



NSW Education Standards Authority

2019 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

**Total marks:
100**

Section I – 20 marks (pages 2–10)

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

Section II – 80 marks (pages 13–32)

- Attempt Questions 21–34
- Allow about 2 hours and 25 minutes for this section

Section I

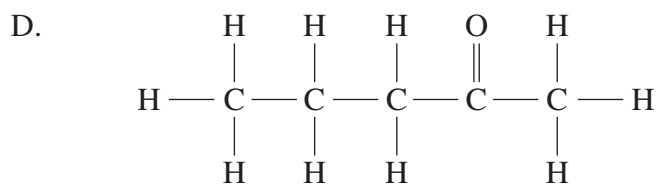
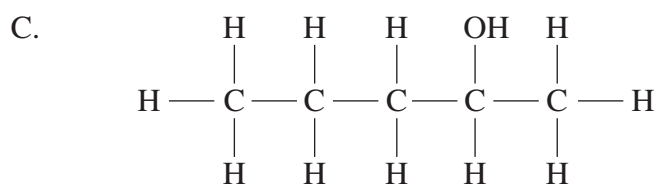
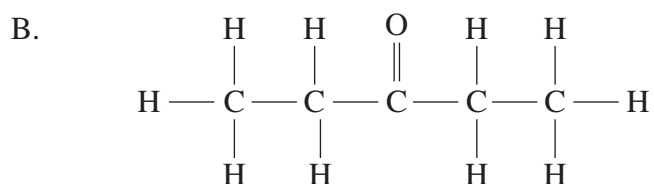
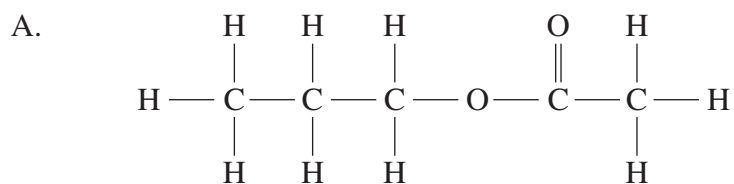
20 marks

Attempt Questions 1–20

Allow about 35 minutes for this section

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

1 Which structural formula represents pentan-2-one?



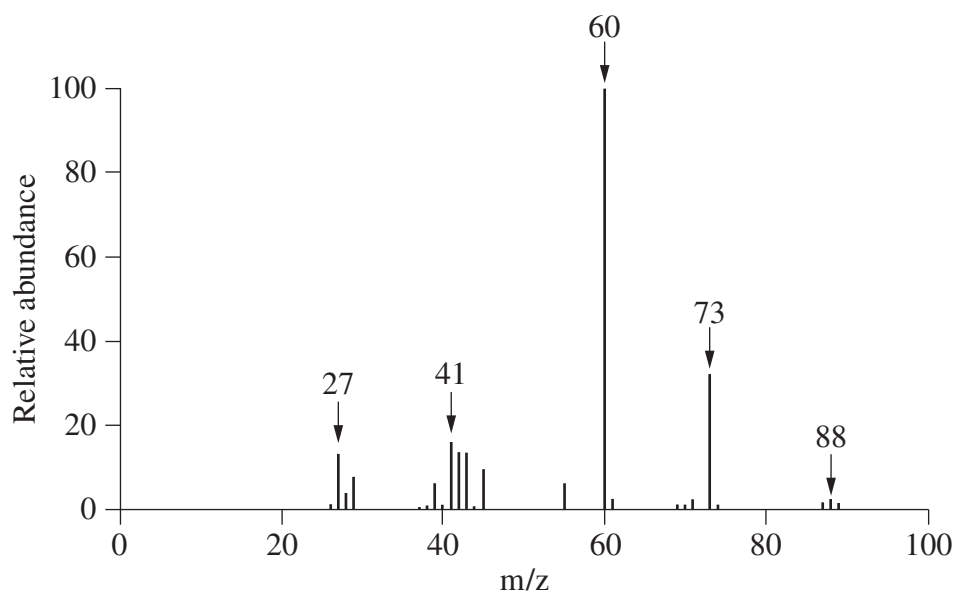
2 Which of the following is an Arrhenius base?

