Relative Vapor Density and Degree of Dissociation (α))

In the context of a reversible reaction represented as A $\rightleftharpoons$ yB, with initial moles of 1 for A and 0 for B, and at equilibrium with (1 – alpha) moles of A and y alpha moles of B, the total moles at equilibrium are given by 1 – alpha + y alpha, which simplifies to 1 + (y – 1). The volume of the equilibrium mixture is then expressed as [1 + alpha (y – 1)] V.

The molar density before dissociation, denoted as D, is calculated as the ratio of the molecular weight to the volume ($\frac{M}{V}$). After dissociation, the molar density (d) is given by $\frac{M}{V}$

$d = \dfrac{M}{(1 + a(y-1)v)}$. The ratio of D to d is expressed as 1 + alpha (y – 1).

To determine the value of alpha, the equation alpha $= \dfrac{D - d}{(d(y-1))}$ is employed. This equation provides a relationship between the degree of dissociation (alpha) and the molar densities (D and d) as well as the stoichiometric coefficient (y) in the equilibrium expression.

Effect of Concentration:

(i)   When you increase the concentration of either H_2 or I_2 at equilibrium, the system adjusts by shifting in a direction that reduces the concentration. This results in an accelerated forward reaction rate, ultimately raising the concentration of HI.

(ii)   When the concentration of N_2 or O_2 is increased, the system shifts in a direction where N_2 or O_2 is consumed, leading to an elevated forward reaction rate.

(iii)   When the concentration of PCl_5 is raised at equilibrium, the forward reaction rate increases, leading to a reduction in the added concentration. Consequently, PCl_5 dissociation intensifies.

Effect of Temperature:

(i)   The formation of HI is an exothermic process. Consequently, elevating the temperature speeds up the reverse reaction, leading to a reduced formation of HI.
  ➢   In summary, to achieve a higher yield of HI, it is favorable to:
  ➢   Increase the concentration of H_2 or I_2.
  ➢   Pressure changes have no impact due to $\Delta n = 0$.
  ➢   Lower the temperature to favor the exothermic forward reaction

(ii)   The formation of NO is an endothermic process. Therefore, an increase in temperature promotes the forward reaction.
  Favorable conditions for a higher NO yield:
  ➢   Maintaining a high concentration of N_2 and O_2.
  ➢   Raising the temperature.
  ➢   Pressure changes have no impact.

(iii)   The dissociation of PCl_5 is an endothermic process. Thus, an increase in temperature promotes and favors the dissociation.
  Favorable conditions for the dissociation of PCl_5 include:
  ➢   A high concentration of PCl_5.
  ➢   Low pressure.
  ➢   Elevated temperature.

Effect of Pressure:

(i)   When pressure is heightened in a system, the volume proportionally decreases, resulting in an increase in the total number of moles per unit volume. According to Le Chatelier's principle, the equilibrium shifts towards the direction where the number of moles decreases. In cases where the number of moles of gases remains unchanged in a reaction, alterations in pressure have no impact on the equilibrium.

(ii)   In the formation of HI, the number of moles of reactants and products remains unchanged ($\Delta n = 0$). Therefore, changes in pressure or volume do not influence this equilibrium.

(iii)   The formation of NO remains unaffected by changes in pressure ($\Delta n = 0$).

(iv)   In the dissociation of PCl_5, an increase in pressure results in an expansion of volume. Consequently, the system shifts towards a decrease in volume, and high pressure is not conducive to the dissociation of PCl_5.

Effect of Catalyst:

There is no significant impact; its role lies in facilitating a quicker attainment of equilibrium.

Effect of Addition of Inert Gas:

The introduction of an inert gas (such as He) into a system at a constant volume does not influence the equilibrium condition. When an inert gas is added to a system at constant pressure, its effect on the equilibrium condition is analogous to that of reducing the system pressure.

In summary:

➤   If the change in the number of moles (Δn_g) is greater than 0, the equilibrium will shift towards the right.

➤   If Δn_g is less than 0, the equilibrium will shift towards the left.

➤   If Δn_g is equal to 0, there is no impact on the equilibrium.