GCE AS/A LEVEL

2410U20–1

TUESDAY, 21 MAY 2024 – 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 |
| SECTION A | 1. to 7. | 10 | |
| SECTION B | 8. | 6 | |
| | 9. | 10 | |
| | 10. | 16 | |
| | 11. | 12 | |
| | 12. | 11 | |
| | 13. | 15 | |
| | Total | 80 | |

## ADDITIONAL MATERIALS

- A calculator and ruler
- 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.**

**SECTION A Answer ALL questions.**
**SECTION B Answer ALL questions.**

**Write your answers in the spaces provided. If you run out of space, use the additional page(s) at the back of this 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 he 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 name of the compound shown in the diagram for Question 1 in the separate Diagram Booklet.

[1 mark]

2. Draw the energy profile diagram for an endothermic reaction on the set of axes provided for Question 2 in the separate Diagram Booklet.

Label the activation energy, $E_a$, and the enthalpy change of the reaction, $\Delta H$. A spare diagram is available for this question.

[2 marks]

3. Give the molecular and empirical formulae of the compound shown in the diagram for Question 3 in the separate Diagram Booklet.

Molecular formula _____

Empirical formula _____

[2 marks]

4. Chloroethene is polymerised to make PVC.

(a) State why the chloroethene monomer does not exhibit *E* – *Z* isomerism.

[1 mark]

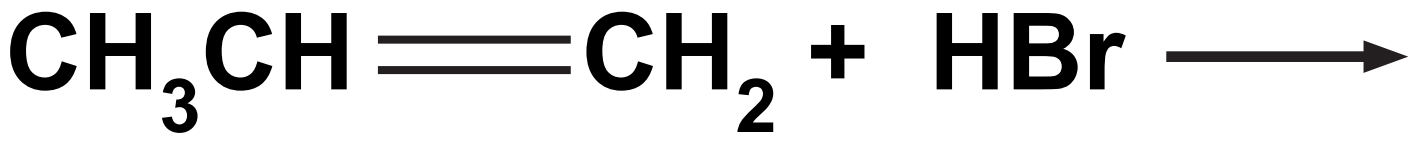
continued on the next page . . .

**Question 4 continued**

**4. (b) Draw the repeating unit for PVC in the space provided below.**

**[1 mark]**

5. Complete the equation below to show the structure of the MAIN product formed.



[1 mark]

6. Give the structure of a tertiary alcohol which contains 5 carbon atoms.

Use the space provided below.

[1 mark]

7. Name the catalyst used in the hydrogenation of unsaturated oils to make saturated fats such as margarine.

[1 mark]

**(TOTAL FOR SECTION A = 10 MARKS)**

## SECTION B

**Answer ALL questions.**

8. On heating, calcium hydroxide decomposes to produce calcium oxide and water. The equation for this reaction is shown in the diagram for Question 8 in the separate Diagram Booklet.

   The enthalpy change of this reaction cannot be measured directly.

continued on the next page . . .

## Question 8 continued

Both calcium hydroxide and calcium oxide react with dilute hydrochloric acid and enthalpy changes can be found for the reactions. Hess's law can then be used to determine $\Delta H_1$

This is also shown in the diagram for Question 8 in the separate Diagram Booklet.

continued on the next page . . .

## Question 8 continued

**Describe the practical steps you would carry out and how you would use Hess's law to determine the enthalpy change for the decomposition of calcium hydroxide, $\Delta H_1$**

**You should state clearly what needs to be measured but you should NOT calculate any values.**

**[6 QER marks]**

**(Total for Question 8 = 6 marks)**

9. Look at the reaction scheme provided for Question 9 in the separate Diagram Booklet and other information about compounds A to D given below.

A is a straight chain hydrocarbon. It contains 85•7 % carbon by mass.

B and C are structural isomers.

D is soluble in water. 0•93 g of D is dissolved in water to make 100 $cm^3$ of solution. 25•0 $cm^3$ of this solution is titrated against 0•100 mol $dm^{-3}$ aqueous sodium hydroxide.

continued on the next page . . .

**Question 9 continued**

**26•40 $cm^3$ of sodium hydroxide is needed for neutralisation. D reacts with sodium hydroxide in a ratio of 1:1**

**(a) Calculate the empirical formula of A.**

**Empirical formula**

_____

**[2 marks]**

**continued on the next page . . .**

## Question 9 continued

**9. (b) Show that the relative molecular mass ($M_r$) of D is 88**

**[3 marks]**

**continued on the next page . . .**

## Question 9 continued

(c) Give the names of compounds A to D.

A _____

B _____

C _____

D _____

**[4 marks]**

continued on the next page . . .

**Question 9 continued**

**9. (d) Name a suitable reagent for the conversion of B to D.**

**[1 mark]**

**(Total for Question 9 = 10 marks)**

10. Refer to the equation for Question 10 in the separate Diagram Booklet. Thiosulfate ions react with acid according to this equation. A student investigates the effect of changing the concentration of thiosulfate ions on the rate of the reaction.

(a) Describe how the student could prepare 250 $cm^3$ of 0•10 mol $dm^{-3}$ sodium thiosulfate solution to use in this experiment. The relative formula mass ($M_r$) of sodium thiosulfate, $Na_2S_2O_3.5H_2O$, is 248•3

continued on the next page . . .

**Question 10 (a) continued**

**You should include the apparatus needed and any relevant masses and volumes.**

[4 marks]

continued on the next page . . .

Question 10 continued

10. (b) The student mixes known volumes of aqueous $0 \cdot 10$ mol $dm^{-3}$ sodium thiosulfate and hydrochloric acid in a beaker. He places the beaker on a cross drawn on a piece of paper and measures the time taken for the cross to be obscured.

(i) State what causes the cross to become obscured.

_____

_____

[1 mark]

continued on the next page . . .

**Question 10 (b) continued**

**10. (b) (ii) Refer to the diagram for Question 10 (b) (ii) in the separate Diagram Booklet.**

**The diagram shows a beaker and a shallow dish.**

**If the student replaced the beaker with a shallow dish, state the effect this would have on the time taken to obscure the cross. Explain your answer.**

**continued on the next page . . .**

**Question 10 (b) (ii) continued**

**Assume that the student used the same volumes and concentrations in each experiment.**

**[1 mark]**

**continued on the next page . . .**

**Question 10 continued**

**10. (c) The student plans to change the concentration of $S_2O_3^{2-}(aq)$ by reducing the volume of aqueous sodium thiosulfate and adding water to keep the total volume constant.**

**The data obtained by the student for one experiment is shown in the table provided for Question 10 (c) in the separate Diagram Booklet.**

**continued on the next page . . .**

**Question 10 (c) continued**

**(i) COMPLETE THE TABLE to show suitable volumes of thiosulfate, water and acid that the student could use to investigate the effect of changing concentration of $S_2O_3^{2-}(aq)$ on the rate of the reaction.**

**[2 marks]**

**continued on the next page . . .**

**Question 10 (c) continued**

**10. (c) (ii) The rate of reaction can be calculated using**

$$\text{rate} = \frac{1000}{\text{time}}$$

**State the unit of rate in this reaction.**

_____

**[1 mark]**

**continued on the next page . . .**

**Question 10 (c) continued**

**10. (c) (iii) The student calculates the rate of reaction using different volumes of $S_2O_3^{2-}(aq)$ and plots a graph.**

**The graph for Question 10 (c) (iii) is shown in the separate Diagram Booklet.**

**State what can be deduced from the shape of this graph.**

_____

_____

_____

**[1 mark]**

**continued on the next page . . .**

**Question 10 continued**

**10. (d) Another student uses a similar experiment to investigate the effect of changing the temperature on the rate of this reaction. He draws a graph of his data. The graph is shown in the diagram for Question 10 (d) in the separate Diagram Booklet.**

**continued on the next page . . .**

**Question 10 (d) (i) continued**

**10. (d) (i) Use the graph to determine the time taken for the cross to be obscured at a temperature of 35 °C.**

**Show clearly how you obtained your answer.**

$$\text{rate} = \frac{1000}{\text{time}}$$

**Time = _____ s**

**[2 marks]**

**continued on the next page . . .**

**Question 10 (d) continued**

**10. (d) (ii) Some textbooks state that a 10 °C temperature rise approximately doubles the rate of many reactions.**

**Use the graph to find to what extent this is true for this reaction.**

[2 marks]

continued on the next page . . .

