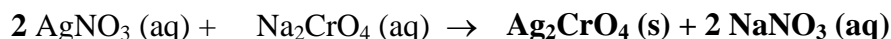
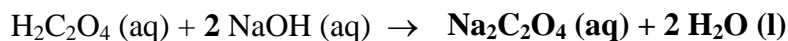
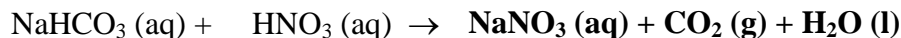


CHEM 120
Fall 2009
Quiz 8

Name: _____

1. (12 Points) Predict the products of the following reactions. Be sure to indicate the state of each product and to balance the resulting chemical equation. If no reaction occurs, write "NR" as the product of the reaction.



2. Zinc blende, ZnS, is an important zinc ore. The first step in the commercial refining process is strongly heating the ore in the presence of oxygen according to the following balanced chemical equation: $2 \text{ZnS} (\text{s}) + 3 \text{O}_2 (\text{g}) \rightarrow 2 \text{ZnO} (\text{s}) + 2 \text{SO}_2 (\text{g})$.

a. (8 Points) What volume of $\text{SO}_2 (\text{g})$ forms per liter of $\text{O}_2 (\text{g})$ consumed? Assume both gases are measured at the same temperature and pressure.

Solving $pV = nRT$ for the volume for each gas gives $V_{\text{O}_2} = n_{\text{O}_2} \frac{RT}{p}$ and

$$V_{\text{SO}_2} = n_{\text{SO}_2} \frac{RT}{p}$$

We want the ratio $\frac{V_{\text{SO}_2}}{V_{\text{O}_2}}$, which may be written as $\frac{V_{\text{SO}_2}}{V_{\text{O}_2}} = \frac{n_{\text{SO}_2} \frac{RT}{p}}{n_{\text{O}_2} \frac{RT}{p}} = \frac{n_{\text{SO}_2}}{n_{\text{O}_2}}$.

We know $\frac{n_{\text{SO}_2}}{n_{\text{O}_2}}$ from the stoichiometric coefficients in the balanced chemical

equation ($n_{\text{SO}_2} = 2$ and $n_{\text{O}_2} = 3$). Thus, $\frac{V_{\text{SO}_2}}{V_{\text{O}_2}} = \frac{2}{3} = 0.667$ (to three significant figures).

b. (2 Points) This reaction is a redox reaction with O_2 being the oxidant and ZnS being the reductant.

3. (10 Points) When an electric current is passed through liquid water the following chemical reaction occurs: $2 \text{H}_2\text{O} (\text{l}) \rightarrow 2 \text{H}_2 (\text{g}) + \text{O}_2 (\text{g})$. If current is passed through water so that 1.320 g of the H_2O reacts in this way, the resulting gas mixture occupies a volume of 2.900 L at 30.0°C and a pressure of 748.0 mmHg. From this information determine the vapor pressure of water, in mmHg, at 30.0°C . The molar masses are H_2O 18.015 g/mole, H_2 2.0158 g/mole and O_2 31.998 g/mole.

Note that I had intended to add an extra significant figure to the mass of H_2O , but forgot to mention it in class. It is shown here, so that the significant figures work out nicely.

The total pressure is given by $p_{\text{total}} = p_{\text{H}_2} + p_{\text{O}_2} + p_{\text{H}_2\text{O}}$.

