# Reversible Reactions

By Dackify (Ahmed Afzal)

Reversible reactions are reactions which occur in two directions Forward & Backward! ($\rightleftharpoons$)

We only consider Forward direction in a reversible reaction because our required product present only in forward direction!

In reversible reactions, 100% product do not produce because some products are converted back into reactant!

If a reversible reaction is Exothermic in one direction it will be Endothermic in other direction!

In Exothermic reversible reaction Temperature will be decreased to favor maximum Yield!

Stage in a reversible reaction when rate of forward reaction is equal to rate of Backward reaction is Called:- "Chemical Equilibrium"

An Equilibrium in which particles constantly move in opposite direction is called "Dynamic Equilibrium"

Hence, All Chemical equilibriums are Dynamic equilibriums!

# Haber Process (Manufacturing of Ammonia)

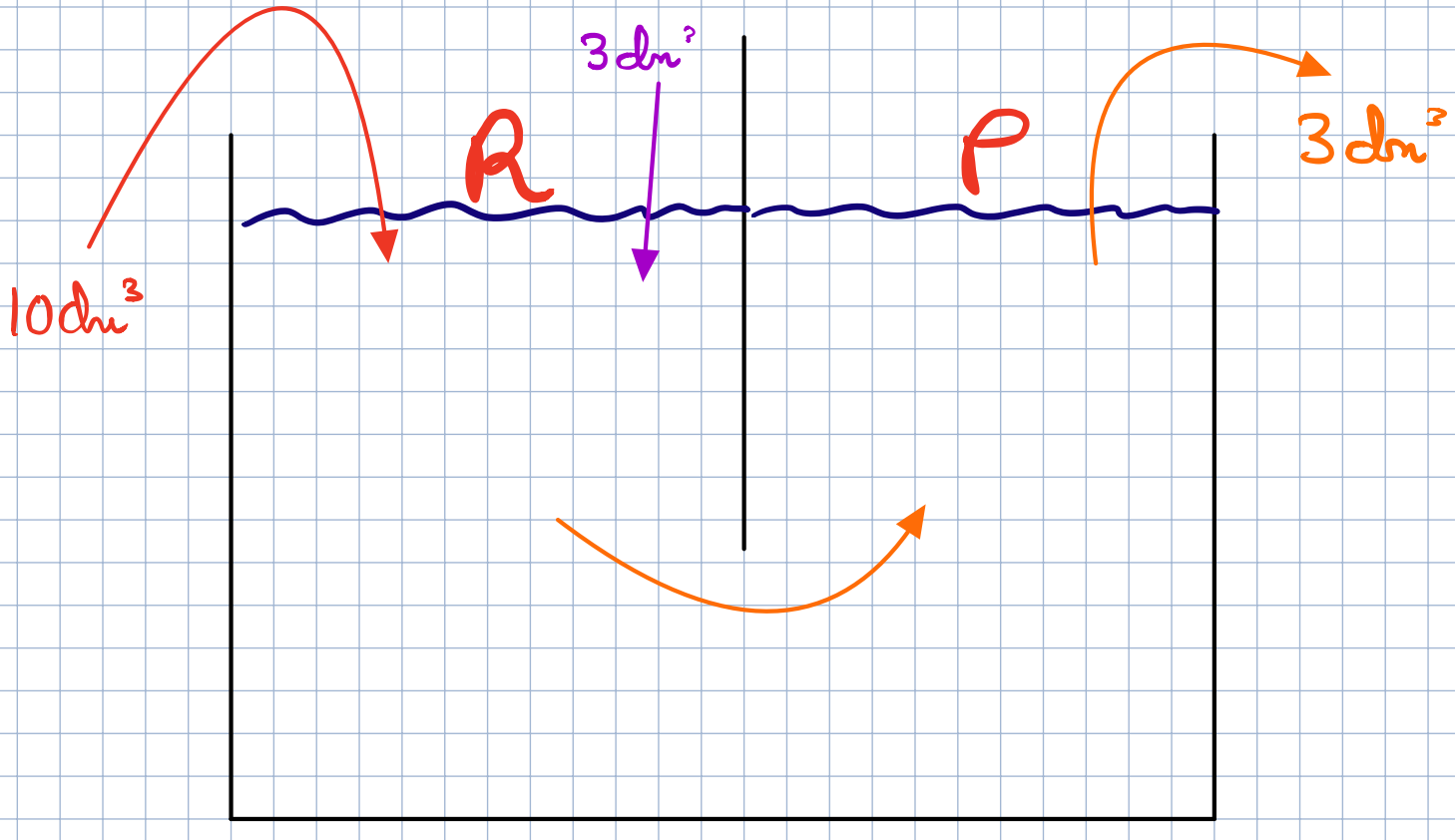
$\Delta H = -180\,kJ$

$$3H_2 + N_2 \underset{\text{Endo}}{\overset{\text{Exo}}{\rightleftharpoons}} 2NH_3$$

## Conditions :-

- Temperature => 450°c
- Catylyst => Fe / Fe (powder)
- Pressure => 200 atm

## Conditions for Maximum Product:-



## i) Concentration :-

→ Increase the concentration of reactants

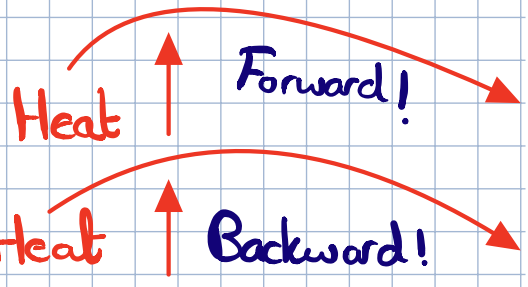
→ Remove the Products !

This will shift the equilibrium in forward direction, hence Yield of products increases !

## ii) Temperature :-

I $A + Heat \underset{Exo}{\overset{Endo}{\rightleftharpoons}} B$

II $A \underset{Endo}{\overset{Exo}{\rightleftharpoons}} B + Heat$




→ In Exothermic reversible reactions, temperature is decreased to increase the yield of product or to Shift equilibrium in forward direction

→ In Endothermic reversible reaction temperature is increased for maximum Product or to shift equilibrium in Forward direction

→ In Exothermic reversible reactions increasing temperature will facilitate the backward reaction while in endothermic reversible reactions increasing temperature will facilitate forward reaction

→ Temp should not be less than optimum otherwise rate of reaction ↓

## iii) Pressure :- $P \propto 1/V$ $V \propto n$ $P \propto 1/n$

Increasing pressure will shift the equilibrium towards that direction where no. of moles are less !

(I) $3H_2 + N_2 \rightleftharpoons 2NH_3$

4 mole → 2 mole

$P \uparrow$

(II) $PCl_5 \rightleftharpoons PCl_3 + Cl_2$

1 mole → 2 mole

$P \downarrow$

(III) $H_2 + Cl_2 \rightleftharpoons 2HCl$

2 mol → 2 mol

No effect of Pressure on equilibrium !

---

→ Catalyst = No effect on Equilibrium !

Catalyst, Temp and Pressure will increase rate of both Forward & Backward reaction !

## Uses of Ammonia :-

o) Fertilizers

o) Manufacturing of explosives

o) Manufacturing of Nitric Acid !

# ≈ Fertilizers ≈

★ Substances which provide essential elements for plant growth !

N P K

- N → Nitrogen
- P → Phosphorus
- K → Potassium

$NH_4NO_3$
$(NH_4)_2SO_4$
$(NH_4)_3PO_4$
] Ammonium Fertilizer

$KNO_3$ !

★) $CaO / Ca(OH)_2$ ⇒ to reduce acidity of soil !

Ammonium fertilizer + Lime ⟶ ✕

$NH_4^+ + OH^- \longrightarrow H_2O + NH_{3(g)}$

◦) A farmer should not use both Ammonium Fertilizer and lime at a time otherwise Ammonia ($NH_3$) gas will produce, hence Nitrogen contents decrease in soil

→ $KNO_3$ is better Fertilizer as it does not react with lime !

# ≈ Contact Process ≈ $H_2SO_4$

I $S + O_2 \longrightarrow SO_2$ = Combustion / Exo

II $\underset{3\,mol}{SO_2 + O_2} \longrightarrow \underset{2\,mol}{2SO_3} + Heat$

## Conditions for reaction :-

Temp = 450°c

Catylyst = $V_2O_5$ (Vanadium (V) oxide)

Pressure = 2atm

## Conditions for Maximum Product :-

i) Concentration :

→ Increase the conc. of reactants !

→ Remove the products !

ii) Temperature :

→ Decrease the temperature !

iii) Pressure :-

→ Increase the Pressure !

III $SO_3 + H_2SO_4 \xrightarrow{\text{conc !}} H_2S_2O_7$ (Oleum)

IV $H_2S_2O_7 + H_2O \longrightarrow 2H_2SO_4$

$SO_3 + H_2O \not\rightleftharpoons H_2SO_4$

→ Very Violent reaction → Toxic fumes produced

→ $H_2SO_4$ formed as thick mist (Useless)

✓ $3H_2 + N_2 \rightleftharpoons 2NH_3$ Diff = 2 $P = 200\,atm$

4 mol 50% 2 mol

✓ $2SO_2 + O_2 \rightleftharpoons 2SO_3$ $P = 2\,atm$

3 mol 98% 2 mol Diff = 1

a) Difference is moles is less a) High pressure is expensive

→ If difference in no of moles of reactants & products is less effect of pressure will be less & vice versa!

| Uses of $H_2SO_4$ :- | Uses of $SO_2$ :- |
|---|---|
| a) Ferlizer | a) Reducing agents |
| a) Pickling agent | a) Food preservation |
| a) Detergent / Paints | a) Bleaching agent ! |