6.5 Explaining and Applying Chemical Kinetics

- Two criteria
    - Frequency of collisions
    - The fraction of those collisions that are effective

Theoretical Effect of Chemical Nature of Reactant

- Different chemicals react differently. E.g.: Ni and HCl vs. Mg and HCl
- The distribution of Kinetic Energy is called the Maxwell-Boltzmann distribution and can be explained by the graph below.
- See figure 2 on page 392.
- The x-axis shows the increasing kinetic energy of the system and the y-axis shows the number of particles with that energy. E_a is the activation energy needed to create an activated complex. The area below the curve and to the right of the E_a gives the number of particles with enough energy to form an activated complex and can react to form product (larger the area the greater the rate of reaction).
- Different reactions have different threshold energies (minimum kinetic energy) which is converted into potential energy as the activated complex forms
- Reactants may have different bond energies or more bonds to break
- Reactants may have a low or high activation energy barrier
- Reactants may have complex structure that affects the collision geometry

Theoretical Effect of Concentration

- The number of molecular collisions depends directly on the concentrations of the reactants.
- The more particles you have the greater the chance of a successful collision.
- For reaction $A+B \rightarrow AB$, rate $\propto [A][B]$ (if you have 2 A's and 3 B's you have the potential of $2 \times 3 = 6$ collisions)

Theoretical Effect of Surface Area:

- As the particles of the solid get smaller more of the solid is exposed to react (greater number of effective collisions) and the greater the rate of reaction. (usually solid with liquid or solid with gas)
- If you divide it small enough you will end up with individual particles, in other words a solution which will have the greatest rate of reaction.

Theoretical Effect of Temperature

- Increase in temperature increases the average kinetic energy of all the particles in the reaction and shifts the Maxwell-Boltzmann Distribution.
- See figure 5 on page 393.
- A 10°C increase in temperature will result in a double or triple rate of rxn.
- It seems that as temperature increases the shape of the graph flattens and shifts to the right
- Considerably more particles have energy levels that exceed the threshold level and we see an increase in the rate of reaction.

Theoretical Effect of Catalysis

- Heterogeneous catalyst: a catalysis that is found in a different phase compared to the reactants.
- Homogeneous catalyst: part of the reaction and is regenerated.
- A catalyst gives a different path for the reaction mechanism. In other words and new set of elementary processes are used which have a lower activation energy.
- See figure 6 on page 395.

E.g. From your Car

- The **reduction catalyst** is the first stage of the catalytic converter. It uses platinum and rhodium to help reduce the NO_x emissions. When an NO or NO_2 molecule contacts the catalyst, the catalyst rips the nitrogen atom out of the molecule and holds on to it, freeing the oxygen in the form of O_2. The nitrogen atoms bond with other nitrogen atoms that are also stuck to the catalyst, forming N_2. For example:

  $$\mathbf{2NO \rightarrow N_2 + O_2} \text{ or } \mathbf{2NO_2 \rightarrow N_2 + 2O_2}$$

- The **oxidation catalyst** is the second stage of the catalytic converter. It reduces the unburned hydrocarbons and carbon monoxide by burning (oxidizing) them over a platinum and palladium catalyst. This catalyst aids the reaction of the CO and hydrocarbons with the remaining oxygen in the exhaust gas. For example:

  $$\mathbf{2CO + O_2 \rightarrow 2CO_2}$$

Homework

- Practice 1,2,4,5