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Unit 10: Stoichiometry

Stoichiometry= the process of using a ____ to determine the relative amounts of reactants and products involved in a reaction.

Info given by a chemical equation:

- Chemical changes involve the __________________________________of atom groupings as one or more substances change to new substances
- Reactants vs. products

What info are we given by the following equation?

- The ____ can be used to describe the reaction
- The coefficients can have units of _______________________ or ___________________

$CO_{(g)}$	+	$2H_{2\,(g)}$	→	$CH_3OH_{(l)}$
1 Molecule CO	+			
6.02×10^{23} CO molecules	+			
1 mol CO molecules	+			

Balancing Equations- first step in all stoichiometry problems is to balance the equation.

Balance the following equation:

______$C_3H_{8\,(g)}$ + _____$O_{2\,(g)}$ → _____ $CO_{2\,(g)}$ + _____$H_2O_{(g)}$

Mole Ratio= the ratio of moles of one substance to moles of another substance in a balanced chemical equation. Mole ratios are determined from the coefficients in a balanced chemical equation. Mole ratios are used as conversion factors in stoichiometry.

Ex: 2Na + Cl_2 → 2NaCl

Mole ratio of sodium to chlorine gas= _____________________________________

Mole ratio of sodium to sodium chloride= __________________________________

Mole ratio of chlorine to sodium chloride= _________________________________

Why is a BALANCED chemical equation important?

Mole to Mole relationships

- We can used a _________________________________ chemical equation to predict the moles of products that a given number of moles of reactant will yield, or moles of reactant needed for a certain amount of product
- ________________________ are used instead of _____________________ because each element/compound has a different mass
- A balanced equation is needed to make a ______________________________ comparison.

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- The ________________________________ in a balanced equation will give us the mole to mole ratio
- ____ are used as conversion factors
- Ex. 1: In a synthesis reaction between nitrogen and hydrogen gas, how many moles of hydrogen is needed to make 4.0 moles of ammonia?
  - Balanced chemical reaction:
  - Mole ratio:
- Ex. 2: In a synthesis reaction between nitrogen gas and hydrogen gas, how many moles of nitrogen are needed to react with 6.0 moles of hydrogen gas?
- Ex. 3: For a synthesis reaction between hydrogen and oxygen to make water answer the following:

  A) How many moles of H_2O are produced when 5.00 moles of oxygen are used?

  B) If 3.00 moles of H_2O are produced, how many moles of oxygen are needed?

  C) How many moles of hydrogen gas are needed to produce 4 moles of water?

Mass to Mass Conversions:

- Moles represent number of molecules and we cannot count molecules directly
- In chemistry we count by _________________________________
- Steps to follow when given a mass of substance A and wanting mass of substance B

  Step 1:

  Step 2:

  Step 3:

  Step 4:

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- When solving these problems:
  - ALWAYS start with a balanced chemical equation
  - Determine molar masses needed
  - Determine mole ratio
  - Use a T chart, starting with given
- Ex. 4: Oxygen gas can be produced by decomposing potassium chlorate (potassium chloride is also produced). If 138.6 g of $KClO_3$ is heated and decomposes completely, what mass of oxygen gas is produced?

- Ex. 5: A chemical reaction between diboron hexahydride and oxygen gas will produce Oxoborinic acid (HBO_2)and water. A.) What mass of O_2 will be needed to burn 36.1g of diboron hexahydride? B.) How many grams of water are produced from 19.2 g of B_2H_6?

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<u>Limiting Reactants</u>

- S'mores: A Non-Chemistry Example
  - What is the "formula" for making s'mores?

  - How many s'mores could I make if I had 8 gram crackers?
  - How many s'mores could I make if I had 8 marshmallows?
  - How many s'mores could I make if I had 8 chocolate squares?
  - If I have 8 gram crackers, 8 marshmallows, and 8 chocolate squares, how many s'mores could I make?
  - Which ingredient limits the amount of s'mores that can be made?
  - Which ingredients are excess (left over?)? How much excess of those ingredients would you have?
- <u>Limiting Reactant</u>: is the reactant which limits how much the product is produced (also called limiting reagent).
  - The limiting reactant ________________________________and ____________________ is left over.
  - The Limiting Reactant _____________ or ______________ the reaction after it is entirely consumed.
- <u>Excess Reactant:</u> does not limit or stop a reaction from occurring (also called limiting reagent)
  - There will be an ______________________ or _________________ of this reactant.
- Steps to determine the Limiting Reactant:
  - Step 1:

  - Step 2:

- Ex. 9: Aluminum reacts with chlorine to form aluminum chloride: **$2Al + 3Cl_2$ ---> $2AlCl_3$**
  If you have 34.0 g of Al and 39.0 g of Cl_2, what is the limiting reactant? What is the excess reactant?

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- Ex. 10: When 3.22 moles of Al reacts with 4.96 moles of HBr, how many moles of H_2 are formed, considering the reaction below? What is the limiting reactant? What is the excess reactant? **$2\ Al + 6\ HBr \rightarrow 2\ AlBr_3 + 3\ H_2$**

- Ex. 11: Example 11: How many grams of aluminum sulfate are produced if 23.33 g Al reacts with 74.44 g $CuSO_4$? What reactant limits the reaction? Which reactant will not be completely used up? **$Al_{(s)} + CuSO_{4\,(aq)} \rightarrow Al_2(SO_4)_{3\,(aq)} + Cu_{(s)}$**

<u>Percent Yield:</u>

- Theoretical Yield:

- Actual Yield:

- Percent Yield:

- Ex. 12: What is the % yield of H_2O if 138 g H_2O is produced from 16 g H_2 and excess O_2?

- Ex. 13: What is the % yield of NH_3 if 40.5 g NH_3 is produced from 20.0 mol H_2 and excess N_2?

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- Ex. 14 Putting it all together: What is the % yield of H_2O if 58 g H_2O are produced by combining 60 g O_2 and 7.0 g H_2? Hint: determine limiting reagent first

- Ex. 15: The electrolysis of water forms H_2 and O_2. What is the % yield of O_2 if 12.3 g of O_2 is produced from the decomposition of 14.0 g H_2O?

- Ex. 16: 107 g of oxygen is produced by heating 300 grams of potassium chlorate. Calculate % yield. $2KClO_3 \rightarrow 2KCl + 3O_2$

- Example 17: What is the % yield of ferrous sulfide if 3.00 moles of Fe reacts with excess sulfur to produce 220 grams of ferrous sulfide? $Fe + S \rightarrow FeS$