Note: when $\Delta n_{gas} = 0$, $K_p = K_c$

II K, the thermodynamic equilibrium constant

This is sometimes used in heterogeneous equilibria – equilibria involving species which are in different phases. When working with heterogeneous equilibria, the concentrations and partial pressures of pure solids and pure liquids are NOT included in the equilibrium constant expression since they are constants and included in the value of the equilibrium constant.

K is a "hybrid" version of K_c and K_p:

(1) species in solution (aq) are expressed as concentration
(2) gases are expressed as partial pressures.

Examples:

① $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ at 25°C

Note: $K = K_p$ when only gases are involved

$$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3} \qquad K_p = \frac{(P_{NH_3})^2}{(P_{N_2})(P_{H_2})^3} \qquad K = \frac{(P_{NH_3})^2}{(P_{N_2})(P_{H_2})^3}$$

② $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$ at 500°C heterogeneous equil.

$$K_c = [CO_2] \qquad K_p = P_{CO_2} \qquad K = P_{CO_2}$$

③ $NiI_2(s) \rightleftharpoons Ni^{2+}(aq) + 2I^-(aq)$ at 25°C heterogeneous

Note: $K = K_c$ when only solutions are involved

$$K_c = [Ni^{2+}][I^-]^2 \qquad K_p = \text{undefined} \qquad K = [Ni^{2+}][I^-]^2$$

④ $CO_2(g) + H_2O(l) \rightleftharpoons H_2CO_3(aq)$ at 25°C heterogeneous

$$K_c = \frac{[H_2CO_3]}{[CO_2]} \qquad K_p = \frac{1}{P_{CO_2}} \qquad K = \frac{[H_2CO_3]}{P_{CO_2}}$$