- A. Na
- B. NaOH
- C. Na_2CO_3
- D. NaHCO_3

3 Which of the following metal carbonates has the highest molar solubility?

- A. Calcium carbonate
- B. Copper(II) carbonate
- C. Iron(II) carbonate
- D. Lead(II) carbonate

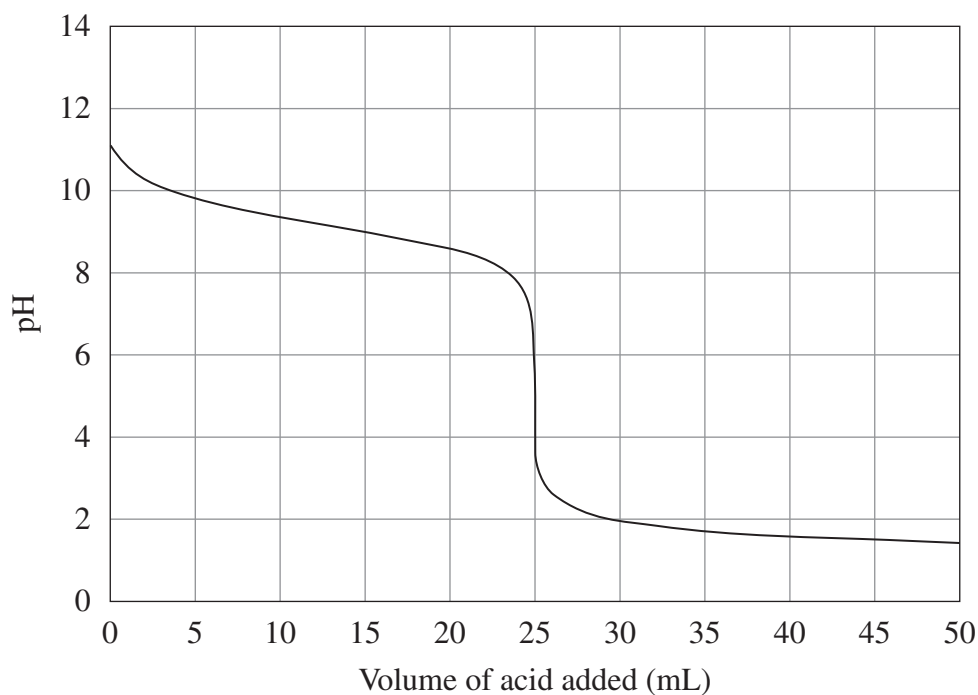
4 The diagram shows the mass spectrum of an organic compound.



Which compound was analysed?

- A. Butan-1-amine
- B. Butanoic acid
- C. Ethanoic acid
- D. Iron(II) sulfide

The diagram represents the titration curve for a reaction between a particular acid and a particular base. Use the diagram to answer Questions 5 and 6.



5 Which indicator would be best for this titration?

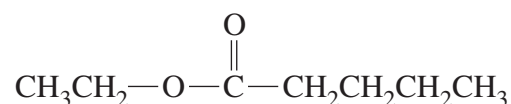
	<i>Indicator</i>	<i>Colour change range (pH)</i>
A.	Martius yellow	2.0 – 3.2
B.	Magdala red	3.0 – 4.0
C.	Isopicramic acid	4.0 – 5.6
D.	Cresol red	7.2 – 8.8

6 Which of the following equations best represents the reaction described by the titration curve?

- A. $\text{NH}_3(aq) + \text{HCl}(aq) \rightarrow \text{NH}_4\text{Cl}(aq)$
- B. $\text{NaOH}(aq) + \text{HCl}(aq) \rightarrow \text{NaCl}(aq) + \text{H}_2\text{O}(l)$
- C. $\text{NH}_3(aq) + \text{CH}_3\text{COOH}(aq) \rightarrow \text{CH}_3\text{COONH}_4(aq)$
- D. $\text{NaOH}(aq) + \text{CH}_3\text{COOH}(aq) \rightarrow \text{CH}_3\text{COONa}(aq) + \text{H}_2\text{O}(l)$

- 7 How does the addition of a catalyst affect a reversible reaction?
- It increases the activation energy of the forward reaction only.
 - It decreases the activation energy of the forward reaction only.
 - It increases the activation energy of both the forward and reverse reactions.
 - It decreases the activation energy of both the forward and reverse reactions.

- 8 The structure of an organic compound is shown.



Which row of the table correctly gives the name of the compound and one of the reactants used to produce it in a one-step reaction?

