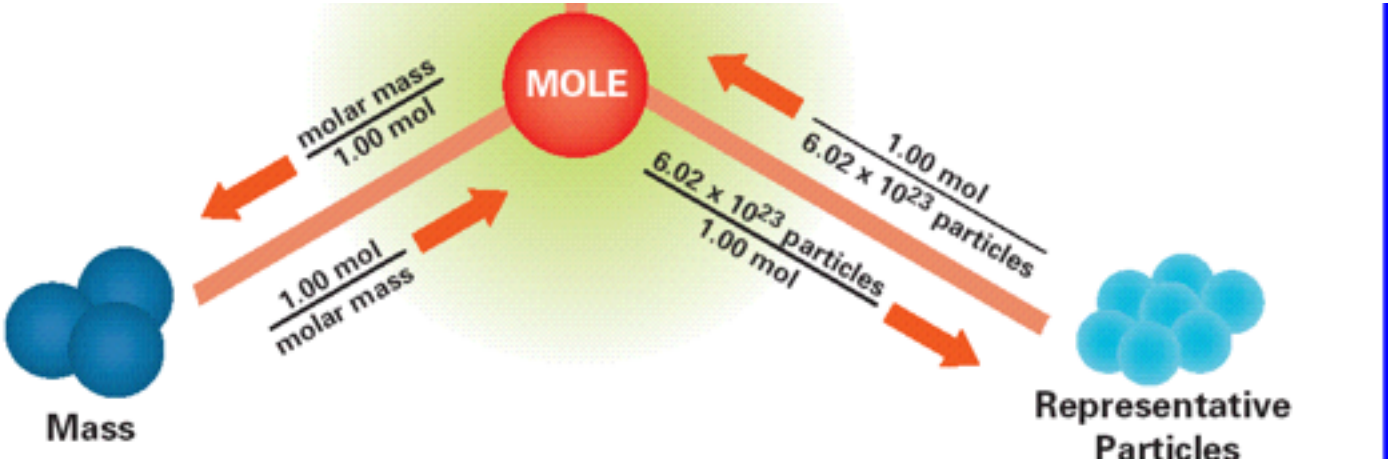
Mass –Moles-Particle

- Particles can be atoms, molecules, ions, etc.
- In one mole of particles, there are 6.02×10^{23} particles
- These particles are so small and we need so many of them to be on a human scale, we must weigh them!

Molar Map



- g A to mole A **or** mole A to g A : use molar mass
- Mole A to particles A or particles A to mole A : use 6.02×10^{23}
- Remember : particles can be molecules, ions, atoms, etc.

How many molecules are in 0.25 moles of CH_4?

How many grams are 5.36×10^{35} formula units of NaCl?

Chocolate Chip Cookies!!

1 cup butter
1/2 cup white sugar
1 cup packed brown sugar
1 teaspoon vanilla extract
2 eggs
2 1/2 cups all-purpose flour
1 teaspoon baking soda
1 teaspoon salt
2 cups semisweet chocolate chips
Makes 3 dozen

How many eggs are needed to make 3 dozen cookies?

How much butter is needed for the amount of chocolate chips used?

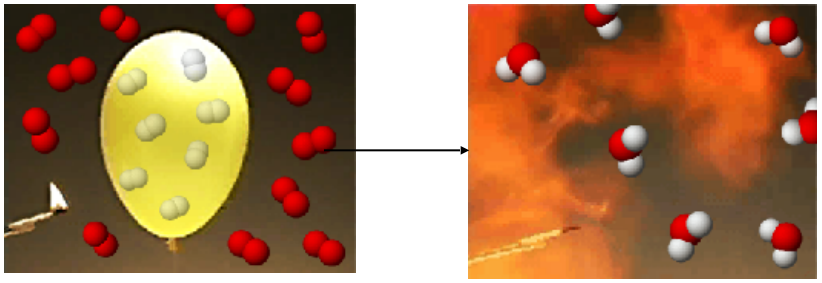
How many eggs would we need to make 9 dozen cookies?

How much brown sugar would I need if I had 1 ½ cups white sugar?

