GCE AS/A LEVEL

2410U20-1

THURSDAY, 25 MAY 2023 – MORNING

CHEMISTRY – AS UNIT 2

ENERGY, RATE AND CHEMISTRY OF CARBON COMPOUNDS

1 hour 30 minutes plus your additional time allowance

Surname: _____

First name(s): _____

Centre Number: _____

Candidate Number: 2 _____

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1. to 7.	**10**	
8.	**6**	
9.	**6**	
10.	**18**	
11.	**10**	
12.	**13**	
13.	**17**	
Total	**80**	

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a

- **calculator;**
- **DATA BOOKLET supplied by WJEC.**

ITEMS INCLUDED WITH QUESTION PAPER

A separate Diagram Booklet.

The Diagram Booklet MUST be handed in to the invigilators and sent for marking.

INSTRUCTIONS TO CANDIDATES

Use black ink, black ball – point pen, black felt tip or your usual method.

Write your name, centre number and candidate number in the spaces on the front cover.

Answer ALL questions in SECTION A.
Answer ALL questions in SECTION B.

Write your answers in the spaces provided.
If you run out of space, use the additional pages at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part – question.

The maximum mark for this paper is 80.

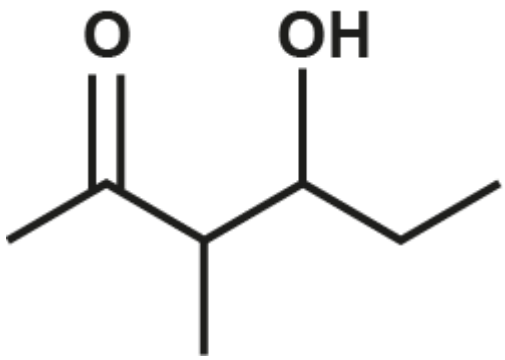
Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

The assessment of the quality of extended response (QER) will take place in question 8.

SECTION A

ANSWER ALL QUESTIONS.

1. Give the molecular formula of the compound shown in the diagram below.



Molecular formula _____

[1 mark]

2. When fuels are burned with insufficient oxygen, incomplete combustion occurs and carbon monoxide is formed instead of carbon dioxide.

Write the equation for the incomplete combustion of propane, C_3H_8

Assume that carbon monoxide is the only carbon – containing product.

_____

[1 mark]

3. Name the reagent that is needed to change unsaturated oils into saturated fats.

_____

[1 mark]

4. Look at the diagram for Question 4 in the separate Diagram Booklet.

Cyclobutane is a cyclic hydrocarbon whose structure is shown in the diagram.

Draw the structures of TWO structural isomers of this compound.

Space for drawing:

[2 marks]

5. Propene reacts with hydrogen bromide.

$$C_3H_6 + HBr \longrightarrow C_3H_7Br$$

Draw the structures of the TWO isomers formed and give the name of the major product.

Space for drawing:

Major product _____

[2 marks]

6. In the forward direction, the enthalpy change of reaction, ΔH, for a reversible endothermic reaction, has the numerical value of

$60\ kJ\ mol^{-1}$

If the activation energy, E_a, of the forward reaction is $100\ kJ\ mol^{-1}$, calculate the activation energy of the backward reaction.

Space for working:

E_a = _____ $kJ\ mol^{-1}$

[1 mark]

7. Look at the diagram for Question 7 in the separate Diagram Booklet.

The diagram shows an *E* – *Z* isomer.

Name the *E* – *Z* isomer in the diagram.

_____

[2 marks]

(Total for SECTION A = 10 marks)

SECTION B

ANSWER ALL QUESTIONS.

8. **The use of biofuels has been proposed as the way to ensure the sustainability of energy production in the future.**

Discuss the extent to which you agree with this proposal, giving both advantages and disadvantages of the use of biofuels. Include relevant examples in your answer.

[6 marks QER]

(Total for Question 8 = 6 marks)

9. Bromide ions react with bromate(V) ions, BrO_3^-

Look at the equation for Question 9 in the separate Diagram Booklet.

Some students investigated the rate of this reaction by following the concentration of bromide ions over time.

Their results are plotted on the graph for Question 9 in the separate Diagram Booklet.

continued on the next page . . .

Question 9 continued

9. (a) (i) The students calculated that the initial rate of the reaction was

$1.20 \text{ mol dm}^{-3} \text{ min}^{-1}$

Use the tangent to the curve to calculate the rate of the reaction when the concentration of bromide ions had fallen to 2.50 mol dm^{-3}

You MUST show your working.

Space for working:

Rate = _____ $\text{mol dm}^{-3} \text{ min}^{-1}$

[2 marks]

continued on the next page . . .

Question 9 (a) continued

9. (a) (ii) Use your answer to part (i) to suggest the relationship between the rate of this reaction and the concentration of bromide ions.

_____

_____

_____

[1 mark]

(b) Suggest how the students could follow the rate of this reaction. Explain your answer.

_____

_____

_____

_____

_____

[2 marks]

continued on the next page . . .

Question 9 continued

9. (c) In the experiment, the concentration of bromide ions fell from $5.0\ mol\ dm^{-3}$ to $2.0\ mol\ dm^{-3}$ over the first 4 minutes. The initial concentration of bromate(V) ions was $1.0\ mol\ dm^{-3}$

Look at the equation for Question 9 (c) in the separate Diagram Booklet.

