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) rate = k $[NO_2]^2$, rate = k, (c) rate = k $[NO]^2$ $[O_2]$

6. Consider the reaction: A $\longrightarrow$ B

   The rate of the reaction is 1.6 x10^{-2} molL^{-1}**s^{-1}** when the concentration of A is 0.35 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.

$$2\ NO_{(g)} + Cl_{2(g)} \longrightarrow 2\ NOCl_{(g)}$$

Experiment	**[NO] (mol/L)**	**[Cl_2] (mol/L)**	**Rate (mol/LCs)**
1	0.01	0.01	1.2 x 10^{-4}
2	0.01	0.02	2.4 x 10^{-4}
3	0.02	0.02	9.6 x 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 [NO] = 0.03 mol/L and the [Cl_2] = 0.04 mol/L.

g) What would be the overall rate of this reaction of the concentration of $NO_{(g)}$ was doubled and the concentration of $Cl_{2\ (g)}$ was halved ? (note: no calculation required !!!)

8. The following data were collected for the decomposition of dinitrogen pentoxide, $N_2O_{5(g)}$, at a fixed temperature.

$$2\ N_2O_{5(g)} \longrightarrow 4\ NO_{2(g)} + O_{2(g)}$$

Experiment	$[N_2O_5]$ (mol/L)	Rate (mol/L⋅min)
1	0.0014	0.4×10^{-4}
2	0.0028	0.8×10^{-4}
3	0.0046	1.3×10^{-4}

a) Analyze the data provided to determine the order of the reaction.

b) Determine the value of the rate constant for the reaction at this temperature.

c) State the units of the rate constant for the reaction at this temperature.

d) What would the reaction rate be for this reaction when the concentration of the dinitrogen pentoxide, $N_2O_{5(g)}$, is:

i. 0.0019 mol/L ii. 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^{-3})	[B] (mol dm^{-3})	[C] (mol dm^{-3})	Initial rate (mol dm^{-3} s^{-1})
1	0.20	0.10	0.40	0.80×10^{-3}
2	0.20	0.40	0.40	3.20×10^{-3}
3	0.10	0.80	0.40	1.60×10^{-3}
4	0.10	0.30	0.20	0.60×10^{-3}

a. Deduce the order of the reaction with respect to A.
b. Deduce the order of the reaction with respect to B.
c. Deduce the order of the reaction with respect to C.
d. What is the rate law for the reaction?
e. 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 :

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

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