AP Chemistry Review
Chapter ~~14~~: Equilibrium
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Name Key

1. Set up the equilibrium constant expressions for K_c and K_p for the following equation:

$$SO_2Cl_2(g) \leftrightarrow SO_2(g) + Cl_2(g)$$

$$K_c = \frac{[SO_2][Cl_2]}{[SO_2Cl_2]} \qquad K_p = \frac{P_{SO_2} P}{P_{SO}}$$

If the $K_p = 2.9 \times 10^{-2}$ at 303 K, what is the K_c?

$$K_c = \frac{K_p}{(RT)^{\Delta n}} = \frac{2.9 \times 10^{-2}}{((.0821)(303))^1} = \boxed{1.2 \times 10^{-3}}$$

2. What is the value of K_p at 298 K for the reaction: $N_2(g) + 2\,O_2(g) \leftrightarrow N_2O_4(g)$
given the following data?

x2	$\left(\frac{1}{2} N_2(g) + \frac{1}{2} O_2(g) \leftrightarrow NO(g)\right)$	$K_{p_1} = 6.9 \times 10^{-16}$
x -2	$\left(NO_2(g) \leftrightarrow NO(g) + \frac{1}{2} O_2(g)\right)$	$K_{p_2} = 6.7 \times 10^{-7}$
x -1	$N_2O_4(g) \leftrightarrow 2\,NO_2(g)$	$K_{p_3} = 0.15$

[illegible]

$N_2 + O_2 \leftrightarrow \cancel{2NO}$

$\cancel{2NO} + O_2 \leftrightarrow \cancel{2NO_2}$

$\cancel{2NO_2} \leftrightarrow N_2O_4$

$$K = (K_{p_1})^2 \left(\frac{1}{K_{p_2}}\right)^2 \left(\frac{1}{K_{p_3}}\right)$$

$$= (6.9 \times 10^{-16})^2 \left(\frac{1}{6.7 \times 10^{-7}}\right)^2 \left(\frac{1}{.15}\right)$$

$$= [illegible]$$

$$(4.76 \times 10^{-31})(2.23 \times 10^{12})(6.67)$$

$$= 7.08 \sim \boxed{7.1 \times 10^{-18}}$$

3. If the equilibrium concentrations found in the reaction $2\,A(g) + B(g) \leftrightarrow C(g)$ are $[A] = 2.4 \times 10^{-2}$ *M*, $[B] = 4.6 \times 10^{-3}$ *M*, and $[C] = 6.2 \times 10^{-3}$ *M*, calculate the value of K_c.

$$K_c = \frac{[C]}{[A]^2[B]} = \frac{6.2 \times 10^{-3}}{(2.4 \times 10^{-2})^2 (4.6 \times 10^{-3})} = \boxed{2.3 \times 10^{3}}$$

4. The water-gas reaction is used to produce combustible gases from carbon (coal) and steam . $C(s) + H_2O(g) \leftrightarrow CO(g) + H_2(g)$

$K_p = 9.7 \times 10^{-17}$ at 298 K $\Delta H^\circ = 131$ kJ

What will be the effect on the final equilibrium amount of $H_2(g)$ if a gaseous mixture originally at equilibrium with a large excess of C(s) at 298 K is subjected to the following changes:

a) more H_2O is added $\longrightarrow$, $[H_2]\uparrow$

b) a catalyst is added no shift, no change in $[H_2]$

↑, P↓, favor ↑ mole ← c) the mixture is transferred to a reaction vessel of greater volume ~~No Δ b/c no Δ gas mol~~

→ , $[H_2]\uparrow$

d) more CO(g) is added $\longleftarrow$, $[H_2]\downarrow$

e) an inert gas is added to the reaction vessel to increase the total pressure Partial Press of each gas do not change, no change in $[H_2]$

f) the temperature is raised to 1000 K

endothermic $\longrightarrow$ $[H_2]\uparrow$

g) a small amount of C(s) is removed

Solids are not part of equil. expression no change in $[H_2]$

5. A mixture of 5.25 g I_2 and 2.15 g Br_2 is brought to equilibrium in a 3.15 L reaction vessel at 115°C. At equilibrium, 1.98 g of I_2 is present. What is K_c at 115°C for the reaction $I_2(g) + Br_2(g) \leftrightarrow 2\,IBr(g)$?

$$\frac{5.25\,g\,I_2}{\cancel{3.15\,L}} \Big| \frac{mol}{253.82\,g} = \frac{.0207\,mol}{3.15\,L} = 6.57 \times 10^{-3}\,\underline{M}\ I_2$$

$$\frac{2.15\,g}{3.15\,L} \Big| \frac{mol}{159.8\,g} = 4.27 \times 10^{-3}\,\underline{M}\ Br_2$$

$$\frac{1.98\,g\,I_2}{3.15\,L} \Big| \frac{mol}{253.82\,g} = 2.48 \times 10^{-3}\,\underline{M}\ I_2$$

	I_2 +	Br_2 $\rightleftharpoons$	2 IBr
I (M)	6.57×10^{-3}	4.27×10^{-3}	—
C	-4.09×10^{-3}	-4.09×10^{-3}	$2(4.09\times10^{-3})$
E	2.48×10^{-3}	1.80×10^{-4}	8.18×10^{-3}

$$K_c = \frac{[IBr]^2}{[I_2][Br_2]} = \frac{(8.18\times10^{-3})^2}{(2.48\times10^{-3})(1.80\times10^{-4})} = 149.9 \sim \boxed{150}$$

6. If a reaction mixture at 588 K contains 20.0 g each of CO and H_2O and 25.0 g each of CO_2 and H_2, in what direction will a net reaction occur to reach equilibrium? Explain. $CO(g) + H_2O(g) \leftarrow\rightarrow CO_2(g) + H_2(g)$ $K_c = 31.4$ at 588 K

$20.0\,g\,CO \left| \frac{mol}{28\,g} \right. = .714\,mol$

$20.0\,g\,H_2O \left| \frac{mol}{18\,g} \right. = 1.11\,mol$

$25.\,g\,CO_2 \left| \frac{mol}{44.0\,g} \right. = .568\,mol$

$25.\,g\,H_2 \left| \frac{mol}{2.0\,g} \right. = 12.5\,mol$

volumes cancel

$$Q_c = \frac{[CO_2][H_2]}{[CO][H_2O]} = \frac{(.568)(12.5)}{(.714)(1.11)} = 8.96$$

$$\boxed{Q_c < K_c}$$

rxn proceeds right to ↑ [P]

7. In the reaction $SB_2S_3(s) + 3\,H_2(g) \leftarrow\rightarrow 2\,Sb(s) + 3\,H_2S(g)$, $K_p = 0.429$ at 713 K. If, at equilibrium, $P_{H2S} = 0.200$ atm, what must be P_{H2} and the total gas pressure, P_{Total}?

$P_T = P_{H_2S} + P_{H_2}$

$[P_{H_2S}]_{eq} = .200\,atm$

$$K_p = \frac{(P_{H_2S})^3}{(P_{H_2})^3} = .429 = \frac{(.200)^3}{x^3}$$

$P_{H_2} = .265\,atm$

$P_T = .200\,atm + .265\,atm$

$= \boxed{.465\,atm}$