Ch. 9.1-9.3 Lecture Guide

H. Chemistry

9.1

- **Review:**
  - Atoms are neither created nor destroyed in a chemical reaction, they are only rearranged.
  - A balanced equation has the same number of each type of atom on both sides of a chemical equation.

Ex) Information Conveyed by a Balanced Equation for the Production of Methanol

CO (g)	+	$2H_2$ (g)	→	CH_3OH (l)
* 1 molecule CO	+	2 molecules H_2	→	1 molecule CH_3OH
* 6.022×10^{23} CO molecules	+	$2(6.022 \times 10^{23})$ H_2 molecules	→	6.022×10^{23} CH_3OH molecules
* 1 mol CO	+	2 mol H_2	→	1 mol CH_3OH

9.2

- **Mole-Mole Relationships**
  - We can use a balanced chemical equation to predict the moles of products that a given number of moles of reactants will yield.
    - Ex) The following chemical reaction is the decomposition of 2 moles of water:
      - $2H_2O$ (l) → $2H_2$ (g) + O_2 (g)
      - 2 moles of water → 2 moles of hydrogen gas + 1 mole of oxygen gas
  - **Question:** How many moles of hydrogen and oxygen gas would be produced from 4 moles of water?
    - Step 1: Multiply the entire equation by 2 to get 4 moles of water.

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

$$4H_2O(l) \rightarrow \underline{4}H_2(g) + \underline{2}O_2(g)$$

Answer: 4 moles H_2 + 2 moles O_2

- **Question:** How many moles of hydrogen and oxygen gas would be produced from 5.8 moles of water?
  - Step 1: Divide the entire equation by 2 to get a 1 in front of water.

$$\left(2\,H_2O\,(l) \longrightarrow 2\,H_2\,(g) + O_2\,(g)\right) / 2$$

$$H_2O\,(l) \rightarrow H_2\,(g) + \tfrac{1}{2}\,O_2\,(g)$$

  - Step 2: Multiply the entire equation by 5.8 to 5.8 moles of water.

$$5.8\left(H_2O\,(l) \longrightarrow H_2\,(g) + 1/2\,O_2\,(g)\right)$$

$$5.8\,H_2O\,(l) \longrightarrow \underline{5.8\,H_2}\,(g) + \underline{2.9\,O_2}\,(g)$$

- **Mole Ratios** Answer: 5.8 moles H_2 + 2.9 moles O_2
  - Ex) Methane burns in oxygen to form carbon dioxide and water according to the balanced equation: CH_4 (g) + $2O_2$ (g) → CO_2 (g) + 2 H_2O (g). What number of moles of oxygen gas is required to react with 7.4 moles of methane?
    - Step 1: Create a conversion factor (mole ratio) using the original balanced chemical equation.

1 mole CH_4 requires ⇒ 2 mole O_2

$$\frac{1\text{ mole } CH_4}{2\text{ mole } O_2} \quad \text{or} \quad \frac{2\text{ mole } O_2}{1\text{ mole } CH_4}$$

    - Step 2: Convert from moles of methane to moles of oxygen.

$$7.4\text{ moles } CH_4 \times \frac{2\text{ moles } O_2}{1\text{ mole } CH_4} = \boxed{14.8\text{ moles } O_2}$$

9.3

- **Mass Calculations**
  - In chemistry, we count by weighing. We know that 2 moles of oxygen atoms weighs approximately 32.00 grams. So how can we determine the amount of one chemical necessary to react with another chemical **in grams?**
  - Ex) For the balanced chemical equation: 2Al (s) + $3I_2$ (s) → $2AlI_3$ (s), what mass of I_2 is necessary to react exactly with 35.0 g of aluminum?
    - Step 1: Set up a mole ratio of Al to I_2 using the original balanced chemical equation.

2 mol Al requires ⇒ 3 mol I_2

$$\frac{2\text{ mol Al}}{3\text{ mol } I_2} \quad \text{or} \quad \frac{3\text{ mol } I_2}{2\text{ mol Al}}$$

- Step 2: Therefore:
  - Moles of Al present x $\frac{3 \text{ mol } I_2}{2 \text{ mol Al}}$ = Moles of I_2 required

- Step 3: Calculate the number of moles of Al present.

$$35.0 \text{ g Al} \times \frac{1 \text{ mol Al}}{26.98 \text{ g Al}} = 1.30 \text{ mol Al}$$

- Step 4: Calculate the number of moles of I_2 required.

$$1.30 \text{ mol Al} \times \frac{3 \text{ mol } I_2}{2 \text{ mol Al}} = 1.95 \text{ mol } I_2$$

Molar mass of I_2
[2 x 126.9 g/mol]

- Step 5 Calculate the number of grams of I_2 required.

$$1.95 \text{ mol } I_2 \times \frac{253.8 \text{ g } I_2}{1 \text{ mol } I_2} = \boxed{495 \text{ g } I_2}$$

> This process of using a chemical equation to calculate the relative masses of reactants and products involved in a reaction is called **stoichiometry**.