**Question 10 (d) continued**

**10. (d) (iii) Explain why the rate of the reaction is affected by an increase in temperature.**

**[2 marks]**

**(Total for Question 10 = 16 marks)**

11. **Compound X is thought to be a halogenoalkane containing only one halogen atom.**

    (a) **Describe a chemical test by which you could identify which halogen is present in X.**

[4 marks]

continued on the next page . . .

**Question 11 continued**

**11. (b) A simplified form of the mass spectrum, the $^{13}C$ NMR spectrum and the low resolution $^{1}H$ NMR spectrum of halogenoalkane X are shown in the diagram for Question 11 (b) in the separate Diagram Booklet.**

**Use this information to find the structure of halogenoalkane X. Show your reasoning.**

**You must use information from ALL the spectra.**

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(Turn over)

(Turn over)

(Turn over)

**Structure of X**

**[8 marks]**

**(Total for Question 11 = 12 marks)**

12. (a) State what is meant by the enthalpy change of combustion.

_____

_____

_____

[2 marks]

(b) (i) Refer to the equation for Question 12 (b) in the separate Diagram Booklet. The equation corresponds to the enthalpy change of combustion of propan –1 – ol.

continued on the next page . . .

## Question 12 (b) (i) continued

Refer to the apparatus shown in the diagram for Question 12 (b) (i) in the separate Diagram Booklet.

The apparatus can be used to determine the enthalpy change for this reaction.

continued on the next page . . .

**Question 12 (b) (i) continued**

**A student used this apparatus and obtained the following results.**

**Initial mass of spirit burner with propan –1 – ol = 126•16 g**

**Final mass of spirit burner with propan –1 – ol = 126•02 g**

**Initial temperature of water = 21•0 °C**

**Final temperature of water = 33•5 °C**

**Volume of water in beaker = 100 $cm^3$**

**continued on the next page . . .**

**Question 12 (b) (i) continued**

**Use these results in parts I and II.**

**I. Calculate the number of moles of propan –1 – ol used up in the reaction.**

**Number of moles = _____ mol**

**[1 mark]**

**continued on the next page . . .**

**Question 12 (b) (i) continued**

**12. (b) (i) II. Calculate the enthalpy change of combustion of propan –1 – ol, $\Delta_c H$, under these conditions of temperature and pressure.**

**Answer space continues on the next page.**

## Question 12 (b) (i) II continued

$\Delta_c H$ = _____ _____ kJ mol$^{-1}$

*sign* *value*

[3 marks]

continued on the next page . . .

**Question 12 (b) continued**

**12. (b) (ii) Another student suggested that leaving the spirit burner to burn for longer would increase the accuracy of the experiment.**

**State whether you agree with this student. Explain your answer.**

**[1 mark]**

**continued on the next page . . .**

**Question 12 continued**

**12. (c) Enthalpy changes of combustion can be used to determine average bond enthalpies.**

**Some average bond enthalpies are given in the table below.**

| Bond | Average bond enthalpy / kJ mol $^{-1}$ |
|---|---|
| O═O | 496 |
| C—H | 412 |
| C—C | 348 |
| C═O | 805 |
| O—H | 463 |

**continued on the next page . . .**

## Question 12 (c) continued

**Refer to the equation for Question 12 (c) in the separate Diagram Booklet. The equation corresponds to the enthalpy change of combustion of butan – 1– ol.**

**continued on the next page . .**

## Question 12 (c) continued

**Use the enthalpy change of combustion of butan – 1– ol and the average bond enthalpies in the table to calculate the average bond enthalpy of a C — O bond.**

**Answer space continues on the next page.**

**Question 12 (c) continued**

**Average bond enthalpy [C — O]**

**= _____ kJ mol$^{-1}$**

**[4 marks]**

**(Total for Question 12 = 11 marks)**

13. (a) Two students were discussing how to prepare chloroethane. One student suggested reacting chlorine with ethane but the other student said that the yield from this reaction was poor and that it was better to react hydrogen chloride with ethene.

(i) State the TYPE of reaction involved in each case.

ethane and chlorine

_____

ethene and hydrogen chloride

_____

[2 marks]

continued on the next page . . .

**Question 13 (a) continued**

**13. (a) (ii) Suggest why the reaction between ethene and hydrogen chloride gives the better yield.**

**[1 mark]**

**continued on the next page . . .**

**Question 13 (a) continued**

**13. (a) (iii) Give the mechanism for the reaction between ethene and hydrogen chloride.**

**Use the space below to show your answer.**

**[4 marks]**

**continued on the next page . . .**

Question 13 continued

13. (b) Refer to the equation for Question 13 (b) in the separate Diagram Booklet. The equation for the reaction between ethanoic acid and methanol to form an ester is shown.

(i) In the preparation of this ester, 25 g of ethanoic acid reacted with excess methanol. If the percentage yield of the reaction was 34 %, calculate the mass of ester formed.

Answer space continues on the next page.

# Question 13 (b) (i) continued

**Mass = _____ g**

**[3 marks]**

**continued on the next page . . .**

**Question 13 (b) continued**

**13. (b) (ii) Refer to the diagram for Question 13 (b) (ii) in the separate Diagram Booklet.**

**The diagram shows the method used to separate the ester from the reaction mixture.**

**DRAW ON THE DIAGRAM**

- **the position of the thermometer**
- **the direction of water flowing through the condenser**

**continued on the next page . . .**

Question 13 (b) continued

A spare diagram is available for this question

[2 marks]

13. (b) (iii) Addition of concentrated sulfuric acid increases the yield of ester. Explain this observation.

[2 marks]

continued on the next page . . .

**Question 13 continued**

**13. (c) Draw the structure of the ester formed when propan – 2 – ol reacts with methanoic acid.**

**[1 mark]**

**(Total for Question 13 = 15 marks)**

**TOTAL FOR SECTION B = 70 MARKS**

**TOTAL FOR PAPER = 80 MARKS**

**END OF PAPER**

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

| Question Number | Additional pages, if required. Write the question number(s) in the left – hand margin. |
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| Question Number | Additional pages, if required. Write the question number(s) in the left – hand margin. |
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GCE AS/A LEVEL

