Calculate the equilibrium constants for the following equilibria.

1) **$N_2(g) + 3H_2(g) \rightleftarrows 2NH_3(g)$**

P_{N2} = 0.60 atm
P_{H2} = 0.42 atm
P_{NH3} = 0.11 atm

$$K = \frac{[NH_3]^2}{[N_2][H_2]^3} = \frac{(0.11)^2}{(0.66)(0.42)^3} = 0.27$$

K = **0.27**

2) **$2SO_2(g) + O_2(g) \rightleftarrows 2SO_3(g)$**

P_{SO2}= 0.344 atm
P_{O2}= 0.172 atm
P_{SO3}= 0.056 atm

$$K = \frac{[SO_3]^2}{[O_2][SO_2]^2} = \frac{(0.056)^2}{(0.172)(0.344)^2} = 0.15$$

K = **0.15**

3) **$2NH_3(g) \rightleftarrows N_2(g) + 3H_2(g)$**

P_{N2} = 0.60 atm
P_{H2} = 0.42 atm
P_{NH3} = 0.11 atm

$$K = \frac{[N_2][H_2]^3}{[NH_3]^2} = \frac{(0.60)(0.42)^3}{(0.11)^2} = 3.7$$

K = **3.7**

4) **$2SO_3(g) \rightleftarrows 2SO_2(g) + O_2(g)$**

P_{SO2}= 0.344 atm
P_{O2}= 0.172 atm
P_{SO3}= 0.056 atm

$$K = \frac{[SO_2]^2[O_2]}{[SO_3]^2} = \frac{(0.344)^2(0.172)}{(0.056)^2} = 6.5$$

K = **6.5**

5) **$CH_3COOH(aq) + H_2O \rightleftarrows CH_3COO^- + H_3O^+$**

$[CH_3COOH] = 0.10$ M
$[CH_3COO^-] = 0.10$ M
$[H_3O^+] = 1.8 \times 10^{-5}$ M
and water is the solvent

$$K = \frac{[CH_3COO^-]\,[H_3O^+]}{[CH_3COOH]} = \frac{(0.10)\,(1.8\times10^{-5})}{(0.10)} = 1.8\times10^{-5}$$

K = **1.8×10^{-5}**

6) **$AgCl(s) \rightleftarrows Ag^+ + Cl^-$**

$[Cl^-] = 1.0 \times 10^{-3}$ M
$[Ag+] = 1.8 \times 10^{-7}$ M

$$K = [Ag^+]\,[Cl^-] = (1.0\times10^{-3})\,(1.8\times10^{-7}) = 1.8\times10^{-10}$$

K = **1.8×10^{-10}**

7) **$[Cu(NH_3)_4]^{2+} \rightleftarrows Cu^{2+} + 4NH_3$**

$[Cu^{2+}] = 0.085$ M
$[Cu(NH_3)_4]^{2+}] = 0.10$ M
$[NH_3] = 1.0 \times 10^{-3}$ M

$$K = \frac{[Cu^{2+}]\,[NH_3]^4}{[Cu(NH_3)_4^{2+}]} = \frac{(0.085)\,(1.0\times10^{-3}]^4}{0.10} = 8.5\times10^{-13}$$

K = **8.5×10^{-13}**

8) **$Fe_2S_3(s) \rightleftarrows 2Fe^{2+} + 3S^{2-}$**

$[Fe^{3+}] = 1.2 \times 10^{-8}$ M
$[S^{2-}] = 1.0 \times 10^{-26}$ M

$$K = [Fe^{3+}]^2\,[S^{2-}]^3 = (1.2\times10^{-8})^2\,(1.0\times10^{-26})^3 = 1.4\times10^{-94}$$

K = **1.4×10^{-94}**

Calculate the missing concentration(s) for the following reactions:

