REVIEW QUESTIONS
Chapter 4

1. The alcohol in "gasohol" burns according to the equation shown below:

$$C_2H_5OH\ (l) + 3\ O_2\ (g) \rightarrow 2\ CO_2\ (g) + 3\ H_2O\ l)$$

How many grams of CO_2 are produced when 3.00 g of C_2H_5OH burns according to this reaction? (Assume excess oxygen)

$$3.00\ \cancel{g}\ \cancel{C_2H_5OH} \times \frac{1\ \cancel{mol}}{46.08\ \cancel{g}} \times \frac{2\ CO_2}{1\ \cancel{C_2H_5OH}} \times \frac{44.01\ g}{1\ \cancel{mol}} = 5.73\ g\ CO_2$$

2. Ammonia burns in air according to the reaction shown below:

$$4\ \ NH_3\ (g) + 5\ O_2\ (g) \rightarrow 4\ NO\ (g) + 6\ H_2O\ (l)$$

a) How many grams of NO form when 1.50 g NH_3 react with 1.85 g of O_2 react with one another.

$$1.50\ \cancel{g}\ \cancel{NH_3} \times \frac{1\ \cancel{mol}}{17.04\ \cancel{g}} \times \frac{4\ NO}{4\ \cancel{NH_3}} \times \frac{30.01\ g}{1\ \cancel{mol}} = 2.64\ g\ NO$$

$$1.85\ \cancel{g}\ \cancel{O_2} \times \frac{1\ \cancel{mol}}{32.00\ \cancel{g}} \times \frac{4\ NO}{5\ \cancel{O_2}} \times \frac{30.01\ g}{1\ \cancel{mol}} = 1.39\ g\ NO \leftarrow \text{LR (correct answer)}$$

b) After the reaction above has completed, which reactant, and how much of it remains unreacted?

$$1.85\ \cancel{g}\ \cancel{O_2} \times \frac{1\ \cancel{mol}}{32.00\ \cancel{g}} \times \frac{4\ \cancel{mol}\ NH_3}{5\ \cancel{mol}\ O_2} \times \frac{17.04\ g}{1\ \cancel{mol}} = 0.788\ g\ NH_3$$

$$\text{Excess } NH_3 = 1.50\ g - 0.788\ g = 0.71\ g$$

3. When 30.0 g of benzene (C_6H_6) and 65.0 g of bromine are reacted together as shown below, 56.7 g of bromobenzene (C_6H_5Br) is formed. What is the percent yield of this reaction?

$$C_6H_6 + Br_2 \rightarrow C_6H_5Br + HBr$$

$$30.0 \cancel{g}\ \cancel{C_6H_6} \times \frac{1\ \cancel{mol}}{78.12\ \cancel{g}} \times \frac{1\ \cancel{mol}\ C_6H_5Br}{1\ \cancel{mol}\ \cancel{C_6H_6}} \times \frac{157.01\ g}{1\ \cancel{mol}} = 60.3\ g\ C_6H_5Br \leftarrow \text{Theoretical Yield}$$

$$65.0 \cancel{g}\ \cancel{Br_2} \times \frac{1\ \cancel{mol}}{159.80\ \cancel{g}} \times \frac{1\ \cancel{mol}\ C_6H_5Br}{1\ \cancel{mol}\ \cancel{Br_2}} \times \frac{157.01\ g}{1\ \cancel{mol}} = 63.9\ g\ C_6H_5Br$$

$$\%\ \text{Yield} = \frac{56.7}{60.3\ g} \times 100 = 94.0\%$$

4. How many grams of solute are present in 50.0 mL of 1.33 M $CuSO_4$ solution?

$$50.0 \cancel{mL} \times \frac{1\ \cancel{L}}{10^3\ \cancel{mL}} \times \frac{1.33\ \cancel{mol}\ CuSO_4}{1\ \cancel{L}} \times \frac{159.61\ g}{1\ \cancel{mol}} = 10.6\ g\ CuSO_4$$

