Homework #3

Chapter 4

Types of Chemical Reactions and Solution Stoichiometry

13. Determine the concentrations of the solutions

Solution A

$$\frac{4\ particles}{1.0\ L} = 4.0\ \frac{particles}{L}$$

Solution B

$$\frac{6\ paticles}{4.0\ L} = 1.5\ \frac{particles}{L}$$

Solution C

$$\frac{4\ particles}{2.0\ L} = 2.0\ \frac{particles}{L}$$

Solution D

$$\frac{6\ particles}{2.0L} = 3.0\ \frac{particles}{L}$$

Therefore, the order of solution from most to least concentrated is

solution A > solution D > solution C > solution B

15. a) Polar solutes will mix with water and nonpolar solutes will not. For polar solutes the water molecules will orientate so that the H-atoms are lined up around the anion and the O-atoms are lined up around the cation. If the solutes are liquids then you will see only see one solution after water has been mixed with a polar solute and two layers when water has been mixed with a nonpolar solute.

b) When KF is put into water it will dissociate into K^+ and F^- because it is a strong electrolyte. The water molecules will orientate themselves so that the H-atoms in the water are near the F^- ions and the O-atoms in the water are near the K^+ ions. When $C_6H_{12}O_6$ dissolves in water it will stay as $C_6H_{12}O_6$ molecules and not dissociate into atoms/ions because $C_6H_{12}O_6$ is a nonelectrolyte. The water molecules will orientate themselves so that the H-atoms in the water are near the partially negative locations in $C_6H_{12}O_6$ and the O-atoms in the water are near the partially positive regions of the molecule.

c) When RbCl is put into water it will dissociate in Rb^+ and Cl^- because it is a strong electrolyte. The water molecules will orientate themselves so that the H-atoms in the water are near the Cl^- ions and the O-atoms in the water are near the Rb^+ ions. When AgCl is put into solution it will stay as a solid because it is not soluble in water.

d) HNO_3 is a strong acid and will complete dissociate into H^+ and NO_3^-. The water molecules will orientate themselves so that the H-atoms in the water are near the NO_3^- ions and the O-atoms in the water are near the H^+ ions. CO is a nonelectrolyte and will not dissociate in water. The water molecules will orientate themselves so that the H-atoms in the water are near the O of the CO and the O-atoms in the water are near the C of the CO.

17. Determine the formula and ions of each of the names

a) barium nitrate $Ba(NO_3)_2$ which is made up of Ba^{2+} and NO_3^-
matches with beaker iv

b) sodium chloride NaCl which is made up of Na^+ and Cl^-
matches with beaker ii

c) potassium carbonate K_2CO_3 which is made up of K^+ and CO_3^{2-}
matches with beaker iii

d) magnesium sulfate $MgSO_4$ which is made up of Mg^{2+} and SO_4^{2-}
matches with beaker i

21. a) L NaOH → g NaOH
L NaOH → mol NaOH → g NaOH

$$2.00\ L\left(\frac{0.250\ mol\ NaOH}{1\ L\ NaOH}\right)\left(\frac{40.00\ g\ NaOH}{1\ mol\ NaOH}\right) = 20.0\ g\ NaOH$$

20.0 g of NaOH would be put into a volumetric flask and then water would be added to the 2.00 L mark.

b) $M_1V_1 = M_2V_2$

$$(1.00\ M)(V_1) = (0.250M)(2.00L)$$

$$V_1 = 0.500\ L$$

0.500 L of the 1.00 M stock solution would be put into a volumetric flask and then water would be added to the 2.00 L mark.

c) L K_2CrO_4 → g K_2CrO_4
L K_2CrO_4 →mol K_2CrO_4 → g K_2CrO_4

$$2.00\ L\ K_2CrO_4\left(\frac{0.100\ mol\ K_2CrO_4}{1\ L\ K_2CrO_4}\right)\left(\frac{194.20\ g\ K_2CrO_4}{1\ mol\ K_2CrO_4}\right) = 38.8\ g\ K_2CrO_4$$

38.8 g of K_2CrO_4 would be put into a volumetric flask and then water would be added to the 2.00 L mark.

d) $M_1V_1 = M_2V_2$

$$(1.75\ M)(V_1) = (0.100M)(2.00L)$$

$$V_1 = 0.114\ L$$

0.114 L of the 1.75 M stock solution would be put into a volumetric flask and then water would be added to the 2.00 L mark

26. a) $Ca(NO_3)_2(s) \rightarrow Ca^{2+}(aq) + 2NO_3^-(aq)$

$$V = 100.0\ mL\left(\frac{1\ L}{1000\ mL}\right) = 0.1000\ L$$

Calculate the molarity of Ca^{2+}

$$n_{Ca^{2+}} = 0.100\ mol\ Ca(NO_3)_2\left(\frac{1\ mol\ Ca^{2+}}{1\ mol\ Ca(NO_3)_2}\right) = 0.100\ mol\ Ca^{2+}$$

$$M = \frac{n}{V} = \frac{0.100\ mol}{0.1000\ L} = 1.00\ M\ Ca^{2+}$$

Calculate the molarity of NO_3^-

$$n_{NO_3^-} = 0.100\ mol\ Ca(NO_3)_2\left(\frac{2\ mol\ NO_3^-}{1\ mol\ Ca(NO_3)_2}\right) = 0.200\ mol\ NO_3^-$$

$$M = \frac{n}{V} = \frac{0.200\ mol}{0.1000\ L} = 2.00\ M\ NO_3^-$$

b) $Na_2SO_4(s) \rightarrow 2Na^+(aq) + SO_4^{2-}(aq)$

$$V = 1.25\ L$$

Calculate the molarity of Na^+

$$n_{Ca^{2+}} = 2.5\ mol\ Na_2SO_4\left(\frac{2\ mol\ Na^+}{1\ mol\ Na_2SO_4}\right) = 5.0\ mol\ Na^+$$

$$M = \frac{n}{V} = \frac{5.0\ mol}{1.25\ L} = 4.0\ M\ Na^+$$

Calculate the molarity of SO_4^{2-}

$$n_{SO_4^{2-}} = 2.5\ mol\ Na_2SO_4 \left(\frac{1\ mol\ SO_4^{2-}}{1\ mol\ Na_2SO_4}\right) = 2.5\ mol\ SO_4^{2-}$$

$$M = \frac{n}{V} = \frac{2.5\ mol}{1.25\ L} = 2.0\ M\ SO_4^{2-}$$

c) $NH_4Cl(s) \rightarrow NH_4^+(aq) + Cl^-(aq)$

$$V = 500.0\ mL \left(\frac{1\ L}{1000\ mL}\right) = 0.5000\ L$$

Calculate the molarity of NH_4^+

g NH_4Cl → mol NH_4Cl → mol NH_4^+

$$5.00\ g\ NH_4Cl \left(\frac{1\ mol\ NH_4Cl}{53.50\ g\ NH_4Cl}\right)\left(\frac{1\ mol\ NH_4^+}{1\ mol\ NH_4Cl}\right) = 0.0935\ mol\ NH_4^+$$