Using the equation, deduce the concentration of bromate(V) ions after 4 minutes.

Space for working:

Question 9 (c) continued

Concentration of bromate(V) ions

= _____ mol dm^{-3}

[1 mark]

(Total for Question 9 = 6 marks)

10. (a) The enthalpy of neutralisation of an acid is defined as the enthalpy change when 1 mol of aqueous H^+ ions is neutralised by aqueous OH^- ions according to the equation shown. The reaction is exothermic.

$$H^+(aq) + OH^-(aq) \longrightarrow H_2O(l)$$

Some students followed the instructions below to determine the enthalpy change of neutralisation of methanoic acid, HCOOH.

INSTRUCTIONS:

1. Weigh 24.7 g of methanoic acid and mix with water to make 250 cm^3 of solution. Record the temperature of the solution.

2. Transfer eight 25.0 cm^3 portions of this solution into eight insulated cups.

continued on the next page . . .

Question 10 (a) continued

3. **Using a burette add $5.0\ cm^3$ of aqueous sodium hydroxide to the solution in the first cup.**
   Stir and record the maximum temperature reached.

4. **Add the following volumes of aqueous sodium hydroxide to each of the remaining cups in turn:**

   $10.0cm^3$ $15.0cm^3$ $20.0cm^3$ $25.0cm^3$

   $30.0cm^3$ $35.0cm^3$ $40.0cm^3$

   Stir and record the maximum temperature reached in each cup.

5. **Plot a graph of maximum temperature reached against volume of sodium hydroxide added.**

continued on the next page . . .

Question 10 (a) continued

Their results are plotted in the graph for Question 10 (a) in the separate Diagram Booklet.

10. (a) (i) Name the apparatus used to transfer exactly $25.0\ cm^3$ of methanoic acid solution into the insulated cups.

_____

[1 mark]

(ii) State why a higher maximum temperature is recorded when increasing volumes of sodium hydroxide are added.

_____

_____

_____

[1 mark]

continued on the next page . . .

Question 10 (a) continued

10. (a) (iii) Explain why the maximum temperature recorded decreases when more than $30\ cm^3$ of sodium hydroxide is added.

_____

_____

_____

_____

_____

[2 marks]

(iv) On the graph for Question 10 (a), draw ONE straight line through the points that show an increase in maximum temperature and ANOTHER straight line through the points that show a decrease in maximum temperature.

[1 mark]

continued on the next page . . .

Question 10 (a) continued

10. (a) (v) From the graph, deduce the volume of sodium hydroxide needed to neutralise $25.0\ cm^3$ of the methanoic acid solution and the temperature increase at that point.

Assume that the initial temperature of every $25.0\ cm^3$ of methanoic acid solution is $22.0^\circ C$

Volume = _____ cm^3

Temperature increase = _____ $^\circ C$

[2 marks]

continued on the next page . . .

Question 10 (a) continued

10. (a) (vi) Use your answers to part (v) to calculate the amount of heat released by the neutralisation reaction.

Space for working:

Heat released = _____ J

[2 marks]

continued on the next page . . .

Question 10 (a) continued

10. (a) (vii) Calculate the number of moles of methanoic acid in $25.0\ cm^3$ of the solution and hence the enthalpy change of neutralisation of methanoic acid.

Space for working:

Enthalpy change of neutralisation =

_____ $kJ\ mol^{-1}$

[3 marks]

continued on the next page . . .

Question 10 (b) continued

10. (b) The experiment is repeated using hydrochloric acid instead of methanoic acid and a more negative value of the enthalpy change of neutralisation is calculated.

Suggest and explain a reason for this difference.

_____

_____

_____

_____

_____

[2 marks]

continued on the next page . . .

Question 10 continued

10. (c) (i) **Write the equation for the reaction that occurs when solid copper(II) carbonate is added to aqueous methanoic acid to form aqueous copper(II) methanoate, $(HCOO)_2Cu$**

Include state symbols.

_____

[2 marks]

(ii) **State what is observed during the reaction in part (i).**

_____

_____

_____

[2 marks]

(Total for Question 10 = 18 marks)

11. (a) Compound X contains carbon, hydrogen and oxygen only. It has no reaction with acidified potassium dichromate.

Look at the diagrams for Question 11 (a) in the separate Diagram Booklet.

The diagrams show simplified versions of the mass spectrum, IR spectrum and ^{13}C NMR spectrum for compound X.

Identify compound X.

You MUST use information from ALL the sources given and explain how you used it.

Question 11 (a) continued

Space for drawing:

Compound X

[8 marks]

continued on the next page . . .

Question 11 (b) continued

11. (b) Look at the diagram for Question 11 (b) in the separate Diagram Booklet.

On the axes, complete the low resolution ^{1}H NMR spectrum you would expect for the compound you identified in part (a).

You should indicate where you would expect to see peaks AND the relative intensities of the peaks.

[2 marks]

(Total for Question 11 = 10 marks)

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12. (a) Y is a halogenocompound in which each molecule contains one atom of chlorine, bromine or iodine.

