

The equilibrium concentration for the above reactions is:

$$[H_2]_{eq} = 0.66 \text{ M} \quad [CO]_{eq} = 1.37 \text{ M}$$

The equilibrium expression is $K_c = \frac{[CH_3OH]^1}{[H_2]^2[CO]^1}$

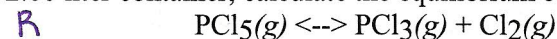
$$K_c = \frac{0.200}{(0.66)^2 \cdot 1.37} \quad K_c = 0.335$$

If an equilibrium concentration is not given in the problem, but the equilibrium constant is given the above procedure is followed except X would be included in your expression and the quadratic is used to solve for X.

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

When using the quadratic to solve for the possibilities of X, one of the roots will result in a negative concentration at equilibrium. This root may be thrown out.

- c. The equilibrium constant, K_c , for the reaction below is 33.3 at 760 °C. If 0.400 mol of PCl_5 are placed in a 2.00 liter container, calculate the equilibrium concentrations of all species.



I	0.200 M	0	0
C	-x	+x	+x
E	0.200 - x	+x	+x

$[PCl_5] = \frac{0.400}{2} = 0.200 \text{ M}$
or use mols

so $[PCl_5]_{eq} = 0.200 - 0.199 = 0.001 \text{ M}$

$[PCl_3] = [Cl_2] = 0.199 \text{ M}$

$$K_c = 33.3 = \frac{[PCl_3][Cl_2]}{[PCl_5]} = \frac{x^2}{0.200 - x}$$

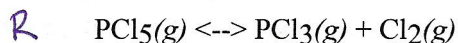
$$33.3(0.200 - x) = x^2$$

$$0 = x^2 + 33.3x - 6.66$$

solve using quadratic

$$x = -33.4988 \text{ or } x = 0.199 \text{ M} \quad [PCl_5] = 0.199, [PCl_3] = 0.001, [Cl_2] = 0.199$$

- d. The equilibrium constant, K_c , for the reaction



is 33.3 at 760 °C. If 0.400 mol of PCl_5 and 1.0 mol of Cl_2 are placed in a 2.00 liter container, calculate the equilibrium concentrations of all species.

I	0.200 M	0	0.500 M
C	-x	+x	+x
E	0.200 - x	x	0.500 + x

$$K_c = 33.3 = \frac{[PCl_3][Cl_2]}{[PCl_5]} = \frac{x(0.500 + x)}{0.200 - x}$$

$$33.3(0.200 - x) = 0.500x + x^2$$

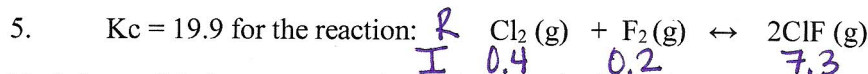
$$6.66 - 33.3x = 0.500x + x^2$$

$$0 = x^2 + 0.500x + 33.3x - 6.66$$

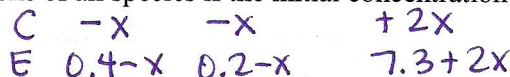
$$0 = x^2 + 33.8x - 6.66$$

$$x = 0.196 \text{ M or } -33.995 \text{ M}$$

$[PCl_5] = 0.196, [PCl_3] = 0.004, [Cl_2] = 0.696$



Find the equilibrium concentrations of all species if the initial concentration of $[\text{Cl}_2]$ is 0.4M, $[\text{F}_2]$ is 0.2 M, and $[\text{ClF}]$ is 7.3 M.