2410U20–1

**TUESDAY, 21 MAY 2024 – 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

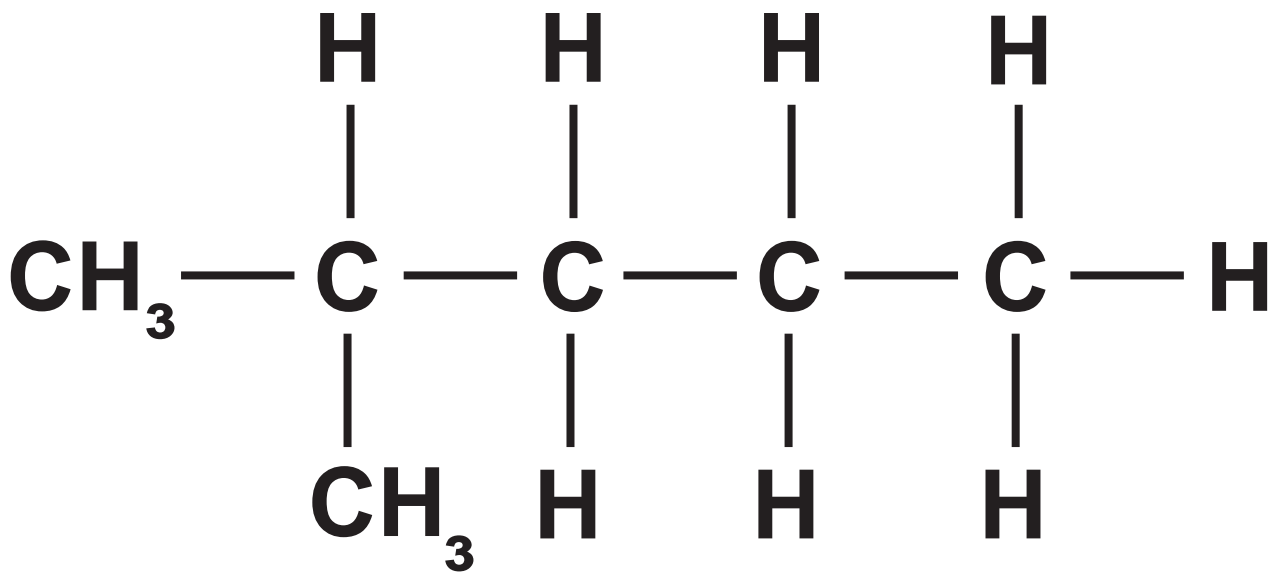
**Surname:** _____

**First Name(s):** _____

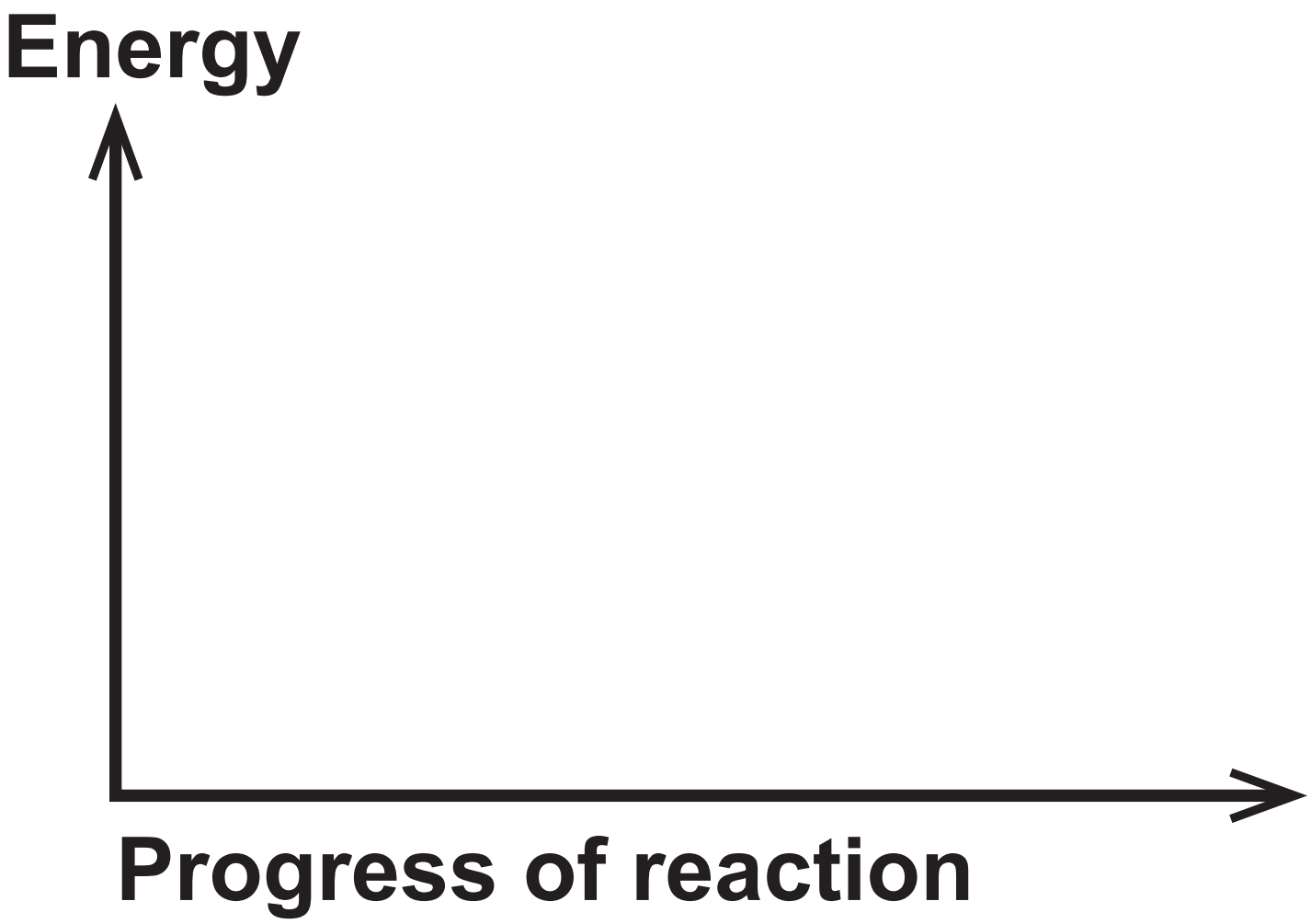
**Centre Number:** _____

**Candidate Number:** 2 _____

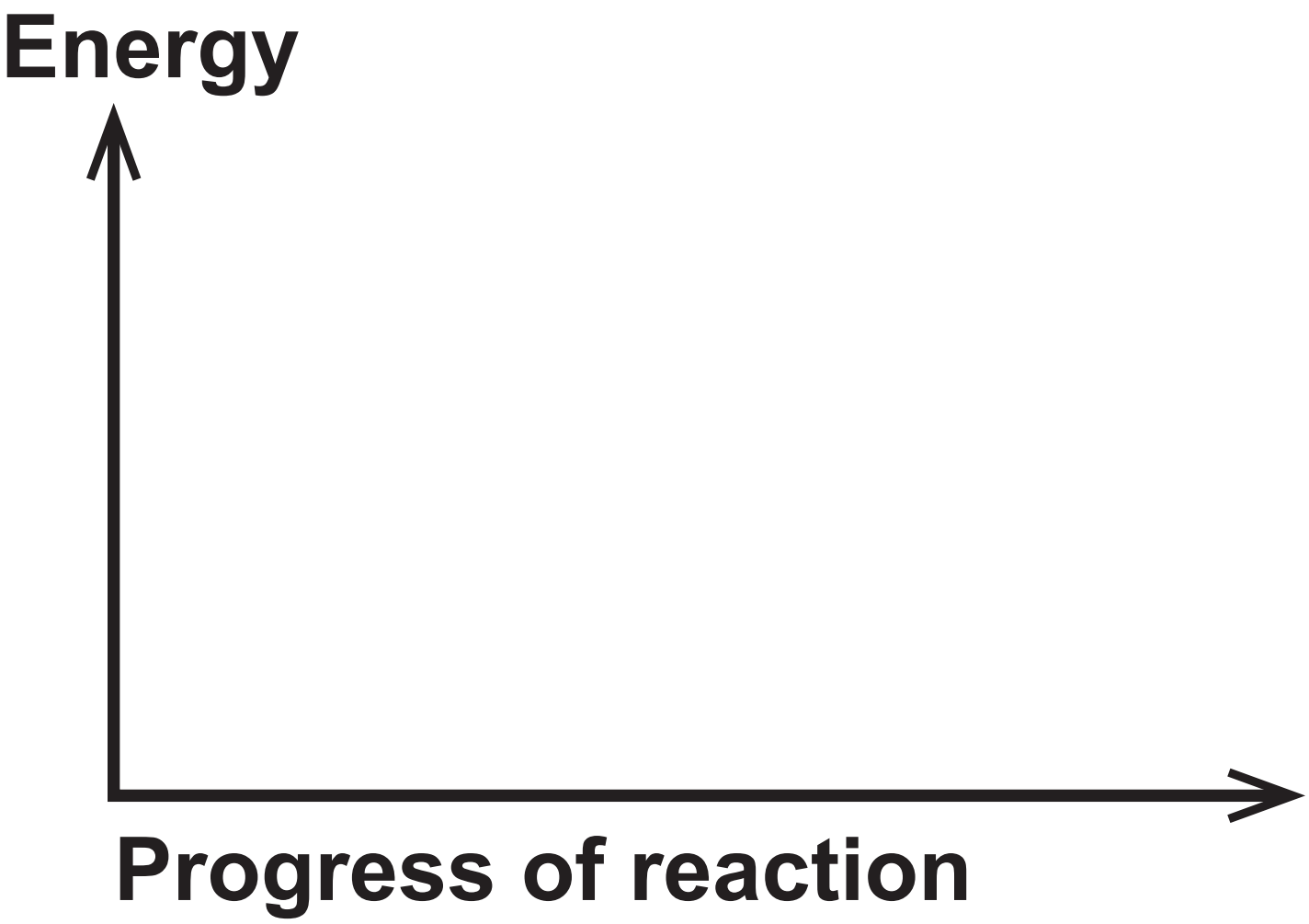
