

Section A

Answer **all** questions in the spaces provided.

- 1** The rate of hydrolysis of an ester **X** ($\text{HCOOCH}_2\text{CH}_2\text{CH}_3$) was studied in alkaline conditions at a given temperature. The rate was found to be first order with respect to the ester and first order with respect to hydroxide ions.

- 1 (a) (i)** Name ester **X**.

.....
(1 mark)

- 1 (a) (ii)** Using **X** to represent the ester, write a rate equation for this hydrolysis reaction.

.....
(1 mark)

- 1 (a) (iii)** When the initial concentration of **X** was $0.024 \text{ mol dm}^{-3}$ and the initial concentration of hydroxide ions was $0.035 \text{ mol dm}^{-3}$, the initial rate of the reaction was $8.5 \times 10^{-5} \text{ mol dm}^{-3} \text{ s}^{-1}$.
Calculate a value for the rate constant at this temperature and give its units.

Calculation

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Units

.....
(3 marks)

- 1 (a) (iv)** In a second experiment at the same temperature, water was added to the original reaction mixture so that the total volume was doubled.
Calculate the initial rate of reaction in this second experiment.

.....

.....
(1 mark)



- 1 (a) (v)** In a third experiment at the same temperature, the concentration of **X** was half that used in the experiment in part **1 (a) (iii)** and the concentration of hydroxide ions was three times the original value.
Calculate the initial rate of reaction in this third experiment.

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.....
(1 mark)

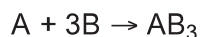
- 1 (a) (vi)** State the effect, if any, on the value of the rate constant k when the temperature is lowered but all other conditions are kept constant. Explain your answer.

Effect

Explanation

.....
(2 marks)

- 1 (b)** Compound **A** reacts with compound **B** as shown by the overall equation



The rate equation for the reaction is

$$\text{rate} = k[A][B]^2$$

A suggested mechanism for the reaction is



Deduce which one of the three steps is the rate-determining step.

Explain your answer.

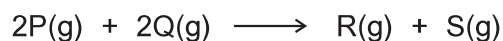
Rate-determining step

Explanation

.....
(2 marks)



- 2** Gases **P** and **Q** react as shown in the following equation.



The initial rate of the reaction was measured in a series of experiments at a constant temperature. The following rate equation was determined.

$$\text{rate} = k[\text{P}]^2[\text{Q}]$$

- 2 (a)** Complete the table of data for the reaction between **P** and **Q**.

Experiment	Initial [P] / mol dm ⁻³	Initial [Q] / mol dm ⁻³	Initial rate / mol dm ⁻³ s ⁻¹
1	2.5×10^{-2}	1.8×10^{-2}	5.0×10^{-5}
2	7.5×10^{-2}	1.8×10^{-2}	
3	5.0×10^{-2}		5.0×10^{-5}
4		5.4×10^{-2}	4.5×10^{-4}

(3 marks)

(Space for working)

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- 2 (b)** Use the data from Experiment **1** to calculate a value for the rate constant (*k*) at this temperature. Deduce the units of *k*.

Calculation

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Units

.....

(3 marks)



- 6 (a)** In the presence of the catalyst rhodium, the reaction between NO and H₂ occurs according to the following equation.



The kinetics of the reaction were investigated and the rate equation was found to be

$$\text{rate} = k[\text{NO}]^2[\text{H}_2]$$

The initial rate of reaction was $6.2 \times 10^{-6} \text{ mol dm}^{-3} \text{ s}^{-1}$ when the initial concentration of NO was $2.9 \times 10^{-2} \text{ mol dm}^{-3}$ and the initial concentration of H₂ was $2.3 \times 10^{-2} \text{ mol dm}^{-3}$.

- 6 (a) (i)** Calculate the value of the rate constant under these conditions and give its units.

Calculation

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Units

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(3 marks)

- 6 (a) (ii)** Calculate the initial rate of reaction if the experiment is repeated under the same conditions but with the concentrations of NO and of H₂ both doubled from their original values.

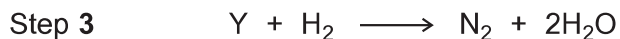
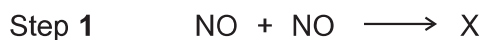
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(1 mark)



- 6 (b)** Using the rate equation and the overall equation, the following three-step mechanism for the reaction was suggested. X and Y are intermediate species.



Suggest which **one** of the three steps is the rate-determining step.

Explain your answer.

Rate-determining step.....

Explanation

.....

.....

(2 marks)

(Extra space)

.....

6

Turn over for the next question

Turn over ►

