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Chemistry 11
Assignment #4

1. What is the concentration of SO_4^{2-} present in 0.135 M $Al_2(SO_4)_3$?

$Al_2(SO_4)_3 \longrightarrow 2Al^{3+}(aq) + 3SO_4^{2-}(aq)$

$$\frac{0.135 \text{ mol } Al_2(SO_4)_3}{L} \times \frac{3 \text{ mol } SO_4^{2-}}{1 \text{ mol } Al_2(SO_4)_3} = \boxed{0.405 \text{ M } SO_4^{2-}}$$

2. What is the concentration of Cl^- produced when 55.0 mL of 0.300 M HCl is mixed with 80.0 mL of 0.550 M $CaCl_2$?

$HCl \longrightarrow H^+(aq) + Cl^-(aq)$

$CaCl_2 \longrightarrow Ca^{2+}(aq) + 2Cl^-(aq)$

$$[HCl]_D = \frac{0.300M \times 0.0550L}{(0.0550L + 0.0800L)} = 0.122 \text{ M HCl}$$

$$[CaCl_2]_D = \frac{0.550M \times 0.0800L}{0.135L} = 0.326 \text{ M } CaCl_2$$

$$[Cl^-] = \frac{0.122 \text{ mol HCl}}{L} \times \frac{1 \text{ mol } Cl^-}{1 \text{ mol HCl}} = 0.122 \text{ M } Cl^-$$

$$[Cl^-] = \frac{0.326 \text{ mol } CaCl_2}{L} \times \frac{2 \text{ mol } Cl^-}{1 \text{ mol}} = 0.652 \text{ M}$$

$$[Cl^-] = 0.122 \text{ M} + 0.652 \text{ M} = \boxed{0.774 \text{ M } Cl^-}$$

3. When 350.0 mL of 0.250 M $MgCl_2$ is boiled down to a final volume of 275.0 mL, what is the $[Cl^-]$ in the resulting solution?

$MgCl_2 \longrightarrow Mg^{2+}(aq) + 2Cl^-(aq)$

$$[MgCl_2]_D = \frac{0.250M \times 0.3500L}{0.2750L} = 0.318 \text{ M } MgCl_2$$

$$[Cl^-] = \frac{0.318 \text{ mol } MgCl_2}{L} \times \frac{2 \text{ mol } Cl^-}{1 \text{ mol } MgCl_2} = \boxed{0.636 \text{ M } Cl^-}$$

(*) 4. Calculate the number of **moles** of all aqueous ions in the following solutions:

a. 0.60 L of 0.20 M K_2SO_4

$K_2SO_4 \longrightarrow 2K^+(aq) + SO_4^{2-}(aq)$

$$\frac{0.20 \text{ mol } K_2SO_4}{1L} \times 0.60 \text{ L} = 0.12 \text{ mol } K_2SO_4$$

$$0.12 \text{ mol } K_2SO_4 \times \frac{2 \text{ mol } K^+}{1 \text{ mol } K_2SO_4} = \boxed{0.24 \text{ mol } K^+}$$

$$0.12 \text{ mol } K_2SO_4 \times \frac{1 \text{ mol } SO_4^{2-}}{1 \text{ mol } K_2SO_4} = \boxed{0.12 \text{ mol } SO_4^{2-}}$$

$Na_3PO_4 \longrightarrow 3Na^+(aq) + PO_4^{3-}(aq)$

b. 0.450 L of 0.300 M Na_3PO_4

$0.300\ mol\ Na_3PO_4 \times 0.450\ L = 0.135\ mol\ Na_3PO_4$

$0.135\ mol\ Na_3PO_4 \times \frac{3\ mol\ Na^+}{1\ mol\ Na_3PO_4} = \boxed{0.405\ mol\ Na^+}$

$0.135\ mol\ Na_3PO_4 \times \frac{1\ mol\ PO_4^{3-}}{1\ mol\ Na_3PO_4} = \boxed{0.135\ mol\ PO_4^{3-}}$

c. 75.0 mL of 0.160 M $MnCl_2$

$MnCl_2 \longrightarrow Mn^{2+}(aq) + 2Cl^-(aq)$

$0.160\ mol\ MnCl_2 \times 0.0750\ L = 0.0120\ mol\ MnCl_2$

$0.0120\ mol\ MnCl_2 \times \frac{2\ mol\ Cl^-}{1\ mol\ MnCl_2} = \boxed{0.0240\ mol\ Cl^-}$

