Quantitative Equilibrium Problems

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• Example #1

0.40 mol $PCl_5(g)$ is placed in a 15.0L flask and allowed to equilibriate. At equilibrium, the final concentration of $Cl_2(g)$ is found to be 0.01 mol/L. Find K_{eq}:

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

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

	$PCl_5(g)$	$\rightleftharpoons$ $PCl_3(g)$	$Cl_2(g)$
Initial [ ]			
Initial Amount	0.40 mol	~~0~~	~~0~~
Final Amount (at equilibrium)	0.40 mol − 0.15 mol initial reacted = 0.25 mol final ④	~~0.15 mol~~ ③ ② ⑤	0.15 mol ①
Final [ ]	0.016 mol/L	0.01 mol/L	0.01 mol/L

$$K_{eq} = \frac{[PCl_3][Cl_2]}{[PCl_5]}$$

*drop units at this point

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

$$K_{eq} = 0.006$$

15.0L Flask

Optional Work:

① $n = CV$ $n = 0.1\text{mol/L} \times 15.0\text{L}$

$n = 0.15\text{mol } Cl_2$

② $0.15\text{mol } Cl_2 \times \frac{1\text{mol } PCl_3}{1\text{mol } Cl_2} = 0.15\text{m } PCl_3$

③ $0.15\text{mol } Cl_2 \times \frac{1\text{mol } PCl_5}{1\text{mol } Cl_2} = 0.15\text{mol } PCl_5$

④ & ⑤ $C = \frac{n}{V}$

• Example #2

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

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

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).

	$N_2(g)$ +	$3H_2(g)$	$\rightleftharpoons$ $2NH_3(g)$
Initial [ ]			
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	~~0~~
Final Amount	0.25 − 0.05 ② = 0.020	0.400 − 0.15 ③ = 0.25	0.1 mol
Final [ ]	④ = 0.05 mol/L	⑤ = 0.0625 mol/L	0.025 mol/L

$$K_{eq} = \frac{[NH_3]^2}{[N_2][H_2]^3} \qquad K_{eq} = \frac{(0.025)^2}{(0.05)(0.0625)^3}$$

$$K_{eq} = 51.2$$

4.0L Flask

① $n = CV$

② $0.1\text{mol } NH_3 \times \frac{3\text{mol } H_2}{2\text{mol } NH_3} = 0.15\text{mol } H_2$

③ $0.1\text{mol } NH_3 \times \frac{1\text{mol } N_2}{2\text{mol } NH_3} = 0.05\text{mol } N_2$

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