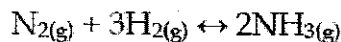


5.3 - ICE Box Problems - Assignment

1. For the reaction



The initial $[\text{N}_2] = 0.32 \text{ M}$ and the initial $[\text{H}_2] = 0.66 \text{ M}$. At a certain temperature and pressure the equilibrium $[\text{H}_2]$ is found to be 0.30 M . What is K_{eq} under these circumstances?

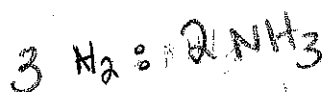
	$[\text{N}_2]$	$[\text{H}_2]$	$[\text{NH}_3]$
[Initial]	0.32	0.66	0
[Change]	-0.12	-0.36	0.24
[Equilibrium]	0.20	0.30	0.24

$$\frac{\text{N}_2}{\boxed{1}} = \frac{\text{H}_2}{\boxed{3}}$$

$$\frac{1 \text{ mol}}{x} = \frac{3 \text{ mol}}{0.36 \text{ M}}$$

$$x = 0.12 \text{ M}$$

$$K_{\text{eq}} = \frac{[\text{NH}_3]^2}{[\text{H}_2]^3 [\text{N}_2]} = \frac{[0.24]^2}{[0.3]^3 [0.2]} = \frac{0.0576}{(0.027)(0.2)} = 10.7$$



$$0.36 : x$$

$$x = 0.24 \text{ M}$$

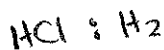
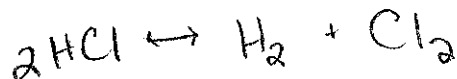
$$M =$$

$$K_{\text{eq}} = 10.7$$

$$57$$

2. Suppose that 2.00 moles of HCl in a 1.00L glass flask slowly decomposes into H_2 and Cl_2 . When equilibrium is reached, the concentrations of H_2 and Cl_2 are both 0.214 M . What is the K_{eq} ?

	HCl	H_2	Cl_2
[Initial]	2.0	0	0
[Change]	-0.428	+0.214	+0.214
[Equilibrium]	1.572	0.214	0.214



$$\frac{2 \text{ mol}}{x} = \frac{1 \text{ mol}}{0.214}$$

$$x = 0.428$$

$$K_{\text{eq}} = \frac{[\text{H}_2][\text{Cl}_2]}{[\text{HCl}]^2} = \frac{[0.214][0.214]}{[1.572]^2}$$

$$= \frac{0.045796}{2.471184}$$

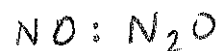
$$= 0.0185$$

$$= 1.85 \times 10^{-2}$$



3. Consider the equilibrium: $2\text{N}_2\text{O(g)} + \text{O}_2\text{(g)} \leftrightarrow 4\text{NO(g)}$ *Keq for this rxn*
 3.00 moles of NO(g) are introduced into a 1.00-Liter evacuated flask. When the system comes to equilibrium, 1.00 mole of N₂O(g) has formed. Determine the equilibrium concentrations of each substance. Calculate the K_c for the reaction based on these data.

	NO	N ₂ O	O ₂
[Initial]	3.0	0	0
[Change]	-2.0	+1.0	+0.5M
[Equilibrium]	1.0	1.0	0.5M



$$\frac{4\text{mol}}{x} = \frac{2\text{mol}}{1.0}$$

$$x = 2.0\text{M}$$



$$\frac{1\text{mol}}{x} = \frac{2\text{mol}}{1.0}$$

$$x = 0.5\text{M}$$

$$K_{eq} = \frac{[\text{NO}]^4}{[\text{N}_2\text{O}]^2 [\text{O}_2]}$$

$$= \frac{[1.0]^4}{[1.0]^2 [0.5]} = \boxed{2.00}$$

4. At some temperature, K_{eq} = 33 for the reaction $\text{H}_2 + \text{I}_2 \rightarrow 2\text{HI}$. If initially, [H₂] = .0600 M and [I₂] = .0300 M, what are all three equilibrium concentrations?

	H ₂	I ₂	HI
[Initial]	0.06	0.03	0
[Change]	-x	-x	+2x
[Equilibrium]			2x

$$0.06-x \quad 0.03-x$$

$$\begin{aligned} \text{Eq:} \\ [\text{H}_2] &= 0.06 - 0.0273 = 0.0327\text{M} \\ [\text{I}_2] &= 0.03 - 0.0273 = 0.0027\text{M} \\ [\text{HI}] &= 2(0.0273) = 0.0546\text{M} \end{aligned}$$

$$K_{eq} = 33$$

$$K_{eq} = \frac{[\text{HI}]^2}{[\text{H}_2][\text{I}_2]} = \frac{[2x]^2}{(0.06-x)(0.03-x)} = \frac{4x^2}{0.0018 - 0.06x - 0.03x + x^2}$$

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

$$33 = \frac{4x^2}{0.0018 - 0.09x + x^2} \Rightarrow 33(0.0018 - 0.09x + x^2) = 4x^2$$

$$0.0594 - 2.97x + 33x^2 = 4x^2$$

$$0.0594 - 2.97x + 29x^2 = 0$$

$$A \quad B \quad A$$

$$x = \frac{-(2.97) \pm \sqrt{(2.97)^2 - 4(0.0594)(29)}}{2(29)}$$

$$x = \frac{2.97 \pm \sqrt{1.9805}}{58}$$

$$x = 0.0152 \text{ or } \boxed{0.0273}$$

5. Graphite (solid carbon) and carbon dioxide are kept at constant pressure at 1000 K until the following reaction reaches equilibrium.



If $K_{eq} = 0.021$, calculate the equilibrium concentration of CO if the concentration of CO_2 was initially 0.012 M.

$K_{eq} = 0.021$

	CO_2	CO
[Initial]	0.012	0
[Change]	-x	+2x
[Equilibrium]	0.012 - x	2x

$$K_{eq} = \frac{[\text{CO}]^2}{[\text{CO}_2]} = \frac{(2x)^2}{(0.012 - x)}$$

$$[\text{CO}] = 2x = 2(0.005735) = 0.01147$$

$$[\text{CO}] = 0.011 \text{ M}$$

$$0.021 = \frac{4x^2}{0.012 - x}$$

$$(0.021)(0.012 - x) = 4x^2$$

$$0.000252 - 0.021x - 4x^2 = 0$$

C B A

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-(-0.021) \pm \sqrt{(-0.021)^2 - 4(4)(0.000252)}}{2(4)}$$

$$x = \frac{0.021 \pm \sqrt{0.004473}}{8}$$

$$x = \frac{0.021 \pm 0.06688049}{8}$$

$$\Rightarrow \frac{-0.04588}{-8} = 0.005735$$

$$\Rightarrow \frac{0.08788}{-8} = -0.01099$$