$0.0120\ mol\ MnCl_2 \times \frac{1\ mol\ Mn^{2+}}{1\ mol\ MnCl_2} = \boxed{0.0120\ mol\ Mn^{2+}}$

d. 0.0950 L of 0.235 M $Fe_2(SO_4)_3$ $\quad Fe_2(SO_4)_3 \rightarrow 2Fe^{3+}(aq) + 3SO_4^{2-}(aq)$

$0.235\ mol\ Fe_2(SO_4)_3 \times 0.0950\ L = 0.0223\ mol\ Fe_2(SO_4)_3$

$0.0223\ mol\ Fe_2(SO_4)_3 \times \frac{2\ mol\ Fe^{3+}}{1\ mol} = \boxed{0.0446\ mol\ Fe^{3+}}$; $\boxed{0.0669\ mol\ SO_4^{2-}}$

5. A solution is made by mixing 100.0 mL of 0.200 M $BaCl_2$ and 150.0 mL of 0.400 M NaCl. What is the concentration of each ionic species in the final solution? $\quad BaCl_2 \longrightarrow Ba^{2+} + 2Cl^- \qquad NaCl \longrightarrow Na^+ + Cl^-$

$[BaCl_2]_0 = \frac{0.200M \times 0.100L}{0.2500L} = 0.0800M\ BaCl_2 \qquad [NaCl]_0 = \frac{0.400M \times 0.1500L}{0.2500L} = 0.240M\ NaCl$

$[Ba^{2+}] = \boxed{0.0800M\ Ba^{2+}} \qquad [Na^+] = \boxed{0.240M\ Na^+}$

$[Cl^-] = 0.0800\ mol\ BaCl_2 \times \frac{2\ mol\ Cl^-}{1\ mol\ BaCl_2} = 0.160M\ Cl^-$

$[Cl^-] = 0.240\ mol\ NaCl \times \frac{1\ mol\ Cl^-}{1\ mol} = 0.240M\ Cl^-$

$\rightarrow \boxed{0.400M\ Cl^-}$

6. IF 75.0 mL of 0.200 M Na_3PO_4 is added to 25.0 mL of 0.800 M K_3PO_4, what is the final concentration? $\quad Na_3PO_4 \longrightarrow 3Na^+ + PO_4^{3-} \qquad K_3PO_4 \rightarrow 3K^+ + PO_4^{3-}$

$[Na_3PO_4]_0 = \frac{0.200M \times 0.0750L}{0.100L} = 0.150M\ Na_3PO_4 \qquad [K_3PO_4]_0 = \frac{0.800M \times 0.0250L}{0.100L} = 0.200M$

$\frac{0.150\ mol\ Na_3PO_4}{1L} \times \frac{1\ mol\ PO_4^{3-}}{1\ mol} = 0.150M\ PO_4^{3-}$

$\frac{0.200\ mol\ K_3PO_4}{1L} \times \frac{1\ mol\ PO_4^{3-}}{1\ mol} = 0.200M\ PO_4^{3-}$

$\boxed{0.350M\ PO_4^{3-}}$

*(7) What is the concentration of all the ions in a solution produced by mixing 15.0 mL of 0.325 M Na_3PO_4 with 35.0 mL of 0.225 M K_2SO_4 ?

$Na_3PO_4 \longrightarrow 3Na^+ + PO_4^{3-} \qquad K_2SO_4 \longrightarrow 2K^+ + SO_4^{2-}$

$[Na_3PO_4]_0 = \frac{0.325M \times 0.0150L}{0.0500L} = 0.0975M \qquad [K_2SO_4]_0 = \frac{0.225M \times 0.0350L}{0.0500L} = 0.158M$

$[Na^+] = \frac{0.0975\ mol}{L} \times \frac{3\ mol}{1\ mol} = \boxed{0.293M\ Na^+}$

$[PO_4^{3-}] = \frac{0.0975\ mol}{L} \times \frac{1\ mol}{1\ mol} = \boxed{0.0975M\ PO_4^{3-}}$

$[K^+] = 0.158\ mol \times \frac{2\ mol\ K^+}{1\ mol} = \boxed{0.316M\ K^+}$

$\boxed{[SO_4^{2-}] = 0.158M\ SO_4^{2-}}$

8. Calculate the concentration of each ion in the following solutions:

a. 0.24 M $Al_2(SO_4)_3$ $\quad Al_2(SO_4)_3 \longrightarrow 2Al^{3+} + 3SO_4^{2-}$

