Session 5: LECTURE OUTLINE (Section H & Sections L.1 & L.2)

I. Writing down the chemical reaction
   a. Reactants
   b. Products
   c. Skeletal equation
   d. Law of conservation of mass
   e. Stoichiometric coefficient
   f. State symbols
   g. Placement of symbol for heat or catalyst over arrow

II. Balancing the chemical reaction
   a. Importance of expressing all components correctly
   b. Balance by inspection

III. Reaction Stoichiometry
   a. mole to mole predictions
   b. mass to mass predictions

suggested problems: pp F60-F61 H.1, H.3, H.7, H.9, H.11
pp F86-F87 L.3, L.5, L.7

CHEMICAL EQUATIONS

1. precisely describe a chemical change
2. symbolize the chemical change using chemical formulae and an arrow
3. symbols on the left are reactants
4. symbols on the right are products
5. based on experimental observation, eg

Methane burns in oxygen to give carbon dioxide and water

Method: a. write down reaction

$CH_4 + O_2 \rightarrow CO_2 + H_2O$

Reactants Products

b. balance equation (Law of Conservation of Mass)

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

1C	1C
4H	4H
4O	4O

More examples:
Mercury(II)oxide decomposes into its elements.

$2HgO(s) \rightarrow 2Hg(l) + O_2(g)$

Iron combines with oxygen to yield iron(III)oxide.

$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$

Solid sodium plus liquid water react to yield hydrogen gas plus a solution of sodium hydroxide and heat.

$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g) + \text{heat}$

The numbers (coefficients) used to balance the elements on each side of the equation can be interpreted as numbers of moles of each of the substances. These are called stoichiometric coefficients and represent the number ratio of element and/or compound across a balanced chemical equation.

Reaction Stoichiometry
Butane burns completely in oxygen to yield carbon dioxide and water.

$$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$$

How many moles of O_2 are required to react completely with 5.6 moles C_4H_{10}?

This question can be answered very easily based on the mole:mole ratios that are inherent in a balanced chemical equation. For example for the above equation 2 moles of C_4H_{10} will react with every 13 moles of O_2. This can also be stated as an equality: 2 mole C_4H_{10} = 13 mole O_2, this equality can be interpreted as a conversion factor or "per expression": 2 moles C_4H_{10} per 13 moles O_2 which can be written in the form of a conversion factor as follows

$$\frac{2 \text{ mole } C_4H_{10}}{13 \text{ mole } O_2} \quad \text{or} \quad \frac{13 \text{ mole } O_2}{2 \text{ mole } C_4H_{10}}$$

Similar expressions can be written for all the reactants and products across a balanced chemical reaction.

We can use this "per expression" as a conversion factor to answer the question.

Given: 5.6 moles C_4H_{10}
Wanted: # moles O_2 needed to react
Conversion: from moles C_4H_{10} to moles O_2
Conversion factor: $\frac{13 \text{ mole } O_2}{2 \text{ mole } C_4H_{10}}$

Solution: $\frac{5.6 \text{ moles } C_4H_{10}}{} \Big| \frac{13 \text{ mole } O_2}{2 \text{ mole } C_4H_{10}} = 36.4 \text{ mole } C_4H_{10}$

Similarly the following can be answered:

How many moles of H_2O are produced when 0.0142 moles of C_4H_{10} burn in excess O_2?

$$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$$

Given: 0.0142 mole C_4H_{10}

Wanted: # moles H_2O produced

Conversion: from moles C_4H_{10} to moles H_2O

Conversion factor: $\dfrac{10 \text{ mole } H_2O}{2 \text{ mole } C_4H_{10}}$

Solution: $\dfrac{0.0142 \text{ mole } C_4H_{10} \mid 10 \text{ mole } H_2O}{\mid 2 \text{ mole } C_4H_{10}}$ = 0.071 mole H_2O

Using our knowledge of the relationship between mass and number of atoms or compounds, that is molar mass, we can also very easily expand our understanding of reaction stoichiometry to include gram to gram conversions:

For example we can answer the following:

How many grams of butane are required to react completely with 47.2 g O_2?

$$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$$

Given: 47.2 g O_2
Wanted: # grams of C_4H_{10} needed to react completely
Conversion: g O_2 to moles O_2 to moles C_4H_{10} to grams C_4H_{10}

Conversion factors: $\frac{16 \text{ g } O_2}{1 \text{ mole } O_2}$ $\frac{2 \text{ mole } C_4H_{10}}{13 \text{ mole } O_2}$ $\frac{58 \text{ g } C_4H_{10}}{1 \text{ mole } C_4H_{10}}$

Solution:

$$\frac{47.2 \text{ g } O_2}{} \left| \frac{1 \text{ mole } O_2}{16 \text{ g } O_2} \right| \frac{2 \text{ mole } C_4H_{10}}{13 \text{ mole } O_2} \left| \frac{58 \text{ g } C_4H_{10}}{1 \text{ mole } C_4H_{10}} \right. = 13.2 \text{ g } O_2$$