1. *Balance* the following oxidation reduction equations and, where possible, ***write the complete chemical equation***. Include phase labels in your final answers. No partial credit for these. The equations are either balanced or they are not.

a. $I_{2(s)} + Sn^{4+}{}_{(aq)} \rightarrow Sn^{2+}{}_{(aq)} + IO_3^-{}_{(aq)}$ in acid

$$6\ H_2O + I_{2(s)} \rightarrow 2\ IO_3^-{}_{(aq)} + 12\ H^+{}_{(aq)} + 10\ e^-$$
$$5(2\ e^- + Sn^{4+}{}_{(aq)} \rightarrow Sn^{2+}{}_{(aq)})$$

$$6\ H_2O_{(l)} + I_{2(s)} + 5\ Sn^{4+}{}_{(aq)} \rightarrow 5\ Sn^{2+}{}_{(aq)} + 2\ IO_3^-{}_{(aq)} + 12\ H^+{}_{(aq)}$$

b. $KMnO_{4(aq)} + Cr(OH)_{3(s)} \rightarrow CrO_4^{2-}{}_{(aq)} + MnO_{2(s)}$ in KOH

$$OH^-{}_{(aq)} + MnO_4^-{}_{(aq)} + Cr(OH)_{3(s)} \rightarrow CrO_4^{2-}{}_{(aq)} + MnO_{2(s)} + 2\ H_2O_{(l)}$$
$$KOH_{(aq)} + KMnO_{4(aq)} + Cr(OH)_{3(s)} \rightarrow K_2CrO_{4(aq)} + MnO_{2(s)} + 2\ H_2O_{(l)}$$

2. Zinc metal reacts with excess Perchloric acid in a single replacement reaction. The gas produced is collected over water in a setup similar to that used in the textbook. The temperature is 22.5°C and the external pressure is 746.8 mmHg. The level of the solution inside the tube is 15.7 cm above the level outside the tube. The total volume of gas collected is 36.72 mL. Other useful information is that the density of the solution is 1.05 g/mL and the density of mercury is 13.58 g/mL. The vapor pressure of water at 22°C is 19.8 mmHg and at 23°C it is 21.1 mmHg. Calculate the number of *grams of Zinc metal* used.

$$Zn_{(s)} + 2\ HClO_{4\,(aq)} \rightarrow Zn(ClO_4)_{2\,(aq)} + H_{2\,(g)}$$

$$P_{height} = \frac{d_{sol'n}h}{d_{Hg}} = \frac{(1.05\text{ g/mL})(15.7\text{ cm})\left(\frac{10\text{ mm}}{1\text{ cm}}\right)}{(13.6\text{ g/mL})} = 1\underline{2}.139\text{ mmHg}$$

$$v.p. = 19.8\text{ mmHg} + \left[(0.5)(21.1\text{ mmHg} - 19.8\text{ mmHg})\right] = 20.\underline{4}5\text{ mmHg}$$

$$P_{atm} = P_{H_2} + P_{height} + v.p.$$

$$P_{H_2} = P_{atm} - (P_{height} + v.p.) = 746.8\text{ mmHg} - (1\underline{2}.139\text{ mmHg} + 20.\underline{4}5\text{ mmHg}) = 71\underline{4}.2\text{ mmHg}$$

$$g_{Zn} = \frac{PV}{RT} = \frac{(71\underline{4}.2\text{ mmHg})(36.72\text{ mL})\left(\frac{10^{-3}\text{ L}}{1\text{ mL}}\right)}{(62.364\text{ L mmHg mol}^{-1}\text{ K}^{-1})(295.7\text{ K})} \times \frac{1\text{ mol Zn}}{1\text{ mol H}_2} \times \frac{65.409\text{ g Zn}}{1\text{ mol Zn}} = 0.0930\text{ g Zn}$$

3. Use the data in the table provided to calculate the amount of energy, in kJ, produced or consumed when 100.00 grams of each of the reactants below is converted into products.

$$4\ NH_{3(g)} + 5\ O_{2(g)} \rightarrow 4\ NO_{(g)} + 6\ H_2O_{(g)}$$

$$\Delta H_{rxn} = \sum_{\text{products}} n\Delta H_f^\circ - \sum_{\text{reactants}} n\Delta H_f^\circ$$

$$= \left[\left(\frac{4\text{ mol NO}}{1\text{ mol rxn}}\right)\left(\frac{90.25\text{ kJ}}{1\text{ mol NO}}\right) + \left(\frac{6\text{ mol H}_2\text{O}}{1\text{ mol rxn}}\right)\left(\frac{-241.818\text{ kJ}}{1\text{ mol H}_2\text{O}}\right)\right]$$

$$- \left[\left(\frac{4\text{ mol NH}_3}{1\text{ mol rxn}}\right)\left(\frac{-46.11\text{ kJ}}{1\text{ mol NH}_3}\right) + \left(\frac{5\text{ mol O}_2}{1\text{ mol rxn}}\right)\left(\frac{0.000\text{ kJ}}{1\text{ mol O}_2}\right)\right]$$

$$= -905.4\underline{6}8\text{ kJ mol}^{-1} = -905.47\text{ kJ mol}^{-1}$$

$$q = 100.00\text{ g NH}_3 \times \frac{1\text{ mol NH}_3}{17.0305\text{ g NH}_3} \times \frac{1\text{ mol rxn}}{4\text{ mol NH}_3} \times \frac{-905.47\text{ kJ}}{\text{mol rxn}} = -1.3292 \times 10^3\text{ kJ}$$

$$q = 100.00\text{ g O}_2 \times \frac{1\text{ mol O}_2}{31.9988\text{ g O}_2} \times \frac{1\text{ mol rxn}}{5\text{ mol O}_2} \times \frac{-905.47\text{ kJ}}{\text{mol rxn}} = -5.6594 \times 10^2\text{ kJ}$$

-565.94 kJ can be produced from this reaction mixture.