$\frac{0.24 \text{ mol } Al_2(SO_4)_3}{L} \times \frac{2 \text{ mol } Al^{3+}}{1 \text{ mol } Al_2(SO_4)_3} = \boxed{0.48 \text{ M } Al^{3+}}$ $\quad \frac{0.24 \text{ mol } Al_2(SO_4)_3}{L} \times \frac{3 \text{ mol } SO_4^{2-}}{1 \text{ mol}} = \boxed{0.72 \text{ M } SO_4^{2-}}$

b. 0.6 M $CrCl_3$ $\quad CrCl_3 \longrightarrow Cr^{3+}(aq) + 3Cl^-(aq)$

$0.6 \text{ mol } CrCl_3 \times \frac{1 \text{ mol } Cr^{3+}}{1 \text{ mol}} = 0.6 \text{ M } Cr^{3+}$ $\quad 0.6 \text{ mol } CrCl_3 \times \frac{3 \text{ mol}}{1 \text{ mol}} = \boxed{2 \text{ M } Cl^-}$

c. 0.18 M Ag_2CrO_4 $\longrightarrow 2Ag^+(aq) + CrO_4^{2-}(aq)$

$0.18 \text{ mol } Ag_2CrO_4 \times \frac{2 \text{ mol } Ag^+}{1 \text{ mol}} = \boxed{0.36 \text{ M } Ag^+}$

$0.18 \text{ mol } Ag_2CrO_4 \times \frac{1 \text{ mol}}{1 \text{ mol}} = \boxed{0.18 \text{ M } CrO_4^{2-}}$

d. 0.25 M Na_3PO_4 $\longrightarrow 3Na^+(aq) + PO_4^{3-}(aq)$

$\frac{0.25 \text{ mol } Na_3PO_4}{L} \times \frac{3 \text{ mol } Na^+}{1 \text{ mol}} = \boxed{0.75 \text{ M } Na^+}$

$0.25 \text{ mol } Na_3PO_4 \times \frac{1 \text{ mol } PO_4^{3-}}{1 \text{ mol}} = \boxed{0.25 \text{ M } PO_4^{3-}}$

e. 0.33 M $Cr_2(SO_4)_3$ $\longrightarrow 2Cr^{3+}(aq) + 3SO_4^{2-}(aq)$

$0.33 \text{ mol } Cr_2(SO_4)_3 \times \frac{2 \text{ mol } Cr^{3+}}{1 \text{ mol}} = \boxed{0.66 \text{ M } Cr^{3+}}$

$0.33 \text{ mol } Cr_2(SO_4)_3 \times \frac{3 \text{ mol } SO_4^{2-}}{1 \text{ mol}} = \boxed{0.99 \text{ M } SO_4^{2-}}$

9. Calculate the concentration of EACH ion in the following MIXED solutions: $\quad MgSO_4 \longrightarrow Mg^{2+} + SO_4^{2-}$ $\quad KCl \longrightarrow K^+ + Cl^-$

a. 3.0 L of 0.5 M $MgSO_4$ mixed with 2.5 L of 0.080 M KCl

$[MgSO_4]_D = \frac{0.5 \text{ M} \times 3.0 \text{ L}}{5.5 \text{ L}} = 0.3 \text{ M } MgSO_4$ $\quad [KCl]_D = \frac{0.080 \text{ M} \times 2.5 \text{ L}}{5.5 \text{ L}} = \boxed{0.036 \text{ M KCl}}$

$[Mg^{2+}] = 0.3 \text{ M} \times \frac{1 \text{ mol}}{1 \text{ mol}} = \boxed{0.3 \text{ M } Mg^{2+}}$ $\quad [K^+] = 0.036 \text{ M} \times \frac{1 \text{ mol}}{1 \text{ mol}} = \boxed{0.036 \text{ M } K^+}$

$[SO_4^{2-}] = 0.3 \text{ M} \times \frac{1 \text{ mol}}{1 \text{ mol}} = \boxed{0.3 \text{ M } SO_4^{2-}}$ $\quad [Cl^-] = 0.036 \text{ M} \times \frac{1 \text{ mol}}{1 \text{ mol}} = \boxed{0.036 \text{ M } Cl^-}$

b. 2.0 L of 6.4 M $AlBr_3$ mixed with 0.300L of 0.020 M $BaBr_2$

$AlBr_3 \longrightarrow Al^{3+} + 3Br^-$ $\quad BaBr_2 \longrightarrow Ba^{2+} + 2Br^-$