Chemistry Recipes

- Looking at a reaction tells us how much of something you need to react with something else to get a product (like the cookie recipe)
- Be sure you have a balanced reaction before you start!
  - Example: $2\ Na + Cl_2 \rightarrow 2\ NaCl$
  - This reaction tells us that by mixing 2 moles of sodium with 1 mole of chlorine we will get 2 moles of sodium chloride
  - What if we wanted 4 moles of NaCl? 10 moles? 50 moles?

Practice



- Write the balanced reaction for hydrogen gas reacting with oxygen gas.

$$2\ H_2 + O_2 \rightarrow \quad 2\ H_2O$$

  - How many moles of reactants are needed?
  - What if we wanted 4 moles of water?
  - What if we had 3 moles of oxygen, how much hydrogen would we need to react, and how much water would we get?
  - What if we had 50 moles of hydrogen, how much oxygen would we need, and how much water produced?

Mole Ratios

- These mole ratios can be used to calculate the moles of one chemical from the given amount of a different chemical
- Example: How many moles of chlorine are needed to react with 5 moles of sodium (without any sodium left over)?

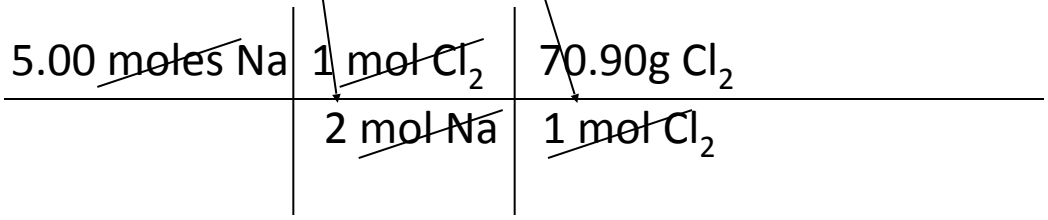
$$2\ Na + Cl_2 \rightarrow 2\ NaCl$$

$$\frac{5\ \text{moles Na} \times 1\ \text{mol } Cl_2}{2\ \text{mol Na}} = 2.5\ \text{moles } Cl_2$$

Mole-Mass Conversions

- Most of the time in chemistry, the amounts are given in grams instead of moles
- We still go through moles and use the mole ratio, but now we also use molar mass to get to grams
    - Example: How many grams of chlorine are required to react completely with 5.00 moles of sodium to produce sodium chloride?

$$2\ Na + Cl_2 \rightarrow 2\ NaCl$$



= 177g Cl_2

Practice

- Calculate the mass in grams of Iodine required to react completely with 0.50 moles of aluminum.
- $I_2 + Al \rightarrow AlI_3$ (unbalanced)

Mass-Mole

- We can also start with mass and convert to moles of product or another reactant
- We use molar mass and the mole ratio to get to moles of the compound of interest
  - Calculate the number of moles of ethane (C_2H_6) needed to produce 10.0 g of water
  - $2\ C_2H_6 + 7\ O_2 \rightarrow 4\ CO_2 + 6\ H_20$

$$\frac{10.0\text{ g } H_2O}{} \left| \frac{1\text{ mol } H_2O}{18.0\text{ g } H_2O} \right| \frac{2\text{ mol } C_2H_6}{6\text{ mol } H_20} = 0.185\text{ mol } C_2H_6$$

Mass-Mass Conversions

- Most often we are given a starting mass and want to find out the mass of a product we will get (called theoretical yield) or how much of another reactant we need to completely react with it (no leftover ingredients!)
- Now we must go from grams to moles, mole ratio, and back to grams of compound we are interested in

Mass-Mass Conversion

- Ex. Calculate how many grams of ammonia are produced when you react 2.00g of nitrogen with excess hydrogen.
- $N_2 + 3\ H_2 \rightarrow 2\ NH_3$

$$2.00\text{g } N_2 \left| \frac{1\text{ mol } N_2}{28.02\text{g } N_2} \right| \frac{2\text{ mol } NH_3}{1\text{ mol } N_2} \left| \frac{17.06\text{g } NH_3}{1\text{ mol } NH_3} \right. = 2.4\text{ g } NH_3$$

Limiting Reagent

- Most of the time in chemistry we have more of one reactant than we need to completely use up other reactant.
- That reactant is said to be in excess (there is too much).
- The other reactant limits how much product we get. Once it runs out, the reaction stops. This is called the limiting reagent.

