

Ch. 9.1-9.3 Lecture Guide

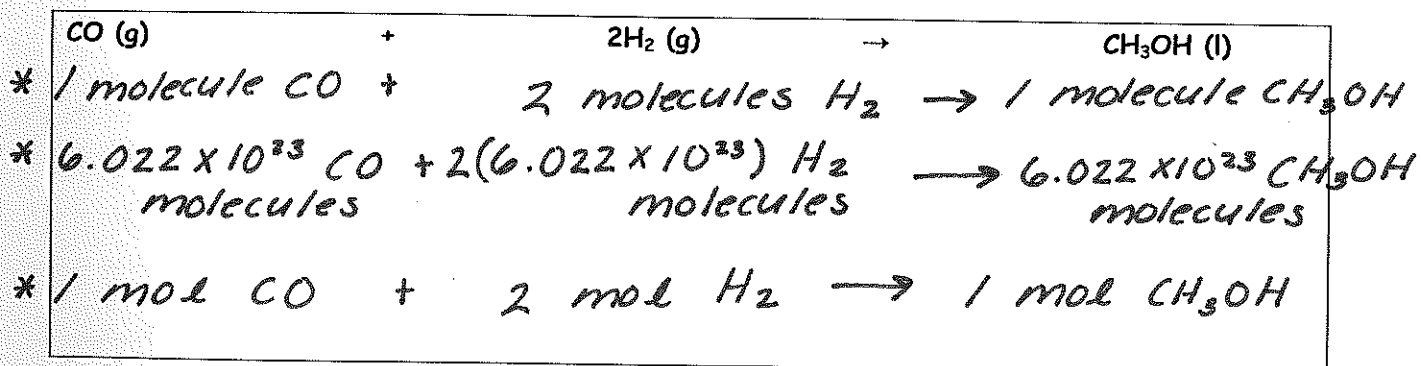
H. Chemistry

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.

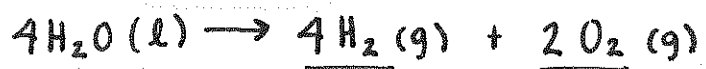
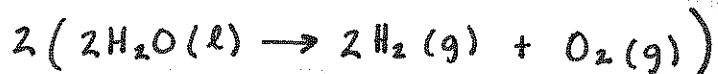
Ex) Information Conveyed by a Balanced Equation for the Production of Methanol



9.2

> Mole-Mole Relationships

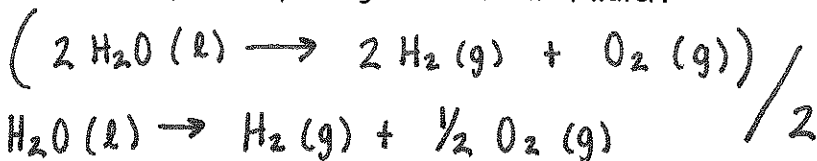
- We can use a balanced chemical equation to predict the moles of products that a given number of moles of reactants will yield.
 - Ex) The following chemical reaction is the decomposition of 2 moles of water:
 - $2\text{H}_2\text{O}(\text{l}) \rightarrow 2\text{H}_2(\text{g}) + \text{O}_2(\text{g})$
 - 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.



Answer: 4 moles H₂ + 2 moles O₂

- 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.



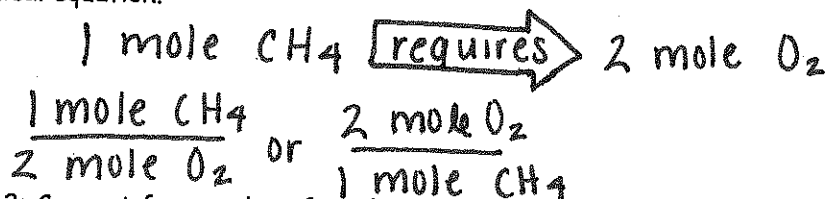
- Step 2: Multiply the entire equation by 5.8 to 5.8 moles of water.



> 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: $\text{CH}_4 (\text{g}) + 2\text{O}_2 (\text{g}) \rightarrow \text{CO}_2 (\text{g}) + 2 \text{H}_2\text{O} (\text{g})$. 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.



