

CHEMICAL EQUILIBRIUM INVOLVING GASES



$$K_c = \frac{[\text{NO}]^2[\text{Cl}_2]}{[\text{ONCl}]^2} \quad \text{and} \quad K_p = \frac{P_{\text{NO}}^2 P_{\text{Cl}_2}}{P_{\text{ONCl}}^2}$$

2. Relationship between K_c and K_p

Assuming the ideal gas law applies for each gas, then the partial pressure of any gas, P , is

$$P = (n/V)RT$$

Therefore for the equilibrium above

$$K_p = \frac{[\text{NO}]^2(RT)^2[\text{Cl}_2](RT)}{[\text{ONCl}]^2(RT)^2} = \frac{[\text{NO}]^2[\text{Cl}_2]}{[\text{ONCl}]^2} (RT) = K_c(RT)$$

where $R = 0.08206 \text{ L-atm-mol}^{-1}\text{K}^{-1}$ and T is in absolute degrees.

The general expression: $K_p = K_c(RT)^{\Delta n}$ can be derived

where $\Delta n = \text{moles of gaseous products} - \text{moles of gaseous reactants}$.

3. No concentration terms are included for pure solids or pure liquids.

4. The value of K_c or K_p for a given equilibrium is constant if the equilibrium temperature does not change. At a given temperature, the values of K_c and K_p will be different unless $\Delta n_{\text{gas}} = 0$.

5. The magnitude of K_c or K_p indicates the position of the equilibrium. A large K_c or K_p indicates the equilibrium lies to the right and the reaction is fairly complete. Conversely, a small value indicates a fairly incomplete reaction and that the equilibrium lies to the left.

6. Le Chatelier's Principle states that a system at equilibrium when placed under stress will counteract the stress and re-establish a new equilibrium state.

(a) Effects of concentration changes on the equilibrium.

(b) Effects of pressure or volume changes on the equilibrium.

(c) Effects of temperature changes on the equilibrium.

7. A catalyst has no effect on the position or value of K_c or K_p , however it will cause the attainment of equilibrium to be faster.

8. Effect of temperature on K_p :

$$\ln (K_{p,2}/K_{p,1}) = \frac{\Delta H^\circ(T_2 - T_1)}{RT_2T_1}$$

where $R = 8.314 \text{ J-mol}^{-1}\text{K}^{-1}$

(a) When $\Delta H^\circ = +ve$ (endothermic reaction)

an increase in T will increase K_p

and a decrease in T will decrease K_p

(b) When $\Delta H^\circ = -ve$ (exothermic reaction)

an increase in T will decrease K_p

and a decrease in T will increase K_p