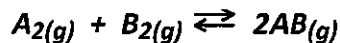


Part A: Finding K_{eq} with all Concentrations at Equilibrium

1. Given the equilibrium equation below:

If, at equilibrium, the concentrations are as follows:

$$[A_2] = 3.45 \text{ M}, \quad [B_2] = 5.67 \text{ M} \quad \text{and} \quad [AB] = 0.67 \text{ M}$$

- a) Write the
- K_{eq}
- expression, and Find the value of the equilibrium constant,
- K_{eq}
- at the temperature that the experiment was done.

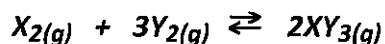
$$K_{eq} = \frac{[AB]^2}{[A_2][B_2]}$$

$$= \frac{(0.67)^2}{(3.45)(5.67)} = \boxed{0.023}$$

- c) Is this equilibrium product or
- reactant
- favoured? How do you know?

$$\hookrightarrow K_{eq} < 1 \quad (\text{more Reactants})$$

2. Given the equilibrium equation:

at a temperature of 50°C , it is found that when *equilibrium is reached* that:

$$[X_2] = 0.37 \text{ M}, \quad [Y_2] = 0.53 \text{ M} \quad \text{and} \quad [XY_3] = 0.090 \text{ M}$$

- a) Write the equilibrium constant expression, and calculate the value of
- K_{eq}
- at
- 50°C
- .

$$K_{eq} = \frac{[XY_3]^2}{[X_2][Y_2]^3}$$

$$= \frac{(0.09)^2}{[(0.37)(0.53)^3]} = \boxed{0.147}$$

- c) Is this equilibrium product or
- reactant
- favoured? How do you know?

$$\hookrightarrow K_{eq} < 1$$

3) Consider the reaction: $A(g) + B(g) \rightleftharpoons C(g)$

a) If in an equilibrium mixture the $[A] = 0.45M$, $[B] = 0.63M$ and $[C] = 0.30M$. Calculate the value of the equilibrium constant for this reaction.

$$K_{eq} = \frac{[C]}{[A][B]} = \frac{(0.3)}{(0.45)(0.63)} = \boxed{1.06}$$

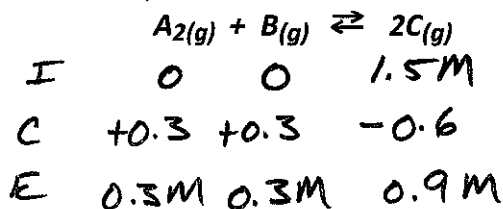
b) At the same temperature, another equilibrium mixture is analyzed and it is found that $[B] = 0.21 M$ and $[C] = 0.70 M$. From this and the information above, calculate the equilibrium $[A]$.

$$1.06 = \frac{(0.7)}{[A](0.21)}$$

$$[A] = \frac{0.7}{(1.06)(0.21)} = \boxed{3.14 \frac{\text{mol}}{\text{L}}}$$

Part B: Finding K_{eq} – NOT all Concentrations at Equilibrium (Using ICE Tables)

4. For the following reaction, it is found that by adding 1.5 moles of C to a 1.0 L container, an equilibrium is established in which 0.30 moles of B are found. (Hint: Make a table and use it to answer the questions below.)



a) What is $[A]$ at equilibrium?

Answer 0.3M

b) What is $[B]$ at equilibrium?

Answer 0.3M

c) What is $[C]$ at equilibrium?

Answer 0.9M

d) Write the K_{eq} expression for the equilibrium constant and calculate the value of K_{eq} at the temperature at the experiment was done.

$$K_{eq} = \frac{[C]^2}{[A_2][B]}$$
$$= \frac{(0.9)^2}{(0.3)(0.3)} = \boxed{9}$$

5. Considering the following equilibrium:



If 0.87 moles of AB_3 are injected into a 5.0 L container at 25°C , at equilibrium the final $[A_2]$ is found to be 0.070 M. (Hint: Make a table and use it to answer the questions below.)

$$\frac{0.87 \text{ mol}}{5 \text{ L}} = 0.174 \frac{\text{mol}}{\text{L}} = [AB_3]$$

	$2AB_3$	\rightleftharpoons	A_2	$+ 3B_2$
I	0.174 M		0	0
C	-0.14		+0.07	+0.21
E	0.034 M		0.07 M	0.21 M

