cl = 2.50 \times 62.50 = 156.25$ g

$= 156$ g

Question 25

Criteria	Marks
• Provides the correct calculations, with correct significant figures	3
• Provides substantially correct calculations OR • Provides the correct calculations with incorrect significant figures	2
• Provides some relevant information	1

Sample answer:

Mass of ester $= 12.2 \times 0.873 = 10.65$ g

Moles of ester $= \dfrac{10.65}{130.2} = 0.0818$ moles

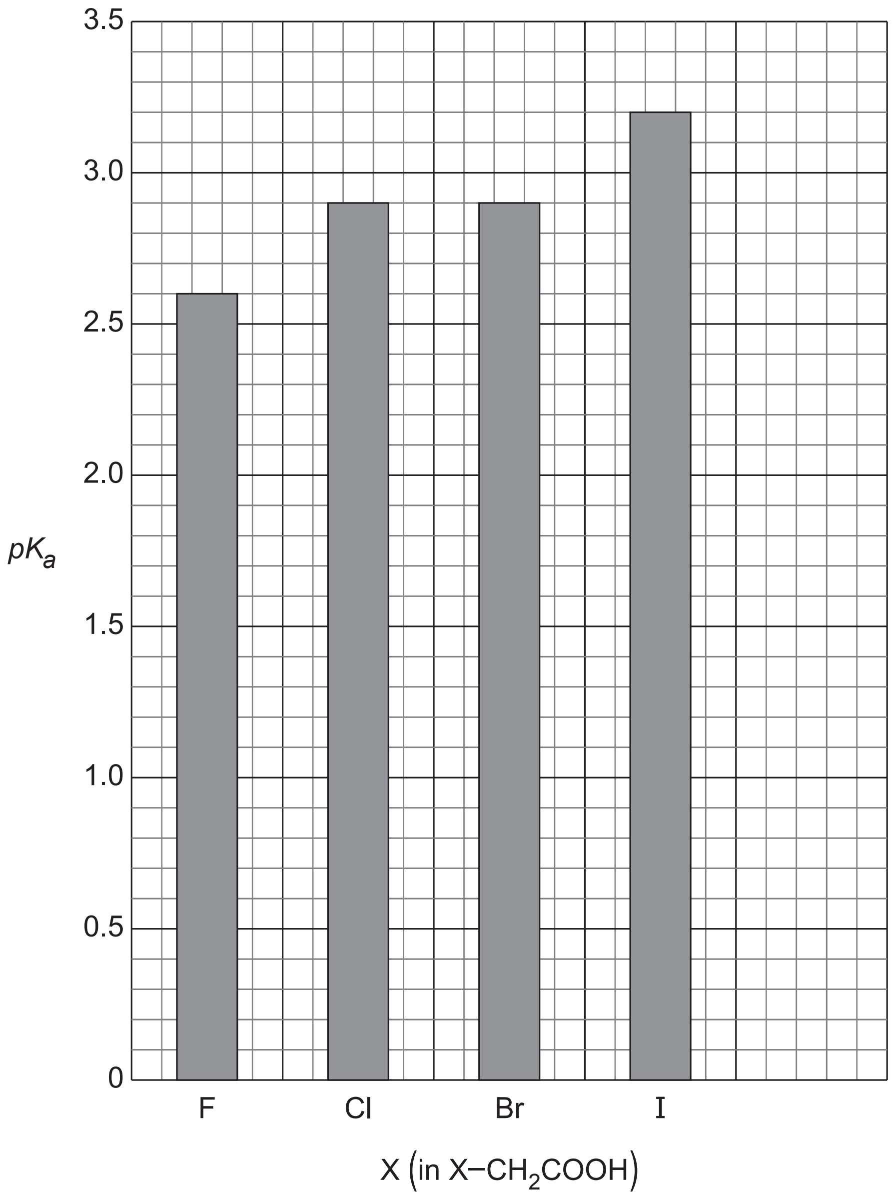
From the data provided, butanoic acid was in excess, propan-1-ol was limiting, so the theoretical yield is 0.267 moles.

