Equilibrium I • CHEM 220

1. Consider the reaction: $SiH_{4(g)} + 2\ Cl_{2(g)} \Leftrightarrow SiCl_{4(g)} + 2\ H_{2(g)}$

A) Write the expression for K_C in terms of reactants and products.

$$K_c = \frac{[H_2]^2[SiCl_4]}{[Cl_2]^2[SiH_4]}$$

B) Write the expression for K_P in terms of reactants and products.

$$K_p = \frac{P_{H_2}^2\ P_{SiCl_4}}{P_{Cl_2}^2\ P_{SiH_4}}$$

C) If $K_C = 56$, for the reaction above at 120°C, what is K_P? $(\Delta n = \emptyset)$

$$K_p = 56$$

D) If $K_C = 56$, for the reaction above at 120°C, what will be the K_C for the following reactions?
Look at each CAREFULLY!

i. $\frac{1}{2}\ SiH_{4(g)} + Cl_{2(g)} \Leftrightarrow \frac{1}{2}\ SiCl_{4(g)} + H_{2(g)}$ $K_C = (56)^{\frac{1}{2}} = 7.5$

ii. $3\ SiCl_{4(g)} + 6\ H_{2(g)} \Leftrightarrow 3\ SiH_{4(g)} + 6\ Cl_{2(g)}$ $K_C = 5.7 \times 10^{-6}$

2. Consider the reaction: $CO_{2(g)} + H_{2(g)} \Leftrightarrow CO_{(g)} + H_2O_{(g)}$, for which $K_C = 6.8$ for this reaction at 550 K.

A) If a mixture had the following concentrations, it would not be at equilibrium. Will it proceed to the right or the left? Provide a mathematical justification of your answer.

$[CO_2] = [H_2] = 0.45\ M$

$[CO] = [H_2O] = 0.71\ M$

$$Q = \frac{(0.71)^2}{(0.45)^2} = 2.5$$

$Q < K$, Rxn shifts right (to PRODUCTS)

B) What will be the concentrations of the new equilibrium condition?

	CO_2	+ H_2	$\rightleftharpoons$ CO	+ H_2O
	$0.45-x$	$0.45-x$	$0.71+x$	$0.71+x$

$$\sqrt{6.8 = \frac{(0.71+x)^2}{(0.45-x)^2}} \Rightarrow 2.608 = \frac{0.71+x}{0.45-x}$$

$1.173 - 2.608x = 0.71 + x$

$0.463 = 3.608x$

$x = 0.13\ M$

$[CO_2] = [H_2] = 0.32\ M$

$[CO] = [H_2O] = 0.84\ M$

3. Consider the reaction: $N_{2(g)} + 3\ Cl_{2(g)} \Leftrightarrow 2\ NCl_{3(g)}$.

A) At 115°C, nitrogen and chlorine gas are mixed in a fixed volume container, with $[N_2]_0 = 4.50\ M$ and $[Cl_2]_0 = 2.00\ M$, and no NCl_3. If the equilibrium concentration of nitrogen trichloride is $[NCl_3] = 1.00\ M$, what is the value of K_C for the reaction?

	$N_{2(g)}$ +	$3Cl_{2(g)}$ $\rightleftharpoons$	$2NCl_{3(g)}$
st.	4.50 M	2.00 M	∅
Δ	−0.50 M	−1.50 M	+1.00 M
eq.	4.00 M	0.50 M	1.00 M

$$K_c = \frac{(1.00\ M)^2}{(0.50\ M)^3(4.00\ M)} = 2.0\ M^{-2}$$

B) What is the value for K_P at the same temperature?

$$K_p = K_c(RT)^{\Delta n} = (2.0\ M^{-2})\left(0.0821 \frac{L \cdot atm}{K \cdot mol} \cdot 388\ K\right)^{-2}$$

$$K_p = 2.0 \times 10^{-3}\ atm^{-2}$$