

## THE RATE LAW

1. Explain what is meant by the rate law of a reaction.
2. What is meant by the order of a reaction?
3. What are the units for the rate constants of zero-order, first-order, and second-order reactions?
4. On which of the following properties does the rate constant of a reaction depend ?
  - a. Reactant concentration, (b) nature of reactants, (c) temperature.
5. Determine the overall orders of the reactions to which the following rate laws apply:
  - (a)  $\text{rate} = k [\text{NO}_2]^2$ , (b)  $\text{rate} = k$ , (c)  $\text{rate} = k [\text{NO}]^2 [\text{O}_2]$

6. Consider the reaction:  $\text{A} \longrightarrow \text{B}$

The rate of the reaction is  $1.6 \times 10^{-2} \text{ mol L}^{-1} \text{ s}^{-1}$  when the concentration of A is  $0.35 \text{ mol L}^{-1}$ . Calculate the rate constant if the reaction is (a) first order in A and (b) second order in A.

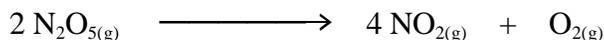
7. Consider the following data for the given reaction carried out at 300K.



Experiment	[NO] (mol/L)	[Cl <sub>2</sub> ] (mol/L)	Rate (mol/Ls)
1	0.01	0.01	$1.2 \times 10^{-4}$
2	0.01	0.02	$2.4 \times 10^{-4}$
3	0.02	0.02	$9.6 \times 10^{-4}$

- a) Analyze the data to determine the values of the orders for this expression.
- b) What is the overall order of this reaction?
- c) What is the molecularity of this reaction?
- d) Use the data to determine the value of the rate constant, and state its units.
- e) Based on your findings, write the rate law expression with the correct value for  $k$  substituted into the equation.
- f) Use the rate law established above to determine the rate of the reaction at 300K, if the  $[\text{NO}] = 0.03 \text{ mol/L}$  and the  $[\text{Cl}_2] = 0.04 \text{ mol/L}$ .
- g) What would be the overall rate of this reaction if the concentration of  $\text{NO}_{(g)}$  was doubled and the concentration of  $\text{Cl}_{2(g)}$  was halved ? (note: no calculation required !!!)

8. The following data were collected for the decomposition of dinitrogen pentoxide,  $\text{N}_2\text{O}_{5(\text{g})}$ , at a fixed temperature.



Experiment	$[\text{N}_2\text{O}_5]$ (mol/L)	Rate (mol/Lcmin)
1	0.0014	$0.4 \times 10^{-4}$
2	0.0028	$0.8 \times 10^{-4}$
3	0.0046	$1.3 \times 10^{-4}$

- Analyze the data provided to determine the order of the reaction.
  - Determine the value of the rate constant for the reaction at this temperature.
  - State the units of the rate constant for the reaction at this temperature.
  - What would the reaction rate be for this reaction when the concentration of the dinitrogen pentoxide,  $\text{N}_2\text{O}_{5(\text{g})}$ , is:
    - 0.0019 mol/L
    - 0.0113 mol/L
9. The following data were obtained by studying the reaction between compounds A, B and C at a constant temperature.

Experiment	[A] (mol dm <sup>-3</sup> )	[B] (mol dm <sup>-3</sup> )	[C] (mol dm <sup>-3</sup> )	Initial rate (mol dm <sup>-3</sup> s <sup>-1</sup> )
1	0.20	0.10	0.40	$0.80 \times 10^{-3}$
2	0.20	0.40	0.40	$3.20 \times 10^{-3}$
3	0.10	0.80	0.40	$1.60 \times 10^{-3}$
4	0.10	0.30	0.20	$0.60 \times 10^{-3}$

- Deduce the order of the reaction with respect to A.
  - Deduce the order of the reaction with respect to B.
  - Deduce the order of the reaction with respect to C.
  - What is the rate law for the reaction?
  - Calculate a value for the rate constant, k, and state its units.
10. The rate equation for the reaction between compounds D and E at a given temperature is :

$$\text{Rate} = k [\text{D}]^2 [\text{E}]$$

The initial rate of reaction is  $8.36 \times 10^{-4} \text{ mol dm}^{-3} \text{ s}^{-1}$  when the initial concentration of D is  $0.84 \text{ mol dm}^{-3}$  and the initial concentration of E is  $1.16 \text{ mol dm}^{-3}$ . Calculate a value for the rate constant, k, at this temperature and deduce its units.