SCH 4U

PREDICTING DIRECTION OF REACTION

$$K_c = \frac{[Products]^x}{[Reactants]^y}$$

1. If Reactants $\rightleftharpoons$ Products, then $[P] \gg [R]$ $\quad \therefore K_c \gg 1$

2. If Reactants $\rightleftharpoons$ Products, then $[P] \approx [R]$ $\quad \therefore K_c \approx 1$

3. If Reactants $\rightleftharpoons$ Products, then $[P] \ll [R]$ $\quad \therefore K_c \ll 1$

To Check if a Reaction has reached Equilibrium,

1. Use reaction quotient, Q_c, (same as K_c, but used to test an equilibrium system).

2. Substitute values into Q_c.

3. If $Q_c = K_c$, system is at equilibrium.

If $Q_c > K_c$, too many products, so reaction will reach equilibrium by going to the <u>LEFT</u>.

If $Q_c < K_c$, too few products, so reaction will reach equilibrium by going to the <u>RIGHT</u>.

Eg. At 500°C, K_c=0.40 for $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

In a container, $[N_{2(g)}]$ = 0.10 mol/L, $[H_{2(g)}]$ = 0.30 mol/L, and $[NH_3]$ = 0.20 mol/L.

A) Is this reaction at equilibrium?

B) If not, which direction will it go to reach equilibrium?

$$Q_c = \frac{[NH_3]^2}{[N_2][H_2]^3} \qquad K_c = 0.40$$

Le Chatelier's Principle

"If a system at equilibrium is subjected to an external stress, the equilibrium will shift so as to minimize the stress."

(A) CHANGES IN [R] & [P]

- If [R] increases or [P] decreases, $Q_c < K_c$, therefore reaction goes to the right.
- If [R] decreases or [P] increases, $Q_c > K_c$, therefore reaction goes to the left.

Eg. $A + B \rightleftharpoons C + D$

(B) CHANGES IN VOLUME OR PRESSURE (OF GASES)

- If V decreases or P increases, reaction goes to side with fewer moles
- If V increases or P decreases, reaction goes to side with more moles

Eg. $A_{(g)} \rightleftharpoons 2B_{(g)}$ if P increases, reaction goes to the left.

(C) CHANGES IN TEMPERATURE

- If exothermic, treat NRG as a product
- If endothermic, treat NRG as a reactant

Eg. $A \rightleftharpoons B + heat$

If temperature increases (more heat), reaction goes to the left.
If temperature decreases (less heat), reaction goes to the right.

Eg. $C + heat \rightleftharpoons D$

If temperature increases, reaction goes to the right.
If temperature decreases, reaction goes to the left.

(D) EFFECT OF A CATALYST

- No effect on equilibrium (would only get there faster)

(E) ADDITION OF A NON-REACTANT/PRODUCT

- Not part of reaction, so it does not affect equilibrium

Eg. How can you shift equilibrium to the right?

$$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)} \qquad \Delta H^{o} = -198 \text{ kJ}$$

A) Temperature –

B) $[SO_2]$ –

C) $[O_2]$ –

D) $[SO_3]$ –

E) Pressure –

F) Volume –

Eg. Which direction will equilibrium shift for ...

$$N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)} \qquad \Delta H^{o} = +179 \text{ kJ}$$

A) add N_2 –

B) remove O_2 –

C) add catalyst –

D) add He –

E) reduce volume to half –