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

$$7.4 \text{ moles CH}_4 \times \frac{2 \text{ moles O}_2}{1 \text{ mole CH}_4} = \boxed{14.8 \text{ moles O}_2}$$

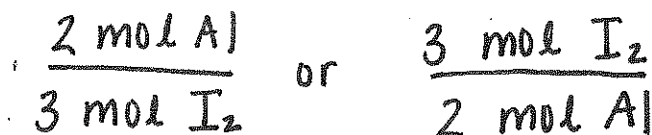
9.3

> 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: $2\text{Al} (\text{s}) + 3\text{I}_2 (\text{s}) \rightarrow 2\text{AlI}_3 (\text{s})$, 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.



- Step 2: Therefore:

- Moles of Al present $\times \frac{3 \text{ mol I}_2}{2 \text{ mol Al}} = \text{Moles of I}_2 \text{ required}$

- 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 I₂ 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 I₂

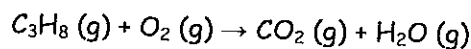
$$[2 \times 126.9 \text{ g/mol}]$$

- Step 5 Calculate the number of grams of I₂ 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.

- o Ex) Propane, C₃H₈, when used in fuel, reacts with oxygen to produce carbon dioxide and water according to the following unbalanced equation:



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

- Step 1: Balance the chemical equation.



- Step 2: Set up a mole ratio of C₃H₈ to CO₂ using the balanced equation.

$$\frac{1 \text{ mole C}_3\text{H}_8}{3 \text{ mole CO}_2} \quad \text{OR} \quad \frac{3 \text{ mole CO}_2}{1 \text{ mole C}_3\text{H}_8}$$

- Step 3: Therefore:

$$\text{Moles C}_3\text{H}_8 \text{ present} \times \frac{3 \text{ mole CO}_2}{1 \text{ mole C}_3\text{H}_8} = \text{Moles CO}_2 \text{ produced}$$

$$\begin{array}{r} 3(12.01) \\ + 8(1.008) \\ \hline 44.09 \text{ g/mol} \end{array}$$

Step 4: Calculate the number of moles of C_3H_8 .

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

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

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

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

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

$$\begin{array}{r} 12.01 \\ + 2(16.00) \\ \hline \end{array}$$

$$44.01 \text{ g/mol}$$

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

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

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

$$\begin{array}{r} 2(1.008) \\ + 16.00 \\ \hline 18.02 \text{ g/mol} \end{array}$$

> 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 $NaHCO_3$.

$$\begin{array}{r} 22.99 \\ + 1.008 \\ + 12.01 \\ + 3(16.00) \\ \hline = 84.01 \text{ g/mol } NaHCO_3 \end{array}$$

- Step 2: Determine the moles of NaHCO_3

$$1.00\text{g } \cancel{\text{NaHCO}_3} \times \frac{1 \text{ mol } \text{NaHCO}_3}{84.01 \text{ g } \cancel{\text{NaHCO}_3}} = 1.19 \times 10^{-2} \text{ mol NaHCO}_3$$

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

$$1.19 \times 10^{-2} \text{ mol } \cancel{\text{NaHCO}_3} \times \frac{1 \text{ mol HCl}}{1 \text{ mol } \cancel{\text{NaHCO}_3}} = 1.19 \times 10^{-2} \text{ mol HCl}$$

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

$$\begin{aligned} & 24.31 \\ & + 2(16.00) \\ & + 2(1.008) \\ & = 58.33 \text{ g/mol } \text{Mg}(\text{OH})_2 \end{aligned}$$

- Step 5: Determine the moles of $\text{Mg}(\text{OH})_2$.

$$1.00\text{g } \cancel{\text{Mg}(\text{OH})_2} \times \frac{1 \text{ mol } \text{Mg}(\text{OH})_2}{58.33 \text{ g } \cancel{\text{Mg}(\text{OH})_2}} = 1.71 \times 10^{-2} \text{ mol } \text{Mg}(\text{OH})_2$$

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

$$1.71 \times 10^{-2} \text{ mol } \cancel{\text{Mg}(\text{OH})_2} \times \frac{2 \text{ mol HCl}}{1 \text{ mol } \cancel{\text{Mg}(\text{OH})_2}} = 3.42 \times 10^{-2} \text{ mol HCl}$$

- Which antacid neutralizes more HCl?

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

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