- a) Calculate the equilibrium concentration of AB_3 . Answer 0.034 M
- b) Calculate the equilibrium $[A_2]$. Answer 0.07 M
- c) Calculate the equilibrium $[B_2]$. Answer 0.21 M
- d) Write the equilibrium expression and solve for the value of K_{eq} .

$$K_{eq} = \frac{[B_2]^3 [A_2]}{[AB_3]^2} = \frac{(0.07)(0.21)^3}{(0.034)^2} = \boxed{0.56}$$

6. Two moles of gaseous NH_3 are introduced into a 1.0 L vessel and allowed to undergo partial decomposition at high temperature according to the reaction:



At equilibrium, 1.0 mole of $NH_3(g)$ remains. (Make a table and use it to answer the questions below:)

	$2NH_3$	\rightleftharpoons	N_2	$+ 3H_2$
I	2 M		0	0
C	-1.0		+0.5	+1.5
E	1.0 M		0.5 M	1.5 M

- a) What is the equilibrium $[N_2]$? Answer 0.5 M
- b) What is the equilibrium $[H_2]$? Answer 1.5 M
- c) Calculate the value of the equilibrium constant at the temperature of the experiment.

$$K_{eq} = \frac{[N_2][H_2]^3}{[NH_3]^2} = \frac{(0.5)(1.5)^3}{(1.0)^2} = \boxed{1.69}$$

7. Calculate the value of the equilibrium constant when 1.0 mol of $\text{NH}_3(\text{g})$ and 0.40 mol of $\text{N}_2(\text{g})$ are placed in a 5.0 L vessel and allowed to reach equilibrium. At equilibrium it is found that 0.78 mol of NH_3 is present. The reaction is:

$$[\text{NH}_3]_i = \frac{1 \text{ mol}}{5 \text{ L}} = 0.2 \text{ M}$$

$$[\text{N}_2]_i = \frac{0.4 \text{ mol}}{5 \text{ L}} = 0.08 \text{ M}$$

$$[\text{NH}_3]_{\text{eq}} = \frac{0.78 \text{ mol}}{5 \text{ L}} = 0.156 \text{ M}$$

	$2\text{NH}_3(\text{g}) \rightleftharpoons 3\text{H}_2(\text{g}) + \text{N}_2(\text{g})$	
I	0.2 M	0
C	-0.044	+0.066
E	0.156 M	0.066 M

$$K_{\text{eq}} = \frac{[\text{N}_2][\text{H}_2]^3}{[\text{NH}_3]^2}$$

$$= \frac{(0.102)(0.066)^3}{(0.156)^2} = \boxed{1.2 \times 10^{-3}}$$

8. When 0.40 mol of PCl_5 is heated in a 10.0 L container, an equilibrium is established in which 0.25 mol of Cl_2 is present.

- a) Calculate the value of the equilibrium constant, K_{eq} , given the reaction:

$$[\text{PCl}_5]_i = \frac{0.4 \text{ mol}}{10 \text{ L}} = 0.04 \text{ M}$$

$$[\text{Cl}_2]_{\text{eq}} = \frac{0.25 \text{ mol}}{10 \text{ L}} = 0.025 \text{ M}$$

	$\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$
I	0.04 M
C	-0.025
E	0.015 M

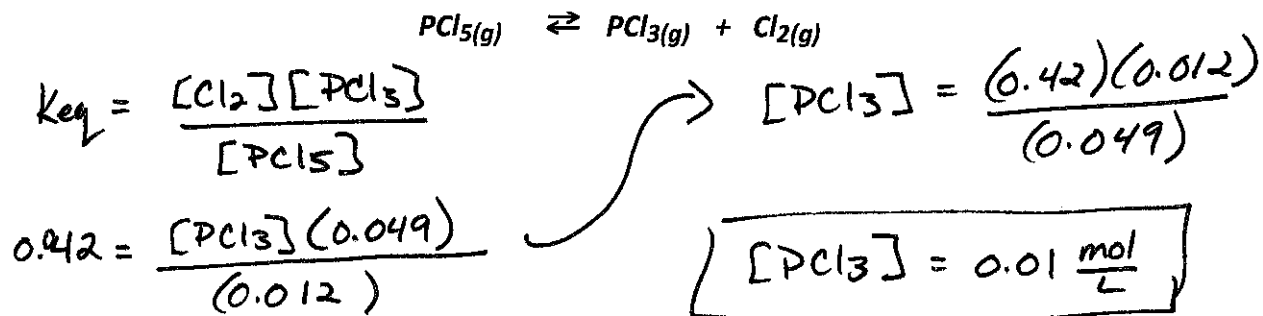
$$K_{\text{eq}} = \frac{[\text{Cl}_2][\text{PCl}_3]}{[\text{PCl}_5]} = \frac{(0.025)(0.025)}{(0.015)} = \boxed{0.042}$$