$$M = \frac{n}{V} = \frac{0.0935\ mol}{0.5000\ L} = 0.187\ M\ NH_4^+$$

Calculate the molarity of Cl^-

g NH_4Cl → mol NH_4Cl → mol Cl^-

$$5.00\ g\ NH_4Cl \left(\frac{1\ mol\ NH_4Cl}{53.50\ g\ NH_4Cl}\right)\left(\frac{1\ mol\ Cl^-}{1\ mol\ NH_4Cl}\right) = 0.0935\ mol\ Cl^-$$

$$M = \frac{n}{V} = \frac{0.0935\ mol}{0.5000\ L} = 0.187\ M\ Cl^-$$

d) $K_3PO_4(s) \rightarrow 3K^+(aq) + PO_4^{3-}(aq)$

$$V = 250.0\ mL \left(\frac{1\ L}{1000\ mL}\right) = 0.2500\ L$$

Calculate the molarity of K^+

g K_3PO_4 → mol K_3PO_4 → mol K^+

$$1.00\ g\ K_3PO_4 \left(\frac{1\ mol\ K_3PO_4}{212.27\ g\ K_3PO_4}\right)\left(\frac{3\ mol\ K^+}{1\ mol\ K_3PO_4}\right) = 0.0141\ mol\ K^+$$

$$M = \frac{n}{V} = \frac{0.0141\ mol}{0.2500\ L} = 0.0564\ M\ K^+$$

Calcualte the molarity of PO_4^{3-}

g K_3PO_4 → mol K_3PO_4 → mol PO_4^-

$$1.00\ g\ K_3PO_4 \left(\frac{1\ mol\ K_3PO_4}{212.27\ g\ K_3PO_4}\right)\left(\frac{1\ mol\ PO_4^{3-}}{1\ mol\ K_3PO_4}\right) = 0.00471\ mol\ PO_4^{3-}$$

$$M = \frac{n}{V} = \frac{0.00471\ mol}{0.2500\ L} = 0.0188\ M\ PO_4^{3-}$$

27. Calculate the number of moles of Na^+ in 70.0 mL of 3.0 M Na_2CO_3

$$M = \frac{n}{V}$$

$$V = 70.0\ mL \left(\frac{1\ L}{1000\ mL}\right) = 0.0700\ L$$

$$n_{Na_2CO_3} = MV = (3.0\ M)(0.0700\ L) = 0.21\ mol\ Na_2CO_3$$

$$n_{Na^+} = 0.21\ mol\ Na_2CO_3 \left(\frac{2\ mol\ Na^+}{1\ mol\ Na_2CO_3}\right) = 0.42\ mol\ Na^+$$

Calculate the number of moles of Na^+ in 30.0 mL of 1.0 M $NaHCO_3$

$$M = \frac{n}{V}$$

$$V = 30.0\ mL \left(\frac{1\ L}{1000\ mL}\right) = 0.0300\ L$$

$$n_{NaHCO_3} = MV = (1.0\ M)(0.0300\ L) = 0.030\ mol\ NaHCO_3$$

$$n_{Na^+} = 0.030\ mol\ NaHCO_3 \left(\frac{1\ mol\ Na^+}{1\ mol\ NaHCO_3}\right) = 0.030\ mol\ Na^+$$

Calculate total moles of Na^+

$$n_{total\ moles\ Na^+} = 0.42\ mol + 0.030\ mol = 0.45\ mol\ Na^+$$

Calculate the total volume

$$V_{total} = 0.0700\ L + 0.0300\ L = 0.1000\ L$$

Calculate the molarity of Na^+ ions

$$M = \frac{n}{V} = \frac{0.45\ mol}{0.1000\ L} = 4.5\ M\ Na^+$$

28. Calculate molarity of stock solution

$$25.0\ g\ (NH_4)_2SO_4 \left(\frac{1\ mol\ (NH_4)_2SO_4}{132.1382\ g\ (NH_4)_2SO_4}\right) = 0.189\ mol\ (NH_4)_2SO_4$$

$$M = \frac{n}{V} = \frac{0.189\ mol\ (NH_4)_2SO_4}{0.100\ L} = 1.89\ M\ (NH_4)_2SO_4$$

Calculate molarity of the diluted solution

$$M_1V_1 = M_2V_2$$

$$(1.89\ M)(0.0100\ L) = M_2(0.0600\ L)$$

$$M_2 = 0.315\ M\ (NH_4)_2SO_4$$

Calculate molarity of NH_4^+ ions

$$0.315\ M\ (NH_4)_2SO_4 \left(\frac{2\ mol\ NH_4^+}{1\ mol\ (NH_4)_2SO_4}\right) = 0.630\ M\ NH_4^+$$

Calculate the molarity of SO_4^{2-} ions

$$0.315\ M\ (NH_4)_2SO_4 \left(\frac{1\ mol\ SO_4^{2-}}{1\ mol\ (NH_4)_2SO_4}\right) = 0.315\ M\ SO_4^{2-}$$

30. Stock Solution

$$n_{Mn} = 1.584\ g\ Mn \left(\frac{1\ mol\ Mn}{54.94\ g\ Mn}\right) = 0.02883\ mol\ Mn$$

All of the Mn^{2+} came from the Mn(s) therefore $n_{Mn} = n_{Mn^{2+}}$

$$n_{Mn^{2+}} = 0.02883\ mol\ Mn \left(\frac{1\ mol\ Mn^{2+}}{1\ mol\ Mn}\right) = 0.02883\ mol\ Mn^{2+}$$