5. How many mL of 1.50 M Na_3PO_4 solution contains 5.00 g of solute?

$$5.00 \cancel{g} \times \frac{1\ \cancel{mol}}{163.94\ \cancel{g}} \times \frac{1\ \cancel{L}}{1.50\ \cancel{mol}} \times \frac{10^3\ mL}{1\ \cancel{L}} = 20.3\ mL$$

6. What volume of 1.50 M solution of sucrose solution is required to prepare 425 mL of 0.100 M solution?

$$V_2 = \frac{M_1V_1}{M_2} = \frac{(0.100\ \cancel{M})(425\ mL)}{1.50\ \cancel{M}} = 28.3\ mL$$

7. Glacial acetic acid has a density of 1.049 g/mL at 25°C. What is the molarity of a solution of acetic acid prepared by dissolving 10.00 mL of glacial acetic acid at 25°C in enough water to make 100.0 mL of solution?

$$10.00 \text{ mL} \times \frac{1.049 \text{ g}}{1 \text{ mL}} \times \frac{1 \text{ mol}}{60.06 \text{ g}} \times \frac{1}{0.1000 \text{ L}} = 1.747 \text{ M}$$

8. The acetylsalicylic content of aspirin can be determined by reaction of the acid with sodium hydroxide as shown below:

$$\underset{\text{acetylsalicylic acid}}{HC_9H_7O_4} + NaOH \rightarrow NaC_9H_7O_4 + H_2O$$

23.0 mL of 0.0770 M NaOH solution was used to completely react with the acid present in a 500-mg aspirin tablet. What is the percent of acetylsalicylic acid in the aspirin tablet?

$$23.0 \text{ mL NaOH} \times \frac{1 \text{ L}}{10^3 \text{ mL}} \times \frac{0.0770 \text{ mol}}{1 \text{ L}} \times \frac{1 \text{ mol } HC_9H_7O_4}{1 \text{ mol NaOH}} \times \frac{180.17 \text{ g}}{1 \text{ mol}} \times \frac{10^3 \text{ mg}}{1 \text{ g}} = 319 \text{ mg } HC_9H_7O_4$$

$$\% \text{ Acid} = \frac{319 \text{ mg}}{500 \text{ mg}} \times 100 = 63.8\%$$

9. Concentrated nitric acid has a density of 1.41 g/mL and contains 70.0% HNO_3 by mass. What is the molarity of this solution?

Assume 1.00 L of solution

$$1.00 \text{ L sol'n} \times \frac{10^3 \text{ mL}}{1 \text{ L}} \times \frac{1.41 \text{ g}}{1 \text{ mL}} \times \frac{70.0 \text{ g acid}}{100 \text{ g sol'n}} \times \frac{1 \text{ mol}}{63.02 \text{ g}} = 15.7 \text{ mol } HNO_3$$

$$\text{molarity} = \frac{15.7 \text{ mol}}{1 \text{ L}} = 15.7 \text{ M}$$

10. How many grams of Na must react with 155 mL of water to produce a solution that is 0.175 M NaOH, as shown below. (Assume a final solution volume of 155 mL)

$$2\ Na\ (s)\ +\ 2\ H_2O\ (l)\ \rightarrow\ 2\ NaOH\ (aq)\ +\ H_2\ (g)$$

$$155\ \cancel{mL} \times \frac{1\ \cancel{L}}{10^3\ \cancel{mL}} \times \frac{0.175\ \cancel{mol\ NaOH}}{1\ \cancel{L}} \times \frac{2\ mol\ Na}{2\ \cancel{mol\ NaOH}} \frac{22.99\ g}{1\ \cancel{mol}} = 0.624\ g\ Na$$

11. A sample of limestone (containing $CaCO_3$) weighing 438 mg is treated with oxalic acid ($H_2C_2O_4$), as shown below:

$$CaCO_3\ (s)\ +\ H_2C_2O_4\ (aq)\ \rightarrow\ CaC_2O_4\ (s)\ +\ H_2O\ (l)\ +\ CO_2\ (g)$$