- b) Is this equilibrium reactant or product favoured? How do you know?

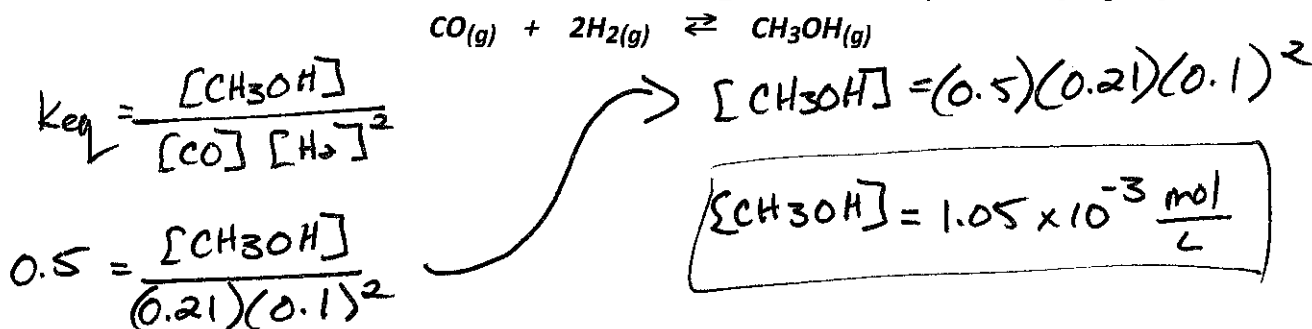
~~reactant~~
 $\rightarrow K_{\text{eq}} < 1$

Part 3: Finding Equilibrium Concentrations (everything at equilibrium)

9. The K_{eq} for the reaction below at 250°C is found to be **0.042**. In an *equilibrium mixture* of these species, it is found that $[\text{PCl}_5] = 0.012 \text{ M}$, and $[\text{Cl}_2] = 0.049 \text{ M}$. What is the equilibrium $[\text{PCl}_3]$ at 250°C ?

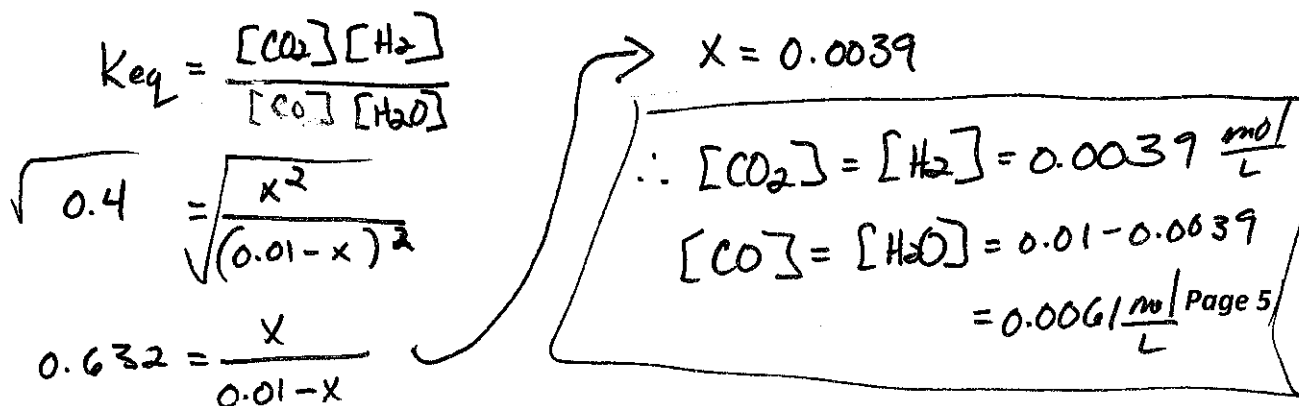
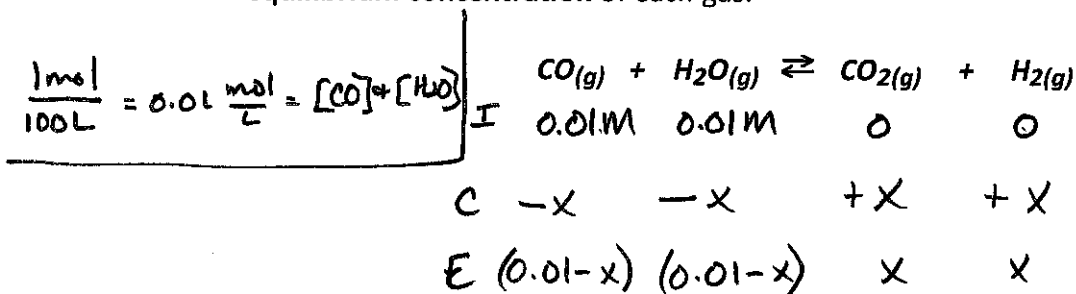


