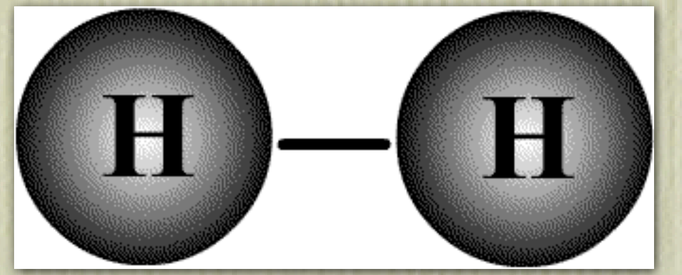
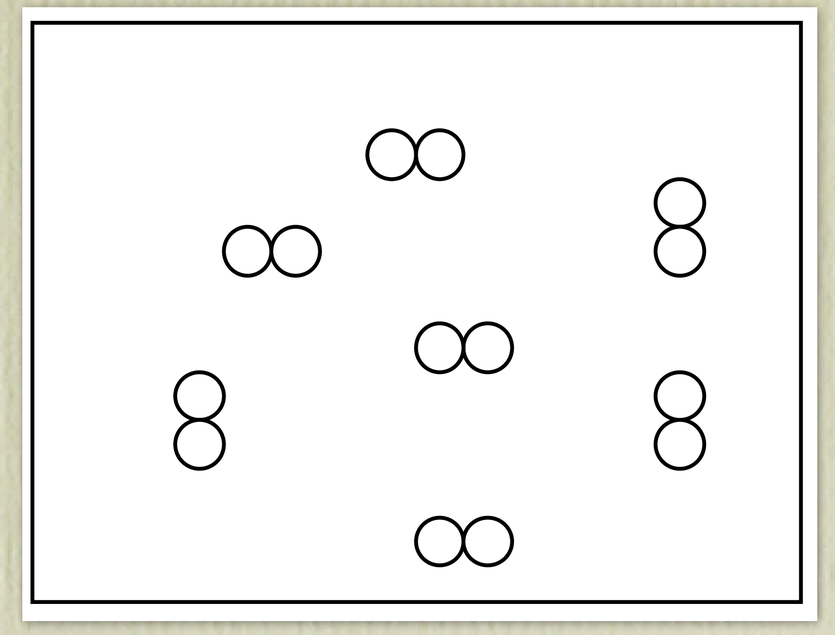
Moles & Stoichiometry

Advanced Topic for Unit 3

Molecules vs. Moles

Hydrogen gas:





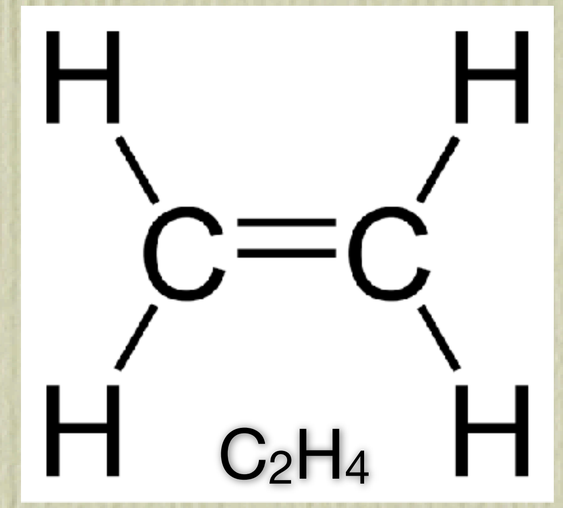
1. How many hydrogen atoms? 14
2. How many hydrogen molecules? 7
3. How many molecules of hydrogen in 1 mole? 6.022×10^{23}
4. How many hydrogen atoms in 1 mole? 12.044×10^{23}

Determining Empirical Formula

Example: A compound formed in the lab is 47% Lithium and 53% Oxygen. What is its empirical formula?

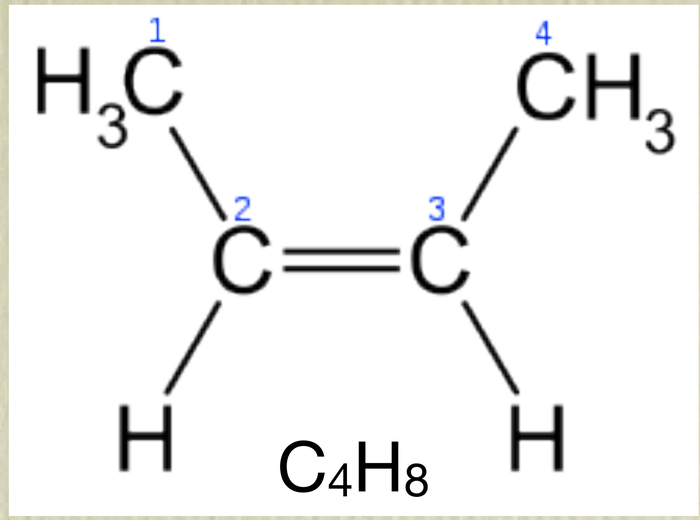
1. Assume a 100 g sample. (Easier math!)
2. Convert grams to moles.
3. Divide mole answers by whichever number is smallest. (Yields the empirical formula.)