The mass of CaC_2O_4 produced in this reaction was found to be 472 mg. Based on this information, what is the mass percent of calcium carbonate in limestone?

$$472\ \cancel{mg}\ \cancel{CaC_2O_4} \times \frac{1\ \cancel{g}}{10^3\ \cancel{mg}} \times \frac{1\ mol}{128.10\ \cancel{g}} \times \frac{1\ mol\ CaCO_3}{1\ \cancel{mol\ CaC_2O_4}} \frac{100.09\ \cancel{g}}{1\ \cancel{mol}} \times \frac{10\ mg}{1\ \cancel{g}} = 0.369\ g\ CaCO_3$$

$$\% = \frac{369\ mg}{438\ mg} \times 100 = 84.2\%$$

12. Identify each of the following substances as a non-electrolyte (NE), weak electrolyte (WE), or strong electrolyte (SE):

a) HF **WE** b) C_2H_5OH **NE**

c) LiOH **SE** d) $HClO_3$ **SE**

e) $Cu(NO_3)_2$ **SE** f) H_3PO_4 **WE**

13. Complete each equation shown below:

a) $AlCl_3\ (s) \xrightarrow{H_2O}$ **$Al^{3+}\ (aq) + 3\ Cl^-\ (aq)$**

b) $Na_3PO_4\ (s) \xrightarrow{H_2O}$ **$3\ Na^+\ (aq) + PO_4^{3-}\ (aq)$**

c) $(NH_4)_2CO_3\ (s) \xrightarrow{H_2O}$ **$2\ NH_4^+\ (aq) + CO_3^{2-}\ (aq)$**

14. Complete the molecular equations shown below, and write balanced net ionic equations for each:

a) $Pb(NO_3)_2\ (aq) + Na_2SO_4\ (aq) \rightarrow$ **$PbSO_4\ (s) + 2\ NaNO_3\ (aq)$**

$Pb^{2+}\ (aq) + SO_4^{2-}\ (aq) \rightarrow PbSO_4\ (s)$

b) $Cr(OH)_3\ (aq) +$ **3** $HNO_3\ (aq) \rightarrow$ **$Cr(NO_3)_3\ (aq) + 3\ H_2O\ (l)$**

$Cr(OH)_3\ (aq) + 3\ H^+ \rightarrow Cr^{3+} + H_2O\ (l)$

15. For each reaction shown below, determine if a reaction occurs. If so, write a balanced net ionic equation. If not, write "No Rxn".

a) $Ca(OH)_2$ (aq) + **2** HCN (aq) → **$Ca(CN)_2$ (aq) + 2 H_2O (l)**

OH^- (aq) + HCN (aq) → CN^- (aq) + H_2O

b) **2** $AgNO_3$ (aq) + Na_2CO_3 (aq) → **Ag_2CO_3 (s) + 2 $NaNO_3$ (aq)**

2 Ag^+ (aq) + CO_3^{2-} → Ag_2CO_3 (s)

c) NaCl (aq) + $(NH_4)_2SO_4$ (aq) → **No Rxn**

d) Na_3PO_4 (aq) + **3** HBr (aq) → **H_3PO_4 (aq) + 3 NaBr (aq)**

PO_4^{3-} (aq) + 3 H^+ → H_3PO_4 (aq)

16. Write balanced net ionic equations for each reaction described below:

a) Solid sodium hydroxide pellets are dropped in solution of sulfuric acid.

2 NaOH (s) + H_2SO_4 (aq) → Na_2SO_4 (aq) + 2 H_2O (l)

NaOH (s) + H^+ (aq) → Na^+ (aq) + H_2O (l)

b) Aqueous solutions of ammonium carbonate and calcium chloride are mixed together.