We can determine p_{H_2} and p_{O_2} from the moles of each gas formed by the reaction of 1.32 g H_2O by rearranging the Ideal Gas Law ($pV = nRT$) and solving for the pressure of each gas to give $p_{\text{O}_2} = n_{\text{O}_2} \frac{RT}{V}$ **and** $p_{\text{H}_2} = n_{\text{H}_2} \frac{RT}{V}$

Substituting these expressions into the equation for the total pressure, and recognizing that for every mole of O_2 the reaction gives 2 mole H_2 (i. e., $n_{\text{H}_2} = 2n_{\text{O}_2}$) gives

$$p_{\text{total}} = 2n_{\text{O}_2} \frac{RT}{V} + n_{\text{O}_2} \frac{RT}{V} + p_{\text{H}_2\text{O}} = 3n_{\text{O}_2} \left(\frac{RT}{V} \right) + p_{\text{H}_2\text{O}}$$

Solving for $p_{\text{H}_2\text{O}}$ yields $p_{\text{H}_2\text{O}} = p_{\text{total}} - 3n_{\text{O}_2} \left(\frac{RT}{V} \right)$.

You could have also left it as $p_{\text{total}} = (n_{\text{H}_2} + n_{\text{O}_2}) \frac{RT}{V} + p_{\text{H}_2\text{O}}$.

For convenience, change the units on R to mmHg.

$$0.0820574 \frac{\text{L} \cdot \text{atm}}{\text{K} \cdot \text{mole}} \left(\frac{760 \text{ mmHg}}{1 \text{ atm}} \right) = 62.3636_2 \frac{\text{L} \cdot \text{mmHg}}{\text{K} \cdot \text{mole}}$$

Convert $^\circ\text{C}$ to K : $30.0^\circ\text{C} + 273.15 = 303.15 \text{ K}$.

Determine the moles of O_2 formed.

$$1.320 \text{ g } \text{H}_2\text{O} \left(\frac{1 \text{ mole } \text{H}_2\text{O}}{18.015 \text{ g } \text{H}_2\text{O}} \right) \left(\frac{1 \text{ mole } \text{O}_2}{2 \text{ mole } \text{H}_2\text{O}} \right) = 0.03663_6 \text{ mole } \text{O}_2$$

If you left the expression for p_{total} in terms of moles of H_2 and moles of O_2 , you would also need to determine moles of H_2 as follows

$$1.320 \text{ g } H_2O \left(\frac{1 \text{ mole } H_2O}{18.015 \text{ g } H_2O} \right) \left(\frac{2 \text{ mole } H_2}{2 \text{ mole } H_2O} \right) = 0.07327_2 \text{ mole } H_2$$

Thus,

$$p_{H_2O} = 748.0 \text{ mmHg} - 3 \left(0.03663_6 \text{ mole} \right) \left(\frac{\left(62.3636_2 \frac{\text{L} \cdot \text{mmHg}}{\text{K} \cdot \text{mole}} \right) (303.1_5 \text{ K})}{2.900 \text{ L}} \right)$$

$$p_{H_2O} = 748.0 \text{ mmHg} - 716.5_0 \text{ mmHg} = 31.5 \text{ mmHg}$$

Or

$$p_{H_2O} = p_{total} - (n_{H_2} + n_{O_2}) \frac{RT}{V}$$

$$p_{H_2O} = 748.0 \text{ mmHg} - (0.07327_2 \text{ mole} + 0.03663_6 \text{ mole}) \left(\frac{\left(62.3636_2 \frac{\text{L} \cdot \text{mmHg}}{\text{K} \cdot \text{mole}} \right) (303.1_5 \text{ K})}{2.900 \text{ L}} \right)$$

$$p_{H_2O} = 748.0 \text{ mmHg} - (0.10990_8 \text{ mole}) \left(6519_1 \frac{\text{mmHg}}{\text{mole}} \right)$$

$$p_{H_2O} = 748.0 \text{ mmHg} - 716.5_0 \text{ mmHg} = 31.5 \text{ mmHg}$$

At this temperature, the vapor pressure of water is 31.5 mmHg.

4. (4 Points) What is the change in the internal energy of a system if it absorbs 58 J of heat and does 58 J of work?

Start with the First Law, $\Delta U = q + w$, with $q = +58 \text{ J}$ and $w = -58 \text{ J}$ according to the sign convention discussed in class. Thus, $\Delta U = +58 \text{ J} + -58 \text{ J} = 0$ and there is no change in the system's internal energy for this process.