

Topic 16 Chemical Kinetics (HL)

Syllabus:

16.1 Rate expression and reaction mechanism

Reaction may occur by more than one step and the slowest step determines the rate of reaction (RDS).

The molecularity of an elementary step is the number of reactant particles taking part in that step.

The order of a reaction can be either integer or fractional in nature. The order of a reaction can describe, with respect to a reactant, the number of particles taking part in the RDS.

Rate equations can only be determined experimentally.

The value of the rate constant(k) is affected by temperature and its units are determined from the overall order of the reaction.

Catalysts alter a reaction mechanism, introducing a step with lower activation energy.

16.2 Activation energy

The Arrhenius equation uses the temperature dependence of the rate constant to determine the activation energy.

A graph of $1/T$ against $\ln k$ is a linear plot with gradient $-E_a/R$ and intercept, $\ln A$.

The frequency factor (A) takes into account the frequency of collisions with proper orientations.

16.1 Rate expression and mechanism

(A) The rate law for a reaction is only determined experimentally

For the reaction: $A + B \rightarrow$ products

The rate expression can be written as

$$\text{Rate} = k[A]^m[B]^n$$

k is rate constant

m is the order with respect to reactant A

n is the order with respect to reactant B

Overall order = $m + n$

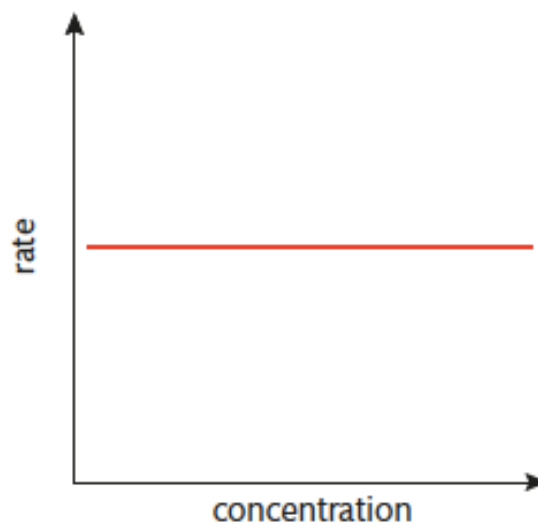
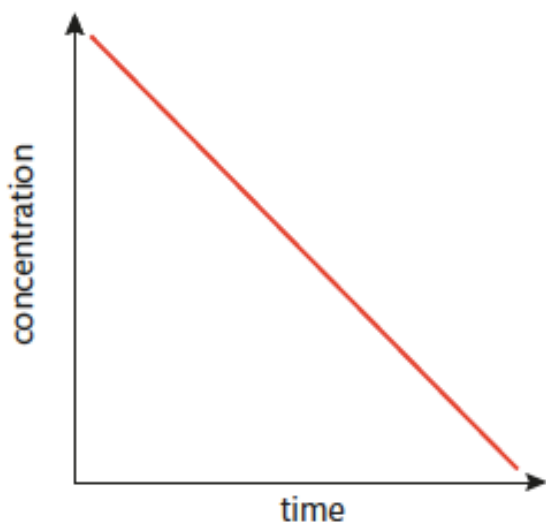
Zero Order

$$\text{Rate} = k[A]^0$$

The unit of k is $\text{mol dm}^{-3} \text{s}^{-1}$

Rate is independent to $[A]$.

$[A]$ decreases linearly with time.



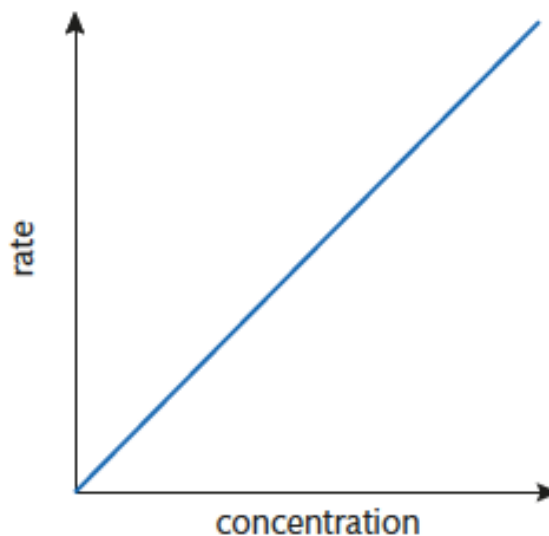
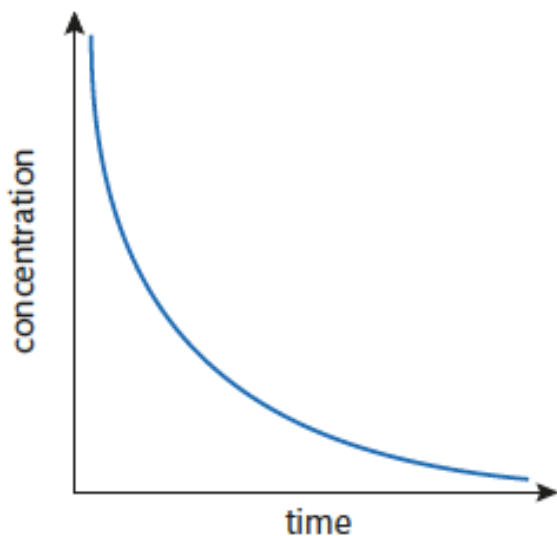
First Order

$$\text{Rate} = k[A]^1$$

The unit of k is s^{-1} .

$[A]$ decreases curvedly with time.

Rate is directly proportional to $[A]$.



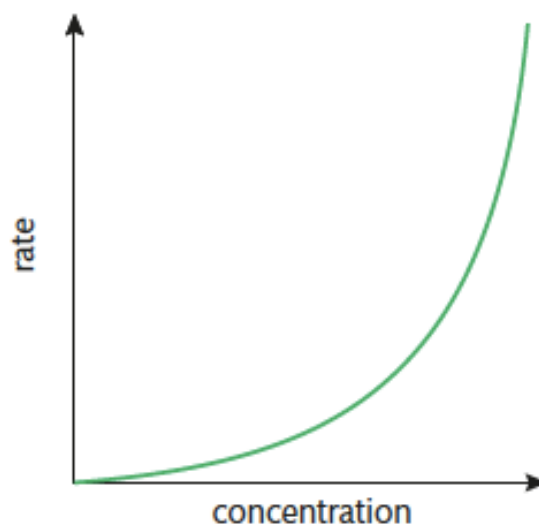
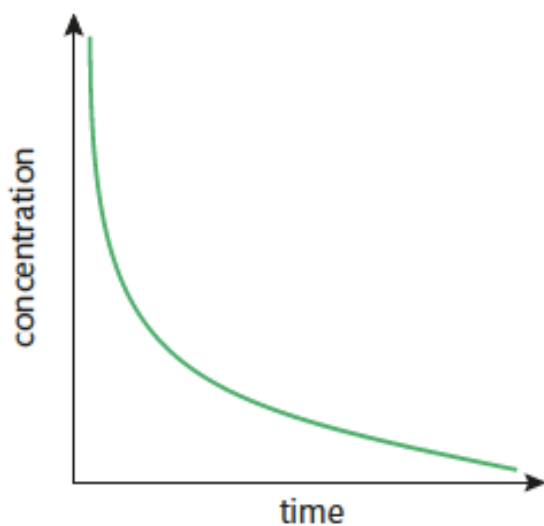
Second Order

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

The unit of k is $\text{mol}^{-1} \text{dm}^3 \text{s}^{-1}$.

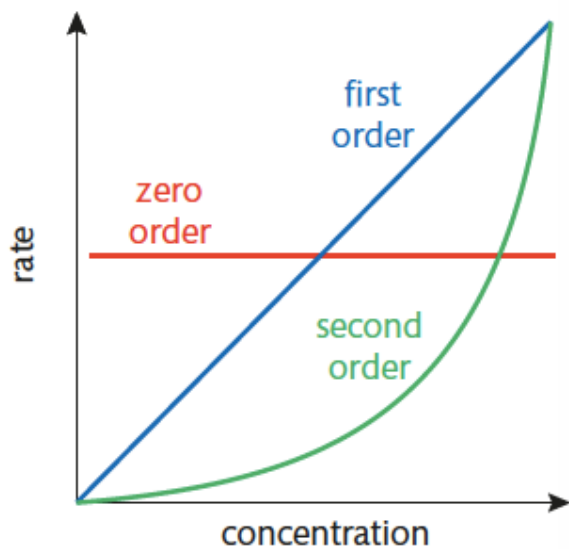
$[A]$ decreases curvedly with time, steeper at the start than the first order graph.