Actual yield $= \dfrac{0.0818}{0.267} \times 100\% = 30.6\%$ (3 significant figures)

Question 26 (a)

Criteria	Marks
• Draws a column graph with accurate scales, axes labels and column heights	3
• Draws a substantially correct graph	2
• Provides a relevant graphical feature	1

Sample answer:



Question 26 (b)

Criteria	Marks
• Correctly describes the trend between acid strength and the identity of the halogen X	2
• Provides some relevant information	1

Sample answer:

From the graph, as the halogen changes going down the group, the strength of the haloethanoic acid decreases.

Question 27 (a)

Criteria	Marks
• Outlines the use AND environmental impact of a named hydrocarbon mixture	2
• Outlines the use OR environmental impact of a named hydrocarbon mixture	1

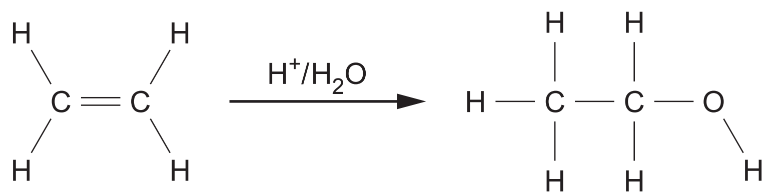
Sample answer:

Combustion of petrol used in vehicle engines produces CO_2. This leads to increased levels of CO_2 in the atmosphere which contributes to climate change.

Question 27 (b)

Criteria	Marks
• Provides a chemical equation with correct structural formulae of organic reactants and product, which includes aqueous acidic conditions	3
• Provides a chemical equation with correct structural formulae of organic reactants and product OR • Provides a chemical equation with correct formulae of organic reactants OR products, which includes aqueous acidic conditions	2
• Provides some relevant information	1

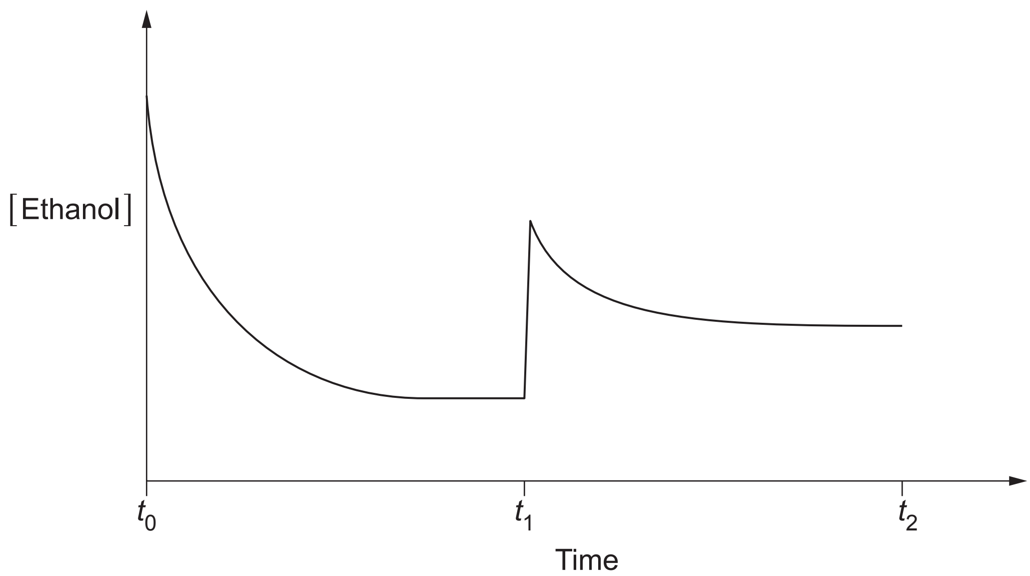
Sample answer:



Question 27 (c)

Criteria	Marks
• Sketches a graph showing the correct changes to the concentration of ethanol	3
• Sketches a graph showing most of the correct changes to the concentration of ethanol	2
• Provides a relevant graphical feature	1

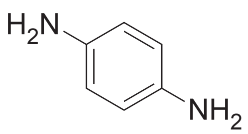
Sample answer:



Question 28 (a)

Criteria	Marks
• Correctly identifies the structure of the monomer	1

Sample answer:



Question 28 (b)

Criteria	Marks
• Explains the intermolecular forces in both polystyrene and Kevlar and relates these forces to the physical properties of the polymers	3
• Identifies the correct intermolecular forces in both polystyrene and Kevlar	2
• Provides some relevant information	1

Sample answer:

Polystyrene only has dispersion forces between individual chains.