# Question 1



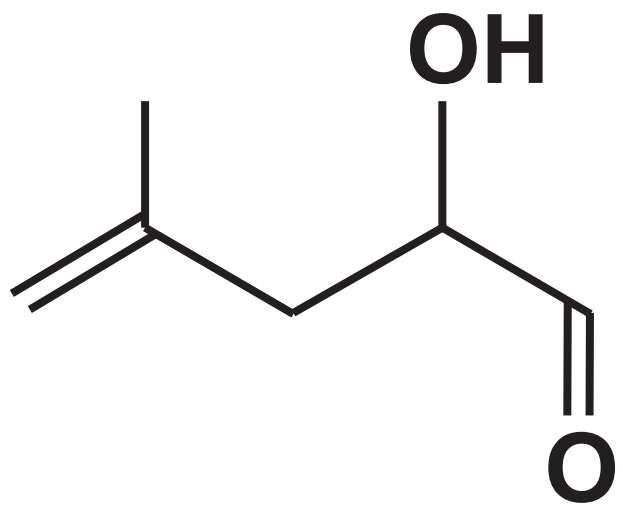
# Question 2



**Spare copy** **Question 2**



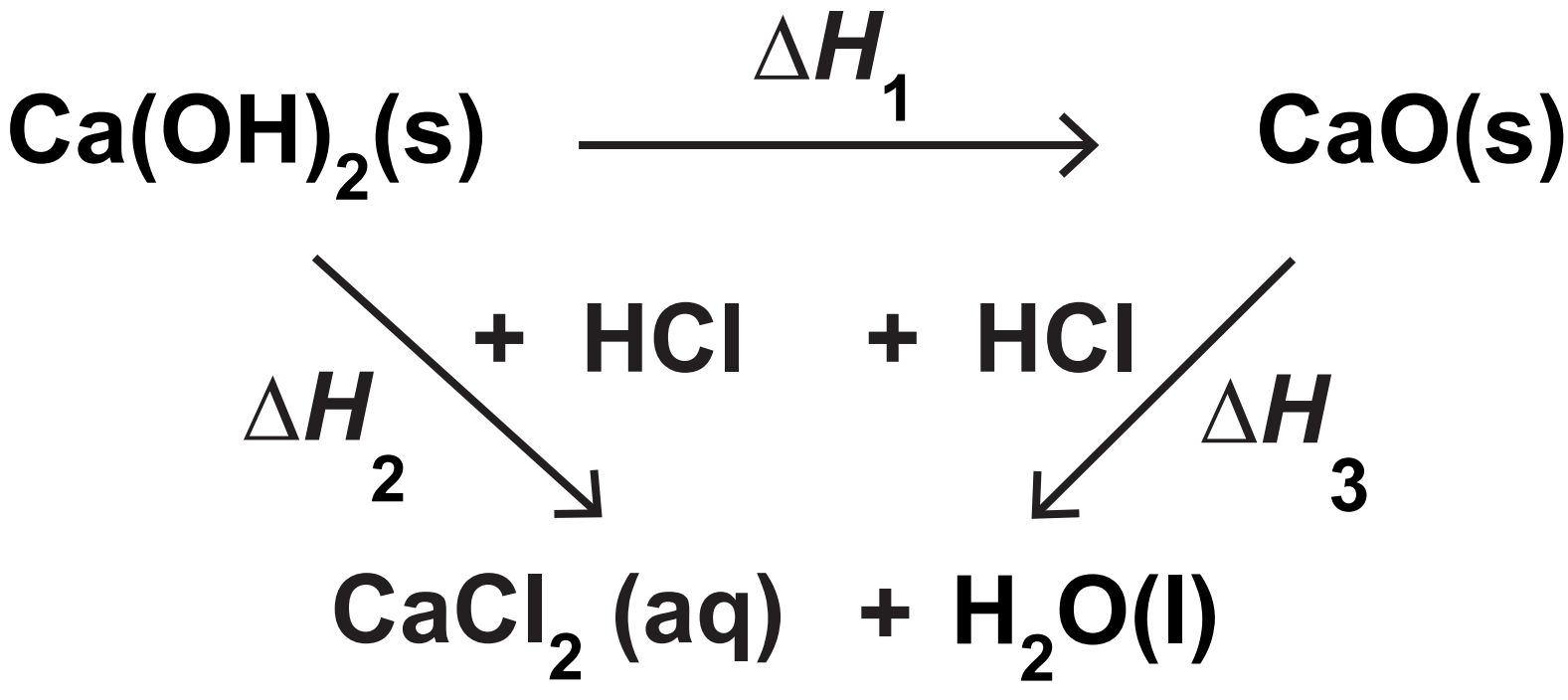
# Question 3



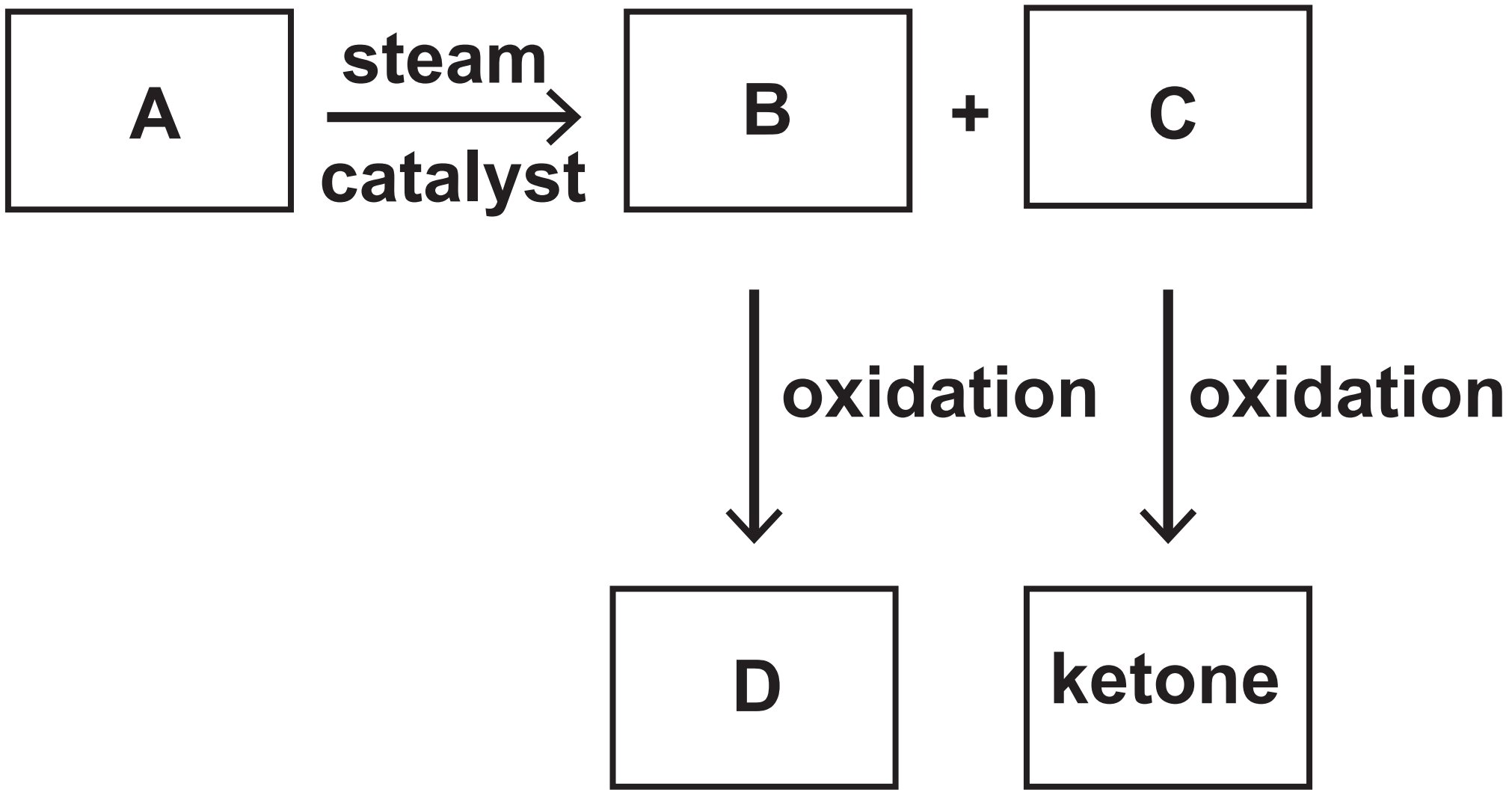