$$M = \frac{n}{V} = \frac{0.02883\ mol}{1.000\ L} = 0.02883\ M\ Mn^{2+}$$

Solution A

$$M_1V_1 = M_2V_2$$

$$V_1 = 50.00\ mL \left(\frac{1\ L}{1000\ mL}\right) = 0.05000\ L$$

$$V_2 = 1000.0\ mL \left(\frac{1\ L}{1000\ mL}\right) = 1.0000\ L$$

$$(0.02883\ M)(0.05000\ L) = M_2(1.0000\ L)$$

$$M = 0.001442\ M\ Mn^{2+}$$

Solution B

$$M_1V_1 = M_2V_2$$

$$V_1 = 10.00\ mL \left(\frac{1\ L}{1000\ mL}\right) = 0.01000\ L$$

$$V_2 = 250.0\ mL \left(\frac{1\ L}{1000\ mL}\right) = 0.2500\ L$$

$$(0.001442\ M)(0.01000\ L) = M_2(0.2500\ L)$$

$$M = 5.766 \times 10^{-5}\ M\ Mn^{2+}$$

Solution C

$M_1V_1 = M_2V_2$

$V_1 = 10.00\ mL\left(\frac{1\ L}{1000\ mL}\right) = 0.01000\ L$

$V_2 = 500.0\ mL\left(\frac{1\ L}{1000\ mL}\right) = 0.5000\ L$

$(5.766 \times 10^{-5}\ M)(0.01000\ L) = M_2(0.5000\ L)$

$M = 1.153 \times 10^{-6}\ M\ Mn^{2+}$

36. The name lead nitrate is incorrect, the correct name should be lead(II) nitrate.
Reaction that occurs: $Pb(NO_3)_2(s) + 2KI(aq) \rightarrow 2KNO_3(aq) + PbI_2(s)$
Complete ionic equation: $Pb^{2+}(aq)+2NO_3^-(aq)+2K^+(aq)+2I^-(aq) \rightarrow 2K^+(aq)+2NO_3^-(aq)+PbI_2(s)$
Yes the solution will still conduct electricity because there will be K^+ and NO_3^- ions in solutions.
Note: all of the Pb^{2+} moles (1.0 mol) and the I^- moles (2.0 mol) will go into forming the solid therefore, there will be none of these ions in solution.

39. a) $(NH_4)_2SO_4(aq) + Ba(NO_3)_2(aq) \rightarrow 2NH_4NO_3(aq) + BaSO_4(s)$
$2NH_4^+(aq) + SO_4^{2-}(aq) + Ba^{2+}(aq) + 2NO_3^-(aq) \rightarrow 2NH_4^+(aq) + 2NO_3^-(aq) + BaSO_4(s)$
$SO_4^{2-}(aq) + Ba^{2+}(aq) \rightarrow BaSO_4(s)$

b) $Pb(NO_3)_2(aq) + 2NaCl(aq) \rightarrow 2NaNO_3(aq) + PbCl_2(s)$
$Pb^{2+}(aq) + 2NO_3^-(aq) + 2Na^+(aq) + 2Cl^-(aq) \rightarrow 2Na^+(aq) + 2NO_3^-(aq) + PbCl_2(s)$
$Pb^{2+}(aq) + 2Cl^-(aq) \rightarrow PbCl_2(s)$

c) $Na_3PO_4(aq) + 3KNO_3(aq) \rightarrow 3NaNO_3(aq) + K_3PO_4(aq)$
$3Na^+(aq) + PO_4^{3-}(aq) + 3K^+(aq) + 3NO_3^-(aq) \rightarrow 3Na^+(aq) + 3NO_3^-(aq) + 3K^+(aq) + PO_4^{3-}(aq)$
No reaction

d) $NaBr(aq) + RbCl(aq) \rightarrow NaCl(aq) + RbBr(aq)$
$Na^+(aq) + Br^-(aq) + Rb^+(aq) + Cl^-(aq) \rightarrow Na^+(aq) + Cl^-(aq) + Rb^+(aq) + Br^-(aq)$
No reaction

e) $CuCl_2(aq) + 2NaOH(aq) \rightarrow Cu(OH)_2(s) + 2NaCl(aq)$
$Cu^{2+}(aq) + 2Cl^-(aq) + 2Na^+(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s) + 2Na^+(aq) + 2Cl^-(aq)$
$Cu^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s)$

40. There are multiple ways to do these problems; this is one way to do them
a) 1. Add NaCl to the solution this will cause AgCl to precipitate
2. Add Na_2SO_4 to the solution this will cause $BaSO_4$ to precipitate (Note: steps one and two could have been switched.)
3. The Cr^{3+} ions will be left in solution

b) 1. Add Li_2SO_4 to the solution this will cause $PbSO_4$ to precipitate
2. Add LiCl to the solution this will cause AgCl to precipitate (Note: steps one and two cannot be switch because if the Cl^- was added first both $PbCl_2$ and AgCl would have precipitated out.)
3. The Cu^{2+} ions will be left in solution

c) 1. Add $CaCl_2$ to the solution this will cause Hg_2Cl_2 to precipitate
2. The Ni^{2+} ions will be left in solution

42. There are multiple ways to do these problems; this is one way to do them.
a) $3NaOH(aq) + FeCl_3(aq) \rightarrow Fe(OH)_3(s) + 3NaCl(aq)$
b) $Hg_2(NO_3)_2(aq) + BaCl_2(aq) \rightarrow Hg_2Cl_2(s) + Ba(NO_3)_2(aq)$

c) $K_2SO_4(aq) + Pb(NO_3)_2(aq) \rightarrow PbSO_4(s) + 2KNO_3(aq)$

d) $(NH_4)_2CrO_4(aq) + BaCl_2(aq) \rightarrow BaCrO_4(s) + 2NH_4Cl(aq)$

44. $2Na_3PO_4(aq) + 3Pb(NO_3)_2(aq) \rightarrow 6NaNO_3(aq) + Pb_3(PO_4)_2(s)$

mL $Pb(NO_3)_2$ → mol $Pb(NO_3)_2$ → mol Na_3PO_4 → L Na_3PO_4

$$150.0\ mL\ Pb(NO_3)_2 \left(\frac{1\ L}{1000\ mL}\right)\left(\frac{0.250\ mol\ Pb(NO_3)_2}{1\ L\ Pb(NO_3)_2}\right)\left(\frac{2\ mol\ Na_3PO_4}{3\ mol\ Pb(NO_3)_2}\right)\left(\frac{1\ L\ Na_3PO_4}{0.100\ mol\ Na_3PO_4}\right) = 0.250\ L$$

45. $2AgNO_3(aq) + CaCl_2(aq) \rightarrow 2AgCl(s) + Ca(NO_3)_2(aq)$

This is a limiting reagent problem

Calculate the moles of $AgNO_3$.

$$100.0\ mL\ AgNO_3 \left(\frac{1\ L}{1000\ mL}\right)\left(\frac{0.20\ mol\ AgNO_3}{1\ L\ AgNO_3}\right) = 0.020\ mol\ AgNO_3$$

Calculate the moles of $CaCl_2$.

$$100.0\ mL\ CaCl_2 \left(\frac{1\ L}{1000\ mL}\right)\left(\frac{0.15\ mol\ CaCl_3}{1\ L\ CaCl_2}\right) = 0.015\ mol\ CaCl_2$$

Calculate the number of moles of $CaCl_2$ needed to fully react $AgNO_3$.

$$0.020\ mol\ AgNO_3 \left(\frac{1\ mol\ CaCl_2}{2\ mol\ AgNO_3}\right) = 0.010\ mol\ CaCl_2$$

Since we have 0.015 mol of $CaCl_2$ the $AgNO_3$ is the limiting reagent.

