Equilibrium Law

Introduction to the Equilibrium law

- Read 14.3 to PE1

Equilibrium constant → $Kc = \frac{[H_2O]^2}{[H_2]^2[O_2]}$ ← Mass action expression

$2H_2(g) + O_2(g) \leftrightarrow 2H_2O(g)$

Step 1: Set up the "equilibrium law" equation
Step 2: Product concentrations go in numerator
Step 3: Concentration in mass action expression is raised to the coefficient of the product
Step 4: Reactant concentrations go in denominator
Step 5: Concentrations in mass action expression are raised to the coefficients of reactants

Equilibrium law: important points

- State (g, l, s, aq) may or may not be added at this point since we will only be dealing with gasses for this section. Later it will matter.
- The equilibrium law includes concentrations of products and reactants in mol/L (M)
- The value of Kc will depend on temperature, thus this is listed along with the Kc value
- Tabulated values of Kc are unitless
- By substituting equilibrium concentrations into equilibrium law, we can calculate Kc …
- Do RE 14.31, 35, 36, 37 (pg. 589)

Equilibrium law: RE 14.31, 14.35

$CO(g) + 2H_2(g) \leftrightarrow CH_3OH(g)$

$C_2H_4(g) + H_2O(g) \leftrightarrow C_2H_5OH(g)$

Equilibrium law: RE 14.36, 14.37

$CO(g) + 2H_2(g) \leftrightarrow CH_3OH(g)$

$N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g)$

When Kc ≠ mass action expression

- We can use the equilibrium law to determine if an equation is at equilibrium or not
- If mass action expression equals equilibrium constant then equilibrium exists

Q - consider: $C_2H_4(g) + H_2O(g) \leftrightarrow C_2H_5OH(g)$
If Kc = 300, []s = 0.0197 M, 0.0200 M, 0.175 M which direction will the reaction need to shift?

$$Kc = \frac{[C_2H_5OH]}{[C_2H_4][H_2O]}, \quad Kc = \frac{[0.175]}{[0.0197][0.0200]} = 300$$

444 ≠ 300

444 must be reduced to 300. Thus, the top must decrease and the bottom must increase. A shift to left is required to establish equilibrium.

More equilibrium law problems

- Do RE 14.32, 33 (pg. 589). For each, state in which direction the reaction needs to shift

$PCl_3(g) + Cl_2(g) \leftrightarrow PCl_5(g)$

$SO_2(g) + NO_2(g) \leftrightarrow NO(g) + SO_3(g)$