4. A gas has a root-mean-square speed of 473 m/s at 40.0°C.

a. Calculate the *molar mass of the gas in g/mol*.

$$u_{rms} = \sqrt{\frac{3RT}{M}} \Rightarrow M = \frac{3RT}{u_{rms}^2} = \frac{3\left(8.314\text{ J mol}^{-1}\text{ K}^{-1}\right)\left(313.2\text{ K}\right)}{\left(473\text{ m s}^{-1}\right)^2} = 3.491092 \times 10^{-2}\text{ kg mol}^{-1}$$

$$= 34.9\text{ g mol}^{-1}$$

b. Calculate the *rate of effusion relative to Helium gas*.

$$\frac{R_u}{R_{He}} = \sqrt{\frac{M_{He}}{M_u}} = \sqrt{\frac{4.0026\text{ g mol}^{-1}}{34.9\text{ g mol}^{-1}}} = 0.339$$

$$R_u = 0.339 R_{He}$$

5. In a calorimetric experiment, 6.48 g of lithium hydroxide, LiOH, was dissolved in water. The temperature of the water rose from 25.00°C to 36.66°C. What is *ΔH for the solution process*?

$$LiOH_{(s)} \rightarrow Li^{+}_{(aq)} + OH^{-}_{(aq)}$$

The heat capacity of the calorimeter and its contents is 547 J/°C.

$$q_{cal} = C\Delta T = \left(547\ \text{J}\ ^{\circ}\text{C}^{-1}\right)\left(36.66^{\circ}\text{C} - 25.00^{\circ}\text{C}\right) = 6.3\underline{7}802\times10^{3}\ \text{J}$$

$$q_{rxn} = -q_{cal} = -6.3\underline{7}802\times10^{3}\ \text{J}$$

$$\Delta H = \frac{q_{rxn}}{n_{LiOH}} = \frac{-6.3\underline{7}802\times10^{3}\ \text{J}}{6.48\ \text{g LiOH}\times\frac{1\ \text{mol LiOH}}{23.948\ \text{g LiOH}}\times\frac{1\ \text{mol rxn}}{1\ \text{mol LiOH}}} = -2.357144\times10^{4}\ \text{J mol}^{-1}$$

$$= -23.6\ \text{kJ mol}^{-1}$$

6. 26.87 L of Nitrogen gas at 683.4 mmHg and 35.9°C reacts with 75.93 L of Hydrogen gas at 702.9 mmHg and 55.1°C to produce ammonia gas. Calculate the *volume, in L, ammonia gas produced at STP*.

$$N_{2(g)} + 3\ H_{2(g)} \rightarrow 2\ NH_{3(g)}$$

$$?\ \text{L NH}_3 = \frac{(26.87\ \text{L})(683.4\ \text{mmHg})}{(62.364\ \text{L mmHg mol}^{-1}\ \text{K}^{-1})(309.1\ \text{K})} \times \frac{2\ \text{mol NH}_3}{1\ \text{mol N}_2} \times \frac{22.414\ \text{L NH}_3}{1\ \text{mol NH}_3} = 42.71\ \text{L NH}_3$$

$$?\ \text{L NH}_3 = \frac{(75.93\ \text{L})(702.9\ \text{mmHg})}{(62.364\ \text{L mmHg mol}^{-1}\ \text{K}^{-1})(328.3\ \text{K})} \times \frac{2\ \text{mol NH}_3}{3\ \text{mol H}_2} \times \frac{22.414\ \text{L NH}_3}{1\ \text{mol NH}_3} = 38.95\ \text{L NH}_3$$

38.95 L of NH_3 can be produced at STP.

7. Calculate the following:

a. A flexible container is filled with Argon so that the volume of the container is 13.4 L at a pressure of 1.033 atm and 243.7 K. The volume is changed to 8.43 L and the temperature is changed to 157.2°C. What is the new *pressure in mmHg*?

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \Rightarrow P_2 = \frac{P_1V_1T_2}{T_1V_2}$$

$$= \frac{(1.033\ \text{atm})(13.4\ \text{L})(430.4\ \text{K})}{(243.7\ \text{K})(8.34\ \text{L})} \times \frac{760\ \text{mmHg}}{1\ \text{atm}} = 2.23\times10^3\ \text{mmHg}$$

b. 10.0 moles each of Neon and Krypton are placed into a 25.00 L container at 5.6°C. What is the *partial pressure* of each gas and the *total pressure* in the container? Express your answer in kPa.

$$n_T = n_{Ne} + n_{Kr} = 20.0\ \text{mol}$$

$$X_{Ne} = X_{Kr} = \frac{10.0\ \text{mol}}{20.0\ \text{mol}} = 0.500$$

$$P_T = \frac{n_TRT}{V} = \frac{(20.0\ \text{mol})(8.314\ \text{L kPa mol}^{-1}\ \text{K}^{-1})(278.8\ \text{K})}{(25.00\ \text{L})} = 1.85\times10^3\ \text{kPa}$$

$$P_{Ne} = P_{Kr} = XP_T = (0.500)(1.85\times10^3\ \text{kPa}) = 927\ \text{kPa}$$