10. At a certain temperature the reaction below has a $K_{eq} = 0.500$. If a reaction mixture at *equilibrium* contains 0.210 M CO and 0.100 M H_2 , what is the *equilibrium* $[\text{CH}_3\text{OH}]$?

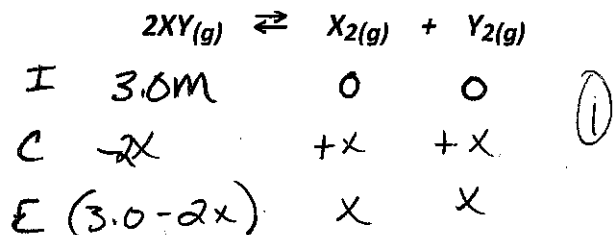


Part 4: Finding Equilibrium Concentrations (NOT everything at equilibrium)

11. At a certain temperature the reaction below has a $K_{eq} = 0.400$. Exactly 1.00 mol of each of the reactants was placed in a 100.0 L vessel and the mixture was allowed to react. Find the *equilibrium concentration* of each gas.



12. The reaction below has a $K_{eq} = 35$ at 25°C . If 3.0 moles of XY are injected into a 1.0 L container at 25°C , find the equilibrium $[X_2]$ and $[Y_2]$.



$$K_{eq} = \frac{[X_2][Y_2]}{[XY]^2}$$

$$\sqrt{35} = \frac{x^2}{(3.0-2x)^2}$$

$$5.92 = \frac{x}{(3.0-2x)}$$

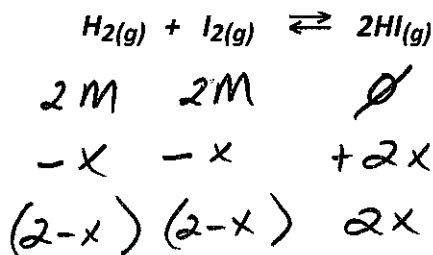
$$17.76 - 11.84x = x$$

$$17.76 = 12.84x$$

$$x = 1.38 \frac{\text{mol}}{\text{L}}$$

$$\therefore [X_2] = [Y_2] = 1.38 \frac{\text{mol}}{\text{L}}$$

13. At 448°C the reaction below has a K_{eq} value of 50. If 1.0 mol of H_2 is mixed with 1.0 mol of I_2 in a 0.50 L container and allowed to react at 448°C , what is the equilibrium $[\text{HI}]$?



$$K_{eq} = \frac{[\text{HI}]^2}{[\text{H}_2][\text{I}_2]}$$

$$\sqrt{50} = \frac{(2x)^2}{(2-x)^2}$$

$$7.07 = \frac{2x}{2-x}$$

$$14.14 - 7.07x = 2x$$

$$14.14 = 9.07x$$

$$x = 1.56$$

$$\therefore [\text{HI}]_{eq} = 2x = 2(1.56) = 3.12 \frac{\text{mol}}{\text{L}}$$