$(NH_4)_2CO_3$ (aq) + $CaCl_2$ (aq) → $CaCO_3$ (s) + 2 NH_4Cl (aq)

CO_3^{2-} + Ca^{2+} → $CaCO_3$ (s)

17. In the compounds below, assign oxidation numbers to the underlined element:

a) $H_3\underline{P}O_2$ **+1**

b) $Na_2\underline{C}_2O_4$ **+3**

c) $Mn\underline{S}O_4$ **+6**

d) $H_2\underline{C}O$ **0**

e) $\underline{Cl}F_4^-$ **+3**

g) $Al\underline{H}_3$ **–1**

18. Identify which substance is oxidized and which substance is reduced in each of the following redox reactions.

a) $\overset{0}{2\,Al} + \overset{0}{3\,Cl_2} \rightarrow \overset{+3\ -1}{2\,AlCl_3}$

oxidized **Al** reduced **Cl**

b) $\overset{-2\quad 0}{2\,NiS + 3\,O_2} \rightarrow \overset{-2\quad +4}{2\,NiO + 2\,SO_2}$

oxidized **S** reduced **O**

c) $\overset{-2\quad +5}{3\,H_2S + 2\,HNO_3} \rightarrow \overset{0\quad +2}{3\,S + 2\,NO} + 4\,H_2O$

Oxidized **S** reduced **N**

19. A solution is prepared by mixing 0.10 L of 0.12 M NaCl and 0.23 L of 0.18 M $MgCl_2$ solutions. What volume of 0.25 M $AgNO_3$ is required to precipitate all the chloride ions in the solution above? (Answer = 0.38 L)

$AgNO_3$ (aq) + Cl^- (aq) ⟶ AgCl (s) + NO_3^- (aq)

$0.10\ \cancel{L\ NaCl} \times \frac{0.12\ \cancel{mol}}{1\ \cancel{L}} \times \frac{1\ mol\ Cl^-}{1\ \cancel{mol\ NaCl}} = 0.012\ mol\ Cl^-$

$0.23\ \cancel{L\ MgCl_2} \times \frac{0.18\ \cancel{mol}}{1\ \cancel{L}} \times \frac{2\ mol\ Cl^-}{1\ \cancel{mol\ MgCl_2}} = 0.0828\ mol\ Cl^-$

Total mol of Cl^- = 0.012 + 0.0828 = 0.0948 mol

$0.0948\ \cancel{mol\ Cl^-} \times \frac{1\ \cancel{mol}\ AgNO_3}{1\ \cancel{mol\ Cl^-}} \times \frac{1\ L}{0.25\ \cancel{mol}} = 0.38\ L$

20. When B_5H_9 reacts with water, it forms boric acid (H_3BO_3) and hydrogen gas. Boric acid combines with sodium oxide to form borate salt $Na_2B_4O_7$ and water. What mass of B_5H_9 is required to form 151 g of the borate salt by this reaction sequence? (Answer = 37.9 g)

$4 \times (B_5H_9 + 15\ H_2O \longrightarrow \cancel{5\ H_3BO_3} + 12\ H_2)$

$5 \times (\cancel{4\ H_3BO_3} + Na_2O \longrightarrow Na_2B_4O_7 + 6\ H_2O)$

$4\ B_5H_9 + 5\ Na_2O + 30\ H_2O \longrightarrow 5\ Na_2B_4O_7 + 48\ H_2$

$$151\ \cancel{g\ Na_2B_4O_7} \times \frac{1\ \cancel{mol}}{201.22\ \cancel{g}} \times \frac{4\ \cancel{mol}\ B_5H_9}{5\ \cancel{mol\ Na_2B_4O_7}} \times \frac{63.14\ g}{1\ \cancel{mol}} = 37.9\ g\ B_5H_9$$

