Additional Aqueous Solution Review Problems

Name Key Period ___

Balancing Chemical Equations

1. Balance each of the following chemical equations by inspection.

a. $4Co_{(s)} + 3O_{2(g)} \rightarrow 2Co_2O_{3(s)}$

b. $2LiClO_{3(s)} \rightarrow 2LiCl_{(s)} + 3O_{2(g)}$

c. $Cu_{(s)} + 2AgC_2H_3O_{2(aq)} \rightarrow Cu(C_2H_3O_2)_{2(aq)} + 2Ag_{(s)}$

d. $Pb(NO_3)_{2(aq)} + 2LiCl_{(aq)} \rightarrow PbCl_{2(s)} + 2LiNO_{3(aq)}$

e. $3H_2SO_{4(aq)} + 2Al(OH)_{3(aq)} \rightarrow Al_2(SO_4)_{3(aq)} + 6H_2O_{(l)}$

Reaction Types

2. Classify each reaction in exercise 1 as one of the following: combination (synthesis), decomposition, single replacement, double displacement, or neutralization.

a. Synthesis (Redox)
b. Decomposition (Redox)
c. Single Replacement (Redox)
d. Double displacement
e. Neutralization

3. Classify each (unbalanced) reaction as precipitation, acid-base neutralization or oxidation-reduction. Write a net ionic equation where possible.

a. $Mg_{(s)} + Cl_{2(g)} \rightarrow MgCl_{2(s)}$
Redox

b. $Ba(OH)_{2(aq)} + H_2SO_{4(aq)} \rightarrow BaSO_4 + 2H_2O$
$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O$ Neutralization

c. $Cu(NO_3)_{2(aq)} + Zn_{(s)} \rightarrow Zn(NO_3)_{2(aq)} + Cu_{(s)}$
Redox
$Cu^{2+}_{(aq)} + Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$

d. $3Na_2CO_{3(aq)} + 2Al(NO_3)_{3(aq)} \rightarrow 6NaNO_{3(aq)} + Al_2(CO_3)_3$
precipitation
$2Al^{3+}_{(aq)} + 3CO_3^{2-}{}_{(aq)} \rightarrow Al_2(CO_3)_{3(s)}$

Solubility Rules

4. Predict which of the following compounds are soluble in water.

a. cobalt(II)hydroxide, $Co(OH)_2$ insoluble
b. iron(II)sulfate, $FeSO_4$ Soluble
c. tin(II)chromate, $SnCrO_4$ insoluble
d. lead(II)acetate, $Pb(C_2H_3O_2)_2$ Soluble

Double Displacement Reactions

5. Write a balanced net ionic equation for each of the following double-displacement reactions.

a. Aqueous solutions of zinc chloride and ammonium hydroxide react to give ammonium chloride and zinc hydroxide.

$Zn^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Zn(OH)_{2(s)}$

b. Aqueous solutions of nickel(II)sulfate and mercury(I)nitrate react to give nickel(II)nitrate and mercury(I)sulfate.

$Hg_2^{2+}{}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow Hg_2SO_{4(s)}$
$(2Hg^+_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow Hg_2SO_{4(s)}$ is acceptable)

Neutralization Reactions

6. Write a balanced molecular equation for each of the following neutralization reactions.

a. Potassium hydroxide solution is added to carbonic acid.

$2KOH_{(aq)} + H_2CO_{3(aq)} \rightarrow K_2CO_{3(aq)} + 2H_2O_{(l)}$

b. Barium hydroxide solution is added to phosphoric acid.

$2H_3PO_{4(aq)} + 3Ba(OH)_{2(aq)} \rightarrow Ba_3(PO_4)_{2(s)} + 6H_2O_{(l)}$

7. Below are indicated the products of acid-base reactions. Complete (and balance) the equations to show which strong acids/strong bases have reacted to form these products.

a. $KOH_{(aq)} + HCl_{(aq)} \rightarrow KCl_{(aq)} + H_2O_{(l)}$

b. $H_2SO_{4(aq)} + 2NaOH_{(aq)} \rightarrow Na_2SO_{4(aq)} + 2H_2O_{(l)}$

c. $HClO_{4(aq)} + CsOH_{(aq)} \rightarrow CsClO_{4(aq)} + H_2O_{(l)}$

d. $HNO_{3(aq)} + KOH_{(aq)} \rightarrow KNO_{3(aq)} + H_2O_{(l)}$

Oxidation-Reduction Reactions

8. In each reaction determine: a) the oxidation number of each element, b) which element is oxidized and which is reduced, c) the oxidizing agent and the reducing agent.

a. $\overset{-3\ +1}{4NH_3} + \overset{+2\ -2}{6NO} \rightarrow \overset{0}{5N_2} + \overset{+1\ -2}{6H_2O}$

N is oxidized $-3 \rightarrow 0$ | NH_3 = Reducing Agent

N is reduced $+2 \rightarrow 0$ | NO = Oxidizing Agent

b. $2\overset{+1\ -1}{LiI} + \overset{0}{F_2} \rightarrow 2\overset{+1\ -1}{LiF} + \overset{0}{I_2}$

I is oxidized $-1 \rightarrow 0$ | LiI = Reducing Agent

F is reduced $0 \rightarrow -1$ | F_2 = Oxidizing Agent

Dilutions

9. Water is added to 25.0mL of 0.866M KNO_3 solution until the volume of the solution is exactly 500.mL. What is the molarity of the final solution?