- Ex) Propane, C_3H_8, when used in fuel, reacts with oxygen to produce carbon dioxide and water according to the following unbalanced equation:

$$C_3H_8\,(g) + O_2\,(g) \rightarrow CO_2\,(g) + H_2O\,(g)$$

What mass of carbon dioxide is produced when 96.1 g of propane reacts with sufficient oxygen?

- Step 1: Balance the chemical equation.

$$C_3H_8\,(g) + \underline{5}\,O_2\,(g) \rightarrow \underline{3}\,CO_2\,(g) + \underline{4}\,H_2O\,(g)$$

- Step 2: Set up a mole ratio of C_3H_8 to CO_2 using the balanced equation.

$$\frac{1 \text{ mole } C_3H_8}{3 \text{ mole } CO_2} \quad \text{OR} \quad \frac{3 \text{ mole } CO_2}{1 \text{ mole } C_3H_8}$$

- Step 3: Therefore:

$$\text{Moles } C_3H_8 \text{ present} \times \frac{3 \text{ mole } CO_2}{1 \text{ mole } C_3H_8} = \text{Moles } CO_2 \text{ produced}$$

$3(12.01)$
$+8(1.008)$
$44.09\ g/mol$

- Step 4: Calculate the number of moles of C_3H_8.

$$96.1\ g\ C_3H_8 \times \frac{1\ mole\ C_3H_8}{44.09\ g\ C_3H_8} = 2.18\ mol\ C_3H_8$$

- Step 5: Calculate the number of moles of CO_2 produced.

$$2.18\ mol\ C_3H_8 \times \frac{3\ mol\ CO_2}{1\ mol\ C_3H_8} = 6.54\ mol\ CO_2$$

12.01
$+2(16.00)$
$44.01\ g/mol$

- Step 6: Calculate the number of grams of CO_2 produced.

$$6.54\ mol\ CO_2 \times \frac{44.01\ g}{1\ mol\ CO_2} = \boxed{288\ g\ CO_2}$$

- Calculate the mass of water formed by the complete reaction of 48.05 g of C_3H_8.

$$48.05\ g\ C_3H_8 \times \frac{1\ mol\ C_3H_8}{44.09\ g\ C_3H_8} \times \frac{4\ mol\ H_2O}{1\ mol\ C_3H_8} \times \frac{18.02\ g\ H_2O}{1\ mol\ H_2O}$$

$$= \boxed{78.55\ g\ H_2O}$$

$2(1.008)$
$+16.00$
$18.02\ g/mol$

- **Comparing Two Reactions**
  - Ex) Baking soda, $NaHCO_3$, is often used as an antacid. The balanced equation for this reaction is: $NaHCO_3\ (s) + HCl\ (aq) \rightarrow NaCl\ (aq) + H_2O\ (l) + CO_2\ (g)$. Milk of magnesia, $Mg(OH)_2$, is also used as an antacid. The balanced equation for this reaction is: $Mg(OH)_2 + 2HCl\ (aq) \rightarrow 2H_2O\ (l) + MgCl_2\ (aq)$. Which antacid can consume the most stomach acid, 1.00 g of $NaHCO_3$ or 1.00 g of $Mg(OH)_2$?
    - Step 1: Calculate the molar mass of $NaHCO_3$.

22.99
$+1.008$
$+12.01$
$+3(16.00)$
$= 84.01\ g/mol\ NaHCO_3$

- Step 2: Determine the moles of $NaHCO_3$

$$1.00\,g\ NaHCO_3 \times \frac{1\ mol\ NaHCO_3}{84.01\ g\ NaHCO_3} = 1.19 \times 10^{-2}\ mol\ NaHC$$

- Step 3: Determine the moles of HCl neutralized by $NaHCO_3$ using mole ratio.

$$1.19 \times 10^{-2}\ mol\ NaHCO_3 \times \frac{1\ mol\ HCl}{1\ mol\ NaHCO_3} = 1.19 \times 10^{-2}\ mol\ HCl$$

- Step 4: Calculate the molar mass of $Mg(OH)_2$.

$$\begin{array}{l} 24.31 \\ + 2(16.00) \\ + 2(1.008) \end{array} = 58.33\,g/mol\ Mg(OH)_2$$

- Step 5: Determine the moles of $Mg(OH)_2$.

$$1.00\,g\ Mg(OH)_2 \times \frac{1\ mol\ Mg(OH)_2}{58.33\ g\ Mg(OH)_2} = 1.17 \times 10^{-2}\ mol\ Mg(OH)_2$$

- Step 6: Determine the moles of HCl neutralized by $Mg(OH)_2$ using mole ratio.

$$1.17 \times 10^{-2}\ mol\ Mg(OH)_2 \times \frac{2\ mol\ HCl}{1\ mol\ Mg(OH)_2} = 3.42 \times 10^{-2}\ mol\ HCl$$

- Which antacid neutralizes more HCl?

1.00g $\boxed{Mg(OH)_2}$ neutralizes more HCl.

➢ Homework: Pg. 269-270, q. 12, 16, 30, 32