(i) Describe a chemical test to determine which halogen is present in Y.

_____

_____

_____

_____

_____

_____

[3 marks]

continued on the next page . . .

Question 12 (a) continued

12. (a) (ii) **Y contains four carbon atoms in each molecule. The percentage by mass of halogen present in Y is less than 40%**

Identify Y. Explain how you reached your conclusion.

_____

_____

_____

_____

_____

_____

[2 marks]

continued on the next page . . .

Question 12 continued

12. (b) (i) Halogenoalkanes react with aqueous sodium hydroxide.

Draw the mechanism to show the reaction of 1 – chloropropane with aqueous sodium hydroxide.

You should include all charges, partial charges and lone pairs, and curly arrows to show electron movement.

Space for drawing:

[4 marks]

continued on the next page . . .

Question 12 (b) continued

12. (b) (ii) Name the type of reaction shown in part (i).

_____

[1 mark]

(c) Halogenoalkanes can also take part in an elimination reaction.

2 – Chloropentane undergoes elimination in a similar way to 1 – chloropropane.

(i) Give the reagent and conditions needed for 2 – chloropentane to undergo elimination.

_____

_____

[1 mark]

continued on the next page . . .

Question 12 (c) continued

12. (c) (ii) When 2 – chloropentane undergoes elimination, two structural isomers are formed.

Give the structures of these TWO isomers.

Space for drawing:

[2 marks]

(Total for Question 12 = 13 marks)

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13. (a) In cold weather the wings of an aeroplane can become covered in ice. For safety reasons the wings must be de – iced.

The liquid ethane – 1,2 – diol, CH_2OHCH_2OH, is used, mixed with water, since this lowers the freezing temperature of water and causes the ice to melt.

(i) Look at the diagram for Question 13 (a) (i) in the separate Diagram Booklet.

Use the diagram to show the intermolecular forces that allow ethane – 1,2 – diol to dissolve in water.

[3 marks]

continued on the next page . . .

Question 13 (a) continued

13. (a) (ii) Suggest a reason why the addition of ethane – 1,2 – diol lowers the freezing temperature of water.

_____

_____

_____

[1 mark]

continued on the next page . . .

Question 13 continued

13. (b) Ethane – 1,2 – diol can be oxidised to ethanedioic acid, $(COOH)_2$

(i) Suggest an oxidising agent suitable to carry out this reaction.

_____

[1 mark]

(ii) Write the equation for this reaction. Use [O] for the oxidising agent.

_____

[2 marks]

continued on the next page . . .

Question 13 (b) continued

13. (b) (iii) To ensure complete oxidation the reagents are refluxed.

Draw and label the apparatus as it is being used in this reaction.

Space for drawing:

[2 marks]

continued on the next page . . .

Question 13 (b) continued

13. (b) (iv) A sample of the reacting mixture was taken during the reflux process and a mass spectrum was produced. One of the peaks recorded was at

m/z 58

Suggest the identity of the MOLECULAR ION that gave this peak.

_____

[1 mark]

continued on the next page . . .

Question 13 (b) continued

13. (b) (v) The reaction can be used to prepare a sample of solid ethanedioic acid. This is generally hydrated as $(COOH)_2 . x H_2O$ where x is an integer.

2.00 g of ethane – $1,2$ – diol was oxidised and 3.94 g of hydrated ethanedioic acid was produced.

Calculate the relative molecular mass of hydrated ethanedioic acid and hence the value of x in its formula.

Space for working:

Question 13 (b) (v) continued

x = _____

[4 marks]

continued on the next page . . .

Question 13 (b) continued

13. (b) (vi) I. Look at the equation for Question 13 (b) (vi) I. in the separate Diagram Booklet. Complete the equation for the reaction which occurs when ethanedioic acid is heated with excess methanol in acidic conditions.

Clearly show the structure of the organic product.

[2 marks]

continued on the next page . . .

Question 13 (b) (vi) continued

13. (b) (vi) II. Name the type of functional group present in the organic product.

_____

[1 mark]

(Total for Question 13 = 17 marks)

END OF PAPER

TOTAL 80 MARKS

Question number	Additional pages, if required. Write the question number(s) in the left - hand margin.

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THURSDAY, 25 MAY 2023 – MORNING

CHEMISTRY – AS UNIT 2

ENERGY, RATE AND CHEMISTRY OF CARBON COMPOUNDS

The Diagram Booklet MUST be handed in to the invigilators and sent for marking.

