

Name of the Student: _____

Max. Marks : 19 Marks

Time : 19 Minutes

Q1.

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.

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

(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}

(Space for working) _____

(3)

(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 _____

Units _____

(3)

(Total 6 marks)

Q2.

- (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 $2.3 \times 10^{-2} \text{ mol dm}^{-3}$.

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

Calculation _____

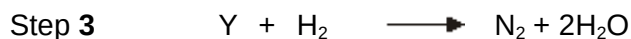
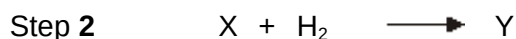
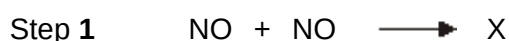
Units _____

(3)

- (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.

(1)

- (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)

(Total 6 marks)

Q3.

The initial rate of the reaction between two gases **P** and **Q** was measured in a series of experiments at a constant temperature. The following rate equation was determined.

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

- (a) Complete the table of data below 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	0.20	0.30	$1.8 = 10^{-3}$
2	0.40	0.60	
3	0.60		$5.4 = 10^{-3}$
4		0.90	$12.2 = 10^{-3}$

(Space for working) _____

(3)

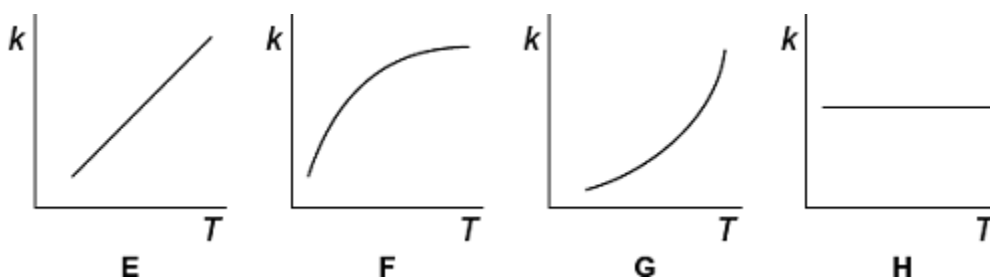
- (b) Use the data from Experiment **1** to calculate a value for the rate constant k and deduce its units.

Calculation _____

Units _____

(3)

- (c) Consider the graphs **E**, **F**, **G** and **H** below.



Write in the box below the letter of the graph that shows how the rate constant k varies with temperature.

(1)

(Total 7 marks)