	<i>Name</i>	<i>Reactant</i>
A.	Ethyl pentanoate	Ethanol
B.	Ethyl pentanoate	Pentan-1-ol
C.	Pent-1-yl ethanoate	Ethanol
D.	Pent-1-yl ethanoate	Pentan-1-ol

- 9 All of the following compounds have similar molar masses.

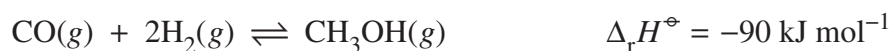
Which has the highest boiling point?

- Butane
 - Ethanoic acid
 - Propan-1-ol
 - Propanone
- 10 Which class of organic compound must contain at least three carbon atoms?
- Aldehydes
 - Alkenes
 - Carboxylic acids
 - Ketones

- 11** A saturated solution of barium carbonate was stored in a flask. Solid barium carbonate containing radioactive carbon-14 was added to the solution. The mixture was allowed to stand for several days and was then filtered.

Radioactivity could reasonably be expected to be found in

- A. the filtrate only.
 - B. the residue only.
 - C. both residue and filtrate.
 - D. neither residue nor filtrate.
- 12** Methanol can be produced from the reaction of carbon monoxide and hydrogen, according to the following equation:



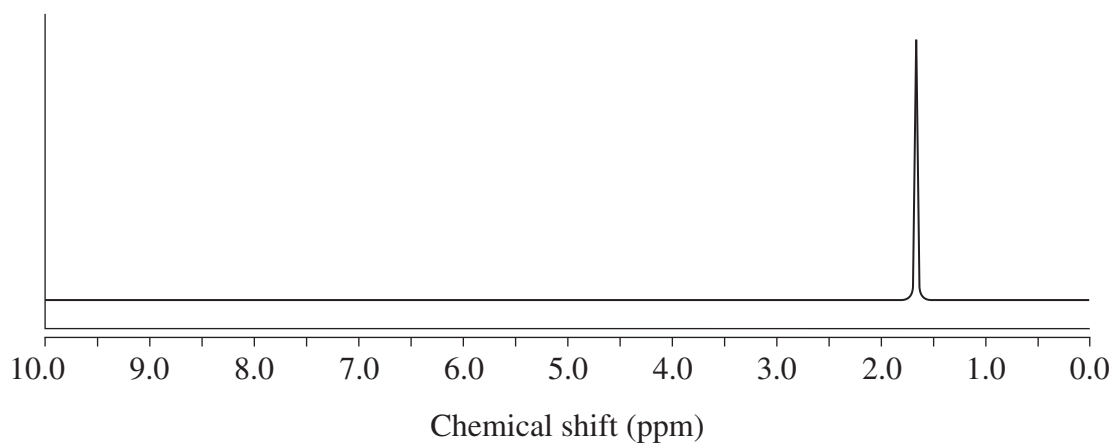
Which set of conditions will produce the maximum yield of methanol?

- A. Low pressure and low temperature
 - B. Low pressure and high temperature
 - C. High pressure and low temperature
 - D. High pressure and high temperature
- 13** A sample of polydifluoroethylene is determined to have an average molar mass of $4.8 \times 10^4 \text{ g mol}^{-1}$.

Approximately how many carbon atoms are there in an average molecule?

- A. 750
- B. 1500
- C. 2500
- D. 4000

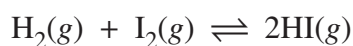
14 A molecule, C_4H_9Cl , is analysed. The 1H NMR spectrum of this molecule is shown.



What is the structural formula of this molecule?

- A.
$$\begin{array}{c} \text{CH}_3 \\ | \\ \text{CH}_3 - \text{C} - \text{Cl} \\ | \\ \text{CH}_3 \end{array}$$
- B.
$$\begin{array}{c} \text{CH}_3 - \text{CH} - \text{CH}_2 - \text{Cl} \\ | \\ \text{CH}_3 \end{array}$$
- C.
$$\begin{array}{c} \text{CH}_3 - \text{CH}_2 - \text{CH} - \text{CH}_3 \\ | \\ \text{Cl} \end{array}$$
- D.
$$\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{Cl}$$

- 15 What is the concentration of hydroxide ions (in mol L⁻¹) in a solution that has a pH of 8.53?
- A. 3.0×10^{-9}
 B. 3.4×10^{-6}
 C. 5.5
 D. 3.0×10^5
- 16 At equilibrium, a 1.00 L vessel contains 0.0430 mol of H₂, 0.0620 mol of I₂, and 0.358 mol of HI. The system is represented by the following equation:

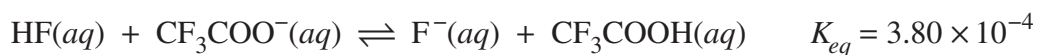


- Which of the following is closest to the value of the equilibrium constant, K_{eq} , for this reaction?
- A. 0.0208
 B. 48.1
 C. 134
 D. 269
- 17 A student makes a solution with a final volume of 200 mL by mixing 100 mL of 0.0500 mol L⁻¹ barium nitrate solution with 100 mL of 0.100 mol L⁻¹ sodium hydroxide solution.