Diagram Booklet

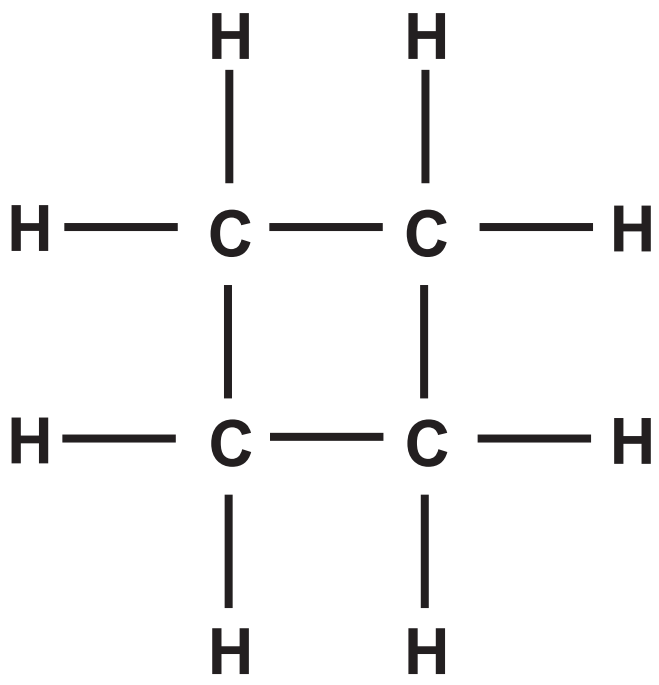
Surname: _____

First name(s): _____

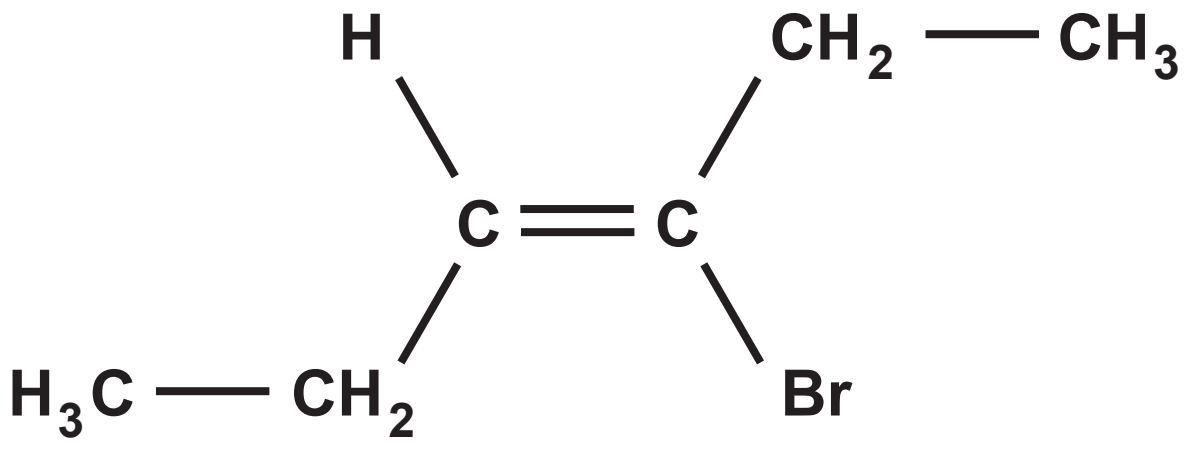
Centre Number: _____

Candidate Number: 2 _____

Question 4

