STOICHIOMETRY

COOKIES & CREAM COOKIE RECIPE

- 1 cup butter, softened
- 1/2 cup packed brown sugar
- 1/2 cup white sugar
- 1 package Cookies n‘ Cream pudding mix
- 2 eggs
- 1 tsp. vanilla
- 2 1/4 cups flour
- 1 tsp salt
- 1 tsp baking soda
- 10 Oreos, chopped
- 1/2 cup white chocolate chips

Combine flour, baking soda and salt in a small bowl.

Beat brown sugar, sugar vanilla, and butter in a large bowl. Add eggs one at time.

Gradually add pudding mix, flour, crushed cookies and morsels.

Bake cookies at 350° for 8 - 10 minutes

Stoichiometry Defined

- Stoichiometry –The study of quantitative (measurable) relationships that exist in chemical formulas and chemical reactions.

ANALYSIS OF AN EQUATION

- $N_2H_4 + 2H_2O_2 \rightarrow N_2 + 4H_2O$

- Same as saying…

1mole N_2H_4 + 2moles H_2O_2 → 1mole N_2 + 4 moles H_2O

- The mole ratio is the “recipe” for the reaction.

MOLE-MOLE PROBLEMS

- $N_2H_4 + 2H_2O_2 \rightarrow N_2 + 4H_2O$

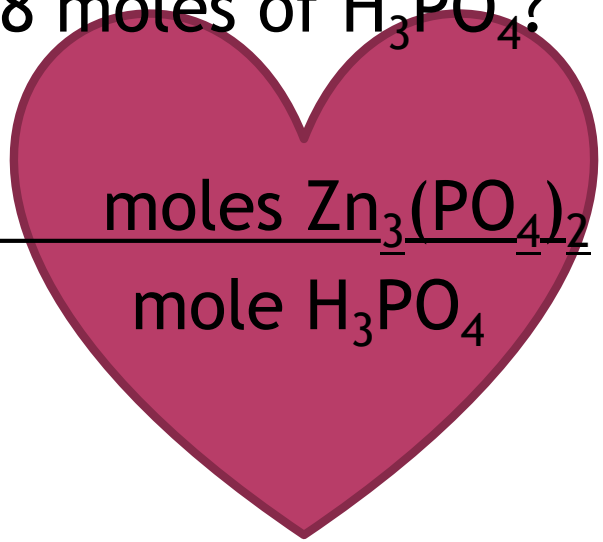
- Ex.1.4 moles of H_2O_2 gives how many moles of N_2?

$$1.4 \text{ moles } H_2O_2 \times \frac{1 \text{ mole } N_2}{2 \text{ mole } H_2O_2} = 0.7 \text{ moles } N_2$$

ANOTHER EXAMPLE

- $3Zn + 2H_3PO_4 \rightarrow Zn_3(PO_4)_2 + 3H_2$

- How many moles of $Zn_3(PO_4)_2$ will be produced from 2.18 moles of H_3PO_4?



$$2.18 \text{ moles } H_3PO_4 \times \frac{\text{moles } Zn_3(PO_4)_2}{\text{mole } H_3PO_4}$$

MASS – MASS PROBLEMS

- Find molar mass of given and unknown
- Change mass of given to moles of given
-  Change moles of given to moles unknown
- Change moles of unknown to mass of unknown

MASS-MASS PROBLEMS

- What mass of water is produced from 1.5 grams of glucose?

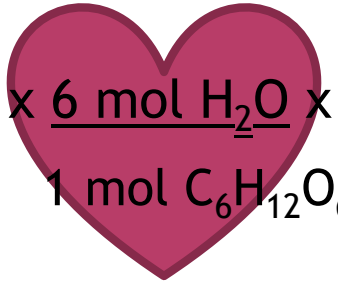
$$\underline{C_6H_{12}O_6} + 6\ O_2 \rightarrow 6\ CO_2 + \underline{6\ H_2O}$$

  - MM $C_6H_{12}O_6$ = 180.0 g H_2O = 18.0 g
  - Change mass glucose to moles using molar mass.
  - Use  change from moles of glucose to moles of water.
  - Change from moles of water to grams using molar mass

THE EXAMPLE OF MASS-MASS

$$\underline{C_6H_{12}O_6} + 6\ O_2 \rightarrow 6\ CO_2 + \underline{6\ H_2O}$$

$$1.5g\ C_6H_{12}O_6 \times \frac{1mol\ C_6H_{12}O_6}{180.0\ g\ C_6H_{12}O_6} \times \frac{6\ mol\ H_2O}{1\ mol\ C_6H_{12}O_6} \times \frac{18.0\ g\ H_2O}{1\ mol\ H_2O} =$$



- 0.9 g H_2O

ANOTHER EXAMPLE

- Ex. What mass of aluminum oxide is produced when 2.3 g of aluminum reacts with iron (III) oxide? (the reaction produces Fe metal and aluminum oxide)

- 4.3g Al_2O_3

- $Al + Fe_2O_3 \rightarrow Fe + Al_2O_3$

$$2.3\text{ g Al} \times \frac{1\text{ mol Al}}{27.0\text{ g Al}} \times \frac{1\text{mol } Al_2O_3}{1\text{ mol Al}} \times \frac{102.0\text{ g } Al_2O_3}{1\text{mol } Al_2O_3}$$