$[AlBr_3]_D = \frac{6.4 \text{ M} \times 2.0 \text{ L}}{2.3 \text{ L}} = \frac{5.6 \text{ M}}{2.0 \text{ M}} AlBr_3$ $\quad [BaBr_2] = \frac{0.020 \text{ M} \times 0.300 \text{ L}}{3 \text{ L}} =$

$[Al^{3+}] = \frac{5.6 \text{ mol}}{L} \times \frac{1 \text{ mol}}{1 \text{ mol}} = \boxed{5.6 \text{ M } Al^{3+}}$ $\quad [Ba^{2+}] = \frac{2.6 \times 10^{-3} \text{ mol}}{L} \times \frac{1 \text{ mol}}{1 \text{ mol}} = \boxed{2.6 \times 10^{-3} \text{ M } Ba^{2+}}$

$[Br^-] = \frac{5.6 \text{ mol}}{L} \times \frac{3 \text{ mol}}{1 \text{ mol}} = 16.8 \text{ M } Br^-$ $\quad [Br^-] = \frac{2.6 \times 10^{-3} \text{ mol} \times 2 \text{ mol}}{L \quad 1 \text{ mol}} = 5.2 \times 10^{-3} \text{ M}$

$[Br^-] = 16.8 \text{ M} + 5.2 \times 10^{-3} \text{ M} = \boxed{16.8 \text{ M } Br^-}$

10. Calculate the concentration of the solute in M (mol/L) in each of the following DILUTED solutions.

a. 125 mL of 0.64 M HCl diluted to 2.0L

$$[HCl]_D = \frac{0.64\ M \times 0.125\ \cancel{L}}{2.0\ \cancel{L}} = \boxed{0.040\ M\ HCl}$$

b. 1.00mL of 0.50 M NH_4Cl diluted to 250.0 mL

$$[NH_4Cl]_D = \frac{0.50\ M \times 0.001\ \cancel{L}}{0.250\ \cancel{L}} = \boxed{0.0020\ M\ NH_4Cl}$$

11. Write the dissociation equations for each of the following solutions and then calculate the concentration of each ion in each solution.

a. 0.060 M $Fe_2(SO_4)_3$ $\longrightarrow$ $2Fe^{3+}_{(aq)} + 3SO_4^{2-}(aq)$

$$\frac{0.060\ \cancel{mol\ Fe_2(SO_4)_3}}{\cancel{L}} \times \frac{2\ mol\ Fe^{3+}}{1\ \cancel{mol}} = \boxed{0.12\ M\ Fe^{3+}}$$

$$\frac{0.060\ \cancel{mol\ Fe_2(SO_4)_3}}{\cancel{L}} \times \frac{3\ mol\ SO_4^{2-}}{1\ \cancel{mol}} = \boxed{0.18\ M\ SO_4^{2-}}$$

b. 2.40 M Li_3PO_4 $\longrightarrow$ $3Li^+_{(aq)} + PO_4^{3-}(aq)$

$$\frac{2.40\ \cancel{mol\ Li_3PO_4}}{\cancel{L}} \times \frac{3\ mol\ Li^+}{1\ \cancel{mol}} = \boxed{7.20\ M\ Li^+}$$

$$\frac{0.240\ \cancel{mol\ Li_3PO_4}}{\cancel{L}} \times \frac{1\ mol\ PO_4^{3-}}{1\ \cancel{mol}} = \boxed{0.240\ M\ PO_4^{3-}}$$

c. 1.70 M $(NH_4)_3PO_4$ $\longrightarrow$ $3NH_4^+(aq) + PO_4^{3-}(aq)$

$$\frac{1.70\ \cancel{mol\ (NH_4)_3PO_4}}{\cancel{L}} \times \frac{3\ mol\ NH_4^+}{1\ \cancel{mol}} = \boxed{5.10\ M\ NH_4^+}$$

$$\frac{1.70\ \cancel{mol\ (NH_4)_3PO_4}}{\cancel{L}} \times \frac{1\ mol\ PO_4^{3-}}{1\ \cancel{mol}} = \boxed{1.70\ M\ PO_4^{3-}}$$