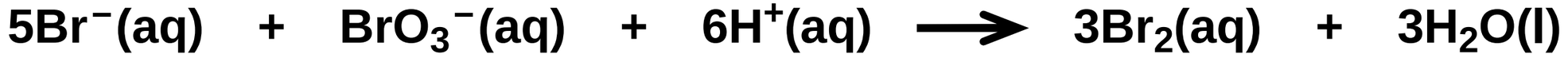


Question 7

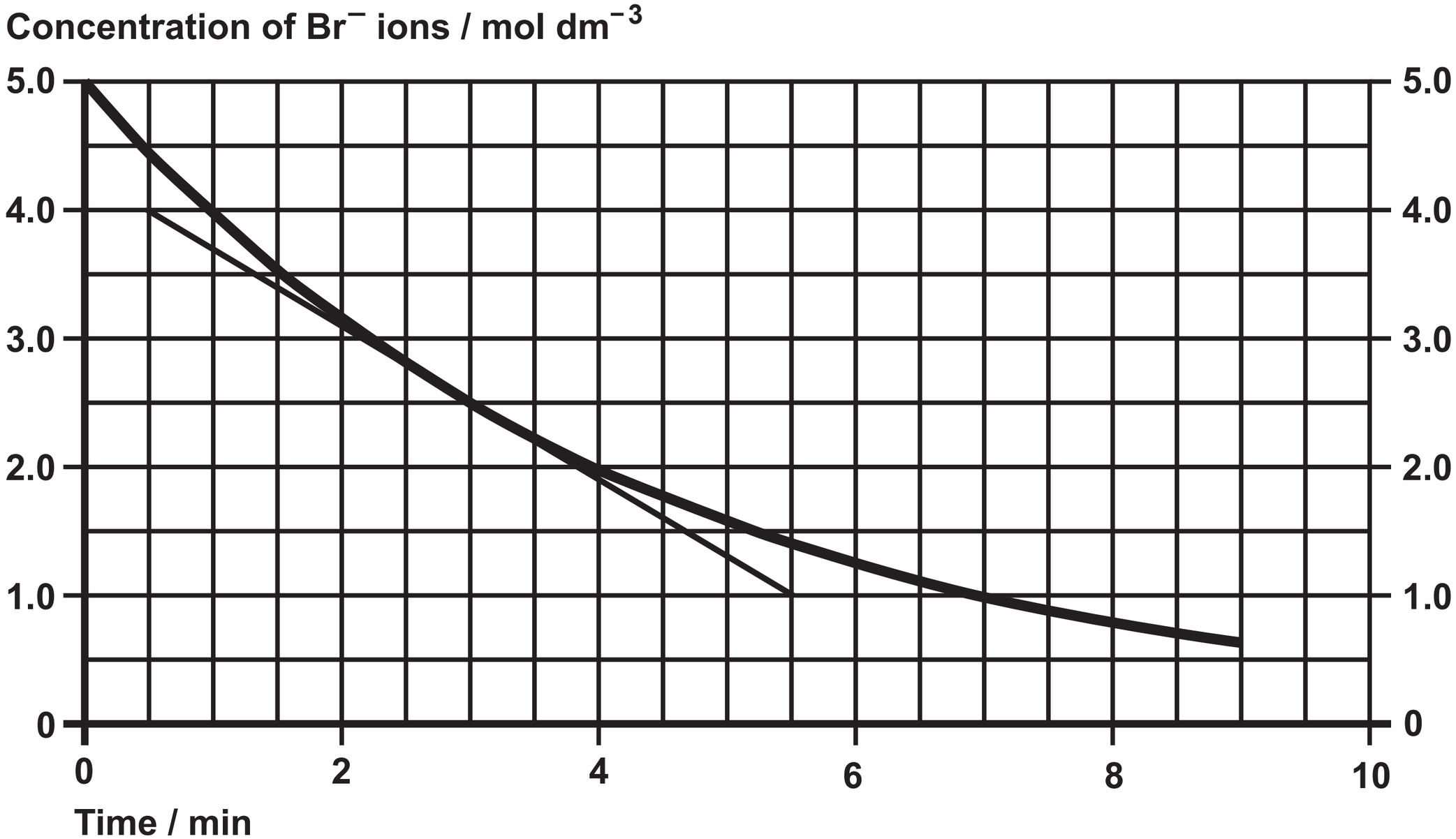


Question 9

Equation

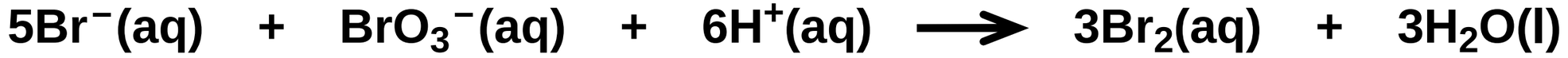


Question 9