$M = \frac{n}{V} = \frac{(.025L)(.866\ mol/L)}{(.500L)} = .0433M$

10. You have 505mL of a 0.125M HCl solution and you want to dilute it to exactly 0.100M. How much water should you add?

$M_1V_1 = M_2V_2$ $\quad (505mL)(0.125M) = V_2(0.100M)$

$V_2 = 631.25 \approx 631$ $\quad 631mL - 505mL = 126mL$

11. 60.0mL of a .014M HCl solution is combined with 125.0mL of a .023M HCl solution. What is the molarity of the combined solution?

$\frac{(.060L)(.014) + (.125L)(.023)}{(.185L)} = .020M$

12. How many grams of sodium nitrate should be added to enough water to produce 350.mL of a .55M solution?

$\frac{.55\ mol}{L}(.350L) = .1925\ mol\ NaNO_3\left(\frac{84.99g}{mol}\right) = 16.36g \approx 16g$

General Reaction Questions

13. 55.0mL of .002M HCl was required to titrate a 30.0mL sample of $Ba(OH)_2$ to its endpoint. What is the molarity of the barium hydroxide solution?

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

$\left[\frac{(.0550L)(.002\frac{mol}{L})\left(\frac{1\ Ba(OH)_2}{2HCl}\right)}{(.030L)}\right] = .0018 \approx .002M$

14. The concentration of a hydrogen peroxide solution can be conveniently determined by titration against a standardized potassium permanganate solution in an acidic medium according to the following equation:

$2MnO_4^- + 5H_2O_2 + 6H^+ \rightarrow 5O_2 + 2Mn^{2+} + 8H_2O$

If 36.44mL of a 0.01625M $KMnO_4$ solution are required to completely oxidize 25.00mL of a H_2O_2 solution, calculate the molarity of the H_2O_2 solution.

$(.03644L)(0.01625M)\left(\frac{5\ H_2O_2}{2\ MnO_4^-}\right) = .00148mol\ H_2O_2$

$M = \frac{n}{V} = \left(\frac{.00148mol\ H_2O_2}{.02500L}\right) = .05922M$

15. How many cubic centimeters of lithium metal are required to react completely with 200.mL of a .08M Cupric nitrate solution? The density of lithium is $5.34 \times 10^2\ kg/m^3 = .534\frac{g}{cm^3}$

$Li = 6.941\ g/mol$

$2Li_{(s)} + Cu(NO_3)_{2(aq)} \rightarrow 2LiNO_{3(aq)} + Cu_{(s)}$

$(.200L)(.08M) = .016\ mol\ Cu\left(\frac{2Li}{1Cu}\right) = .032\ mol\ Li$

$(.032\ mol\ Li \times 6.941\ g/mol)\left(\frac{1cm^3}{.534g}\right) = .416g \approx .4g$

16. A 60.0mL sample of a solution known to contain calcium chloride is mixed with an excess of silver nitrate solution. If .23g of silver chloride is produced, what was the molarity of the original calcium chloride solution? $AgCl = 143.32\ g/mol$

$CaCl_2 + 2AgNO_3 \rightarrow 2AgCl + Ca(NO_3)_2$

$\left(\frac{.23g\ AgCl}{143.32\ g/mol}\right) = .0016mol\left(\frac{1\ CaCl_2}{2\ AgNO_3}\right) = .000803\ mol$

$\frac{.000803\ mol}{(.060L)} = .013M$

17. A 100.g sample of an unknown alkali metal sulfate compound is dissolved in water. When excess barium nitrate is added, 164.31g of insoluble barium sulfate is produced. What is the identity of the original sulfate compound? $BaSO_4 = 233.37\ g/mol$

X_2SO_4 $\quad X$ = alkali metal

$\left(\frac{164.31g\ BaSO_4}{233.37\ g/mol}\right) = .704\ mol\ BaSO_4$ $\quad = .704\ mol\ SO_4^{2-} = 67.63g\ SO_4^{2-}$

$.704\ mol\ SO_4^{2-}\left(\frac{2X^+}{1\ SO_4^{2-}}\right) = 1.408\ mol$ $\quad \frac{(100 - 67.63)}{1.408\ mol} = 22.99 \approx Na$

18. The following reaction takes place in basic solution. Use the half-reaction method to write a balanced ionic equation.

$NiO_{2(s)} + S_2O_3^{2-}{}_{(aq)} \rightarrow Ni(OH)_{2(s)} + SO_3^{2-}{}_{(aq)}$

$NiO_2 \rightarrow Ni(OH)_2$

$2H^+ + NiO_2 \rightarrow Ni(OH)_2$

$2H^+ + NiO_2 + 2e^- \rightarrow Ni(OH)_2$

$4H^+ + 2NiO_2 + 4e^- \rightarrow 2Ni(OH)_2$

$2NiO_2 + 3H_2O + S_2O_3^{2-} \rightarrow 2Ni(OH)_2 + 2SO_3^{2-} + 2H^+$

$+2OH^-$ $\quad +2OH^-$

$2OH^- + 2NiO_2 + H_2O + S_2O_3^{2-} \rightarrow 2Ni(OH)_2 + 2SO_3^{2-}$

$S_2O_3^{2-} \rightarrow SO_3^{2-}$

$S_2O_3^{2-} \rightarrow 2SO_3^{2-}$

$3H_2O + S_2O_3^{2-} \rightarrow 2SO_3^{2-}$

$3H_2O + S_2O_3^{2-} \rightarrow 2SO_3^{2-} + 6H^+$

$3H_2O + S_2O_3^{2-} \rightarrow 2SO_3^{2-} + 6H^+ + 4e^-$