Overall Reaction Order

Zero order reaction rate: the rate of the reaction is always the Same.

$$aA \rightarrow bB \qquad \text{Rate} = k[A]^0 = k$$

- Doubling [A] will have NO effect on the reaction rate.
  - rate is independent of time!

First order reaction rate: the rate of the reaction is directly proportional to the reactant concentration.

$$aA \rightarrow bB \qquad \text{Rate} = k[A]^1 = k[A]$$

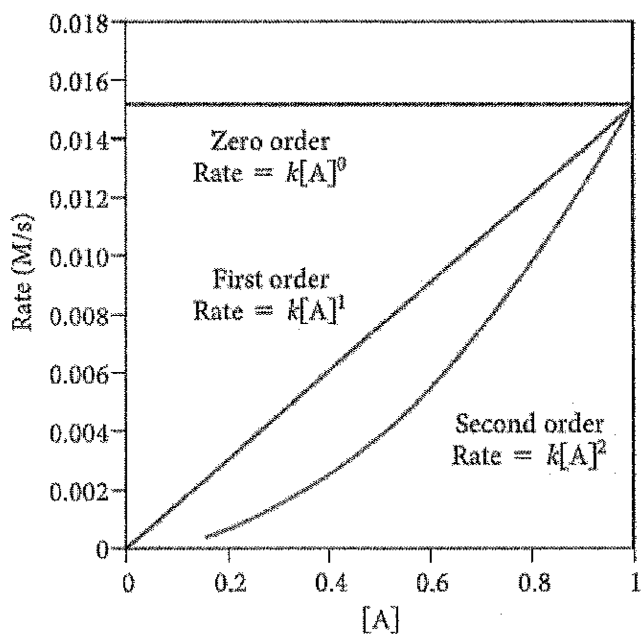
- Doubling [A] will double the reaction rate.

Second order reaction rate: the rate is directly proportional to the square of the reactant concentration.

$$aA \rightarrow bB \qquad \text{Rate} = k[A]^2$$

- Doubling [A] will quadruple the reaction rate.

Rate versus Reactant Concentration



How to determine orders:

1. Order must be determined experimentally!
2. In reaction with multiple reactants, changing the concentration of 1 reactant will affect the overall rate of the reaction.
   a. Change the initial concentration of 1 reactant at a time, while holding the initial concentration of the other reactants constant!
   b. Conduct multiple trials with changing concentrations of each reactant, and measure the rate each time to determine the affect of each change.

Example:

For example, for the following reaction, $2NO(g) + Cl_2(g) \rightarrow 2NOCl(g)$

this data was collected:

Trial	[NO] mol/L	$[Cl_2]$ mol/L	Rate (M/s)
1	0.200	0.200	1.20×10^{-6}
2	0.400	0.200	4.80×10^{-6}
3	0.200	0.400	2.40×10^{-6}
4	0.400	0.400	9.6×10^{-6}

a) Comparing Trial 1 and Trial 2:
- ➔ the concentration of NO: 2X (doubled)
- ➔ the concentration of Cl_2: Constant
- ➔ The reaction rate is increased 4 times,

Therefore, the rate of reaction with respect to NO is second order ($2^2 = 4$).

$2^x = 4 \Rightarrow x = 2$

To justify your answer, you will need to explain this process. You could explain the above answer like this:

From trials 1 and 2: doubling [NO] (or 2x[NO]) while keeping $[Cl_2]$ constant increases rate by a factor of 4 (or ↑ rate x 4), thus rxn is 2nd order w/ respect to NO.

b) Comparing Trial 1 and Trial 3:
- ➔ the concentration of NO: Constant
- ➔ the concentration of Cl_2: 2X (doubled)
- ➔ The reaction rate is increased 2 times,

Therefore, the rate of reaction with respect to Cl_2 is first order ($2^1 = 2$).

$2^x = 2 \Rightarrow x = 1$

Justify your answer here:

From trials 1 and 3: $2 \times [Cl_2]$ while [NO] constant ↑ rate x 2, thus the rxn is 1st order w/ respect to Cl_2.

c) What is the rate law for the reaction? $rate = k[NO]^2[Cl_2]$

d) What is the value of the rate constant, k? (You can use any trial!) ☆my answer uses trial 1

$$k = \frac{rate}{[NO]^2[Cl_2]} = \frac{1.20E-6\ M/s}{(0.200)^3 (M)^3} = \boxed{1.50 \times 10^{-4}\ M^{-2}s^{-1}\ \left(\frac{1}{M^2 s}\right)}$$

e) For trial 3, calculate the concentration of Cl_2 remaining when 25% of the original amount of NO has been consumed.

$$0.25 \times 0.200\,M = 0.050\ \frac{mol}{L}\ NO \times \frac{1\ mol\ Cl_2}{2\ mol\ NO} = 0.025\ M\ Cl_2 \text{ used up!}$$

$$\text{remaining} = 0.400\,M - 0.025\,M = \boxed{0.375\ M\ Cl_2}$$