Determining Molecular Formula

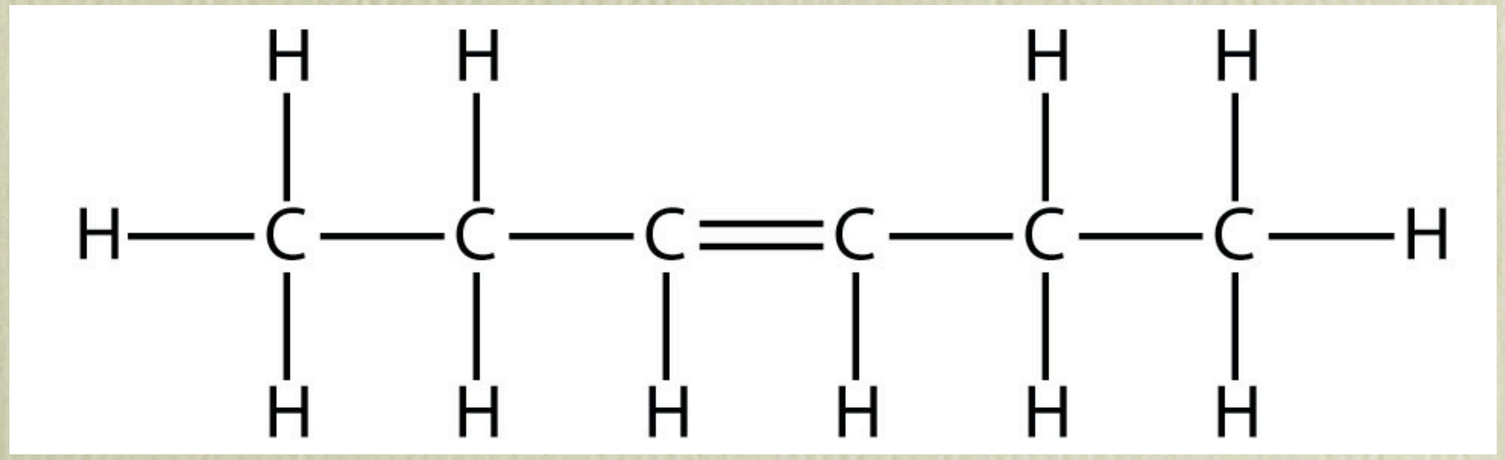


C_2H_4

CH_2



C_4H_8



C_6H_{12}

Determining Molecular Formula

Example: A compound composed of 75% carbon and 25% hydrogen and has a molecular mass of 32 g/mol. Determine its molecular formula.

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1. Assume a 100 g sample. (Easier math!)
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3. Divide mole answers by whichever number is smallest. (Yields the empirical formula.)
4. Determine the molecular mass of the empirical formula.
   - Determine ‘multiplier’ to get molecular mass.
   - Multiply this number by each atom of the empirical formula.

Multi-Step Dimensional Analysis

Gram to Gram Conversions

Use the 'mole-to-mole' ratio as a bridge to convert.

$$2\ NaOH + H_2SO_4 \rightarrow 2\ H_2O + Na_2SO_4$$

How many grams of sodium sulfate will be formed if you start with 200 grams of sodium hydroxide and you have an excess of sulfuric acid?

Molar Volume Calculations (Gases Only)

1 mole = 22.7 Liters

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

How many liters of hydrogen will be needed to make 350 liters of water vapor?

Molar Volume Calculations (Gases Only)

1 mole = 22.7 Liters

$$2Cu_{(s)} + O_{2(g)} \rightarrow 2CuO_{(s)}$$

How many grams of Copper (II) oxide will be formed from 10 liters of oxygen gas?

Particle Calculations - Avogadro

1 mole = 6.022 x 10^{23} particles. *(not atoms)*

$$H_2SO_4 + 2NaOH \rightarrow 2H_2O + Na_2SO_4$$

How many water molecules will be formed from the reaction of 250 grams of NaOH?

How many moles of hydrogen atoms is that?