Rate is proportional to $[A]$, increasing parabola.

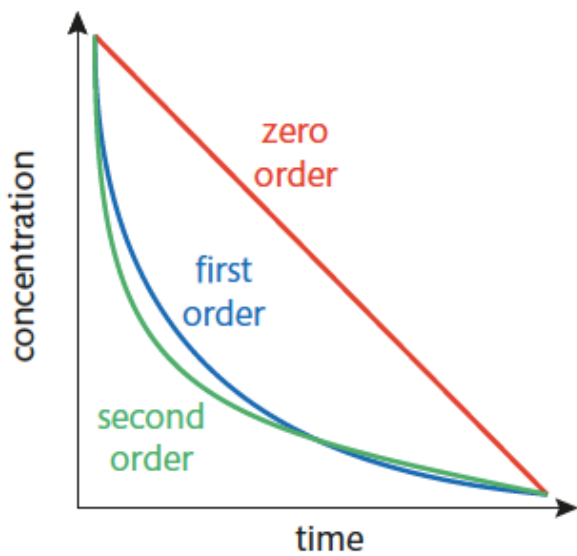


➤ **Summary of the graphs**

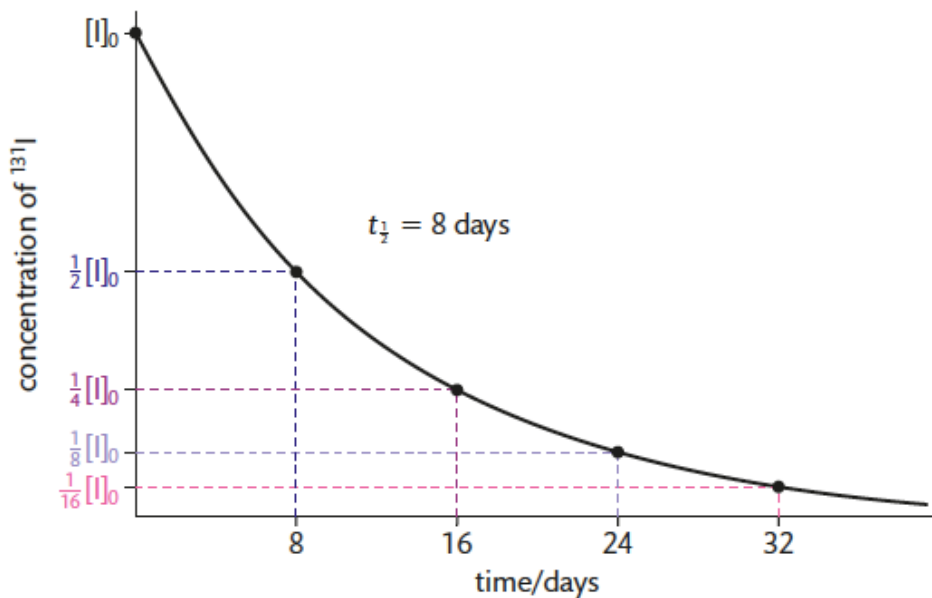
Rate vs Concentration



Concentration vs Time



- **How to distinguish first or second order of concentration-time graph**
First order reactions have a constant half-life.



(B) Determination of the order of a reaction

Question 1

Use the data in the following table to find the order with respect to reactants A and B and thus write the rate expression for this reaction.

Experiment	[A] / mol dm ⁻³	[B] / mol dm ⁻³	Initial rate / mol dm ⁻³ s ⁻¹
1	0.10	0.20	3 x 10 ⁻²
2	0.10	0.40	6 x 10 ⁻²
3	0.20	0.20	3 x 10 ⁻²