Objective 4

Perform mole-mass calculations with compounds and reactions.
Determine chemical formula from elemental analysis (% composition).
Determine masses of reactants/product from mass of products/reactants in chemical reaction.

How Many Pennies Are In That Jar?

http://www.seemosaic.com/blog/for-better-managed-print-think-beyond-the-pennies-per-page/

Hint: Counting By Weighing
Convert mass ------> # of pennies
What is the conversion factor?

http://theshiksa.com/2012/06/04/salt-friend-or-foe/

I may have high blood pressure.
Maybe I should watch my diet.
But I love salt.
How much sodium is in 1 teaspoon of salt?

Hint: Convert tsp NaCl → mass of Na
Answer: approx. 2.3 g Na

Objective: Calculate Moles From Mass
(Convert mass to moles)

You measure 2 g of H.
How many moles of H are present?

You measure 16 g of O.
How many moles of O are present?

You measure 18 g of H_2O.
How many moles of H_2O are present?

Think: What is the Conversion Factor?

Counting by Weighing:

Scientist do not deal with 1 or 2 or 10 atoms but ***a lot*** of atoms.

We can determine the number of atoms/molecules/ions or ***moles*** (1 mole = 6.02×10^{23} = Avogadro's # = Chemist's dozen) of a substance by knowing the mass of one mole (***molar mass***) and measuring its total ***mass***.

Molar mass - see chem formula and atomic weight in Periodic Table

$$\text{molar mass} = \frac{\text{mass}}{\text{moles}} \quad \text{or} \quad \text{moles} = \frac{\text{mass}}{\text{molar mass}}$$

Use Molar Mass as a Conversion Factor

Counting by Weighing:

$$\text{molar mass} = \frac{\text{mass}}{\text{moles}} \quad \text{or} \quad \text{moles} = \frac{\text{mass}}{\text{molar mass}}$$

You measure 2 g of H, 16 g of O, 18 g of H_2O
How many moles of each substance are present?

For H: molar mass = 1 g/mole so moles = 2 g/(1 g/mole) = 2 moles.

For O: molar mass = 16 g/mole so moles = 16 g/(16 g/mole) = 1 moles.

For H_2O: molar mass = 18 g/mole so moles = 18 g/(18 g/mole) = 1 moles.

Think: Use Molar Mass as a Conversion Factor

Water is Everywhere!

Person consumes 2×10^6 gallons of water per year
Plants are 95% water
Fish are 80% water
Humans are 60% water

http://wwf.panda.org/about_our_earth/teacher_resources/own_goals/wasting_water/

97% of water is a salt solution
Less than 1% of water is fresh water we can use. Most of the water is locked up in the polar ice caps and glaciers.
Ref: World of Chemistry video, "Water"

What Is The Uncertainty In Each Measurement?

What is your "Water Footprint"?
http://www.waterfootprint.org
1 apple = 125 liters of water
1 glass of wine = 110 liters of water

Objective: Calculate Moles From Mass

How many moles of H are in 1 drop of water?

1 drop of water = 0.05 ml

http://www.wilpf.org/node/735

How many moles of H_2O, H, and O are in 1 drop of water?

http://www.wilpf.org/node/735

1 drop of water = 0.05 ml
Convert from ml to g using density of water (1 g/ml)

So 0.05 ml = 0.05 g

Convert g to moles using molar mass

0.05 g of water/(18 g/mole) = 0.003 moles of water

Convert moles of water to moles of H using _____.

Convert moles of water to moles of O using _____.

Salt helps maintain the balance of fluids in our body. The RDA of sodium is 2,300 mg/day.
How many tsp of salt is equivalent to 2,300 mg of sodium?
(1 tsp salt = 5.7 g salt)

Think: Conversions

Answer: approx. 1 tsp

The Top 10 Chemicals Produced in the U.S.

2000 RANK (by mass)	CHEMICAL	2000 PRODUCTION (in 10^9 kg)	FORMULA	Element or Compound? Element/ Compound Type	PRODUCTION (in moles)	RANK (by moles)
1	Sulfuric acid	39.62				
2	Ethylene	25.15	C_2H_4			
3	Lime	20.12				
4	Phosphoric acid	16.16				
5	Ammonia	15.03	NH_3			
6	Propylene	14.45	C_3H_6			
7	Chlorine	12.01				
8	Sodium hydroxide	10.99				
9	Sodium carbonate	10.21				
10	Ethylene chloride	9.92	$C_2H_4Cl_2$			

Application of Mass to Moles Conversion

Objective: Determine Chemical Formula of a Compound from % Composition

What is the % composition (% H by mass and %O by mass) of H_2O?

Elemental analysis experiment: 11% H by mass and 89% O by mass. What is the chemical formula of this compound?

Application of Mass to Moles Conversion

Objective: Determine Chemical Formula of a Compound from % Composition

What is the % composition (% H by mass and %O by mass) of H_2O?