Limiting Reagent

- To find the correct answer, we have to try all of the reactants. We have to calculate how much of a product we can get from each of the reactants to determine which reactant is the limiting one.
- The lower amount of a product is the correct answer.
- The reactant that makes the least amount of product is the limiting reagent. Once you determine the limiting reactant, you should ALWAYS start with it!
- Be sure to pick a product! You can't compare to see which is greater and which is lower unless the product is the same!

Limiting Reactant: Example

- 10.0g of aluminum reacts with 35.0 grams of chlorine gas to produce aluminum chloride. Which reactant is limiting, which is in excess, and how much product is produced?

$2\ Al + 3\ Cl_2 \rightarrow 2\ AlCl_3$

- Start with Al:

10.0 g Al	1 mol Al	2 mol $AlCl_3$	133.5 g $AlCl_3$
	27.0 g Al	2 mol Al	1 mol $AlCl_3$

= 49.4g $AlCl_3$

- Now Cl_2:

35.0g Cl_2	1 mol Cl_2	2 mol $AlCl_3$	133.5 g $AlCl_3$
	71.0 g Cl_2	3 mol Cl_2	1 mol $AlCl_3$

= 43.9g $AlCl_3$

Therefore, Cl_2 is limiting

LR Example Continued

- We get 49.4g of aluminum chloride from the given amount of aluminum, but only 43.9g of aluminum chloride from the given amount of chlorine. Therefore, chlorine is the limiting reactant. Once the 35.0g of chlorine is used up, the reaction comes to a complete 

.

Limiting Reactant Practice

- 15.0 g of potassium reacts with 15.0 g of iodine. Calculate which reactant is limiting and how much product is made.

Finding the Amount of Excess

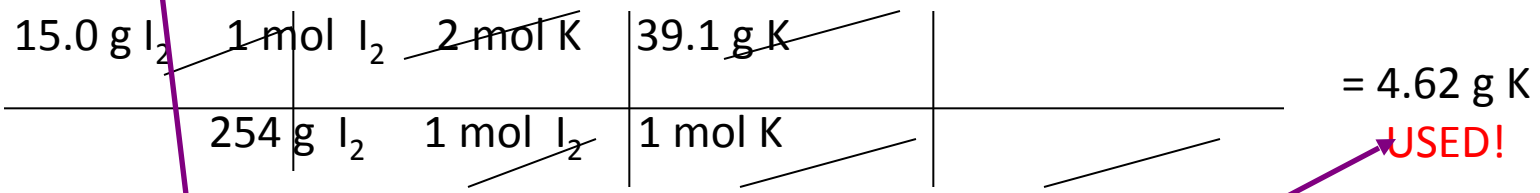
- By calculating the amount of the excess reactant needed to completely react with the limiting reactant, we can subtract that amount from the given amount to find the amount of excess.
- Can we find the amount of excess potassium in the previous problem?

Finding Excess Practice

- 15.0 g of potassium reacts with 15.0 g of iodine.

  $2\ K + I_2 \rightarrow \quad 2\ KI$

- We found that Iodine is the limiting reactant, and 19.6 g of potassium iodide are produced.



15.0 g K – 4.62 g K = 10.38 g K EXCESS

Given amount of excess reactant

Amount of excess reactant actually used

Note that we started with the limiting reactant! Once you determine the LR, you should only start with it!

Limiting Reactant: Recap

1. You can recognize a limiting reactant problem because there is MORE THAN ONE GIVEN AMOUNT.
2. Convert ALL of the reactants to the SAME product (pick any product you choose.)
3. The lowest answer is the correct answer.
4. The reactant that gave you the lowest answer is the LIMITING REACTANT.
5. The other reactant(s) are in EXCESS.
6. To find the amount of excess, subtract the amount used from the given amount.
7. If you have to find more than one product, be sure to start with the limiting reactant. You don't have to determine which is the LR over and over again!