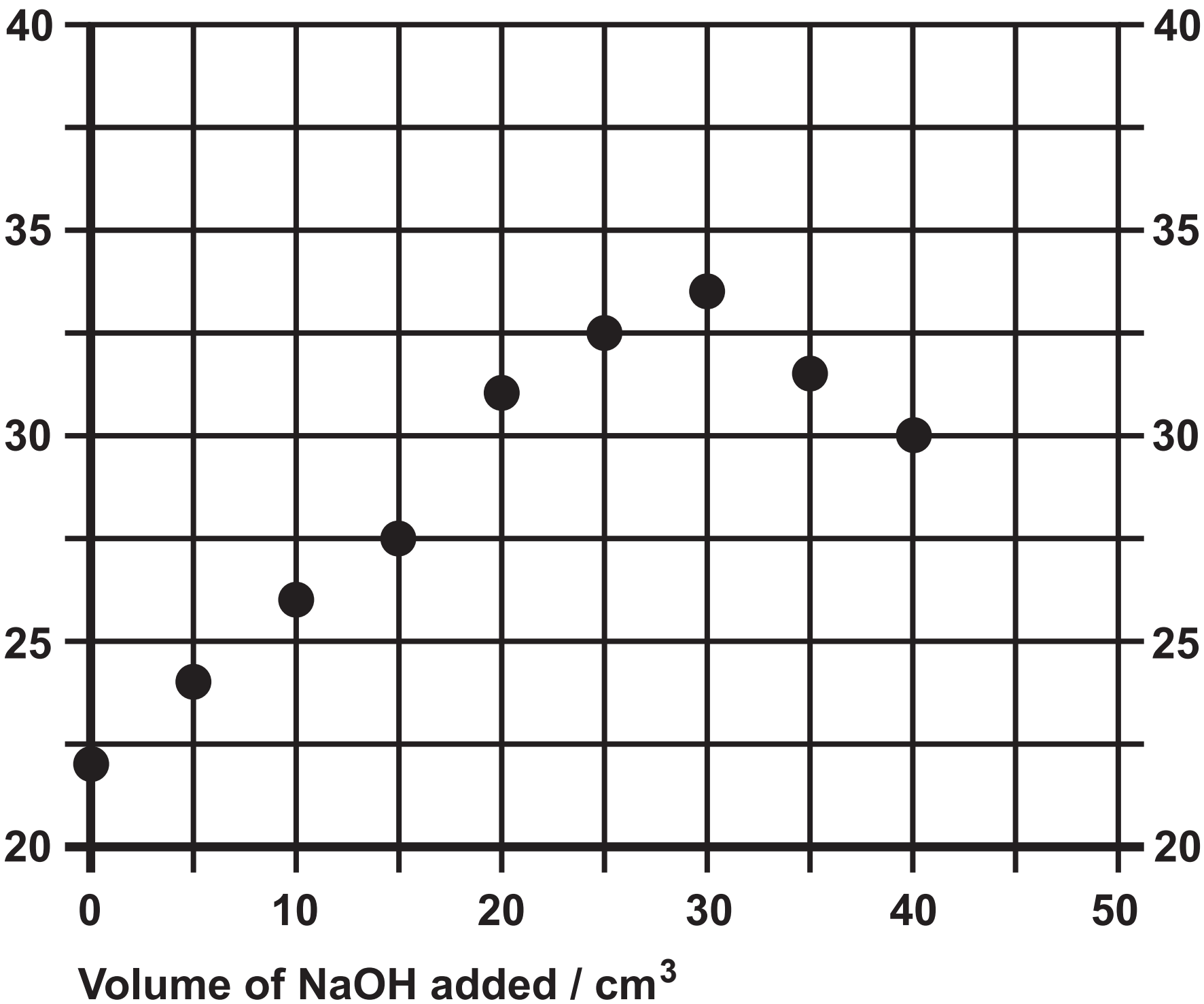

Concentration of Br⁻ ions / mol dm⁻³
5.0
4.0
3.0
2.0
1.0
0
0
2
4
6
8
10
Time / min

Question 9 (c)

Equation

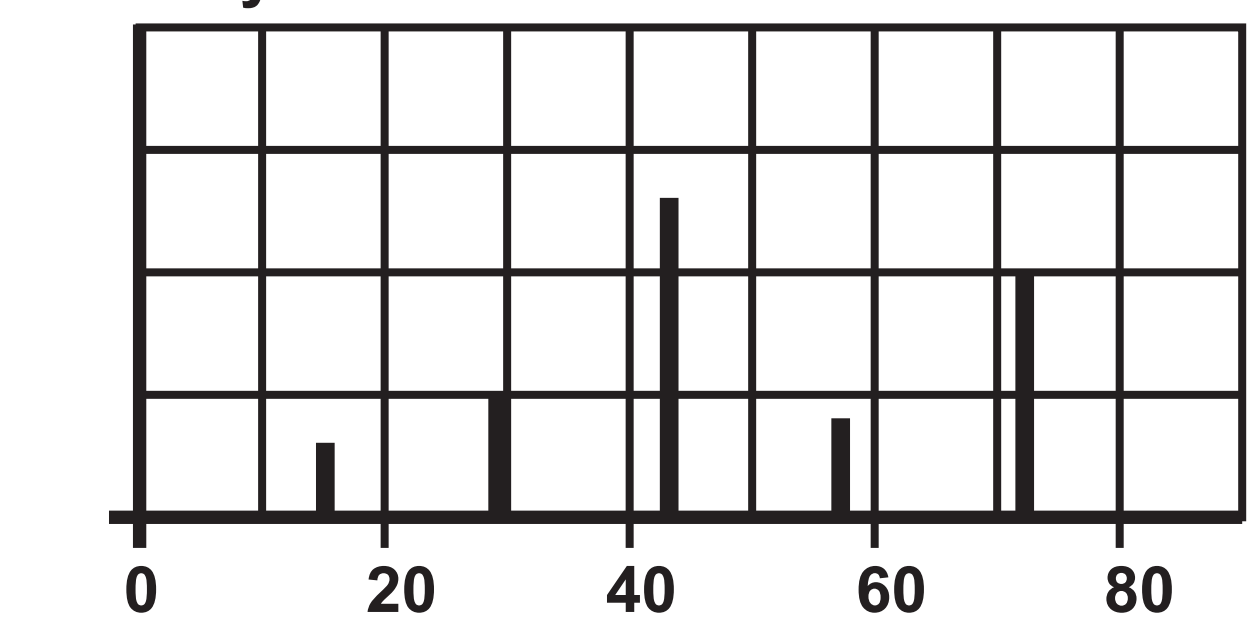


Question 10 (a)