Which row of the table correctly identifies if a precipitate will form under these conditions and the reason?

	<i>Will a precipitate form?</i>	<i>Reason</i>
A.	Yes	$Q > K_{sp}$
B.	Yes	$Q < K_{sp}$
C.	No	$Q > K_{sp}$
D.	No	$Q < K_{sp}$

18 Consider the following equilibrium.



Which row of the table correctly identifies the strongest acid and the strongest base in this system?

	<i>Strongest acid</i>	<i>Strongest base</i>
A.	$\text{CF}_3\text{COOH}(aq)$	$\text{F}^-(aq)$
B.	$\text{CF}_3\text{COOH}(aq)$	$\text{CF}_3\text{COO}^-(aq)$
C.	$\text{HF}(aq)$	$\text{F}^-(aq)$
D.	$\text{HF}(aq)$	$\text{CF}_3\text{COO}^-(aq)$

19 Compound X shows three signals in its ^{13}C NMR spectrum.

Treatment of X with hot acidified potassium permanganate produces a compound Y. Compound Y turns blue litmus red.

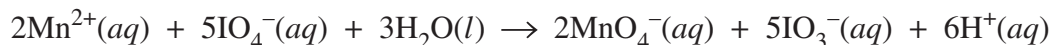
Compound X produces compound Z upon reaction with hot concentrated sulfuric acid.

Which of the following correctly identifies compounds X, Y and Z?

	<i>Compound X</i>	<i>Compound Y</i>	<i>Compound Z</i>
A.	butan-1-ol	butanoic acid	but-1-ene
B.	butan-2-ol	butanone	but-2-ene
C.	methyl ethanoate	methanoic acid	ethene
D.	2-methylpropan-1-ol	2-methylpropanoic acid	2-methylprop-1-ene

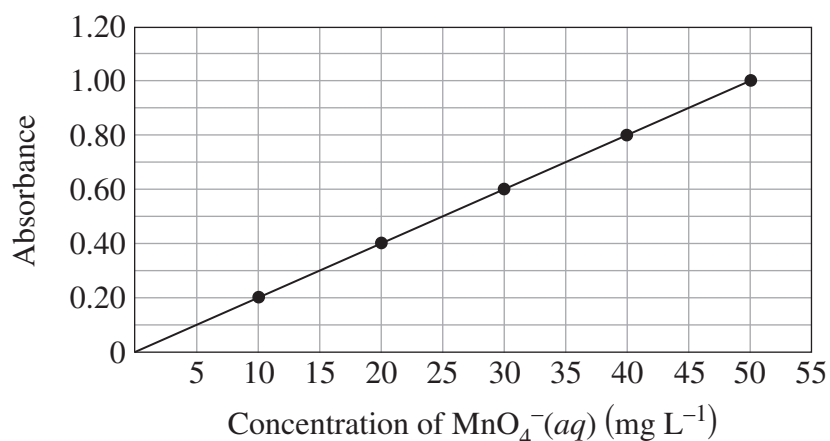
- 20 The manganese content in a 12.0-gram sample of steel was determined by measuring the absorbance of permanganate (MnO_4^-) using the following process.

The steel sample was dissolved in nitric acid and the $\text{Mn}^{2+}(\text{aq})$ ions produced were oxidised to $\text{MnO}_4^-(\text{aq})$ by periodate ions, $\text{IO}_4^-(\text{aq})$, according to the following equation.



The resulting solution was made up to a volume of 1.00 L, then 20.0 mL of this solution was diluted to 100.0 mL. The absorbance at 525 nm of the resulting solution was 0.50.

A calibration curve for $\text{MnO}_4^-(\text{aq})$ was constructed and is shown below.



What was the percentage by mass of manganese in the steel sample?

