Haber Process

For

• Industrial manufacture of ammonia

Raw materials

• Nitrogen (fractional distillation of liquid air)

• Hydrogen (cracking of hydrocarbons)

Conditions

• Temperature: 450°C

→ Low temperature since reaction is exothermic

• Pressure: 200 to 300 atm

→ Favours side with lower gaseous moles (products side)

• Catalyst: Iron granules

→ Granules used as they have high surface area, which helps speed up reaction (save time)

• N_2 and H_2 are continuously added in 1:3

→ Increases concentration, shifting equilibrium position to the right (increasing yield)

• NH_3 is continuously collected

→ Decreasing concentration of products shifts equilibrium position to the right (increasing yeild)

Reaction

$N_{2(9)} + H_{2(9)} \rightarrow 2NH_3$ (ΔH= negative, exothermic)

+ Using higher temperature will reduce yield of NH_3
+ Using lower temperature will slow down the rate of reaction too much.
+ Using higher pressure will make the process too expensive
+ Using lower pressure will reduce yield of NH_3

Contact process

For

• Manufacture of sulfuric acid

Raw materials

• Oxygen (from air)

• Sulfur

Conditions

• Temperature: 450°C (low temperature)

→ Reactions is exothermic thus, shifting equilibrium position to the left (higher temperature means lower yield and lower temperature means)

• Pressure: 2 atm (high pressure)

→ Increase in pressure shifts equilibrium position to the right (lower gaseous moles present there)

• Catalyst: V_2O_5

→ To increase rate of reaction

Reaction

• $S + O_2 \rightarrow SO_2$ (oxidation/combustion of sulfur)

• $2SO_2 + O_2 \rightleftharpoons 2SO_3$ (oxidation/combustion of SO_2 to SO_3)

Contact process (cont)

• $SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$ (sulfur trioxide absorbed to H_2SO_4 to produce oleum)

• $H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$ (oleum added to water to make H_2SO_4)

Purification of gases

• Takes place after SO_2 is made to purify SO_2 and O_2

→ Gases are passed through an electrostatic dust precipitator to remove insoluble impurities such as sand

→ Gases are passed through a scrubber to remove water soluble impurities

→ Gases are passed through a drying tower to remove moisture

→ Gases are passed through an arsenic purifier to remove arsenic impurities

+ Lower temperature not used, rate of reaction will be too slow
+ Low pressure favors side with more gaseous moles (reactants side in this reaction)
+ Conditions such as adding the reactants and removing the product continuously are not mentioned as they don't affect the yield significantly
+ Trioxide is not absorbed into water because it produces a fine mist of sulfuric acid which is difficult to condense and highly dangerous

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