Kevlar has hydrogen bonding between individual chains, as well as dispersion forces.

As H-bonds are stronger than dispersion forces for similarly sized molecules, it is harder to pull apart Kevlar polymer chains as compared to polystyrene.

Question 29

Criteria	Marks
• Provides a thorough explanation of the impact on the temperature of this system	4
• Provides an explanation that shows a sound understanding of equilibrium systems	3
• Provides a description of an impact on the system	2
• Provides some relevant information	1

Sample answer:

Addition of argon gas does not change the amount of NO_2 or N_2O_4 present. As the volume of the system remains consistent, the concentrations of NO_2 and N_2O_4 are unchanged. Therefore $Q = K_{eq}$ and the system remains at equilibrium. Accordingly, the temperature remains constant.

Answers could include:

The rates of the forward and reverse reaction remain equal, and the system remains at equilibrium.

The system is undisturbed and remains at equilibrium, in accordance with Le Châtelier's Principle.

The partial pressures of NO_2 and N_2O_4 are unchanged.

Question 30 (a)

Criteria	Marks
• Justifies a named precaution	2
• Provides any relevant information	1

Sample answer:

Phosgene is dangerous to the environment because it is toxic. Therefore, it is important to ensure it does not leak from the reaction vessel, which requires constant monitoring.

Answers could include:

– Regular maintenance of reaction vessels
– Sufficient training of industry staff
– Correct PPE for all staff
– Ensuring gas pressures stay below safe limits

Question 30 (b)

Criteria	Marks
• Explains the use of a catalyst AND • Explains the use of a large excess of CO	3
• Describes how BOTH features affect the reaction but does NOT link cause and effect OR • Explains how one feature affects the reaction	2
• Provides any relevant information	1

Sample answer:

The use of a catalyst saves time and money because it increases the rate of reaction by lowering the activation energy. The use of a large excess of CO causes the equilibrium to shift to the products side, therefore improving the yield of phosgene.

Question 31 (a)

Criteria	Marks
• Confirms the molecular formula using a substantially correct chemical equation	2
• Provides a partially correct chemical equation OR • Provides some relevant reasoning	1

Sample answer:

Stoichiometry implies that a hydrazine molecule contains 2 nitrogen atoms and 4 hydrogen atoms.

$$\mathrm{N}_x\mathrm{H}_y(g) + 3\mathrm{O}_2(g) \longrightarrow \underset{\substack{2\ \mathrm{N} \\ \text{atoms}}}{2\mathrm{NO}_2(g)} + \underset{\substack{4\ \mathrm{H} \\ \text{atoms}}}{2\mathrm{H}_2\mathrm{O}(g)}$$

Answers could include:

Given the volumes, the stoichiometry of the reaction is:

$$1\mathrm{N}_x\mathrm{H}_y(g) + 3\mathrm{O}_2(g) \longrightarrow 2\mathrm{NO}_2(g) + 2\mathrm{H}_2\mathrm{O}(g)$$

This only balances if $x = 2,\ y = 4$

$\therefore$ N_2H_4 is correct.

Question 31 (b)

Criteria	Marks
• Correctly calculates the pH • Provides a correct chemical equation	4
• Provides the main steps of the calculation	3
• Provides some steps of the calculation OR • Provides a correct chemical equation	2
• Provides some relevant information	1

Sample answer:

Hydrazinium ion, $N_2H_5^+$, reacts with water to produce an acidic solution in the following way:

$$N_2H_5^+(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + N_2H_4(aq)$$

R	$N_2H_5^+(aq)$	$H_2O(l)$	$H_3O^+(aq)$	$N_2H_4(aq)$
I	0.20	–	0	0
C	$-x$	–	$+x$	$+x$
E	$(0.20 - x)$	–	x	x

$$K_a = \frac{K_w}{K_b} = \frac{1.0 \times 10^{-14}}{1.7 \times 10^{-6}} = 5.88 \times 10^{-9}$$