- A. 0.019%
- B. 0.096%
- C. 0.48%
- D. 1.0%

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Centre Number

Chemistry

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Student Number

Section II Answer Booklet

80 marks

Attempt Questions 21–34

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

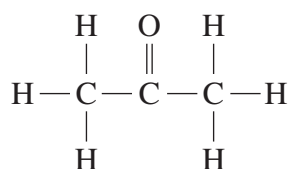
Question 21 (7 marks)

- (a) The structural formula for 2-methylpropan-2-ol is shown in the table. 2

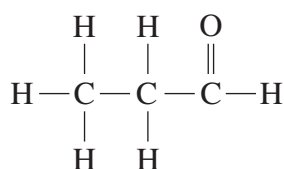
Draw one structural isomer of this alcohol and state its name.

	<i>Alcohol</i>	<i>Isomer</i>
Structure	$ \begin{array}{ccccc} & \text{H} & & \text{OH} & & \text{H} \\ & & & & & \\ \text{H} & - \text{C} & - & \text{C} & - & \text{C} - \text{H} \\ & & & & & \\ & \text{H} & & \text{H} - \text{C} - \text{H} & & \text{H} \\ & & & & & \\ & & & \text{H} & & \end{array} $	
Name	2-methylpropan-2-ol	

- (b) The structural formulae for two compounds are shown below. 2



Isomer A



Isomer B

Why are these two compounds classed as functional group isomers?

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- (c) A chemical test is required to distinguish between the isomers in part (b). 3

Identify a suitable test and explain the expected observations.

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Question 22 (4 marks)

A buffer was prepared with acetic acid and sodium acetate. A few drops of universal indicator were then added. When small amounts of either $0.1 \text{ mol L}^{-1} \text{ HCl}(aq)$ or $0.1 \text{ mol L}^{-1} \text{ NaOH}(aq)$ were added, no change in the colour of the solution was observed.

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Explain these observations. Support your answer with at least ONE chemical equation.

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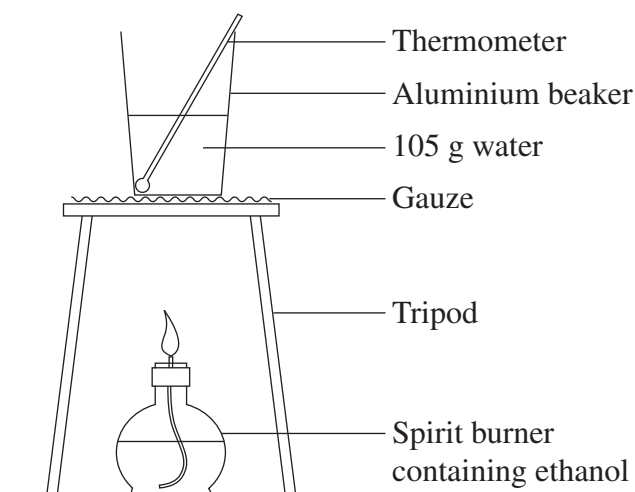
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Question 23 (6 marks)

The following apparatus was used in an experiment to determine the molar enthalpy of combustion of ethanol.



- (a) Calculate the experimental molar enthalpy of combustion ($\Delta_c H$) of ethanol when 0.370 g ethanol was used to raise the water temperature from 18.5°C to 30.0°C.

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Question 23 continues on page 17

Question 23 (continued)

- (b) Upon replication, the molar enthalpy of combustion obtained in the experiment was consistently much lower than the accepted value. 2

Explain ONE change that could be made to the experiment that would improve the accuracy of the obtained value.

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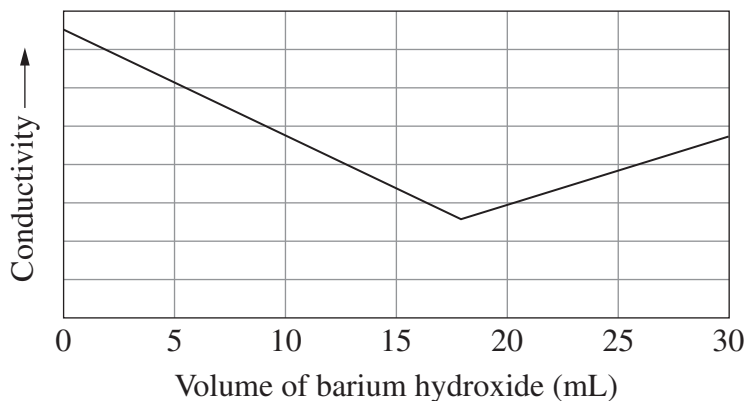
End of Question 23

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Question 24 (7 marks)

A conductometric titration was undertaken to determine the concentration of a barium hydroxide solution. The solution was added to 250.0 mL of standardised $1.050 \times 10^{-3} \text{ mol L}^{-1}$ hydrochloric acid solution. The results of the titration are shown in the conductivity graph.