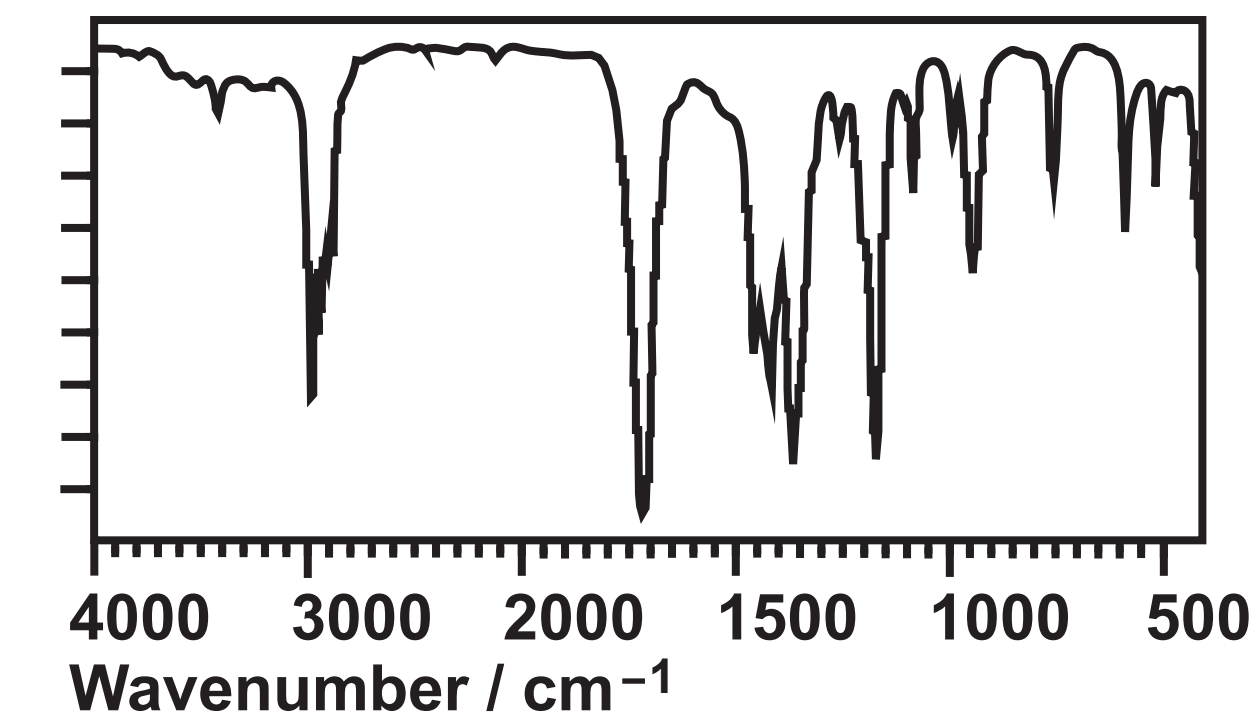


Question 11 (a)

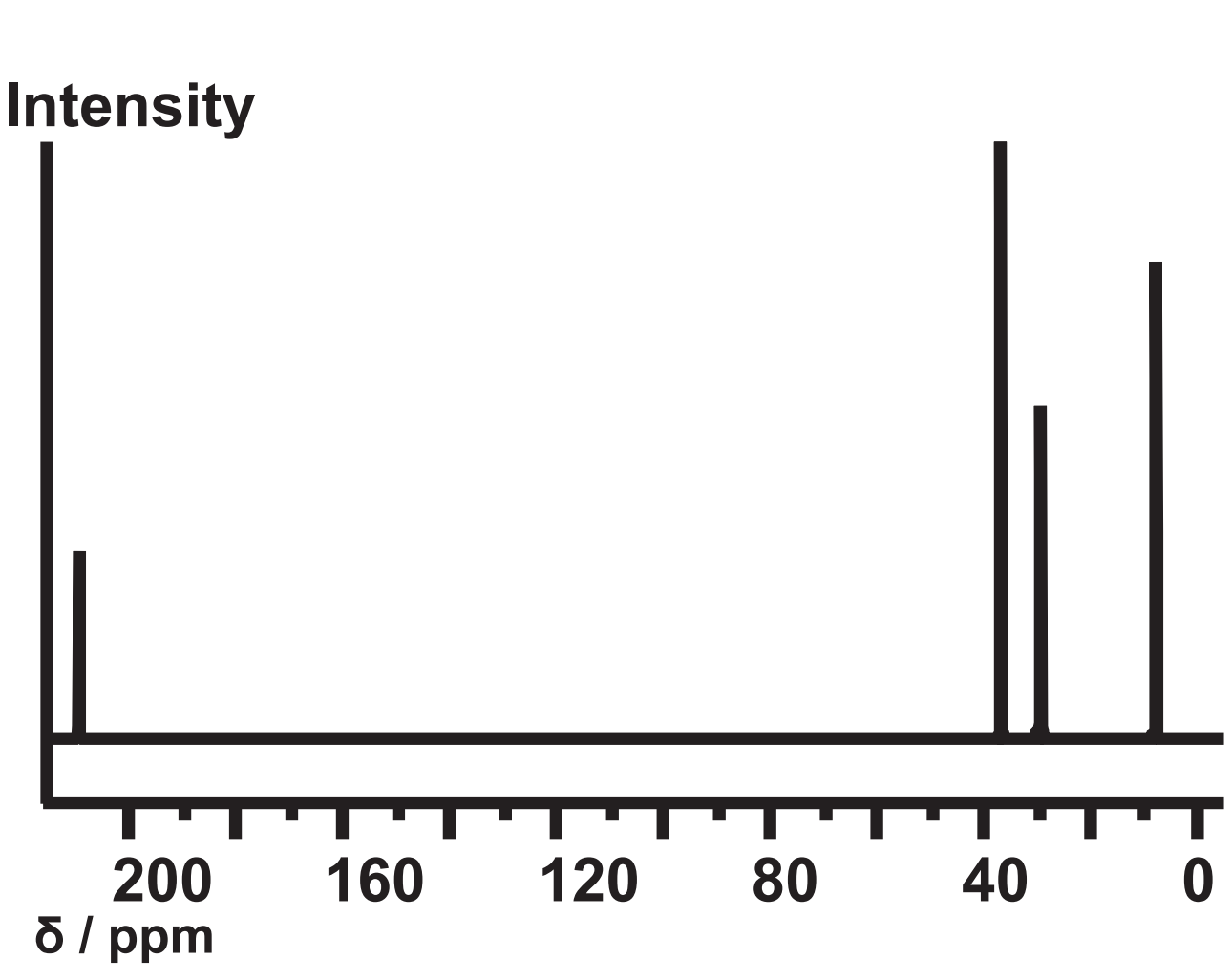
Mass spectrum:



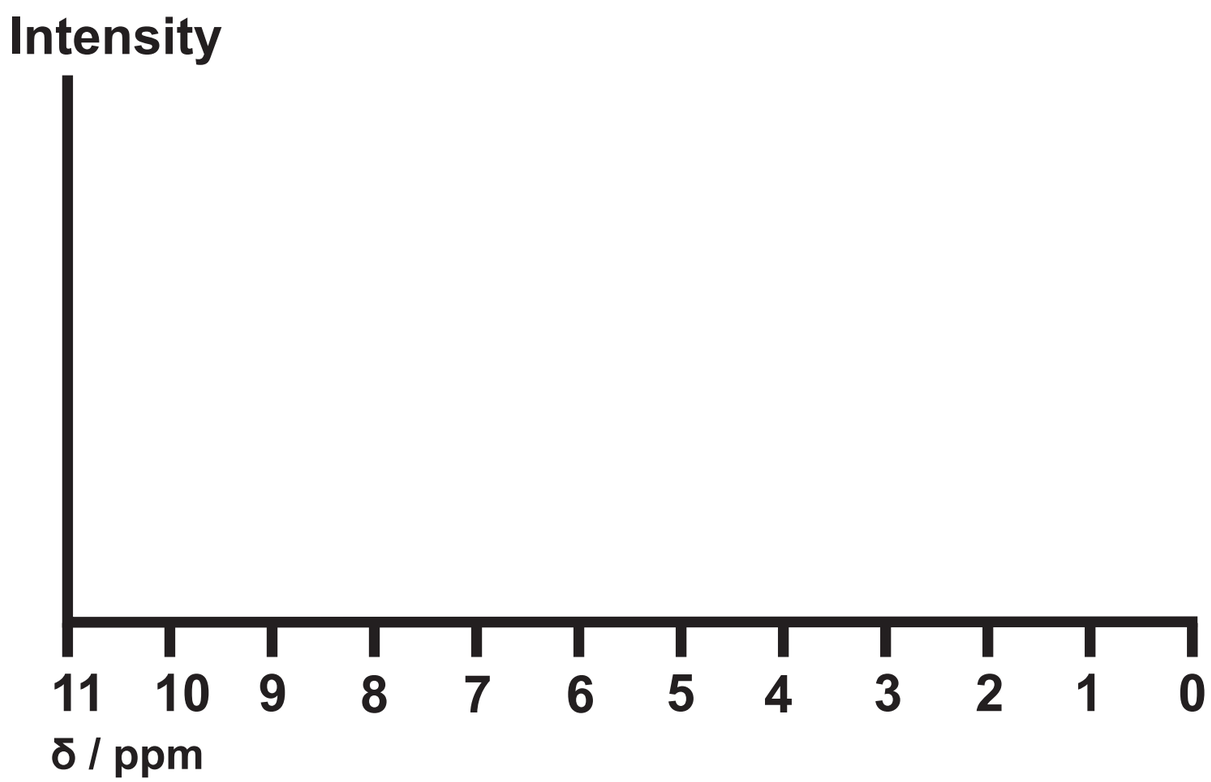
IR spectrum:



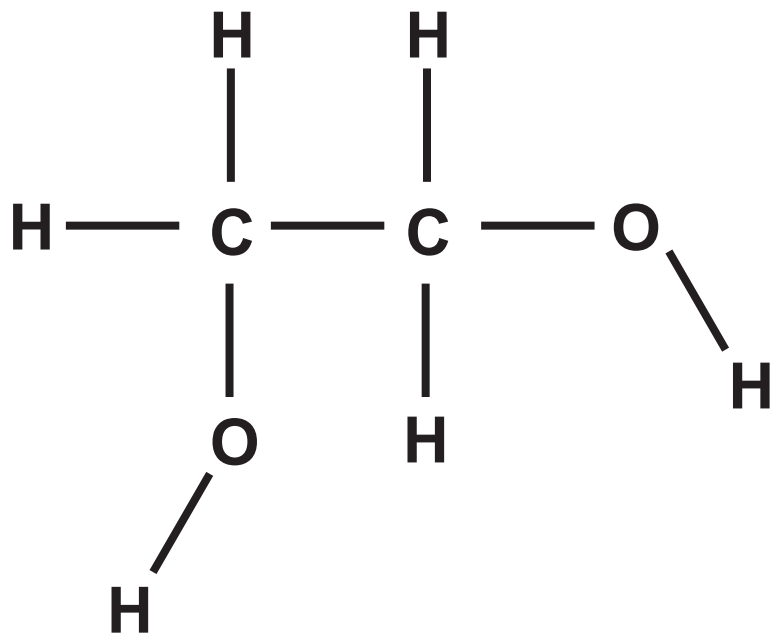
^{13}C NMR spectrum:



Question 11 (b)



Question 13 (a) (i)



Question 13 (b) (vi) I.