	$AgNO_3(aq)$ (L.R)	$CaCl_2(aq)$	$AgCl(s)$	$Ca(NO_3)_2$
I (mol)	0.020	0.015	0	0
C (mol)	-2x=-0.020	-x=-0.010	+2x=0.020	+x=0.010
F (mol)	0	0.005	0.020	0.010

$$0.020 - 2x = 0$$

$$x = 0.010$$

Calculate the grams of AgCl produced.

$$0.020\ mol\ AgCl \left(\frac{143.32\ g\ AgCl}{1\ mol\ AgCl}\right) = 2.9\ g\ AgCl$$

Calculate the concentration of the all the ions.

Final Volume of Solutions

$$100.0\ mL + 100.0\ mL = 200.0\ mL \left(\frac{1\ L}{1000\ mL}\right) = 0.2000\ L$$

Calculate the concentration of Ag^+ ion

0 M Ag^+ all went into forming AgCl

Calculate the molarity of Cl^- ions

$$M = \frac{n}{V} = \frac{2(0.005\ mol)}{0.2000\ L} = 0.05\ M\ Cl^-$$ from the $CaCl_2$

Calculate the molarity of Ca^+ ions

$$M = \frac{n}{V} = \frac{0.010\ mol + 0.005\ mol}{0.2000\ L} = 0.075\ M\ Ca^+$$ from the $Ca(NO_3)_2$ and $CaCl_2$

Calculate the concentration of NO_3^- ions

$$M = \frac{n}{V} = \frac{2(0.010\ mol)}{0.2000\ L} = 0.10M\ NO_3^-$$ from the $Ca(NO_3)_2$

49. $Na_2CrO_4(aq) + 2AgNO_3(aq) \rightarrow 2NaNO_3(aq) + Ag_2CrO_4(s)$

mL $AgNO_3$ → L $AgNO_3$ → mol $AgNO_3$ → mol Na_2CrO_4 → g Na_2CrO_4

$$75.0\ mL\ AgNO_3 \left(\frac{1\ L}{1000\ mL}\right)\left(\frac{0.1\ mol\ AgNO_3}{1\ L\ AgNO_3}\right)\left(\frac{1\ mol\ Na_2CrO_4}{2\ mol\ AgNO_3}\right)\left(\frac{161.98\ g\ Na_2CrO_4}{1\ mol\ Na_2CrO_4}\right)$$
$$= 0.607\ g\ Na_2CrO_4$$

53. g $BaSO_4$ → mol $BaSO_4$ → mol $C_7H_5NO_3S$ → g $C_7H_5NO_3S$

$$0.5032\ g\ BaSO_4 \left(\frac{1\ mol\ BaSO_4}{233.40\ g\ BaSO_4}\right)\left(\frac{1\ mol\ C_7H_5NO_3S}{1\ mol\ BaSO_4}\right)\left(\frac{1\ mol\ C_7H_5NO_3S}{1\ mol\ S\ in\ C_7H_5NO_3S}\right)\left(\frac{183.20\ g\ C_7H_5NO_3S}{1\ mol\ C_7H_5NO_3S}\right)$$
$$= 0.3950\ g\ C_7H_5NO_3S$$

This is the amount of saccharin in 10 tablets therefore there is 0.3950 g of saccharin in one tablet.

The mass of 10 tablets is 0.5032 g and the mass of the saccharin in 10 tablets is

$$\frac{0.3950\ g}{10} = 0.03950\ g\ saccharin\ per\ tablet$$

The average mass % saccharin

$$\left(\frac{0.3950\ g}{0.5894\ g}\right)100\% = 67.02\%$$

55. $M_2SO_4(aq) + CaCl_2(aq) \rightarrow 2MCl(aq) + CaSO_4(s)$

g $CaSO_4$ → mol $CaSO_4$ → mol M_2SO_4

$$1.36\ g\ CaSO_4 \left(\frac{1\ mol\ CaSO_4}{136.15\ g\ CaSO_4}\right)\left(\frac{1\ mol\ M_2SO_4}{1\ mol\ CaSO_4}\right) = 0.00999\ mol\ M_2SO_4$$

$$M_{M_2SO_4} = \frac{m}{n} = \frac{1.42\ g}{0.00999\ mol} = 142\ \frac{g}{mol}$$

$$M_{M_2SO_4} = 2M_M + M_S + 4M_O$$

$$142\ \frac{g}{mol} = 2M_M + 32.07\ \frac{g}{mol} + 4\left(16.00\ \frac{g}{mol}\right)$$

$$M_M = 23\ \frac{g}{mol}$$

Since the molar mass is 23 the metal is sodium (Na)

61. V NaOH → mol NaOH → mol acid → V acid

$$50.0\ mL\ NaOH \left(\frac{1\ L}{1000\ mL}\right) = 0.0500\ L\ NaOH$$

$$0.0500\ L\ NaOH \left(\frac{0.100\ mol\ NaOH}{1\ L\ NaOH}\right) = 0.00500\ mol\ NaOH$$

a) $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

$$0.00500\ mol\ NaOH \left(\frac{1\ mol\ HCl}{1\ mol\ NaOH}\right)\left(\frac{1\ L\ HCl}{0.100\ mol\ HCl}\right) = 0.0500\ L\ HCl$$

b) $2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$

$$0.00500\ mol\ NaOH \left(\frac{1\ mol\ H_2SO_4}{2\ mol\ NaOH}\right)\left(\frac{1\ L\ H_2SO_4}{0.100\ mol\ H_2SO_4}\right) = 0.0250\ L\ H_2SO_4$$

c) $3NaOH(aq) + H_3PO_4(aq) \rightarrow Na_3PO_4(aq) + 3H_2O(l)$

$$0.00500\ mol\ NaOH \left(\frac{1\ mol\ H_3PO_4}{3\ mol\ NaOH}\right)\left(\frac{1\ L\ H_3PO_4}{0.200\ mol\ H_3PO_4}\right) = 0.00833\ L\ H_3PO_4$$

d) $NaOH(aq) + HNO_3(aq) \rightarrow NaNO_3(aq) + H_2O(l)$

$$0.00500\ mol\ NaOH \left(\frac{1\ mol\ HNO_3}{1\ mol\ NaOH}\right)\left(\frac{1\ L\ HNO_3}{0.150\ mol\ HNO_3}\right) = 0.0333\ L\ HNO_3$$

e) $NaOH(aq) + HC_2H_3O_2(aq) \rightarrow NaC_2H_3O_2(aq) + H_2O(l)$

$$0.00500\ mol\ NaOH \left(\frac{1\ mol\ HC_2H_3O_2}{1\ mol\ NaOH}\right)\left(\frac{1\ L\ HC_2H_3O_2}{0.200\ mol\ HC_2H_3O_2}\right) = 0.0250\ L\ HC_2H_3O_2$$

f) $2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$

$$0.00500\ mol\ NaOH \left(\frac{1\ mol\ H_2SO_4}{2\ mol\ NaOH}\right)\left(\frac{1\ L\ H_2SO_4}{0.300\ mol\ H_2SO_4}\right) = 0.00833\ L\ H_2SO_4$$

