3/6/2019 Writing the chem eq affects K!

(1) ex: $A \rightleftharpoons B$, K_1

reversing: $B \rightleftharpoons A$, $K_2 = 1/K_1$

(2) multiply by 'n'

$A + 2B \rightleftharpoons 3C$; $K_c = \frac{[C]^3}{[A][B]^2}$

×n

$nA + 2nB \rightleftharpoons 3nC$; $K_c' = \frac{[C]^{3n}}{[A]^n[B]^{2n}}$

$$K_c' = \left(\frac{[C]^3}{[A][B]^2}\right)^n = K_c^n$$

× chem eq. by n, $K \rightarrow K^n$

(3) Adding chem eqs:

ex: $A \rightleftharpoons 2B$ $K_1 = \frac{[B]^2}{[A]}$

$2B \rightleftharpoons 3C$ $K_2 = \frac{[C]^3}{[B]^2}$

(+)

$A + \cancel{2B} \rightleftharpoons \cancel{2B} + 3C$ $K_3 = \frac{[B]^2[C]^3}{[A][B]^2} = \frac{[C]^3}{[A]}$

$A \rightleftharpoons 3C$, $K_3 = K_1 \cdot K_2$ $= K_1 \times K_2$

*WHEN ADDING CHEM EQ's, WE MULTIPLY EQ. CONSTS.

Other eq. constants.

$K_c \sim \frac{[P]}{[R]}$, let's meet K_p

(K_c ← molar concs; K_p ← (partial) pressures.)

ex: $2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$

$$K_c = \frac{[SO_2]^2[O_2]}{[SO_3]^2} \quad , \quad K_p = \frac{(P_{SO_2})^2(P_{O_2})}{(P_{SO_3})^2}$$

(@ eq)

Relating K_c and K_p

$[A] \neq P_A$, so in general $K_c \neq K_p$

$[A] = \frac{n_A}{V}$, and using ideal gas eq: $pV = nRT$

$$\Rightarrow P_A V = n_A \cdot RT \quad , \quad \Rightarrow \boxed{\frac{n_A}{V} = \frac{P_A}{RT}}$$

OR: $[A] = \frac{P_A}{RT}$ OR: $P_A = [A] \cdot RT$

simple eq: $aA(g) \rightleftharpoons bB(g)$; $K_c = \frac{[B]^b}{[A]^a}$

$\frac{x^a}{x^b} = x^{a-b}$

$$K_p = \frac{(P_B)^b}{(P_A)^a} = \frac{([B] \cdot RT)^b}{([A] \cdot RT)^a} = \frac{[B]^b (RT)^b}{[A]^a (RT)^a} = K_c \cdot (RT)^{b-a}$$

$(b-a) = \Delta n_{gas}$ (change in # mol gas) $\Rightarrow \boxed{K_p = K_c (RT)^{\Delta n_{gas}}}$

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

(otherwise, $K_c \neq K_p$!)

ex: $2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$; $K_p = 2.2 \times 10^{12}$ (25°C)

What is K_c ?

$$K_p = K_c (RT)^{\Delta n_{gas}}$$

$\Delta n_{gas} = (2) - (3)$
$= -1$

$$K_c = \frac{K_p}{(RT)^{\Delta n_{gas}}}$$

T: 25 + 273.15 = 298.15 K

R: 8.3145 J/mol·K // 0.08206 atm·L/mol·K

$$K_c = \frac{2.2 \times 10^{12}}{(0.08206 \times 298)^{-1}} = 5.4 \times 10^{13}$$

Units of K_c, K_p

- actually just use #, not units when [ ] and P

$[A] = 2.0$ ~~M~~

$P_A = 0.10$ ~~atm~~

Reality

~~[A]~~ $\frac{[A]}{c^\ominus}$ ~~P_A~~ $\frac{P_A}{P^\ominus}$

$c^\ominus$: std state conc (1M)

$P^\ominus$: std. state pressure (1 atm) ex: if $[A] = 2.0M$

$$\frac{[A]}{c^{\ominus}} = \frac{2.0\cancel{M}}{1\cancel{M}} = 2.0 \quad (\text{pure \#})$$

$$P_A / P^{\ominus} = \frac{3.0\cancel{atm}}{1\cancel{atm}} = 3.0 \quad (\text{pure \#})$$