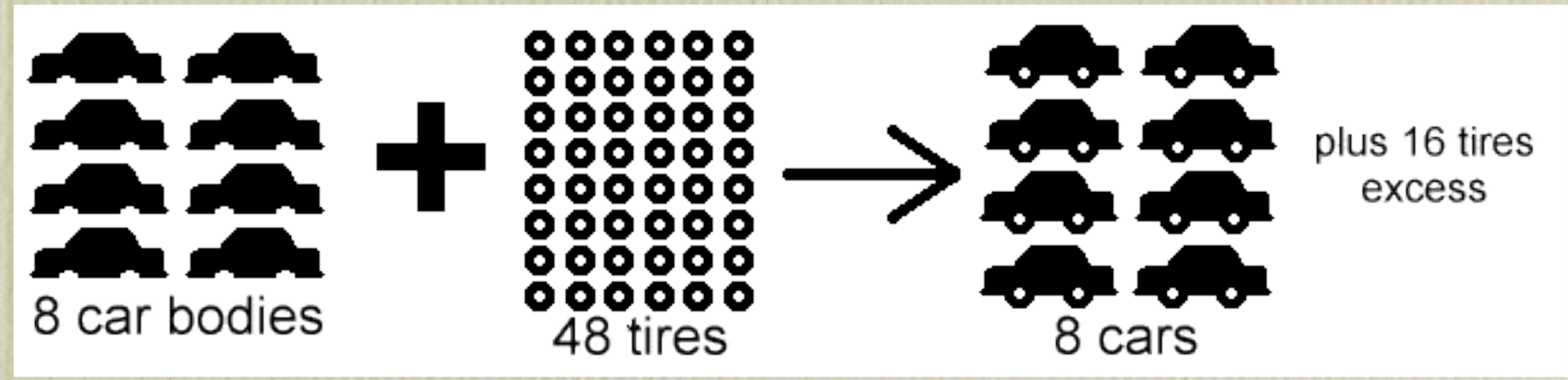
Putting it All Together

1. A 5.0 g sample of CO_2 is in a container at STP. What volume is the container?

2. How many grams of CH_4 are there in 1.5×10^{25} molecules of CH_4?

3. Look on *Table I* for the equation for the formation of ammonia gas. What volume of NH_3 at STP is produced if 25.0 g of H_2 is reacted with an excess of N_2?

Limiting Reagent & Theoretical Yield



This analogy can be extended to Chemistry!!

Sample LR Calculation

A 2.00 g sample of ammonia is mixed with 4.00 g of oxygen. Which is the limiting reactant and how much excess reactant remains after the reaction has stopped?

1. Create a balanced equation for the reaction:

   $$\_\_\ NH_{3(g)} + \_\_\ O_{2(g)} \rightarrow \_\_ N_{2(g)} + \_\_ H_2O_{(g)}$$

2. Use stoichiometry to calculate how much one product would be produced by **each** reactant. *(NOTE: It does not matter which product you choose for your calculations, but the same product must be used for both reactants so that the amounts can be compared.)*
3. Math to follow ...

Sample LR Calculation

If 15 grams of copper (II) chloride react with 20 grams of sodium nitrate, how much sodium chloride can be formed?

$$\_\_\_\ CuCl_2 + \_\_\_\ NaNO_3 \rightarrow \_\_\_\ Cu(NO_3)_2 + \_\_\_\ NaCl$$

What is the limiting reagent for the reaction?

How much of the non-limiting reagent is left over (excess) in this reaction?

Percent Yield

Error in experiments result in less product obtained than we originally calculated. The amount we get is the Percent Yield.

Percent = (Part / Whole) x 100

% Yield = amount you got / amount you should have gotten x 100

If 11.3 grams of sodium chloride are formed in the reaction, what is the percent yield of this reaction?

Vocabulary & Constants

Relative Atomic Mass (A_r) = the weighted mean of all naturally occurring isotopes of an element. We call this the Atomic Mass; the decimal number on the periodic table of elements.

Avogadro's Constant (N_A or L) = 6.022×10^{23}

Molar Mass (M) = mass of one mole of a substance. The units are **g mol^{-1}.** We report it as g/mol.

Relative Molecular Mass (M_r) = mass of one molecule (molecular and covalent compounds)

Relative Formula Mass: This is similar to M_r except it's the mass of one FORMULA UNIT for ionic compounds.

Limiting Reagent (Reactant): The reactant in a chemical reaction that limits the amount of product that can be formed. The reaction will stop when all of the limiting reagent is consumed (used up).

Excess Reagent (Reactant): The reactant in a chemical reaction that remains when a reaction stops after the limiting reagent is completely consumed. The excess reactant remains because there is nothing with which it can react.