(a) Explain the shape of the titration curve.

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(b) The equivalence point was reached when a volume of 17.15 mL of barium hydroxide was added.

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Calculate the concentration of barium hydroxide (in mol L^{-1}), and give a relevant chemical equation.

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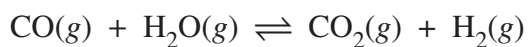
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Question 25 (5 marks)

The concentrations of reactants and products as a function of time for the following system were determined.

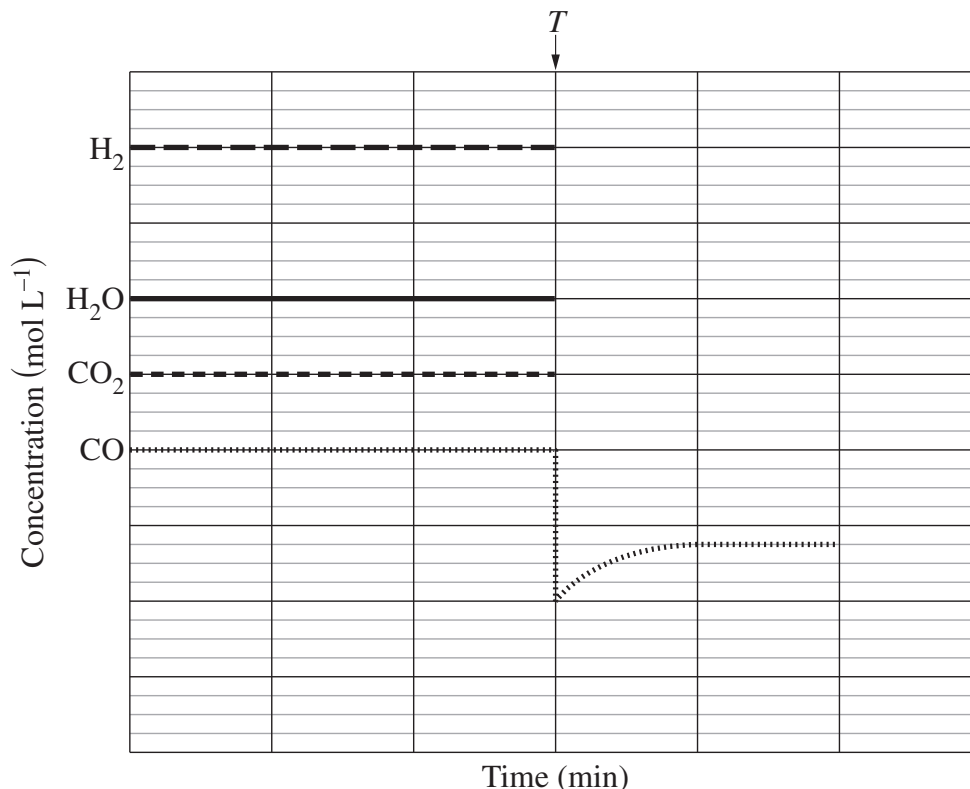


At time T , some $\text{CO}(g)$ was removed from the system.

- (a) The concentration of CO after time T is shown.

2

Sketch the concentrations after time T for the remaining species.



- (b) Using collision theory, explain the change in the concentration of CO after time T .

