#2 Manipulating the Equilibrium Constant

① The Keq of a reaction in the reverse direction is the reciprocal of the Keq of the forward.

Ex: $N_2O_4 \rightleftharpoons 2NO_2 = K_c = \frac{[NO_2]^2}{[N_2O_4]} = 0.212 @ 100°C$

$2NO_2 \rightleftharpoons N_2O_4 = K_c = \frac{[N_2O_4]}{[NO_2]^2} = \frac{1}{0.212} @ 100°C$

$= 4.72 @ 100°C$

② If change the coefficients, you must do the same to the power of Keq

$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$ $aA + bB \rightleftharpoons cC + dD$

Ex: $2\,SO_{3(g)} \rightleftharpoons 2\,SO_{2(g)} + O_{2(g)}$

$K_c = 2.4 \times 10^{-3}$ at 200°C

(A) What is the K_{eq} for the reverse?

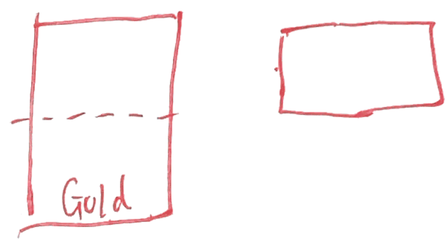
$$K_c = \frac{1}{2.4 \times 10^{-3}} = 420$$

(B) What is the K_{eq} for the <u>reverse</u> rxn if the coefficients are halved?

$$(420)^{1/2} = \sqrt{420} = 20 = K_c$$

Heterogeneous Equilibrium

Concentrations of solids & liquids are essentially constant, thus they are not in the equilibrium expression



$$PbCl_{2(s)} \rightleftharpoons Pb^{2+}_{(aq)} + 2Cl^-_{(aq)}$$

$$K_c = [Pb^{2+}][Cl^-]^2$$

AKA K_{sp} = Solubility Product Constant

Ex: Write K_{eq} for K_c & K_p

(a) $CO_{2(g)} + H_{2(g)} \rightleftharpoons CO_{(g)} + H_2O_{(l)}$

$$K_c = \frac{[CO]}{[CO_2][H_2]} \qquad K_p = \frac{P_{CO}}{(P_{CO_2})(P_{H_2})}$$

(b) $SnO_{2(s)} + 2CO_{(g)} \rightleftharpoons Sn_{(s)} + 2CO_{2(g)}$

$$K_c = \frac{[CO_2]^2}{[CO]^2} \qquad K_p = \frac{(P_{CO_2})^2}{(P_{CO})^2}$$

Equilibrium Calculations

① A mixture of H_2 & N_2 attains equilibrium at 472°C

0.1207 M H_2
0.0402 M N_2
0.00272 M NH_3

Calculate K_c

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

$$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3} = \frac{(0.00272)^2}{(0.1207)^3(0.0402)} = 0.105$$

$K_c = 0.105$

(2) $K_p = 1.45 \times 10^{-5}$ @ 500°C

In an equil. mixture at 500°C, P. pressure of

$H_2 = 0.928$ atm

$N_2 = 0.432$ atm

What is the P Pressure of NH_3 in the mixture

$$K_p = \frac{(P_{NH_3})^2}{(P_{N_2})(P_{H_2})^3}$$

$$1.45 \times 10^{-5} = \frac{(P_{NH_3})^2}{(0.432 \text{ atm})(0.928)^3}$$

$P_{NH_3} = 0.0022\,4$ ATM