

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)
- N₂ and H₂ are continuously added in 1:3
 - Increases concentration, shifting equilibrium position to the right (increasing yield)
- NH₃ is continuously collected
 - Decreasing concentration of products shifts equilibrium position to the right (increasing yield)

Reaction



- + Using higher temperature will reduce yield of NH₃
- + 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 NH₃

Contact process

For

- Manufacture of sulfuric acid

Raw materials

- Oxygen (from air)
- Sulfur

Conditions

- Temperature: 450°C (low temperature)
 - Reaction 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: V₂O₅
 - To increase rate of reaction

Reaction

- S + O₂ → SO₂ (oxidation/combustion of sulfur)
- 2SO₂ + O₂ ⇌ 2SO₃ (oxidation/combustion of SO₂ to SO₃)



Contact process (cont)

- $\text{SO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{H}_2\text{S}_2\text{O}_7$ (sulfur trioxide absorbed to H_2SO_4 to produce oleum)
- $\text{H}_2\text{S}_2\text{O}_7 + \text{H}_2\text{O} \rightarrow 2\text{H}_2\text{SO}_4$ (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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