64. $NaOH(aq) + KHC_8H_4O_4(aq) \rightarrow NaKC_8H_4O_4(aq) + H_2O(l)$

g KHP → mol KHP → mol NaOH

$$0.1082\ g\ KHP \left(\frac{1\ mol\ KHP}{204.22\ g}\right)\left(\frac{1\ mol\ NaOH}{1\ mol\ KHP}\right) = 5.298 \times 10^{-4}\ mol\ NaOH$$

Calculate the molarity of the NaOH solution

$$V = 34.67\ mL\left(\frac{1\ L}{1000\ mL}\right) = 0.03467\ L$$

$$M = \frac{n}{V} = \frac{5.298 \times 10^{-4}\ mol}{0.03467\ L} = 0.01528\ M\ NaOH$$

66. $3Ba(OH)_2(aq) + 2H_3PO_4(aq) \rightarrow Ba_3(PO_4)_2(s) + 6H_2O(l)$

mL H_3PO_4 → L H_3PO_4 → mol H_3PO_4 → mol $Ba(OH)_2$ → V $Ba(OH)_2$

$$14.20\ mL\ H_3PO_4\left(\frac{1\ L}{1000\ mL}\right)\left(\frac{0.141\ mol\ H_3PO_4}{1\ L\ H_3PO_4}\right)\left(\frac{3\ mol\ Ba(OH)_2}{2\ mol\ H_3PO_4}\right)\left(\frac{1\ L\ Ba(OH)_2}{0.0521\ mol\ Ba(OH)_2}\right)$$
$$= 0.0576\ L\ Ba(OH)_2$$

67. a) $HC_2H_3O_2(aq) + NaOH(aq) \rightarrow NaC_2H_3O_2(aq) + H_2O(l)$

mL NaOH → L NaOH → mol NaOH → mol $HC_2H_3O_2$

$$16.58\ mL\ NaOH\left(\frac{1\ L}{1000\ mL}\right)\left(\frac{0.5062\ mol\ NaOH}{1\ L\ NaOH}\right) = 0.008393\ mol\ HC_2H_3O_2$$

Calculate the molarity of the acetic acid

$$V = 10.0\ mL\left(\frac{1\ L}{1000\ mL}\right) = 0.0100\ L$$

$$M = \frac{n}{V} = \frac{0.008393\ mol}{0.0100\ L} = 0.8393\ M\ HC_2H_3O_2$$

b) Calculate the mass of the acetic acid

$$0.008393\ mol\ HC_2H_3O_2\left(\frac{60.06\ g\ HC_2H_3O_2}{1\ mol\ HC_2H_3O_2}\right) = 0.5041\ g$$

Calculate the mass of the vinegar in 10.0 mL

$$10.00\ mL\left(\frac{1\ cm^3}{1\ mL}\right)\left(\frac{1.006\ g}{1\ cm^3}\right) = 10.06\ g$$

Calculate the mass %

$$\left(\frac{m_{HC_2H_3O_2}}{m_{total}}\right)100\% = \left(\frac{0.5041\ g}{10.06\ g}\right)100\% = 5.011\%$$

71. This is a limiting reagent problem. Find out if OH^- or H^+ is present in excess.

$2HCl(aq) + Ba(OH)_2(aq) \rightarrow BaCl_2(aq) + 2H_2O(l)$

Net Ionic Equations: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

Determine the initial moles of H^+

$$75.0\ mL\ HCl\left(\frac{1\ L}{1000\ mL}\right)\left(\frac{0.250\ mol\ HCl}{1\ L\ HCl}\right)\left(\frac{1\ mol\ H^+}{1\ mol\ HCl}\right) = 0.0188\ mol\ H^+$$

Determine the initial moles of OH^-

$$225.0\ mL\ Ba(OH)_2\left(\frac{1\ L}{1000\ mL}\right)\left(\frac{0.0550\ mol\ Ba(OH)_2}{1\ L\ Ba(OH)_2}\right)\left(\frac{2\ mol\ OH^-}{1\ mol\ Ba(OH)_2}\right) = 0.0248\ mol\ OH^-$$

Calculate the number of moles of OH^- needed to fully react with 0.0188 mol H^+

$$0.0188\ mol\ H^+\left(\frac{1\ mol\ HCl}{1\ mol\ H^+}\right)\left(\frac{1\ mol\ Ba(OH)_2}{2\ mol\ HCl}\right)\left(\frac{2\ mol\ OH^-}{1\ mol\ Ba(OH)_2}\right) = 0.0188\ mol\ OH^-$$

Since we have 0.0248 moles of OH^-, H^+ is the limiting reagent and will be completely consumed.

	$H^+(aq)$ (L.R)	$OH^-(aq)$	$H_2O(l)$
I (mol)	0.0188	0.0248	0
C (mol)	-x=-0.0188	-x=-0.0188	+x=0.0188
F (mol)	0	0.0060	0.0188

$$0.0188 - x = 0$$

$$x = 0.0188$$

Calculate the molarity of OH^- left in solution.

$$V = 75.0\ mL + 225.0\ mL = 300.0\ mL\left(\frac{1\ L}{1000\ mL}\right) = 0.3000\ L$$

$$M = \frac{n}{V} = \frac{0.0060\ mol}{0.3000\ L} = 0.020\ M\ OH^-$$

75. a) K +1, Mn +7, and O -2
b) Ni +4, and O -2
c) Fe +2
d) NH_4 +1 (N -3 and H +1), and HPO_4 -2 (H +1, P +5, and O -2)
e) P +3, and O -2
f) Fe +8/3, and O -2
g) Xe +6, O -2, and F -1
h) S +4, and F -1
i) C +2, and O -2
j) C 0, H +1, and O -2

77. a) Sr 2+, Cr +6, and O -2
b) Cu +2, and Cl -1
c) O 0
d) H +1 and O -1 (peroxide)
e) Mg +2, C +4, and O -2
f) Ag 0
g) Pb 2+, and SO_3 -2 (S +4 and O -2)
h) Pb 4+, and O 2-
i) Na +1, C +3, and O -2
j) C +4, and O -2
k) NH_4 +1 (N -3 and H +1), Ce 4+, and SO_4 2- (S +6 and O -2)
l) Cr +3, and O -2

