Reaction Stoichiometry I
Mass-Mole Relationships and Limiting Reactant

1. According to the equation given on the board, what mass of H_2 can be produced by the reaction of 10.0 g of Zn with the hydrochloric acid?

$$Zn_{(s)} + 2\ HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$$

$$m_{H_2} = 10.0\text{ g Zn} \times \frac{1\text{ mol Zn}}{63.59\text{ g Zn}} \times \frac{1\text{ mol H}_2}{1\text{ mol Zn}} \times 2.016\ {}^{\text{g H}_2}\!/_{\text{mol H}_2} = 0.3083\text{ g} = 0.308\text{ g H}_2$$

2. According to the equation of the reaction of H_2 with O_2, what mass of water can be made from the mass of hydrogen from question 1?

$$2\ H_{2(g)} + O_{2(g)} \rightarrow 2\ H_2O_{(g)}$$

$$m_{H_2O} = \frac{0.3083\text{ g H}_2}{2.016\frac{\text{g H}_2}{\text{mol H}_2}} \times \frac{2\text{ mol H}_2\text{O}}{2\text{ mol H}_2} \times 18.015\frac{\text{g H}_2}{\text{mol H}_2} = 2.76\text{ g H}_2\text{O}$$

3. For the equation…

$$AgNO_{3(aq)} + BaCl_{2(aq)} \rightarrow AgCl_{(s)} + Ba(NO_3)_{2(aq)}$$

a) Balance the equation

$$2\ AgNO_{3(aq)} + BaCl_{2(aq)} \rightarrow 2\ AgCl_{(s)} + Ba(NO_3)_{2(aq)}$$

b) How many moles of silver chloride can be produced starting with 2.0 moles of $AgNO_3$? …1.5 moles $BaCl_2$?

$$n_{\text{AgCl from AgNO}_3} = 2.0\text{ mol AgNO}_3 \times \frac{2\text{ mol AgCl}}{2\text{ mol AgNO}_3} = 2.0\text{ mol AgCl}$$

$$n_{\text{AgCl from AgNO}_3} = 1.5\text{ mol BaCl}_2 \times \frac{2\text{ mol AgCl}}{1\text{ mol BaCl}_2} = 3.0\text{ mol AgCl}$$

c) How many mol of AgCl will be produced if 3.00 g of $BaCl_2$ react with a sufficient amount of $AgNO_3$?

$$n_{\text{AgCl}} = 3.00\text{ g BaCl}_2 \times \frac{1\text{ mol BaCl}_2}{208.24\text{ g BaCl}_2} \times \frac{2\text{ mol AgCl}}{1\text{ mol BaCl}_2} = 0.0288\text{ mol AgCl}$$

d. What mass of $BaCl_2$ is necessary to form 5.15 g of AgCl? (show the solution using the mass conservation and the "mole-method".

$$m_{\text{BaCl}_2} = 5.15\text{ g AgCl} \times \frac{1\text{ mol AgCl}}{143.3\text{ g AgCl}} \times \frac{1\text{ mol BaCl}_2}{2\text{ mol AgCl}} \times 208.24\,\tfrac{\text{g BaCl}_2}{\text{mol BaCl}_2} = 3.74\text{ g BaCl}_2$$

4. What mass of water would be formed from the reaction of 5.0 g H_2, and 30.0 g O_2? How much of the excess reagent remains unreacted?

$$2\,H_2(g) + O_2(g) \rightarrow 2\,H_2O(g)$$

$$n_{\text{H}_2\text{O from H}_2} = \left(5.0\text{ g H}_2 \Big/ 2.016\,\tfrac{\text{g H}_2}{\text{mol H}_2} \right) \times \frac{2\text{ mol H}_2\text{O}}{2\text{ mol H}_2} = 2.48\text{ mol H}_2\text{O}$$

$$n_{\text{H}_2\text{O from O}_2} = \left(30.0\text{ g O}_2 \Big/ 32.00\,\tfrac{\text{g O}_2}{\text{mol O}_2} \right) \times \frac{2\text{ mol H}_2\text{O}}{1\text{ mol O}_2} = 1.875\text{ mol H}_2\text{O}$$

O_2 is limiting reactant so it determines the mass of H_2O that can be produced:

$$m_{\text{H}_2\text{O}} = 1.875\text{ mol H}_2\text{O} \times 18.015\,\tfrac{\text{g H}_2\text{O}}{\text{mol H}_2\text{O}} = \boxed{34\text{ g H}_2\text{O}}$$

Determine the mass of H_2 remaining:

$$m_{\text{H}_2\text{ reacted}} = 1.875\text{ mol H}_2\text{O} \times \frac{2\text{ mol H}_2}{2\text{ mol H}_2\text{O}} \times 2.016\,\tfrac{\text{g H}_2}{\text{mol H}_2} = 3.78\text{ g H}_2$$

$$m_{\text{H}_2\text{ remaining}} = 5.0\text{ g H}_2 - 3.78\text{ g H}_2 = \boxed{1.2\text{ g H}_2\text{ remains unreacted}}$$

5. Calculate the mass of iron(III) chloride produced when 1.05 g iron(II) chloride reacts with 1.10 g of potassium permanganate ($KMnO_4$) according the to the equation...

$$5\,FeCl_2 + KMnO_4 + 8\,HCl \rightarrow 5\,FeCl_3 + MnCl_2 + KCl + 4\,H_2O$$

$$M_{\text{FeCl}_2} = 126.75\,\text{g/mol} \quad M_{\text{FeCl}_3} = 162.21\,\text{g/mol} \quad M_{\text{KMnO}_4} = 158.04\,\text{g/mol}$$

$$n_{\text{FeCl}_3\text{ from FeCl}_2} = 1.05\text{ g FeCl}_2 \times \frac{1\text{ mol FeCl}_2}{126.75\text{ g FeCl}_2} \times \frac{1\text{ mol FeCl}_3}{1\text{ mol FeCl}_2} = 8.284\times10^{-3}\text{ mol FeCl}_3$$

$$n_{\text{FeCl}_3\text{ from KMnO}_4} = 1.10\text{ g KMnO}_4 \times \frac{1\text{ mol FeCl}_2}{158.04\text{ g KMnO}_4} \times \frac{5\text{ mol FeCl}_3}{1\text{ mol KMnO}_4} = 3.480\times10^{-2}\text{ mol FeCl}_3$$

$FeCl_2$ is limiting:

$$m_{\text{FeCl}_3} = 8.284\times10^{-3}\text{ mol FeCl}_3 \times 162.21\,\tfrac{\text{g FeCl}_3}{\text{mol FeCl}_3} = \boxed{1.34\text{ g FeCl}_3}$$

Now calculate the mass of $KMnO_4$ remaining.