21. Balance each oxidation or reduction half-reaction shown below:

a) $\overset{+7}{\underline{1}}\ MnO_4^- + \underline{2}\ H_2O + 3\ e^- \rightarrow \overset{+4}{\underline{1}}\ MnO_2 + \underline{4}\ OH^-$

b) $\underline{1}\ H_2O + \underline{1}\ \overset{+4}{HSO_3^-} \rightarrow \overset{+6}{\underline{1}}\ SO_4^{2-} + \underline{3}\ H^+ + 2\ e^-$

c) $\underline{2}\ H_2O\ \underline{1}\ \overset{+4}{NiO_2} + 2\ e^- \rightarrow \overset{+2}{\underline{1}}\ Ni(OH)_2 + \underline{2}\ OH^-$

d) $\underline{2}\ H^+ + \underline{1}\ \overset{+5}{ClO_3^-} + 1e^- \rightarrow \underline{1}\ ClO_2 + \underline{1}\ H_2O$

22. What is the overall equation formed from combining half-reactions (b) and (d) above?

$H_2O + HSO_3^- \rightarrow SO_4^{2-} + 3\ H^+ + 2\ e^-$

$2 \times (2\ H^+ + ClO_3^- + 1e^- \rightarrow ClO_2 + H_2O)$

Combining the equations above and cancelling electrons, H^+ and H_2O, results the following overall equation:

$H^+ + HSO_3^- + 2\ ClO_3^- \rightarrow SO_4^{2-} + 2\ ClO_2 + H_2O$

23. A person's blood alcohol (C_2H_5OH) can be determined by titrating a sample of blood plasma with a sodium dichromate solution. The balanced equation is:

$$16\ H^+(aq) + 2\ Cr_2O_7^{2-}(aq) + C_2H_5OH(aq) \rightarrow 4\ Cr^{3+}(aq) + 2\ CO_2(g) + 11\ H_2O(l)$$

If 35.46 mL of 0.04961 M $Cr_2O_7^{2-}$ is required to titrate 25.00 g of plasma, what is the mass percent of alcohol in blood? (Answer = 0.1621%)

$$35.46\ \cancel{mL}\ \cancel{Cr_2O_7^{2-}} \times \frac{1\ L}{10^3\ \cancel{mL}} \times \frac{0.04961\ \cancel{mol}}{1\ L} \times \frac{1\ \cancel{mol}\ C_2H_5OH}{2\ \cancel{mol}\ \cancel{Cr_2O_7^{2-}}} \times \frac{46.08\ g}{1\ \cancel{mol}} = 0.04053\ g\ C_2H_5OH$$

$$\%\ C_2H_5OH = \frac{0.04053\ g\ C_2H_5OH}{25.00\ g\ blood} \times 100 = 0.1621\%$$

24. Phosphoric acid can be produced by reaction of aqueous sodium phosphate and sulfuric acid. The other product in the reaction is sodium sulfate.

a) What volume (in mL) of 1.55 M sulfuric acid is required to completely react with 27.5 mL of 1.20 M sodium phosphate?

$$2\ Na_3PO_4(aq) + 3\ H_2SO_4(aq) \longrightarrow 2\ H_3PO_4(aq) + 3\ Na_2SO_4(aq)$$

$$27.5\ \cancel{mL}\ \cancel{Na_3PO_4} \times \frac{1\ L}{10^3\ \cancel{mL}} \times \frac{1.20\ \cancel{mol}}{1\ L} \times \frac{3\ \cancel{mol}\ H_2SO_4}{2\ mol\ \cancel{Na_3PO_4}} \times \frac{1\ \cancel{L}}{1.55\ \cancel{mol}} \times \frac{10^3\ mL}{1\ \cancel{L}} = 31.9\ mL$$

b) What is the concentration of the phosphoric acid produced in the final solution?

$$27.5\ \cancel{mL}\ \cancel{Na_3PO_4} \times \frac{1\ \cancel{L}}{10^3\ \cancel{mL}} \times \frac{1.20\ \cancel{mol}}{1\ \cancel{L}} \times \frac{2\ mol\ H_3PO_4}{2\ \cancel{mol}\ \cancel{Na_3PO_4}} = 0.0330\ mol\ H_3PO_4$$

Total volume of solution = 27.5 mL + 31.9 mL = 59.4 mL = 0.0594 L

$$\text{Molarity of } H_3PO_4 = \frac{0.0330\ mol}{0.0594\ L} = 0.556\ M$$