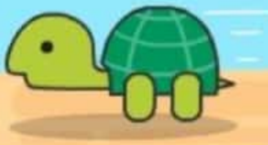
Part 1

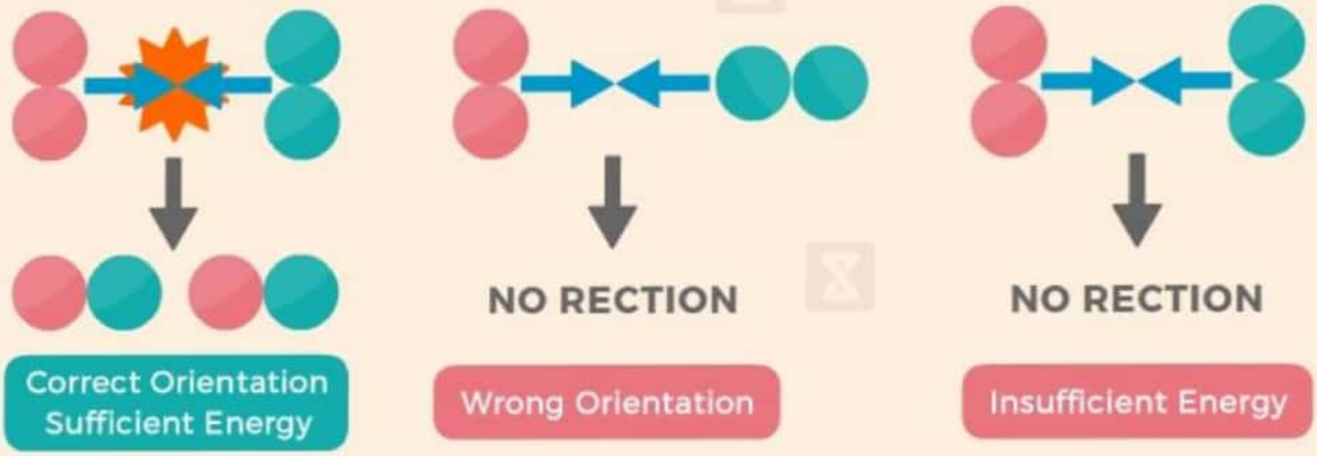
CHEMICAL KINETICS



MAKING CHEMICAL REACTION HAPPEN FASTER

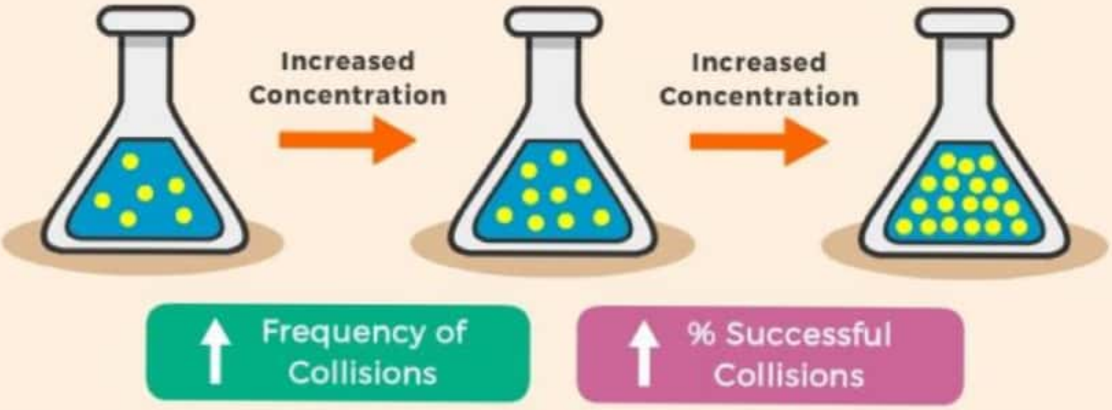
There are a number of different things that we can change to make a chemical reaction faster. Here, we explain the concept of collision theory, and how it can be used to explain the effects of five different factors on the rate of a chemical reaction.

COLLISION THEORY



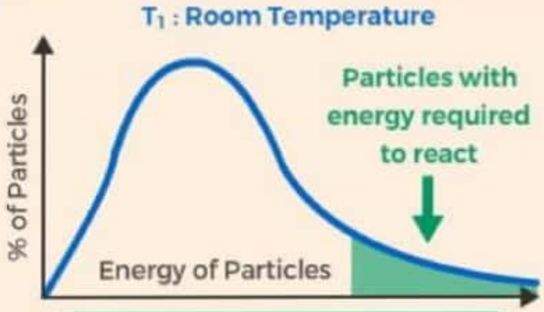
Collision theory states that for a reaction to occur, particles must collide with the **correct orientation** and with **sufficient energy** for a reaction to occur. Different factors affect the rate of the reaction by affecting the frequency of particle collisions, and the proportion of collisions that have enough energy to react.

01 INCREASE CONCENTRATION OF REACTANTS

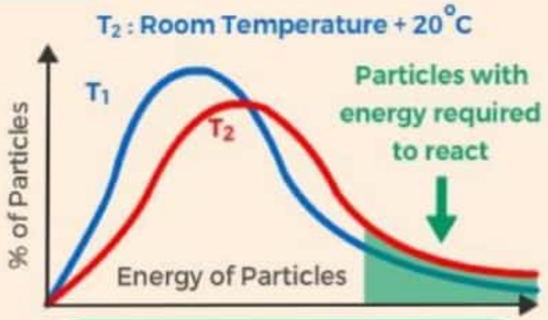


Increasing the concentration of reactants in solution increases the rate of reaction as there are a greater number of particles to react. This increases the frequency of collision between particles.

