Topic 4: Reversible Reactions

Reversible reactions: Chemical reactions that proceed in two directions (forward and backwards).

- They tend not to go into completion – as such, a mixture of both the reactants and the products is always obtained, no matter how long the reaction carries on
- When the concentrations of the reactants and products are constant, the mixture is at equilibrium

Dynamic equilibrium:

- Forward reaction:
    - At the start, the reactants are in maximum concentrations → Frequency of collision of reactant particles for the forward reaction is highest → Forward reaction is fastest
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    - As such, forward reaction: fast → slow
- Backward reaction:
    - At the start, the products are at minimum concentrations → Frequency of effective collisions of particles for backward reaction is lowest → Backward reaction is slowst
    - As such, backward reaction: slow → fast
- At some point, rates of the two reactions will be the same → equilibrium is attained
- Reversible reactions attain a state of equilibrium when the rate of forward reaction is equal to the rate of backward reaction – yet, the reaction does not stop (therefore, dynamic)
- Notes:
    - For this to be true, reaction must be in a closed system
    - Equilibrium does not mean that mixture is 50% reactant and 50% product, it means that the concentrations of reactants and products are constant

Le Chatelier's Principle: If a system at equilibrium is subjected to a small change, the equilibrium's response is to counteract the change so as to minimize the effect of the change.

	Increased Temperature	Decreased Temperature
Exothermic	Both the rates of forward and backward reactions will increase. Rate of forward reaction increases less than rate of backward reaction. Equilibrium shifts left	Both the rates of forward and backward reactions will decrease. Rate of forward reaction decreases less than rate of backward reaction. Equilibrium shifts right
Endothermic	Both the rates of forward and backward reactions will increase. Rate of forward reaction increases more than rate of backward reaction Equilibrium shifts right	Both the rates of forward and backward reactions will decrease. Rate of forward reaction decreases more than rate of backward reaction Equilibrium shifts left

Terminology: "equilibrium shifts left" means more of the left reaction will occur (+ likewise)

Factors to change to affect yield:

- Concentration
- Temperature
- Pressure

Note: A catalyst increases the speeds of both the forward and backward reactions → no effect on yield (just that yield will be achieved faster)

Haber process:

- $450^{o}C$, 200atm, iron as catalyst
- Produces ammonia
    - Ammonia is used to produce nitrogenous fertilizers (example: ammonium nitrate)
    - A highly soluble colorless gas
- Produced using:
    - Nitrogen from air
    - Hydrogen from petroleum