78. Since they ask for substance oxidized they want entire compound not just element oxidized

a) Redox reaction

Element	Beginning Oxidation #	Ending Oxidation #
O	0	-2
C	-4	+4

O is reduced, O_2 is species reduced
C is oxidized, CH_4 is species oxidized
O_2 is the oxidizing agent
CH_4 is the reducing agent

b) Redox reaction

Element	Beginning Oxidation #	Ending Oxidation #
Zn	0	+2
H	+1	0

Zn is oxidized
H is reduced, HCl is species reduced
Zn is the reducing agent
HCl is the oxidizing agent

c) Not a redox reaction

d) Redox Reaction

Element	Beginning Oxidation #	Ending Oxidation #
O	0	-2
N	+2	+4

O is reduced, O_3 is species reduced
N is oxidized, NO is species oxidized
O_3 is the oxidizing agent
NO is the reducing agent

e) Redox Reaction

Element	Beginning Oxidation #	Ending Oxidation #
O	-1	0
O	-1	-2

O is reduced, H_2O_2 is species reduced
O is oxidized, H_2O_2 is species oxidized
H_2O_2 is the oxidizing agent
H_2O_2 is the reducing agent

f) Redox Reaction

Element	Beginning Oxidation #	Ending Oxidation #
Cu	+1	0
Cu	+1	+2

Cu is reduced, CuCl is species reduced
Cu is oxidized, CuCl is species oxidized
CuCl is the oxidizing agent
CuCl is the reducing agent

g) Not a Redox Reaction

h) Not a Redox Reaction

i) Redox Reaction

Element	Beginning Oxidation #	Ending Oxidation #
Si	+4	0
Mg	0	+2

Si is reduced, $SiCl_4$ is species reduced
Mg is oxidized
$SiCl_4$ is the oxidizing agent
Mg is the reducing agent

81. a) Balance Oxidation ½ Reaction

$Cu \rightarrow Cu^{2+}$

$Cu \rightarrow Cu^{2+} + 2e^-$

Balance Reduction ½ Reaction

$NO_3^- \rightarrow NO$

$NO_3^- \rightarrow NO + 2H_2O$

$NO_3^- + 4H^+ \rightarrow NO + 2H_2O$

$NO_3^- + 4H^+ + 3e^- \rightarrow NO + 2H_2O$

Total Balanced Equation

$3(Cu \rightarrow Cu^{2+} + 2e^-)$

$\underline{2(NO_3^- + 4H^+ + 3e^- \rightarrow NO + 2H_2O)}$

$3Cu(s) + 2NO_3^-(aq) + 8H^+(aq) \rightarrow 3Cu^{2+}(aq) + 2NO(g) + 4H_2O(l)$

b) Balance Recution ½ Reaction

$Cr_2O_7^{2-} \rightarrow Cr^{3+}$

$Cr_2O_7^{2-} \rightarrow 2Cr^{3+}$

$Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 7H_2O$

$Cr_2O_7^{2-} + 14H^+ \rightarrow 2Cr^{3+} + 7H_2O$

$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

Balance Oxidation ½ Reaction

$Cl^- \rightarrow Cl_2$

$2Cl^- \rightarrow Cl_2$

$2Cl^- \rightarrow Cl_2 + 2e^-$

Total Balanced Equation

$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

$\underline{3(2Cl^- \rightarrow Cl_2 + 2e^-)}$

$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6Cl^-(aq) \rightarrow 2Cr^{3+}(aq) + 7H_2O(l) + 3Cl_2(g)$

c) Balance Reduction ½ Reaction

$PbO_2 + H_2SO_4 \rightarrow PbSO_4$

$PbO_2 + H_2SO_4 \rightarrow PbSO_4 + 2H_2O$

$PbO_2 + H_2SO_4 + 2H^+ \rightarrow PbSO_4 + 2H_2O$

$PbO_2 + H_2SO_4 + 2H^+ + 2e^- \rightarrow PbSO_4 + 2H_2O$

Balance Oxidation ½ Reaction

$Pb + H_2SO_4 \rightarrow PbSO_4$

$Pb + H_2SO_4 \rightarrow PbSO_4 + 2H^+$

$Pb + H_2SO_4 \rightarrow PbSO_4 + 2H^+ + 2e^-$

Total Balanced Equation

$PbO_2 + H_2SO_4 + 2H^+ + 2e^- \rightarrow PbSO_4 + 2H_2O$

$\underline{Pb + H_2SO_4 \rightarrow PbSO_4 + 2H^+ + 2e^-}$

$PbO_2(s) + 2H_2SO_4(aq) + Pb(s) \rightarrow 2PbSO_4(s) + 2H_2O(l)$

d) Skip this equation. You will not be able to balence this because there is no sodium on the products side of the equation.

e) Balance Reducation ½ Reaction

$H_3AsO_4 \rightarrow AsH_3$

$H_3AsO_4 \rightarrow AsH_3 + 4H_2O$

$H_3AsO_4 + 8H^+ \rightarrow AsH_3 + 4H_2O$

$H_3AsO_4 + 8H^+ + 8e^- \rightarrow AsH_3 + 4H_2O$

Balance Oxidation ½ Reaction

$Zn \rightarrow Zn^{2+}$

$Zn \rightarrow Zn^{2+} + 2e^-$

Total Balanced Equation

$H_3AsO_4 + 8H^+ + 8e^- \rightarrow AsH_3 + 4H_2O$

$\underline{4(Zn \rightarrow Zn^{2+} + 2e^-)}$

$H_3AsO_4(aq) + 8H^+(aq) + 4Zn(s) \rightarrow AsH_3(g) + 4H_2O(l) + 4Zn^{2+}(aq)$

f) Balance Oxidation ½ Reaction

$As_2O_3 \rightarrow H_3AsO_4$

$As_2O_3 \rightarrow 2H_3AsO_4$

$As_2O_3 + 5H_2O \rightarrow 2H_3AsO_4$

$As_2O_3 + 5H_2O \rightarrow 2H_3AsO_4 + 4H^+$

$As_2O_3 + 5H_2O \rightarrow 2H_3AsO_4 + 4H^+ + 4e^-$

Balance Reducation ½ Reaction

$NO_3^- \rightarrow NO$

$NO_3^- \rightarrow NO + 2H_2O$

$NO_3^- + 4H^+ \rightarrow NO + 2H_2O$

$NO_3^- + 4H^+ + 3e^- \rightarrow NO + 2H_2O$

Total Balanced Equation

$3(As_2O_3 + 5H_2O \rightarrow 2H_3AsO_4 + 4H^+ + 4e^-)$

$\underline{4(NO_3^- + 4H^+ + 3e^- \rightarrow NO + 2H_2O)}$

$3As_2O_3(s) + 7H_2O(l) + 4NO_3^-(aq) + 4H^+(aq) \rightarrow 6H_3AsO_4(aq) + 4NO(g)$

g) Balance Oxidation ½ Reaction

$Br^- \rightarrow Br_2$

$2Br^- \rightarrow Br_2$

$2Br^- \rightarrow Br_2 + 2e^-$

Balance Reducation ½ Reaction

$MnO_4^- \rightarrow Mn^{2+}$

$MnO_4^- \rightarrow Mn^{2+} + 4H_2O$

$MnO_4^- + 8H^+ \rightarrow Mn^{2+} + 4H_2O$

$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$

Total Balanced Equation

$5(2Br^- \rightarrow Br_2 + 2e^-)$

$\underline{2(MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O)}$

$10Br^-(aq) + 2MnO_4^-(aq) + 16H^+(aq) \rightarrow 5Br_2(l) + 2Mn^{2+}(aq) + 8H_2O(l)$

h) Balance Oxidation ½ Reaction

$CH_3OH \rightarrow CH_2O$

$CH_3OH \rightarrow CH_2O + 2H^+$

$CH_3OH \rightarrow CH_2O + 2H^+ + 2e^-$

Balance Reducation ½ Reaction

$Cr_2O_7^{2-} \rightarrow Cr^{3+}$

$Cr_2O_7^{2-} \rightarrow 2Cr^{3+}$

$Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 7H_2O$

$Cr_2O_7^{2-} + 14H^+ \rightarrow 2Cr^{3+} + 7H_2O$

$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

Total Balance Equation

$3(CH_3OH \rightarrow CH_2O + 2H^+ + 2e^-)$

$\underline{Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O}$

$3CH_3OH(aq) + Cr_2O_7^{2-}(aq) + 8H^+(aq) \rightarrow 3CH_2O(aq) + 2Cr^{3+}(aq) + 7H_2O(l)$

82. a) Balance Oxidation ½ Reaction

$Al \rightarrow Al(OH)_4^-$

$Al + 4H_2O \rightarrow Al(OH)_4^-$

$Al + 4H_2O \rightarrow Al(OH)_4^- + 4H^+$

$Al + 4H_2O \rightarrow Al(OH)_4^- + 4H^+ + 3e^-$

Balance Reducation ½ Reaction

$MnO_4^- \rightarrow MnO_2$

$MnO_4^- \rightarrow MnO_2 + 2H_2O$

$MnO_4^- + 4H^+ \rightarrow MnO_2 + 2H_2O$

$MnO_4^- + 4H^+ + 3e^- \rightarrow MnO_2 + 2H_2O$

Total Balanced Equation

$Al + 4H_2O \rightarrow Al(OH)_4^- + 4H^+ + 3e^-$

$\underline{MnO_4^- + 4H^+ + 3e^- \rightarrow MnO_2 + 2H_2O}$

$Al(s) + 2H_2O(l) + MnO_4^-(aq) \rightarrow Al(OH)_4^-(aq) + MnO_2(s)$

Since there are no H^+ in the equation the equation is the same for acid or basic conditions.

b) Balance Reducation ½ Reaction

$Cl_2 \rightarrow 2Cl^-$

$Cl_2 + 2e^- \rightarrow 2Cl^-$

Balance Oxidation ½ Reaction

$Cl_2 \rightarrow 2ClO^-$

$Cl_2 + 2H_2O \rightarrow 2ClO^-$

$Cl_2 + 2H_2O \rightarrow 2ClO^- + 4H^+$

$Cl_2 + 2H_2O \rightarrow 2ClO^- + 4H^+ + 2e^-$

Total Balanced Equation

$Cl_2 + 2e^- \rightarrow 2Cl^-$

$\underline{Cl_2 + 2H_2O \rightarrow 2ClO^- + 4H^+ + 2e^-}$

$2Cl_2(g) + 2H_2O(l) \rightarrow 2Cl^-(aq) + 2ClO^-(aq) + 4H^+(aq)$

Reduce to smallest numbers

$Cl_2(g) + H_2O(l) \rightarrow Cl^-(aq) + ClO^-(aq) + 2H^+(aq)$

Switch to basic

$Cl_2(g) + H_2O(l) + 2OH^-(aq) \rightarrow Cl^-(aq) + ClO^-(aq) + 2H^+(aq) + 2OH^-(aq)$

$Cl_2(g) + 2OH^-(aq) \rightarrow Cl^-(aq) + ClO^-(aq) + H_2O(l)$

c) Balance Reducation ½ Reaction

$NO_2^- \rightarrow NH_3$

$NO_2^- \rightarrow NH_3 + 2H_2O$

$NO_2^- + 7H^+ \rightarrow NH_3 + 2H_2O$

$NO_2^- + 7H^+ + 6e^- \rightarrow NH_3 + 2H_2O$

Balance Oxidation ½ Reaction

$Al \rightarrow AlO_2^-$

$Al + 2H_2O \rightarrow AlO_2^-$

$Al + 2H_2O \rightarrow AlO_2^- + 4H^+$

$Al + 2H_2O \rightarrow AlO_2^- + 4H^+ + 3e^-$

Total Balanced Equation

$NO_2^- + 7H^+ + 6e^- \rightarrow NH_3 + 2H_2O$

$\underline{2(Al + 2H_2O \rightarrow AlO_2^- + 4H^+ + 3e^-)}$

$NO_2^-(aq) + 2Al(s) + 2H_2O(l) \rightarrow NH_3(g) + 2AlO_2^-(aq) + H^+(aq)$

Switch to basic

$NO_2^-(aq) + 2Al(s) + 2H_2O(l) + OH^-(aq) \rightarrow NH_3(g) + 2AlO_2^-(aq) + H^+(aq) + OH^-(aq)$

$NO_2^-(aq) + 2Al(s) + H_2O(l) + OH^-(aq) \rightarrow NH_3(g) + 2AlO_2^-(aq)$

d) Balance Reduction ½ Reaction

$MnO_4^- + S^{2-} \rightarrow MnS$

$MnO_4^- + S^{2-} \rightarrow MnS + 4H_2O$

$MnO_4^- + S^{2-} + 8H^+ \rightarrow MnS + 4H_2O$

$MnO_4^- + S^{2-} + 8H^+ + 5e^- \rightarrow MnS + 4H_2O$

Balance Oxidation ½ Reaction

$S^{2-} \rightarrow S$

$S^{2-} \rightarrow S + 2e^-$

Total Balanced Equation

$2(MnO_4^- + S^{2-} + 8H^+ + 5e^- \rightarrow MnS + 4H_2O)$

$\underline{5(S^{2-} \rightarrow S + 2e^-)}$

$2MnO_4^-(aq) + 7S^{2-}(aq) + 16H^+(aq) \rightarrow 2MnS(s) + 8H_2O(l) + 5S(s)$

Switch to Basic

$2MnO_4^-(aq)+7S^{2-}(aq)+16H^+(aq)+16OH^-(aq)\rightarrow 2MnS(s)+8H_2O(l)+5S(s)+16OH^-(aq)$

$2MnO_4^-(aq) + 7S^{2-}(aq) + 8H_2O(l) \rightarrow 2MnS(s) + 5S(s) + 16OH^-(aq)$

e) Balance Reducation ½ Reaction

$CN^- \rightarrow CNO^-$

$CN^- + H_2O \rightarrow CNO^-$

$CN^- + H_2O \rightarrow CNO^- + 2H^+$

$CN^- + H_2O \rightarrow CNO^- + 2H^+ + e^-$

Balance Oxidation ½ Reaction

$MnO_4^- \rightarrow MnO_2$

$MnO_4^- \rightarrow MnO_2 + 2H_2O$

$MnO_4^- + 4H^+ \rightarrow MnO_2 + 2H_2O$

$MnO_4^- + 4H^+ + 3e^- \rightarrow MnO_2 + 2H_2O$

Total Balanced Equatioin

$3(CN^- + H_2O \rightarrow CNO^- + 2H^+ + e^-)$

$\underline{2(MnO_4^- + 4H^+ + 3e^- \rightarrow MnO_2 + 2H_2O)}$

$3CN^-(aq) + 2MnO_4^-(aq) + 2H^+(aq) \rightarrow 3CNO^-(aq) + 2MnO_2(s) + H_2O(l)$

Switch to basic conditions

$3CN^-(aq) + 2MnO_4^-(aq) + 2H^+(aq) + 2OH^-(aq) \rightarrow 3CNO^-(aq) + 2MnO_2(s) + H_2O(l) + 2OH^-(aq)$

$3CN^-(aq) + 2MnO_4^-(aq) + H_2O(l) \rightarrow 3CNO^-(aq) + 2MnO_2(s) + 2OH^-(aq)$

85. 1st balance the equation

Balance Reduction ½ Reaction

$MnO_4^- \rightarrow Mn^{2+}$

$MnO_4^- \rightarrow Mn^{2+} + 4H_2O$

$MnO_4^- + 8H^+ \rightarrow Mn^{2+} + 4H_2O$

$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$

Balance Oxidation ½ Reaction

$H_2C_2O_4 \rightarrow CO_2$

$H_2C_2O_4 \rightarrow 2CO_2$

$H_2C_2O_4 \rightarrow 2CO_2 + 2H^+$

$H_2C_2O_4 \rightarrow 2CO_2 + 2H^+ + 2e^-$

Total Balanced Equation

$2(MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O)$

$\underline{5(H_2C_2O_4 \rightarrow 2CO_2 + 2H^+ + 2e^-)}$

$2MnO_4^-(aq) + 6H^+(aq) + 5H_2C_2O_4(aq) \rightarrow 2Mn^{2+}(aq) + 8H_2O(l) + 10CO_2(g)$

Calculate the moles of MnO_4^-

$$0.1058\ g\ H_2C_2O_4 \left(\frac{1\ mol\ H_2C_2O_4}{90.04\ g\ H_2C_2O_4}\right)\left(\frac{2\ mol\ MnO_4^-}{5\ mol\ H_2C_2O_4}\right) = 4.700 \times 10^{-4}\ mol\ MnO_4^-$$

Calculate the molarity of the MnO_4^- solution

$$M = \frac{n}{V}$$

$$V = 28.97\ mL \left(\frac{1\ L}{1000\ mL}\right) = 0.02897\ L$$

$$M = \frac{n}{V} = \frac{4.700 \times 10^{-4}\ mol}{0.02897\ L} = 0.01622\ M\ MnO_4^-$$

86. a) Balance the equation

Balance Reduction ½ Reaction

$MnO_4^- \rightarrow Mn^{2+} + 4H_2O$

$MnO_4^- + 8H^+ \rightarrow Mn^{2+} + 4H_2O$

$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$

Balance Oxidation ½ Reaction

$Fe^{2+} \rightarrow Fe^{3+}$

$Fe^{2+} \rightarrow Fe^{3+} + e^-$

Total Balanced Equation

$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$

$\underline{5(Fe^{2+} \rightarrow Fe^{3+} + e^-)}$

$MnO_4^-(aq) + 8H^+(aq) + 5Fe^{2+}(aq) \rightarrow Mn^{2+}(aq) + 4H_2O(l) + 5Fe^{3+}(aq)$

Calculate the moles of Fe^{2+}

mL $KMnO_4$ → L $KMnO_4$ → mol $KMnO_4$ → mol MnO_4^- → mol Fe^{2+}

$$20.62\ mL\ KMnO_4 \left(\frac{1\ L}{1000\ mL}\right)\left(\frac{0.0216\ mol\ KMnO_4}{1\ L\ KMnO_4}\right)\left(\frac{1\ mol\ MnO_4^-}{1\ mol\ KMnO_4}\right)\left(\frac{5\ mol\ Fe^{2+}}{1\ mol\ MnO_4^-}\right)$$
$$= 0.00222\ mol\ Fe^{2+}$$

Calculate the molarity of the Fe^{2+} solution

$$M = \frac{n}{V}$$

$$V = 50.00\ mL\left(\frac{1\ L}{1000\ mL}\right) = 0.05000\ L$$

$$M = \frac{n}{V} = \frac{0.00222\ mol}{0.05000\ L} = 0.0445\ M\ Fe^{2+}$$

b) Balance the equation

Balance Reduction ½ Reaction

$Cr_2O_7^{2-} \rightarrow Cr^{3+}$

$Cr_2O_7^{2-} \rightarrow 2Cr^{3+}$

$Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 7H_2O$

$Cr_2O_7^{2-} + 14H^+ \rightarrow 2Cr^{3+} + 7H_2O$

$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

Balance Oxidation ½ Reaction

$Fe^{2+} \rightarrow Fe^{3+}$

$Fe^{2+} \rightarrow Fe^{3+} + e^-$

Total Balanced Equation

$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

$\underline{6(Fe^{2+} \rightarrow Fe^{3+} + e^-)}$

$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6Fe^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 7H_2O(l) + 6Fe^{3+}(aq)$

Calculate the V of K_2CrO_7

mol Fe^{2+} → mol $Cr_2O_7^{2-}$ → mol $K_2Cr_2O_7$ → V K_2CrO_7

$$0.00222\ mol\ Fe^{2+}\left(\frac{1\ mol\ Cr_2O_7^{2-}}{6\ mol\ Fe^{2+}}\right)\left(\frac{1\ mol\ K_2Cr_2O_7}{1\ mol\ Cr_2O_7^{2-}}\right)\left(\frac{1\ L\ K_2Cr_2O_7}{0.0150\ mol\ K_2Cr_2O_7}\right)$$
$$= 0.0247\ L\ K_2Cr_2O_7$$