02 INCREASE TEMPERATURE OF REACTION



↑ Frequency of Collisions



↑ % of Successful Collisions

Increasing the temperature increases the kinetic energy of particles. This increases the frequency of particle collisions and a greater proportion of collisions will have the sufficient energy required to react.

03 INCREASE SURFACE AREA OF REACTANTS

↑ Frequency of Collisions

↑ % of Successful Collisions

Increasing the surface area of solid reactants increases the number of particles that are exposed and available to react and as a consequence this increases the frequency of particle collisions, thus increasing the rate.

04 INCREASES PRESSURE OF REACTION

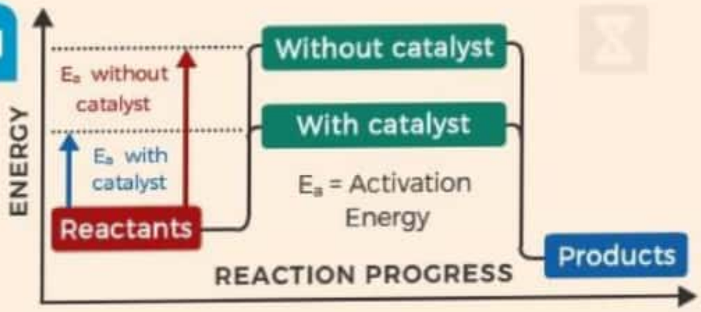
↑ Frequency of Collisions

↑ % of Successful Collisions

Increasing the pressure of a reaction involving gases, forces the gas particles closer together. This will increase the frequency of particle collisions and therefore increases the rate of reaction.

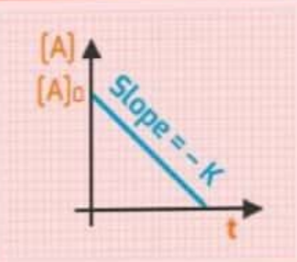
05 USE A CATALYST IN A REACTION

A catalyst provides an alternative route for the reaction with a lower activation energy. This means that particle collisions need less energy in order for a reaction to occur, thus increasing the rate of the reaction.



ORDER OF REACTION

Zero Order Reactions

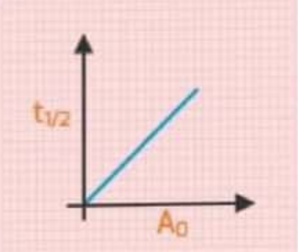


A zero order reaction has a constant rate that is independent of the concentration of the reactant(s); the rate law is simply. $\text{Rate} = k$

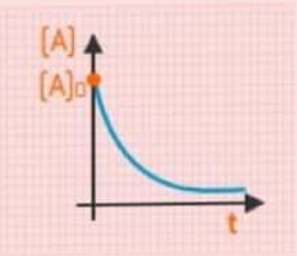
HALF LIFE ($t_{1/2}$)

Time in which half of inital amount is left.

$$t_{1/2} = \frac{[A]_0}{2k}$$



First Order Reactions

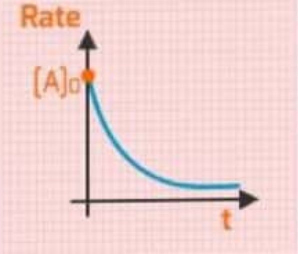


A first-order reaction is a reaction that proceeds at a rate that depends linearly on only one reactant concentration.

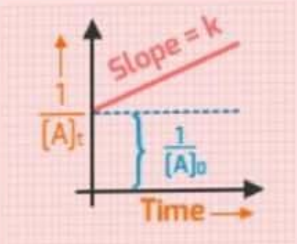
$$k = \frac{2.303}{t}\log\frac{[A]_0}{[A]}$$

HALF LIFE ($t_{1/2}$)

$$t_{1/2} = \frac{0.693}{k} \qquad [A] = \frac{[A]_0}{2^n}$$



Second Order Reactions

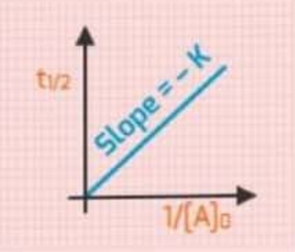


A chemical reaction in which the rate of the reaction is determined by the concentration of two chemical reactants involved or the square of the concentration of one chemical reactant.

$$k = \frac{1/[A] - 1/[A]_0}{t}$$

HALF LIFE ($t_{1/2}$)

$$t_{1/2} = \frac{1}{k[A]_0}$$

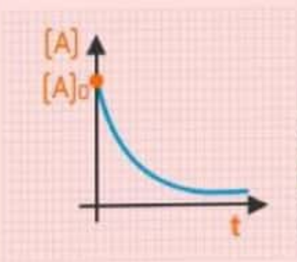


Pseudo first order reactions

If the concentration of a reactant remains constant (because it is a catalyst or it is in great excess with respect to the other reactants), its concentration can be included in the rate constant, obtaining a pseudo-first-order (or occasionally pseudo-second-order) rate equation.

For example, the hydrolysis of sucrose in acid solution rate r = k[sucrose]. The true rate equation is third-order, r = k[sucrose] [H+] [H_2O]; however, the concentrations of both the catalyst H^+ and the solvent H_2O are normally constant, so that the reaction is pseudo-first-order.

Nth order reactions



N$_{th}$ order reaction is one which proceeds at the rate that depends on concentration of multiple reactants or on multiple steps.

$$\Rightarrow k = \frac{1}{(n-1)\,t}\left[\frac{1}{[A]_t^{n-1}} - \frac{1}{[A]_0^{n-1}}\right]$$

HALF LIFE ($t_{1/2}$)

$$t_{1/2} = \lim_{x \to n} \frac{2^{x-1}-1}{(x-1)\,k[A]_0^{x-1}}$$