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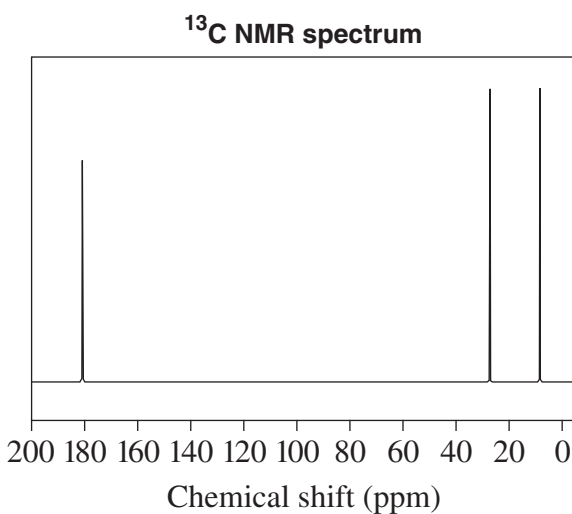
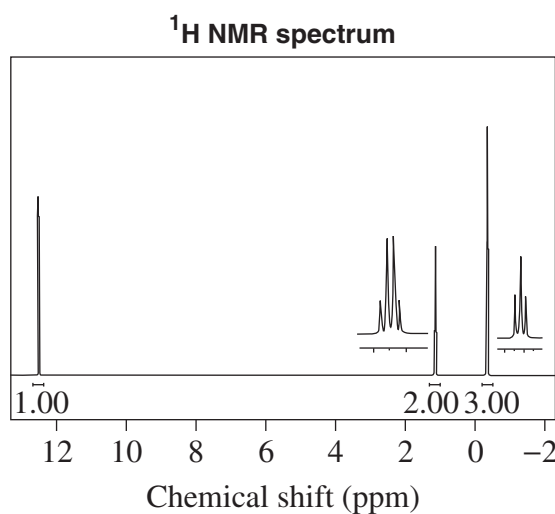
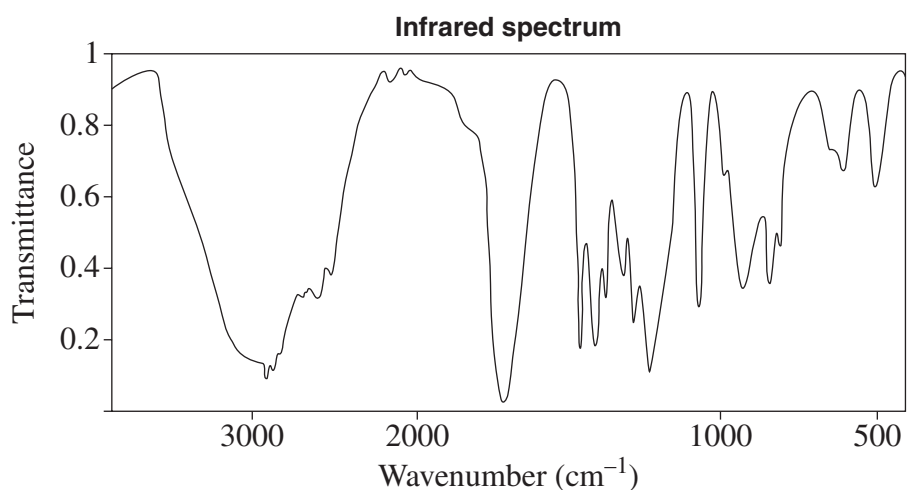
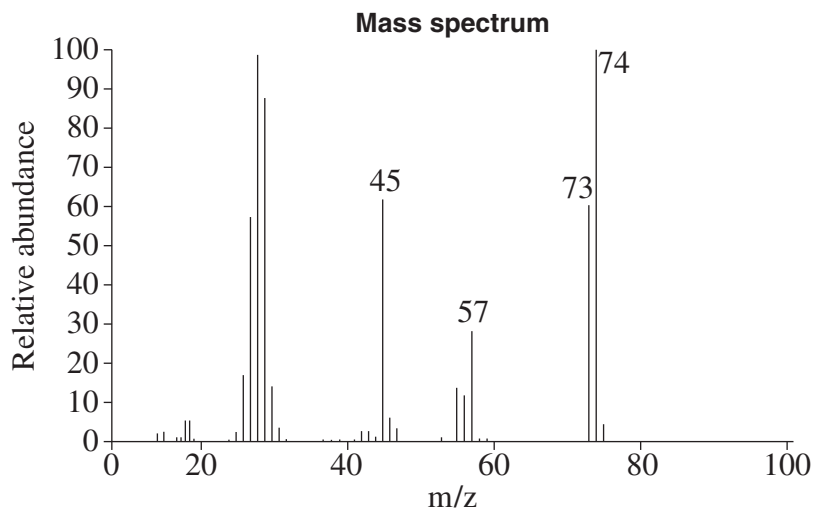
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Question 26 (8 marks)

The following data were obtained for an organic compound containing carbon, hydrogen and oxygen. The compound is a colourless liquid that reacts with sodium carbonate powder to produce bubbles.



Question 26 continues on page 21