# Question 8

# EQUATION

$$Ca(OH)_2(s) \longrightarrow CaO(s) + H_2O(l) \qquad \Delta H_1$$

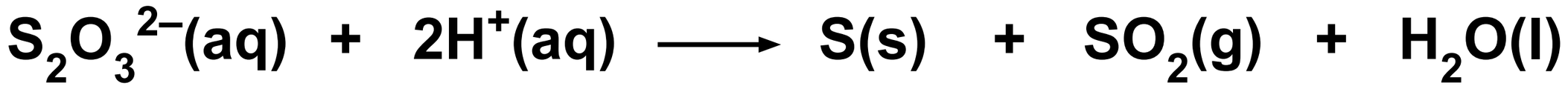


# Question 9

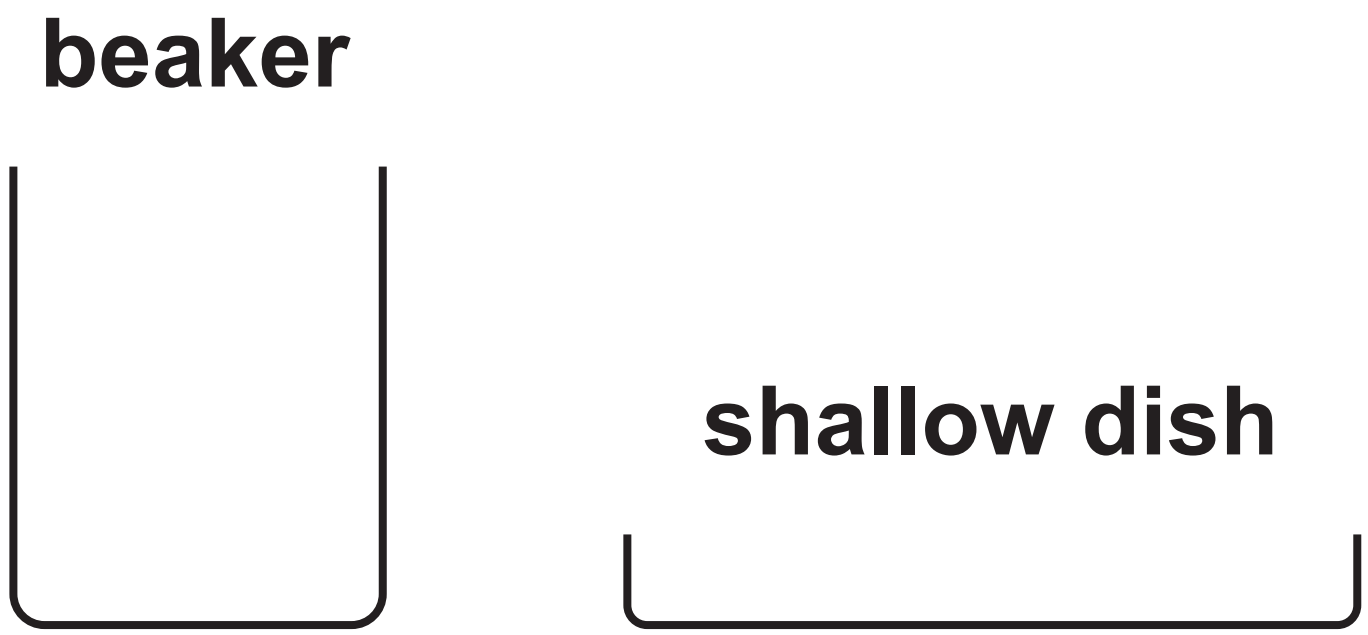


# Question 10

## EQUATION



# Question 10 (b) (ii)

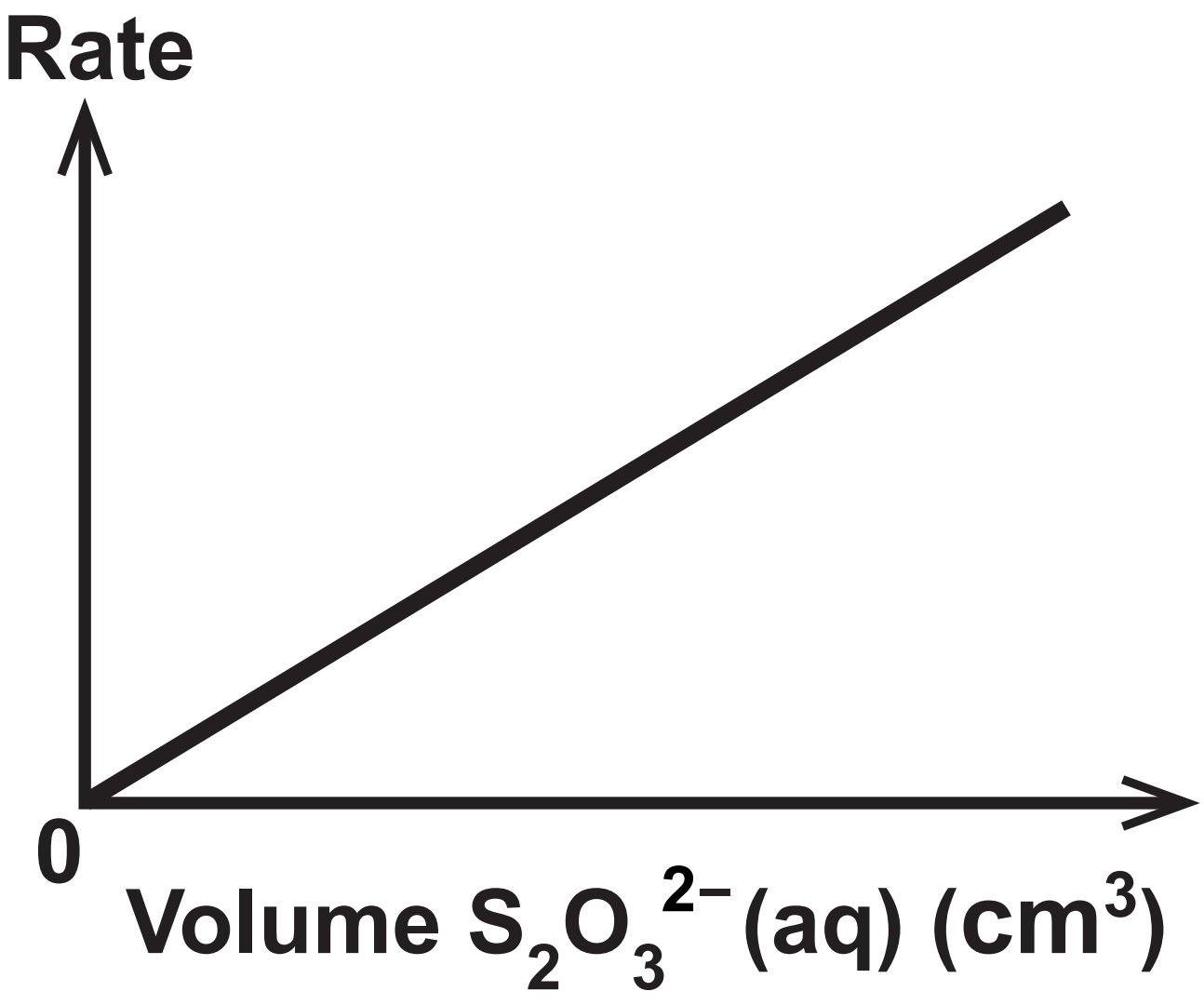


