CHEMICAL EQUILIBRIUM INVOLVING GASES

1. $$2\ \text{ONCl}(g) \rightleftharpoons 2\ \text{NO}(g) + \text{Cl}_2(g)$$

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

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

$$P = (n/V)\text{R}T$$

Therefore for the equilibrium above

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

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

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

where Δn = moles of gaseous products - 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 $\Delta n_{gas} = 0$.

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:

$$\ln(K_{p,2}/K_{p,1}) = \frac{\Delta H°(T_2 - T_1)}{\text{R}T_2T_1}$$

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

(a) When $\Delta H°$ = +ve (endothermic reaction)
an increase in T will increase K_p
and a decrease in T will decrease K_p

(b) When $\Delta H°$ = -ve (exothermic reaction)
an increase in T will decrease K_p
and a decrease in T will increase K_p