Equilibrium Key

1. Answer the following three questions for the reaction of HF gas decomposing into hydrogen gas and fluorine gas at 78.5 ^oC.
   a. Write out the balanced reaction and the K_c and K_p expressions.

   $2\ HF(g) \leftrightharpoons H_2\ (g) + F_2\ (g)$

   $$Kc = \frac{[H_2][F_2]}{[HF]^2} \qquad Kp = \frac{P_{H2}\ P_{F2}}{P_{HF}^{\ 2}}$$

   b. Given $K_p = 4.25 \times 10^{-4}$ calculate K_c.

   $(4.25 \times 10^{-4}) = Kc\ [(0.08206)(351.5K)]^0$ so $4.25 \times 10^{-4} = Kc$ (anything raised to 0 is equal to 1)

   c. If I begin the reaction with 0.224 g of pure hydrogen fluoride in a 1550 mL closed flask, calculate all the equilibrium concentrations for each species in the reaction in units of moles/L.

   $$0.224\text{ g HF}\left(\frac{1\text{ mol}}{20.0\text{ g}}\right)\left(\frac{1}{1.550\text{ L}}\right) = 7.2258 \times 10^{-3}M$$

   Set up ICE table

	$2\ HF(g)$	$\leftrightharpoons H_2\ (g)$	$+ F_2\ (g)$
I	.0072258	0	0
C	-2x	+x	+x
E	.0072258 - 2x	x	x

   Thus $4.25 \times 10^{-4} = x^2 / (0.0072258 - 2x)^2$
   take the square root of both sides, no quadratic necessary
   $0.020616 = x / (0.0072258 - 2x)$
   collect terms
   $1.4896 \times 10^{-4} - 0.041232x = 1x$
   $1.4896 \times 10^{-4} = 1.041232x$
   $x = [H_2] = [F_2] = 1.43 \times 10^{-4}M$ and $[HF] = 6.94 \times 10^{-3}M$

2. A 0.0240 mol sample of $N_2O_4(g)$ is allowed to reach equilibrium with $NO_2(g)$ in a 0.372 L flask at 25.0^oC. Calculate the concentration of $N_2O_4(g)$ at equilibrium. $N_2O_4(g) \leftrightharpoons 2\ NO_2(g)$ $K_c = 4.61 \times 10^{-3}$

   $$\text{initial molarity } N_2O_4(g) = \left(\frac{.0240\text{ mol}}{.372L}\right) = .06452M$$

	$N_2O_4(g)$	$\leftrightharpoons 2\ NO_2(g)$
I	.06452	0
C	-x	+2x
E	(.06452 - x)	2x

   $4.61 \times 10^{-3} = (2x)^2 / (0.06452 - x)$
   $4x^2 = -4.61 \times 10^{-3}x + 2.974 \times 10^{-4}$
   $4x^2 + 4.61 \times 10^{-3}x - 2.974 \times 10^{-4} = 0$

quadratic formula with a = 4, b = +4.61 x 10^{-3} and c = - 2.974 x 10^{-4}
x = 8.065 x 10^{-3} (the other solution is negative and can't have negative concentration)
thus [N_2O_4] = 0.0565M

3. Consider the reaction $N_2O_4(g) \leftrightarrows 2\ NO_2(g)$, where K_c = 5.7 at 250 °C. If the initial concentration of N_2O_4 is 0.350 M and that of NO_2 is 1.20 M in a flask at 250 °C, will the reaction go forwards or backwards to reach equilibrium? *(Must show work for credit)*

$$Q = \left(\frac{(1.20)^2}{0.350}\right)$$ **= 4.11 which is less than K so reaction is going forwards till ⇆ reached**

4. A quantity of 2.40 moles of pure SO_2Cl_2 gas was placed in an 8.00 L sealed flask. At 500 K, after equilibrium is established, there are 1.60 moles of the product gas SO_2 present. Calculate K_c for the reaction. $SO_2Cl_2(g) \leftrightarrows SO_2(g) + Cl_2(g)$

2.40 mol / 8.00 L = .300M initial SO_2Cl_2 (g) **1.60 mol / 8.00L = .200 M SO_2 (g) at ⇆**

	SO_2Cl_2 (g) ⇆	SO_2 (g) +	Cl_2 (g)
I	**.300**	**0**	**0**
C	**-x**	**+x**	**+x**
E	**(.300-x)**	**.200**	**x**

So x must = .200 so $K_c = (.200)^2\ /\ .100 = .400$

5. Consider this endothermic reaction: $CO_2(g) + C(s) \leftrightarrows 2\ CO(g)$. To make the most CO gas:
   a. You could increase the pressure. (true or false?) _ **false**
   b. You could increase the volume. (true or false?) _ **true, more space for more moles of gas**
   c. You could add more carbon monoxide gas. (true or false?) __ **false** ___
   d. You could decrease the temperature. (true or false?) ____ **false (heat is a reactant)**_
   e. You could add more carbon. (true or false?) _____ **false solids don't affect K**_
   f. You could add a catalyst. (true or false?) ___ **false, catalysts make rxns reach ⇆ faster**_

6. Write the equilibrium constant expressions K_c and K_p and the balanced reaction for the reaction between aqueous potassium sulfate and aqueous calcium nitrate.

$K_2SO_4(aq) + Ca(NO_3)_2(aq) \leftrightarrows CaSO_4(s) + 2\ KNO_3(aq)$

$K_c = [KNO_3]^2\ /\ [K_2SO_4]\ [Ca(NO_3)_2]$ **K_p = none, there are no gases**

7. Calculate K_p for the formation of steam reaction if at equilibrium at 150°C the gas pressures are 0.145 atm for hydrogen, 0.108 atm for oxygen, and 15.4 atm for steam.

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

$K_p = [H_2O]^2\ /\ [H_2]^2\ [O_2] = (15.4)^2\ /\ (.145)^2(.108) = 1.04 \times 10^5$ (product favored)