$$19.9 = \frac{[\text{ClF}]^2}{[\text{Cl}_2][\text{F}_2]} = \frac{(7.3+2x)^2}{(0.4-x)(0.2-x)} = \frac{53.29 + 29.2x + 4x^2}{.08 - 0.6x + x^2}$$

$$19.9(.08 - 0.6x + x^2) = 53.29 + 29.2x + 4x^2$$

$$1.592 - 11.94x + 19.9x^2 = 53.29 + 29.2x + 4x^2$$

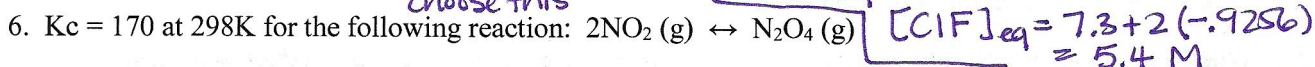
$$15.9x^2 - 41.14x - 51.698 = 0$$

$$x = 3.5129 \text{ or } -0.9256$$

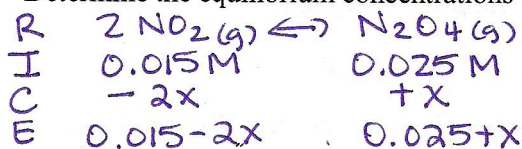
↑
choose this

$$[\text{Cl}_2]_{\text{eq}} = 0.4 - (-0.9256) = 1.3 \text{ M}$$

$$[\text{F}_2]_{\text{eq}} = 1.1 \text{ M}$$



a) Suppose the initial concentration of NO_2 is 0.015 M and the concentration of N_2O_4 is 0.025 M. Determine the equilibrium concentrations of all species. x is negligible, $170 \gg 0.015$



$$K_c = 170 = \frac{[\text{N}_2\text{O}_4]}{[\text{NO}_2]^2} = \frac{.025+x}{(.015-2x)^2}$$

$$170(.015-2x)^2 = .025+x$$

$$170(0.000225 - 0.0006x + 4x^2) = .025+x$$

$$.03825 - .102x + 680x^2 = .025+x$$

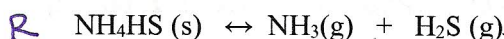
$$680x^2 - 0.102x + .01325 = 0$$

Complex roots - ignore the "i"

$$x = .000075 \text{ M}$$

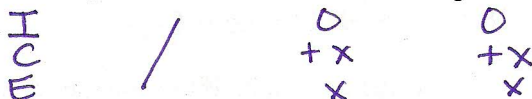
$$[\text{NO}_2] = 0.015 - 2(.000075) \approx .015 \text{ M}$$

7. K_c for the decomposition of ammonium hydrogen sulfide is 1.8×10^{-4} at 298K.



$$[\text{N}_2\text{O}_4] = .025 + .000075 \approx .025 \text{ M}$$

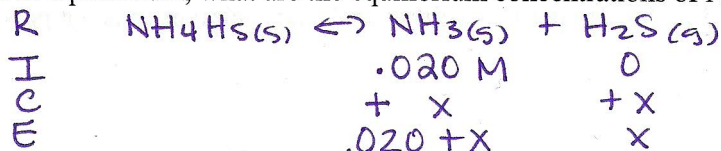
a) When the pure salt decomposes in a flask, what are the equilibrium concentration of NH_3 and H_2S ?



$$K_c = 1.8 \times 10^{-4} = [\text{NH}_3][\text{H}_2\text{S}] = x^2$$

$$\sqrt{1.8 \times 10^{-4}} = x = .013 \text{ M} = [\text{NH}_3]_{\text{eq}} = [\text{H}_2\text{S}]_{\text{eq}}$$

b) If NH_4HS is placed in a flask already containing 0.020 mol/L of NH_3 and then the system is allowed to come to equilibrium, what are the equilibrium concentrations of NH_3 and H_2S ?



$$K_c = 1.8 \times 10^{-4} = [\text{NH}_3][\text{H}_2\text{S}] = (.020+x)(x)$$

$$1.8 \times 10^{-4} = .020x + x^2$$

$$0 = x^2 + .020x - 1.8 \times 10^{-4}$$

$$x = -.02673 \text{ M or } 0.00673 \text{ M}$$

$$[\text{H}_2\text{S}]_{\text{eq}} = [\text{NH}_3]_{\text{eq}} = .0067 \text{ M}$$