UNIT 8 - REACTION KINETICS

Rate of reaction

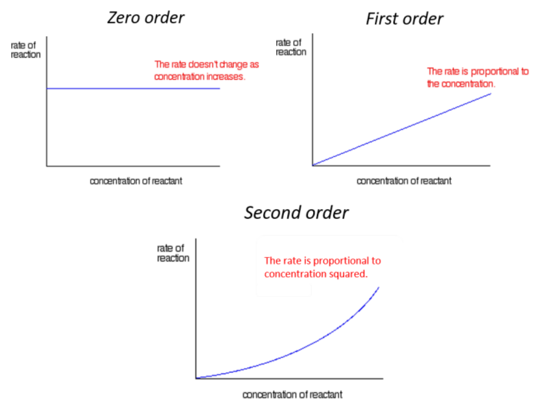
The rate of a reaction is expressed as the change in concentration of a reactant or product per unit time

There are several factors which affect whether or not particles will react when they collide:
- Orientation of collision
- The energy of collision (which must exceed activation energy)

Since there are more particles in the same volume, more particles will collide, so raising the concentration of reactants will usually increase the pace of the reaction. Therefore, there is a higher likelihood that the particles will collide successfully if they are in the right orientation and have enough energy to respond.

<u>Rate-concentration graphs</u>

The order can also be deduced using rate-concentration graphs.



A rate-concentration graph showing a curve isn't necessarily second order (it may be third order or a fractional order). To prove that the reaction is the second order for reactant X, the rate would have to be plotted against X. This would be a straight line graph if it was second order.

Reaction mechanisms

A reaction mechanism describes the steps involved in making and breaking bonds during a reaction. The slowest step of a reaction (or the rate-determining step) must include reactants which have an impact on the rate of reaction when their concentrations are changed.

Zero-order reactants have no Influence on the rate of a reaction so they cannot be included in the rate-determining step. When constructing a reaction mechanism, the powers in the equation indicate the number of molecules of each substance involved in the slowest step.

Measuring the rate of a reaction

There are several ways in which the rate of reaction can be measured, depending on the reaction:
- If a precipitate is produced, the rate could be measured by placing the conical flask of reaction mixture over a black cross and timing how long it takes for the cross to disappear.
- If the reaction mixture changes colour during the reaction, colourimetry could be used to measure the amount of light absorbed by the mixture.
- If hydrogen ions are reacting or are produced, the pH could be measured using a pH probe. This method only works for large changes in the concentration of hydrogen ions.
- Electrical conductivity measurements can be taken to work out the rate of reaction. The electrical conductivity of a liquid depends on the concentration of ions so if ions are being used up, the conductivity will decrease.

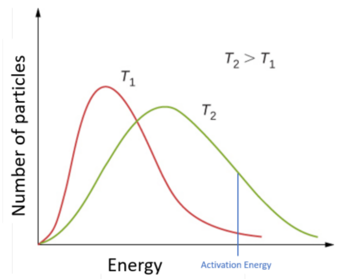
For a reaction which produces a gas the rate of reaction could be measured using:
- A gas syringe to record the volume of gas produced
- An upturned measuring cylinder in a trough of water to measure the volume of gas produced
- A mass balance to measure the change in mass (mass will be lost as the gas escapes)
- The rate of reaction can be calculated by measuring the time taken to produce a specified volume of gas: rate = volume ÷ time
- If you want to compare the initial rates of two reactions where the volume of gas collected is the same, it can be said that the Initial rate is inversely proportional to the time: Initial rate = 1/t
- 1/t could be used and plotted as the initial rate.

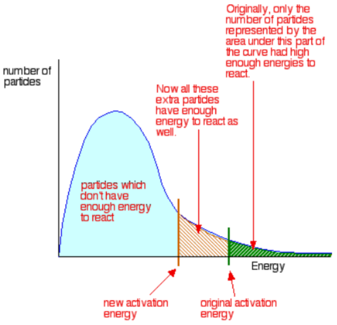
Temperature and rate

<u>Activation energy and the Boltzmann distribution</u>

Activation energy is the minimum amount of energy required for a reaction to occur. Only molecules with energy above the activation energy will react when they collide at the correct orientation.

For gases, the relative energies of the particles can be plotted on the Boltzmann distribution. There are several key points to remember about Boltzmann distributions:
- The area under the curve is equal to the total number of particles present.
- No particles have any energy
- There is no maximum energy
- Only particles with energy above the activation energy have sufficient energy to react when they collide





<u>Changing temperature</u>

This is a Boltzmann distribution showing the relative energies of particles at 2 different temperatures (T_2, is a higher temperature),

The particles will collide more frequently as the temperature rises as they will have more kinetic energy. Additionally, more collisions will produce a reaction since a larger proportion of the particle energy is higher than the activation energy. Because successful collisions will occur more frequently, the reaction rate will rise.

<u>Catalysts</u>

A catalyst is a substance which speeds up the rate of a reaction without being chemically changed at the end. A homogeneous catalyst is in the same phase as the reactants while a heterogeneous catalyst is in a different phase to the reactants (e.g. a solid catalyst with liquid or gaseous reactants). In the presence of a catalyst, a reaction has a different mechanism, with a lower activation energy.