Kinetics

Reaction Kinetics

- The speed of a chemical reaction (reaction rate)
- Operational definition
  - How fast or slow a reactant disappears or a product forms

Reaction Rates

- Reaction rate is described as a change in an observable property over time.
- The observable property should be selected based upon what can be measured in a laboratory
  - Color change, temperature change, pressure change, pH, conductivity, appearance of a new substance

- Mathematically, we describe reaction rate as change per unit time

$$\text{Average rate} = \frac{\Delta quantity}{\Delta t}$$

Pressure

- Change in pressure can be measured with a manometer
- A simpler method would be to use a gas syringe

pH

- pH is an indication of how acidic or basic a solution is
- A pH meter can measure the change in acidity over time
- This data can be used to determine the concentration of hydrogen (hydronium) ions over time

Color

- A spectrometer can be used to measure the color given off or absorbed by a reactant or product over time

Temperature

- Temperature changes can be monitored with a thermometer

Conductivity

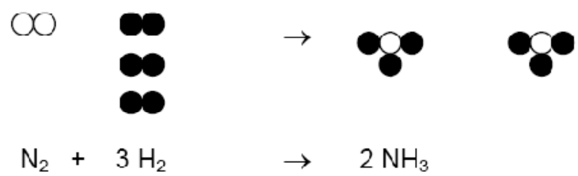
- Electrodes can be placed in the reaction mixture and the increase/decrease in conductivity of the products can be used to measure reaction rate
- This method is usually used when nonionic reactants form ionic products

Reaction Rate

- Reaction rate can be calculated by finding the change in formation of product over time, or by finding the change in consumption of a reactant over time.

Calculating Reaction Rates

- Consider the reaction: $N_2 + 3H_2 \rightarrow 2NH_3$



- The rate of consumption of H_2 is 3x that of N_2
- The rate of production of NH_3 is 2x the rate of consumption of N_2
- N_2 is consumed at ⅓ the rate of H_2 and ½ the rate of NH_3

Mathematically

$$rate = -\frac{\Delta[N_2]}{\Delta t}$$

Therefore…

$$rate = -\frac{\Delta[N_2]}{\Delta t} = -\frac{1}{3}\frac{\Delta[H_2]}{\Delta t} = \frac{1}{2}\frac{\Delta[NH_3]}{\Delta t}$$

Example

- For the reaction $N_2 + 3H_2 \rightarrow 2NH_3$, if the hydrogen reacts at a rate of 1.5 mol/Ls what is the rate of formation of ammonia?

$$-\frac{1}{3}\frac{\Delta[\mathrm{H_2}]}{\Delta t}=\frac{1}{2}\frac{\Delta[\mathrm{NH_3}]}{\Delta t}$$

$$-\frac{1}{3}\left(-1.5\,\tfrac{mol}{Ls}\right)=\frac{1}{2}\frac{\Delta[NH_3]}{\Delta t}$$

$$\frac{\Delta[\mathrm{NH_3}]}{\Delta t}=1.0\,\tfrac{mol}{Ls}$$