Assume equilibrium concentration of $N_2H_5^+ = 0.20$ mol L^{-1} (ie, x is very small)

$$K_a = \frac{\left[H_3O^+\right]\left[N_2H_4\right]}{\left[N_2H_5^+\right]} = 5.88 \times 10^{-9}$$

$$\frac{x^2}{0.20} = 5.88 \times 10^{-9}$$

$$x = \sqrt{\left(5.88 \times 10^{-9} \times 0.20\right)}$$

$$x = 3.43 \times 10^{-5} = \left[H_3O^+\right]$$

$$\text{pH} = -\log_{10}\left(3.43 \times 10^{-5}\right)$$

$$= 4.46$$

Question 32

Criteria	Marks
• Identifies the correct precipitate, with justification using correct calculations	5
• Identifies the correct precipitate, with justification using substantially correct calculations OR • Identifies the order of precipitation supported by substantially correct calculations	4
• Identifies the correct precipitate, supported by some relevant calculations OR • Identifies the incorrect precipitate(s), supported by substantially correct calculations	3
• Demonstrates some understanding of solubility constants and/or solubility products	2
• Provides some relevant information	1

Sample answer:

$[Mg^{2+}] = 6 \times 10^{-3}$ $[OH^-] = 1 \times 10^{-2}$ $[CO_3^{2-}] = 2 \times 10^{-3}$

$[Mg^{2+}][OH^-]^2 = 6 \times 10^{-7}$ $K_{sp} = 5.61 \times 10^{-12}$

$[Mg^{2+}][CO_3^{2-}] = 1.2 \times 10^{-5}$ $K_{sp} = 6.82 \times 10^{-6}$

$Mg(OH)_2$ is a lot less soluble than $MgCO_3$.

$Mg(OH)_2$ will precipitate. The Mg^{2+} is in excess. Its concentration will drop to approximately $6 \times 10^{-3} - \dfrac{1 \times 10^{-2}}{2} = 1 \times 10^{-3}$.

$[Mg^{2+}][CO_3^{2-}]$ becomes 2×10^{-6} which is less than K_{sp}.

$MgCO_3$ won't precipitate.

Question 33

Criteria	Marks
• Correctly identifies the brand • Provides all correct calculations • Provides a balanced chemical equation including states	7
• Provides substantially correct calculations • Provides a balanced chemical equation	6
• Provides the main steps in the calculation • Provides a balanced chemical equation	4–5
• Provides some steps in the calculation	2–3
• Provides some relevant information	1

Sample answer:

Exclude the outlier.

Average volume KOH used excluding Trial 1 $= \dfrac{7.10 + 7.20 + 7.15}{3} = 0.00715$ L

$HCl(aq) + KOH(aq) \longrightarrow KCl(aq) + H_2O(l)$

moles KOH $= 0.10 \times 0.00715 = 0.000715$ mol KOH

Ratio HCl : KOH = 1 : 1 $\therefore$ 0.000715 mol HCl for each sample

$\therefore$ $0.000715 \times 5 = 0.003575$ mol total in sampled solution

Initial nHCl $= 0.550 \times 0.1000 = 0.0550$ mol HCl

nHCl that reacted with $CaCO_3 = 0.0550 - 0.003575$

$= 0.051425$ mol HCl

$2HCl(aq) + CaCO_3(s) \longrightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$

Ratio HCl : $CaCO_3$ = 2 : 1 $\therefore$ $\dfrac{0.051425}{2} = 0.0257125$ mol $CaCO_3$

Mass $CaCO_3 = 0.0257125 \times MM\ CaCO_3\ (100.09)$

$= 2.5735641$ g

$\% \ CaCO_3 = \dfrac{2.5735641}{3.00} \times 100 = 85.7854\% \approx 85.8\%$

Chalk sample has to be Brand X.

Question 34 (a)

Criteria	Marks
• Correctly calculates the K_a of the acid	3
• Provides a substantially correct calculation	2
• Provides some relevant information	1

Sample answer:

From the shape of the titration curve, the acid was weak.

Halfway to the equivalent point, at 0.012 L, $[HA] = [A^-]$

Here the pH is approximately 4.4, or $[H^+]$ is 4.0×10^{-5}.

$$K_a = [H^+] \times \frac{[A^-]}{[HA]}$$

At this pH, $[A^-] = [HA]$ so $K_a = 4.0 \times 10^{-5}$.

Answers could include:

Equivalence point is at 0.024 L NaOH added.

Shape of curve shows acid is monoprotic.

$[HA] \times 0.010 = 0.1 \times 0.024$

$[HA] = 0.24 \text{ mol L}^{-1}$

pH at start is approximately 2.5

So, $[H^+] = 3.16 \times 10^{-3}$

$$K_a = \frac{[H^+][A^-]}{[HA]} \qquad [A^-] = [H^+]$$

$[HA] = 0.24 - 3.16 \times 10^{-3}$

$\quad = 0.237$

$$K_a = \frac{(3.16 \times 10^{-3})^2}{0.237} = 4.2 \times 10^{-5}$$

Question 34 (b)

Criteria	Marks
• Provides a valid explanation	2
• Provides some relevant information	1

Sample answer:

Some of the hydroxide was neutralised by the acid.

The 10 mL of acid also diluted the NaOH.

So the NaOH concentration of the mixture will be less than 0.1 mol L^{-1} and the pH will be less than 13.

Question 35

Criteria	Marks
• Shows how both Le Chatelier's principle AND collision theory account for the colour change, with reference to the energy profile	5
• Demonstrates a sound understanding of how both collision theory AND Le Chatelier's principle account for the colour change	4
• Demonstrates a sound understanding of how collision theory OR Le Chatelier's principle accounts for the colour change	3
• Demonstrates some understanding of collision theory OR Le Chatelier's principle	2
• Provides some relevant information	1

Sample answer:

The energy profile diagram shows that the forward reaction is exothermic.

Le Chatelier's principle considers heat as a 'substance' that the system seeks to replace when lost. As this system is cooled, it responds in a way as to minimise the disturbance. Consequently, the forward reaction is favoured so the solution turns pink.

Collision theory considers the proportion of molecules above a particular activation energy. Decreasing the temperature slows the rates of both forward and reverse reactions, due to a drop in the average kinetic energy of all particles. However, the rate of the reverse reaction decreases more than the forward reaction. This is due to a greater proportion of particles falling below the relatively higher activation energy of the reverse reaction, E_{a2}, as shown in the reaction profile. Since the forward reaction is faster, $\left[CoCl_4{}^{2-}\right]$ will decrease, and $\left[Co(H_2O)_6{}^{2+}\right]$ will increase, and the colour changes to pink.

Question 36

Criteria	Marks
• Predicts the expected spectroscopic observations of ALL four techniques showing an extensive understanding of the relationship between molecular features and spectroscopic outcomes for these techniques	7
• Predicts the expected spectroscopic observations of ALL four techniques showing a thorough understanding of the relationship between molecular features and spectroscopic outcomes for these techniques	6
• Predicts the expected spectroscopic outcomes of most techniques showing a sound understanding of the relationship between molecular features and spectroscopic outcomes for these techniques	4–5
• Relates the expected spectroscopic outcomes of some techniques showing a basic understanding of the relationship between molecular features and spectroscopic outcomes for these techniques	2–3
• Provides some relevant information	1

Answers could include:

IR

- Strong broad OH signal at approximately 2750 cm^{-1}
- Strong sharp CO signal at approximately 1700 cm^{-1}

^{13}C NMR

- 3 chemical environments (either outright stated or through inference)
- 1 signal at 5−40 ppm (CH_3)
- 1 signal at 20−50 ppm (CH_2)
- 1 signal at 160−185 ppm (acid CO)

^{1}H NMR

- 3 chemical environments (either outright stated or through inference)
- 1 signal at 0.7−2.1 ppm (CH_3), triplet splitting pattern, integration of 3
- 1 signal at 2.1−4.5 ppm (CH_2), quartet splitting pattern, integration of 2
- 1 signal at 9.0−13.0 ppm (COOH), singlet, integration of 1

MS

- Molecular ion at 74 m/z

Question 37

Criteria	Marks
• Correctly determines the structure of compound A • Correctly justifies the structure using all the data provided	4
• Correctly determines the structure of compound A AND justifies the structure using some of the data provided OR • Correctly interprets all of the data provided	3
• Correctly interprets some of the data provided	2
• Provides some relevant information	1

Sample answer:

Compounds B and C are alkanols.

Compound B cannot be oxidised – so B must be a tertiary alkanol, therefore there must be branching.

Compound C can be oxidised but not to a carboxylic acid (no reaction with carbonate) – so the oxidation product is a ketone, so compound C is a secondary alkanol.

To explain the alkanols produced above, the C=C in compound A is not in the terminal position.

Therefore compound A is 2-methylbut-2-ene $\left(C_5H_{10}\right)$.

2025 HSC Chemistry
Mapping Grid

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