# Question 10 (c)

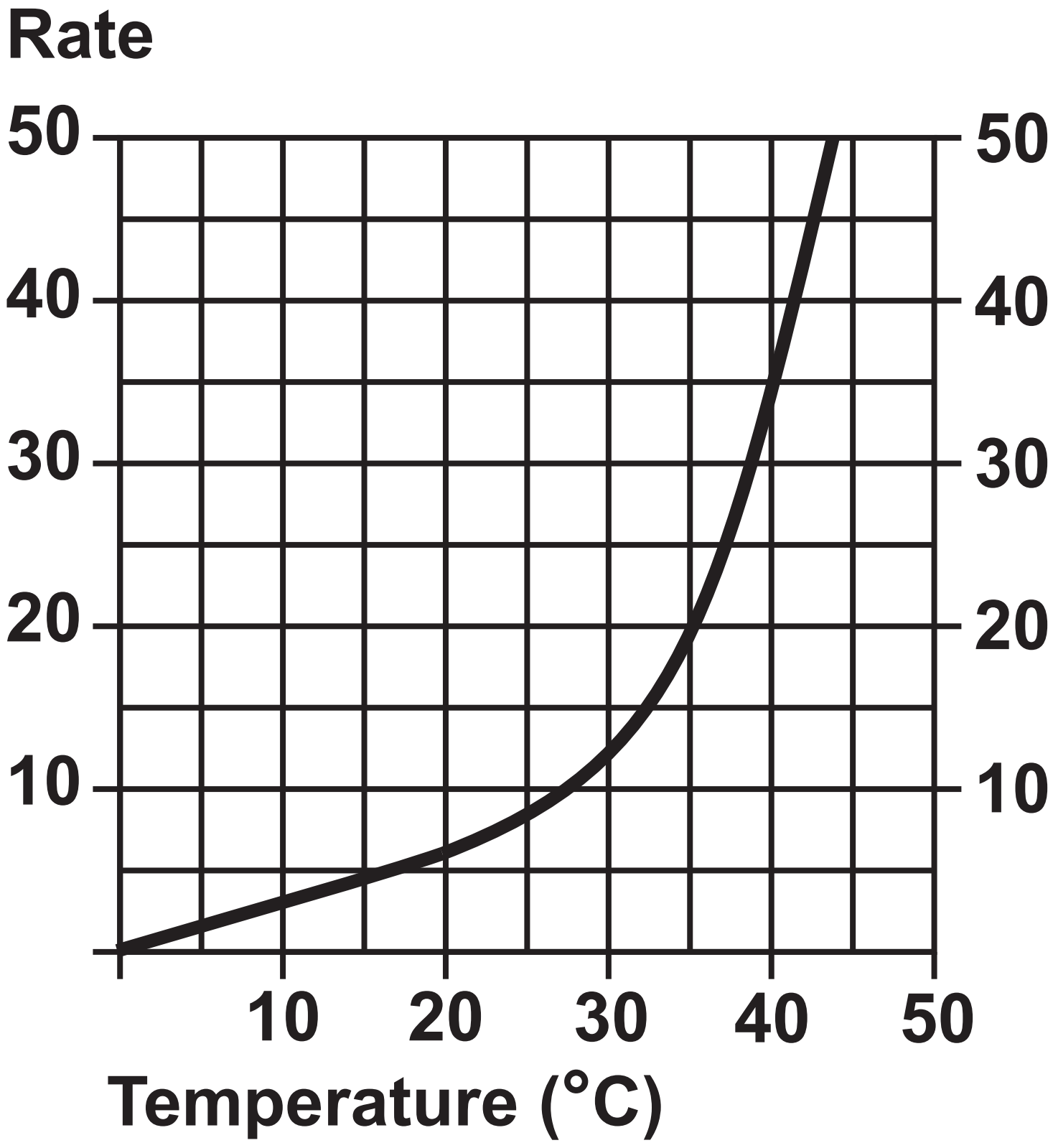
## TABLE

| Volume $S_2O_3^{2-}$(aq) ($cm^3$) | Volume $H_2O$ ($cm^3$) | Volume HCl(aq) ($cm^3$) | Time (s) |
|---|---|---|---|
| 40 | 0 | 10 | 50 |
| | | | |
| | | | |
| | | | |

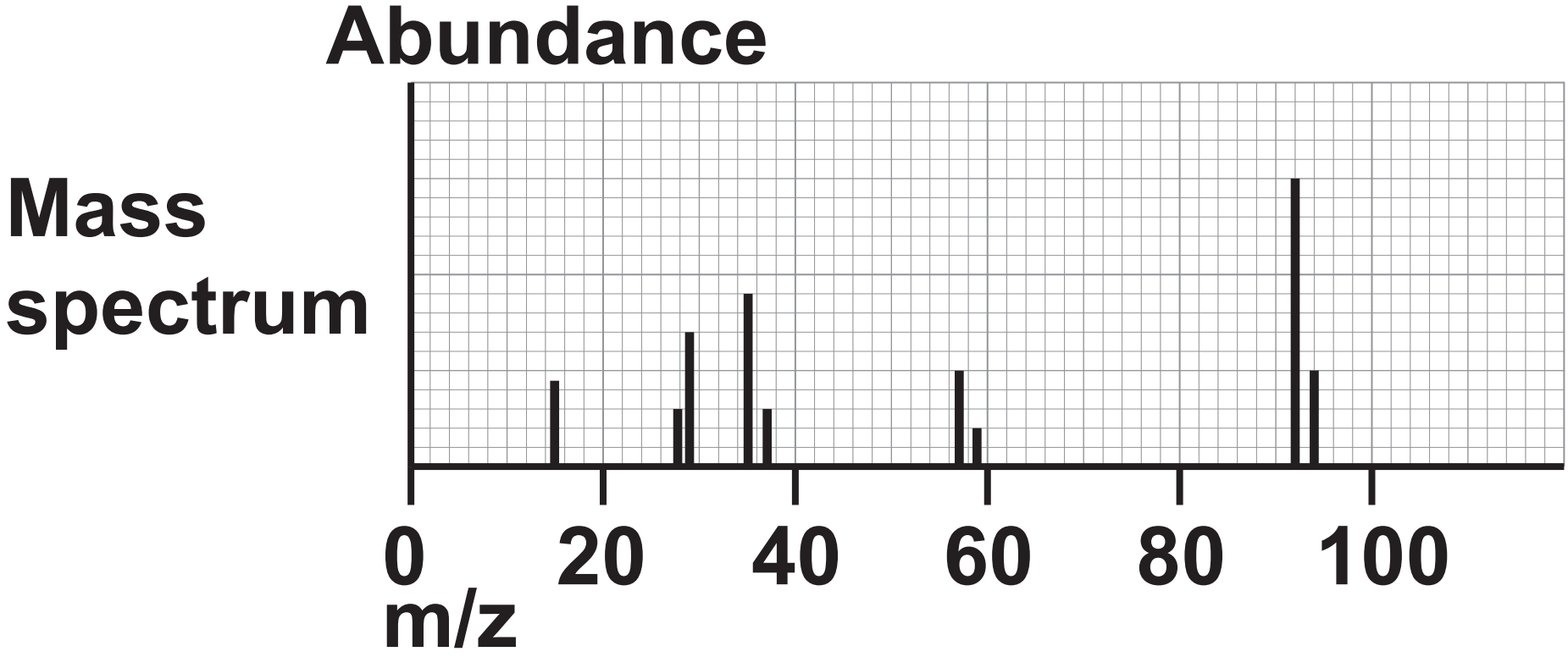
# Question 10 (c) (iii)

