Collision Theory

There are two main factors that affect the rate of chemical reactions, concentration and temperature, increasing either one will increase the reaction rate. Any model that seeks to explain reaction rates must address these two factors. The model that we will use is called the collision model and is built around the concept that molecules must collide to react.

Reaction Rates

We define the reaction rate in terms of the change in the concentration of the products or the reactants. So the reaction rate is the change in concentration of the species of interest divided by the amount of time that has passed.

$$\text{Rate} = \frac{\Delta[A]}{\Delta t}$$

By convention we define all reaction rates as positive, this means that if we are dealing with reactants which are decreasing we need to add a negative sign to the rate equation.

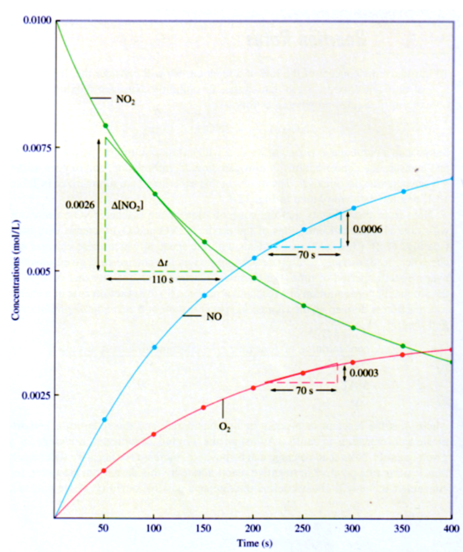
We can relate the rates of decrease of the reactants to the rate of increase of the products by using the balanced chemical equation.

$$2\mathrm{NO}_{2(\mathrm{g})} \rightarrow 2\mathrm{NO}_{(\mathrm{g})} + \mathrm{O}_{2(\mathrm{g})}$$

$$-\frac{\Delta[NO_2]}{\Delta t} = \frac{\Delta[NO]}{\Delta t} = 2\left(\frac{\Delta[O_2]}{\Delta t}\right)$$

Average & Instantaneous Rates

We have defined the average rate so far, however we may want to know the rate at any particular instant. That is we may want to calculate the instantaneous rate. We measure the instantaneous rate by finding the slope of the concentration-time curve at the time of interest, by finding the slope of the tangent to the curve at the time we are interested in.



Rate Laws

We want to mathematically express how the rate depends on the concentrations of the products and the reactants. This can be difficult if the reaction is reversible.

$$2NO_{2(g)} \rightarrow 2NO_{(g)} + O_{2(g)}$$
$$2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$$

To deal with reversible reactions we design the experimental conditions so that the reverse reaction rate is so small that it can be neglected. If this is done correctly then the reaction rate will only depend on the concentrations of the reactants.

$$\text{Rate} = k[NO_2]^n$$

This type of equation where
the rate depends on the concentration of the reactants is called the rate law, or more specifically the differential rate law. We must define what we are using to measure the rate when using the rate law.

The rate is determined in relation to which species we are measuring, this has the effect of changing the rate constant (k) based on what chemical we are measuring.

Table 12.[illegible] Initial Rates from Three Experiments for the Reaction $NH_4^+(aq) + NO_2^-(aq) \rightarrow N_2(g) + 2H_2O(l)$

Experiment	*Initial Concentration of* NH_4^+	*Initial Concentration of* NO_2^-	*Initial Rate (mol/L · s)*
1	0.100 *M*	0.0050 *M*	1.35×10^{-7}
2	0.100 *M*	0.010 *M*	2.70×10^{-7}
3	0.200 *M*	0.010 *M*	5.40×10^{-7}

Ex: