Lechattelier's principle and its application to industrial processes

- The effect of change of pressure, concentration and temperature on equilibrium was studied by Henry Lewis Lechatterlier in 1885 and F. Brawn. So this is called Lechattelier- Brawn Principle or simply Lechattelier's principle.
- If a system at equilibrium is subjected to a stress, the system shifts the equilibrium in such a way to reduce or nullify the stress.
- Effect of concentration : Increase in concentration of reactants or decrease in concentration of products favours the shift of equilibrium towards products side and rate of forward reaction is increased.

  Increase in the concentration of the products or decrease in the concentration of reactants favours the shift of equilibrium towards the reactant side and rate of backward reaction is increased.

Effect of pressure :

- Pressure has no effect on equilibrium if Δv or $\Delta n=0$, ($n_p= n_r$).

  Eg : $H_{2(g)} + I_{2(g)} \Leftrightarrow 2HI_{(g)}$
- Pressure has effect on equilibrium if $\Delta v\neq0$ or $\Delta n\neq0$, ($n_p\neq n_r$). When pressure increases, equilibrium shifts in a direction of decrease of volume or towards less mole number and vice vessa.

  Eg : $N_{2(g)} + 3H_{2(g)} \Leftrightarrow 2NH_{3(g)}$

  When pressure increases, equilibrium shifts towards right and forward reaction rate increases.
- Pressure does not show any marked effect on equilibrium reactions taking place in the solution phase or in the solid phase.

Effect of temperature : increase of temperature of the equilibrium system favors endothermic reactions, and decrease of temperature of the equilibrium system favors exothermic reactions.

Effect of Catalyst : Catalyst has no net effect on equilibrium. It helps the system to attain equilibrium at a faster rate by increasing the rate of forward as well as backward reaction to the same extent.

Eg:**(1)** Synthesis of ammonia by Haber's process:

$N_{2(g)} + 3H_{2(g)} \Leftrightarrow 2NH_{3(g)}$ + heat $\Delta H = -92.0$ K.J

Favourable conditions for high yield of NH_3:

High pressure:200atm, Catalyst : Fe as catalyst

Low temperature : 773 K, Promoter: small amount of molybdenum or Al_2O_3 and K_2O.

(2) Manufacture of H_2SO_4 by the contact process.

$2SO_{2(g)} + O_{2(g)} \Leftrightarrow 2SO_{3(g)}$ + Heat; $\Delta H = -189$ K.j

Favourable conditions for higher yield of SO_3.

I) High pressure : 1.5 – 1.7 atm.

ii) Low temperature : 673 k

iii) Catalyst : V_2O_5 or platinised asbestos

$N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$ – heat

i) High temperature ii) No effect of pressure

Melting of ice :

$H_2O_{(s)}$+ heat $\rightleftharpoons$ H_2O

I) high temperature ii) high pressure