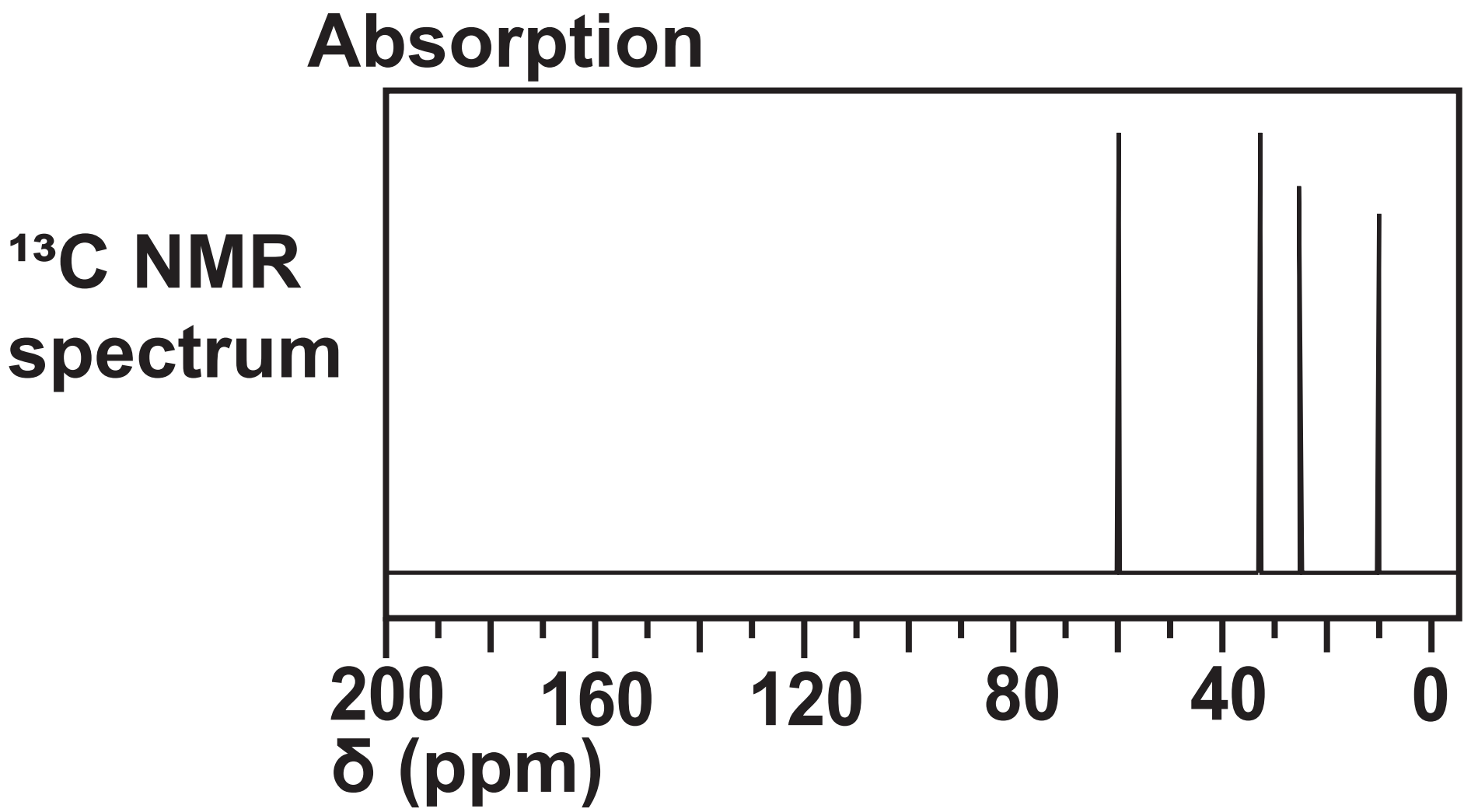


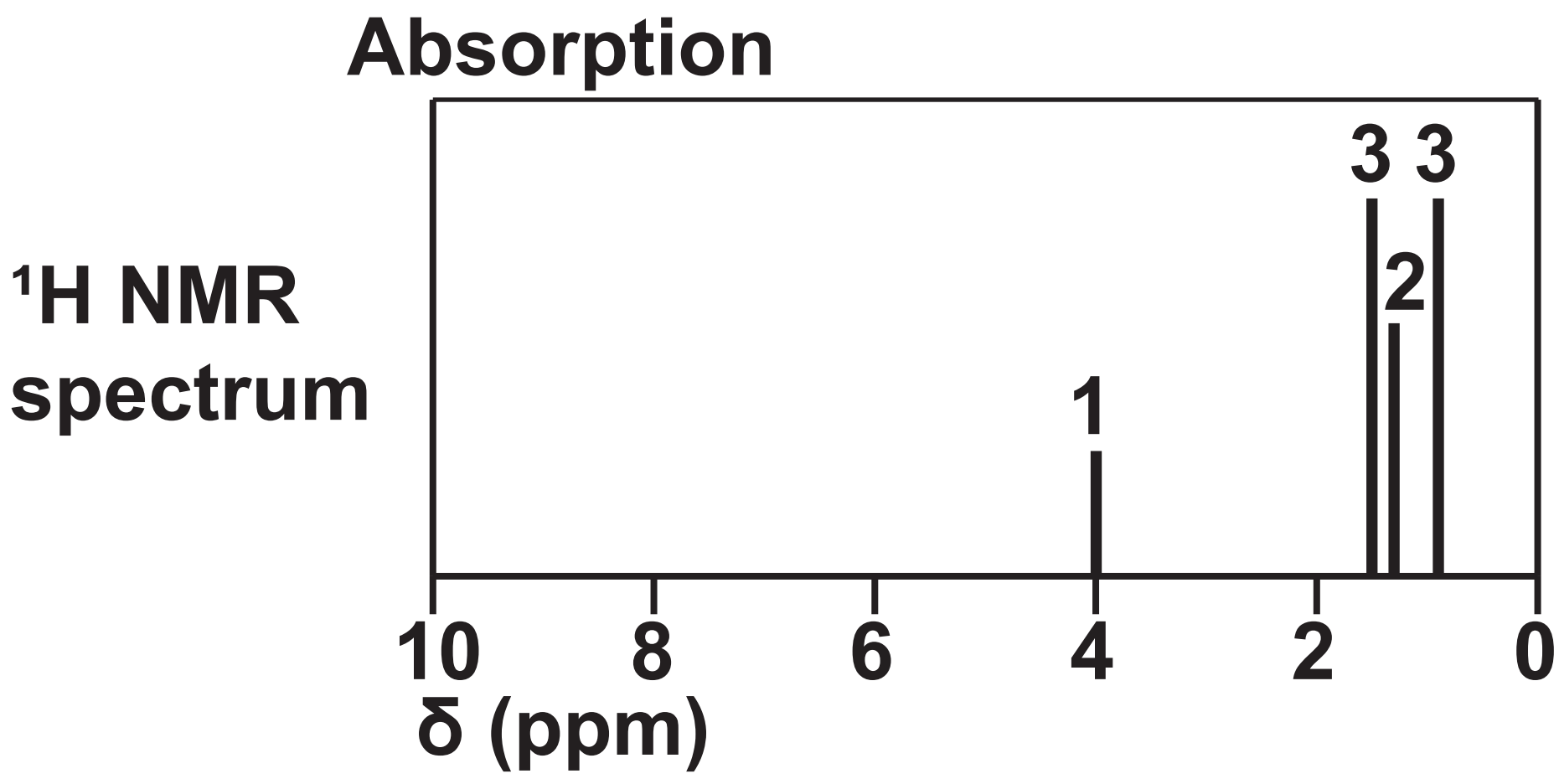
# Question 10 (d)



