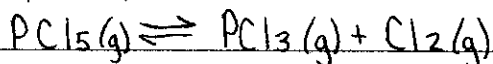


Quantitative Equilibrium Problems

December 12, 2008

• Example #1

0.40 mol $\text{PCl}_5(\text{g})$ is placed in a 15.0L flask and allowed to equilibrate. At equilibrium, the final concentration of $\text{Cl}_2(\text{g})$ is found to be 0.01 mol/L. Find K_{eq} :



(really, find all concentrations 1st and then find K_{eq})

| | $\text{PCl}_5(\text{g})$ | $\text{PCl}_3(\text{g})$ | $\text{Cl}_2(\text{g})$ | 15.0L Flask |
|----------------|--|--------------------------|-------------------------|--|
| Initial [] | _____ | _____ | _____ | Optional Work: |
| Initial Amount | 0.40 mol | \emptyset | \emptyset | ① $n = CV$ $n = 0.01 \text{ mol/L} \times 15.0\text{L}$ |
| Final Amount | 0.40 mol - 0.15 mol initial reacted = 0.25 mol final | ③ 0.15 mol ↓ ⑤ | ② = 0.15 mol | $n = 0.15 \text{ mol Cl}_2$ |
| Final [] | ④ 0.016 mol/L | 0.01 mol/L | ① 0.01 mol/L | ② $0.15 \text{ mol Cl}_2 \times \frac{1 \text{ mol PCl}_3}{1 \text{ mol Cl}_2}$ = 0.15 mol PCl_3 |

$$K_{\text{eq}} = \frac{[\text{PCl}_3][\text{Cl}_2]}{[\text{PCl}_5]} \quad \text{*drop units at this point}$$

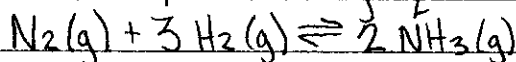
$$K_{\text{eq}} = \frac{(0.01)(0.01)}{(0.016)}$$

$$K_{\text{eq}} = 0.006$$

③ $0.15 \text{ mol Cl}_2 \times \frac{1 \text{ mol PCl}_5}{1 \text{ mol Cl}_2}$
= 0.15 mol PCl_5
④ & ⑤ $C = \frac{n}{V}$

• Example #2

In a 4.0L flask, the following equilibrium is set up:



This is done by injecting 7.005g of N_2 and 0.808g of H_2 . After equilibrium has been reached, the concentration of NH_3 is found to be 0.025 mol/L. Find K_{eq} (assume constant temp).

| | $\text{N}_2(\text{g})$ | $+ 3 \text{H}_2(\text{g})$ | $\rightleftharpoons 2 \text{NH}_3(\text{g})$ | 4.0L Flask |
|----------------|--|--|--|--|
| Initial [] | _____ | _____ | _____ | ① $n = CV$ |
| Initial Amount | $7.005\text{g} \times \frac{1 \text{ mol}}{28.02\text{g}}$ = 0.25 mol | $0.808\text{g} \times \frac{1 \text{ mol}}{2.02\text{g}}$ = 0.400 mol | \emptyset | ② $0.1 \text{ mol NH}_3 \times \frac{3 \text{ mol H}_2}{2 \text{ mol NH}_3}$ = 0.15 mol H_2 |
| Final Amount | 0.25 - 0.05 ④ = 0.020 | 0.400 - 0.15 ⑤ = 0.25 | 0.1 mol | ③ $0.1 \text{ mol NH}_3 \times \frac{1 \text{ mol NH}_2}{2 \text{ mol NH}_3}$ = 0.05 mol N_2 |
| Final [] | ④ = 0.05 mol/L | ⑤ = 0.0625 mol/L | 0.025 mol/L | |

$$K_{\text{eq}} = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3} \quad K_{\text{eq}} = \frac{(0.025)^2}{(0.05)(0.0625)^3}$$

$$K_{\text{eq}} = 51.2$$

Hilroy