MASS-VOLUME PROBLEMS

- Find the molar mass of given
- Change mass of given to moles
- Use💗to change to moles of unknown
- Change moles to volume of gaseous unknown

EXAMPLE

- If I have 125 g of Al_2O_3 how many L of O_2 do I have @ STP using the following equation…

$$2\ Al_2O_3 \rightarrow 4\ Al + 3\ O_2$$

- MM of Al_2O_3 = 102.0 g

$$125\ g\ Al_2O_3 \times \frac{1 mol\ Al_2O_3}{102.0\ g\ Al_2O_3} \times \frac{3\ mol\ O_2}{2\ mol\ Al_2O_3} \times \frac{22.4\ L}{1 mol\ O_2} = 41.2\ L\ O_2$$

ANOTHER EXAMPLE

- Find the mass of aluminum required to produce 1.32L of H_2 gas @ STP in the following reaction…

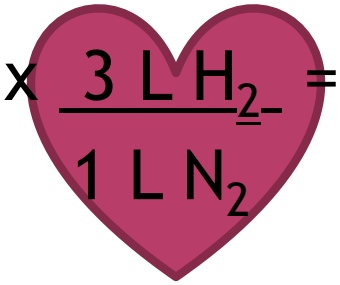
$$2Al + 3\ H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3\ H_2$$

- 1.06 g Al

VOLUME-VOLUME PROBLEMS

- Same as mole-mole just using volumes instead!
- If I have 15.5 L of N_2 gas, how many L of H_2 will react in this reaction $N_2 + 3\ H_2 \rightarrow 2\ NH_3$?

$$15.5\ L \times \frac{3\ L\ H_2}{1\ L\ N_2} = 46.5\ L\ H_2$$



11-3 LIMITING REACTANTS AND PERCENT YIELD

- When chemicals combine, they are usually in non-stoichiometric proportions. (not the exact proportions that the equation shows). This means there will be a ***limiting reactant***.
  - Limiting Reactant will be completely used up in the reaction.
  - The other, leftover amount is said to be in excess.
- The quantities of products formed in a reaction are always determined by the quantity of limiting reactant.

DETERMINING THE LR

- Solve 2 separate mass-mass problems (one for each reactant and BOTH to the same product).
- The mass-mass problem which is smaller amount of product is the limiting reactant.

EXAMPLE OF LR

- Ex. 3.5 g of Cu is added to 6.0 g silver nitrate. Find the limiting reactant.
- (Note: you can calculate the mass of either product, use the easier one to find the molar mass!)

$$\underline{Cu} + \underline{2\ AgNO_3} \rightarrow Cu(NO_3)_2 + \underline{\underline{2\ Ag}}$$

$$3.5\text{ g Cu} \times \frac{1\text{mol Cu}}{63.5\text{ g Cu}} \times \frac{2\text{ mol Ag}}{1\text{ mol Cu}} \times \frac{107.9\text{ g Ag}}{1\text{ mol Ag}} = 11.9\text{ g Ag}$$

$$6.0\text{ g } AgNO_3 \times \frac{1\text{mol } AgNO_3}{169.9\text{ g } AgNO_3} \times \frac{2\text{ mol Ag}}{2\text{ mol } AgNO_3} \times \frac{107.9\text{ g Ag}}{1\text{ mol Ag}} = 3.81\text{ g Ag}$$

THEORETICAL YIELD AND LR

- Theoretical yield is the amount of product that should be able to be produced in a chemical reaction
- Determined using STOICHIOMETRY!!!
- May also involve LR…which means you will determine two yields and then pick the smaller value as the correct one!

PERCENT YIELD

- Percent yield = $\left(\frac{\text{actual yield}}{\text{theoretical yield}}\right)$ x 100
- Actual yield = what you got in lab (or what is given in the problem)
- Theoretical yield = what it was supposed to be according to STOICHIOMETRY!

EXAMPLE

- A piece of copper with a mass of 5.00 g is placed in a solution of $AgNO_3$. The silver metal produced has a mass of 15.2g. What is the percent yield for this reaction?
  - Use stoich (mass-mass) to calculate the theoretical mass of the silver.
  - Calculate the %yield using the actual mass and the theoretical mass

EXAMPLE CONTINUED

- $\underline{Cu} + 2AgNO_3 \rightarrow \underline{2\ Ag} + Cu(NO_3)_2$

- MM Cu = 63.5 g Ag = 107.9 g

$$5.00\ g\ Cu \times \frac{1\ mol\ Cu}{63.5\ g\ Cu} \times \frac{2\ mol\ Ag}{1\ mol\ Cu} \times \frac{107.9\ g\ Ag}{1\ mol\ Ag} = 17.0\ g$$

- % yield = $\frac{15.2\ g}{17.0\ g} = 89.4\ \%$

TRY THESE…

- WS 11-3 # 19
  - Answer 106% yield
- WS 11-3 # 20
  - Answer 88.3% yield