# Question 11 (b)



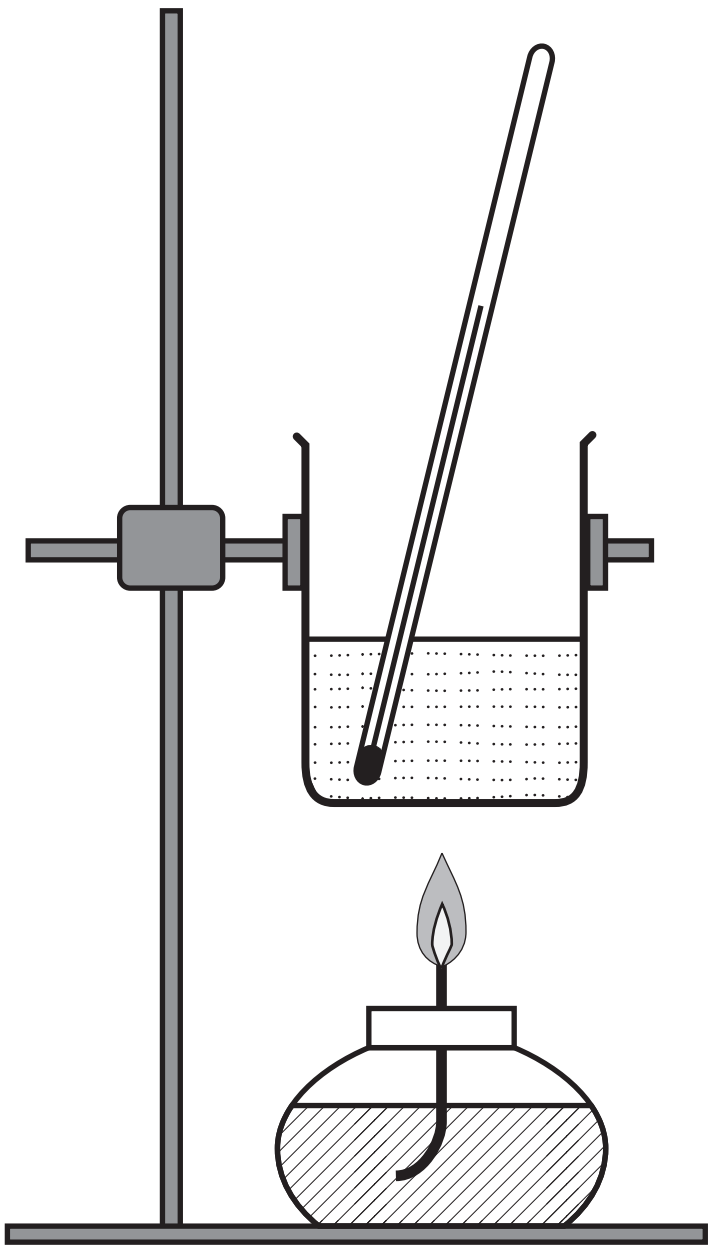



# Question 12 (b) (i)

## EQUATION

$$C_3H_7OH(l) + 4\frac{1}{2}O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(l)$$

# Question 12 (b) (i)



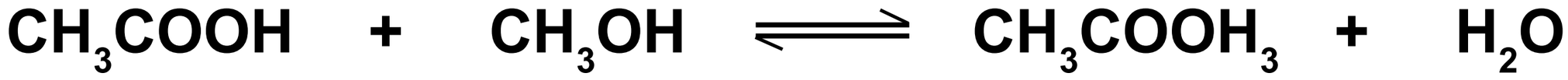
# Question 12 (c)

## EQUATION

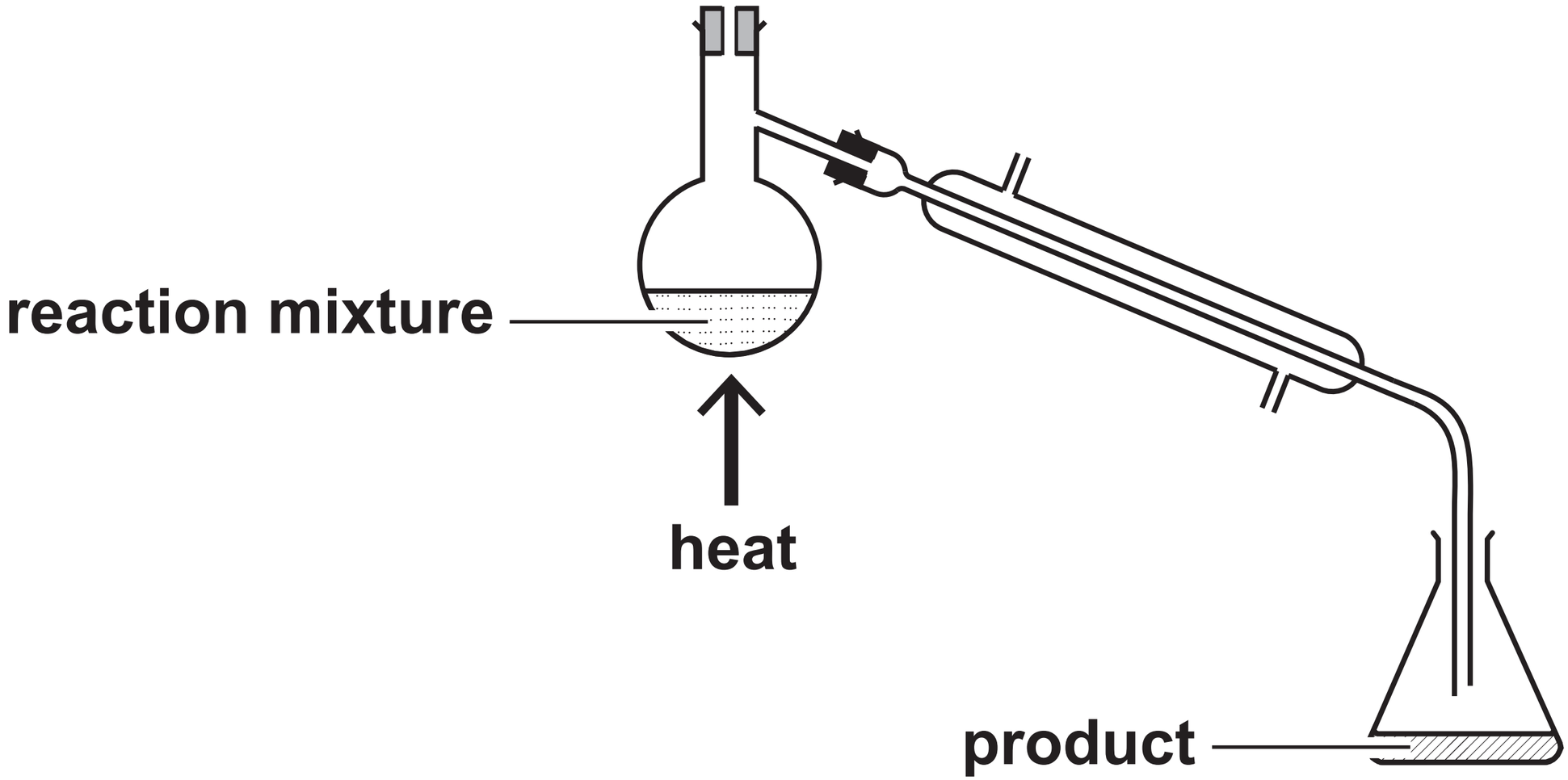
$$C_4H_9OH(l) + 6O_2(g) \longrightarrow 4CO_2(g) + 5H_2O(l) \qquad \Delta_c H = -2\,676 \text{ kJ mol}^{-1}$$

# Question 13 (b)

## EQUATION



# Question 13 (b) (ii)



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**Question 13 (b) (ii)**