9) **$N_2(g) + 3H_2(g) \rightleftarrows 2NH_3(g)$**

P_{N2}= 0.10 atm
P_{H2}= 0.55 atmK = value obtained in 1) above

$$0.27 = K = \frac{P_{NH_3}^2}{P_{N_2} P_{H_2}^3} = \frac{P_{NH_3}^2}{(0.10)(0.55)^3}$$

$$P_{NH_3}^2 = (0.55)^3(0.10)(0.27) = 4.5\times10^{-3} \quad \therefore \quad P_{NH_3} = 6.7\times10^{-2}\ atm$$

P_{NH_3} = **6.7 x 10^{-2} atm**

10) **$N_2(g) + 3H_2(g) \rightleftarrows 2NH_3(g)$**

P_{N2}= 0.10 atm
P_{NH3}= 0.55 atmK = value obtained in 1) above

$$0.27 = K = \frac{P_{NH_3}^2}{P_{N_2} P_{H_2}^3} = \frac{(0.55)^2}{(0.10) P_{H_2}^3}$$

$$P_{H_2}^3 = \frac{(0.55)^2}{(0.10)(0.27)} = 11.2 \quad \therefore \quad P_{H_2} = 2.2$$

P_{H_2} = **2.2 atm**

11) **$PbS(s) \rightleftarrows Pb^{2+} + S^{2-}$**

$[S^{2-}]$= 1.3 x 10^{-23} M K = 8.4 x 10^{-28}

$$8.4\times10^{-28} = K = [Pb^{2+}][S^{2-}] = [Pb^{2+}](1.3\times10^{-23})$$

$$[Pb^{2+}] = \frac{(8.4\times10^{-28})}{(1.3\times10^{-23})} = 6.5\times10^{-5}$$

$[Pb^{2+}]$ = **6.5 x 10^{-5}**

12) **$H_2SO_3(aq) + H_2O \rightleftarrows HSO_3^- + H_3O^+$**

$[H_2SO_3]$ = 0.10 M
$[H_3O^+]$ = 1.0 M K = 1.2 x 10^{-2}

$$1.2\times10^{-2} = K = \frac{[HSO_3^-][H_3O^+]}{[H_2SO_3]} = \frac{[HSO_3^-](1.0)}{(0.10)}$$

$[HSO_3^-]$ = **1.2 x 10^{-3}**

13) **$H_2SO_3(aq) + H_2O \rightleftarrows HSO_3^- + H_3O^+$**

$[H_2SO_3] = 0.10\ \underline{M}$

$[H_3O^+] = [HSO3^-]$

$K = 1.2 \times 10^{-2}$

$$1.2\ x\ 10^{-3} = K = \frac{[H+][HSO4^-]}{[H_2SO_4]} = \frac{x^2}{0.10}$$

$$x^2 = 1.2\ x\ 10^{-3} \quad \therefore \quad x = 3.5\ x\ 10^{-2}$$

$[HSO_3^-] =$ **3.5×10^{-2}**

14) **$CH_3COOH(aq) + H_2O \rightleftarrows CH_3COO^- + H_3O^+$**

$[CH_3COOH] = [CH_3COO^-]$

$K = 1.8 \times 10^{-5}$

$$1.8\ x\ 10^{-5} = K = \frac{[CH_3COO^-][H^+]}{[CH_3COOH]} = \frac{x\ [H^+]}{x} = [H^+]$$

$[H_3O^+] =$ **1.8×10^{-5}**

15) **$AgCl \rightleftarrows Ag^+ + Cl^-$**

$[Cl^-] = [Ag^+]$

$K = 1.8 \times 10^{-10}$

$$1.8\ x\ 10^{-10} = K = [Ag^+][Cl^-] = x^2$$

$[Ag^+] =$ **1.3×10^{-5}**

16) $NH_3(aq) + H_2O \rightleftarrows NH_4^+ + OH^-$

$[NH_3] = [NH_4^+]$

$K = 1.8 \times 10^{-5}$

$$1.8\ x\ 10^{-5} = K = \frac{[NH_4^+][OH^-]}{[NH_3]} = \frac{x\ [OH^-]}{x} = [OH^-]$$

$[OH^-] =$ **1.8×10^{-5}**

STOP - Obtain a quiz from your instructor.