Solution: (*remember:* subscripts represent _____)

2 moles H x (1 g H/mole H) = 2 g H

1 mole O x (16 g O/mole O) = 16 g O

Total Mass = 2 g + 16 g = 18 g (*What does 18 g represent?)*

% H = (mass of H/total mass)x100 = (2 g H/18 g H_2O)x100 = 11%H

% O = (mass of O/total mass)x100 = (16 g O/18 g H_2O)x100 = 89%O

Elemental analysis experiment: 11% H by mass and 89% O by mass. What is the chemical formula of this compound?

Solution: (work above example backwards)

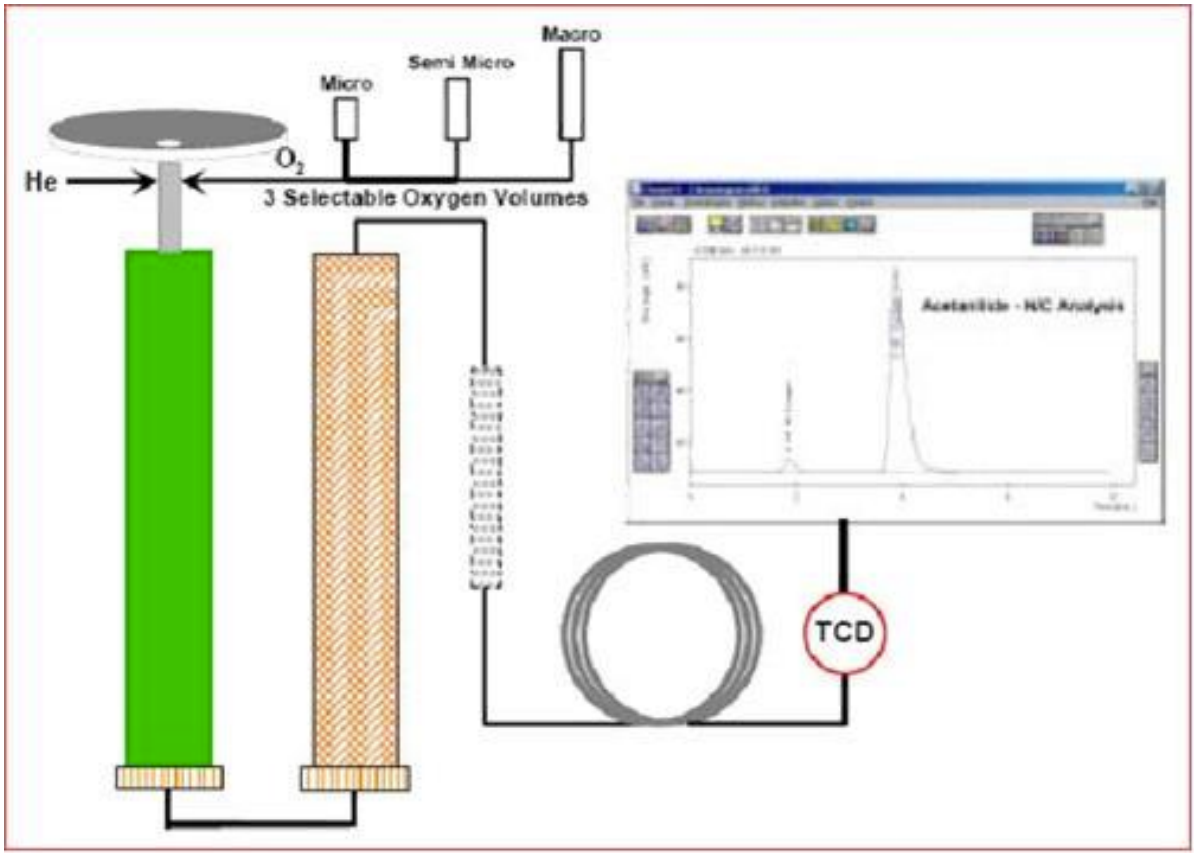
11% H = 11 g H x (1 mole H/1 g H) = 11 moles H

89% O = 89 g O x (1 mole O/16 g O) = 5.55 moles O

Chemical Formula = $H_{11}O_{5.5}$.

What's wrong with this formula?

Elemental analysis shows 5.9% H and 94.1% O. Is this compound water? If not, what is the chemical formula of this compound?



http://180.211.114.59:1111/econtent/basic-chemistry-II/characterization.php

Fertilizers contain nitrogen, phosphorus, and potassium (NPK).

See http://scifun.chem.wisc.edu/CHEMWEEK/PDF/Agricultural_Fertilizers.pdf

Analysis of a fertilizer material gives a % composition of 13.9% N, 38.6% K, and 47.5% O. Determine the chemical formula and give the chemical name of this compound.

See Practice Problems, Question 6a.

http://www.ianrpubs.unl.edu/pages/publicationD.jsp?publicationId=1172

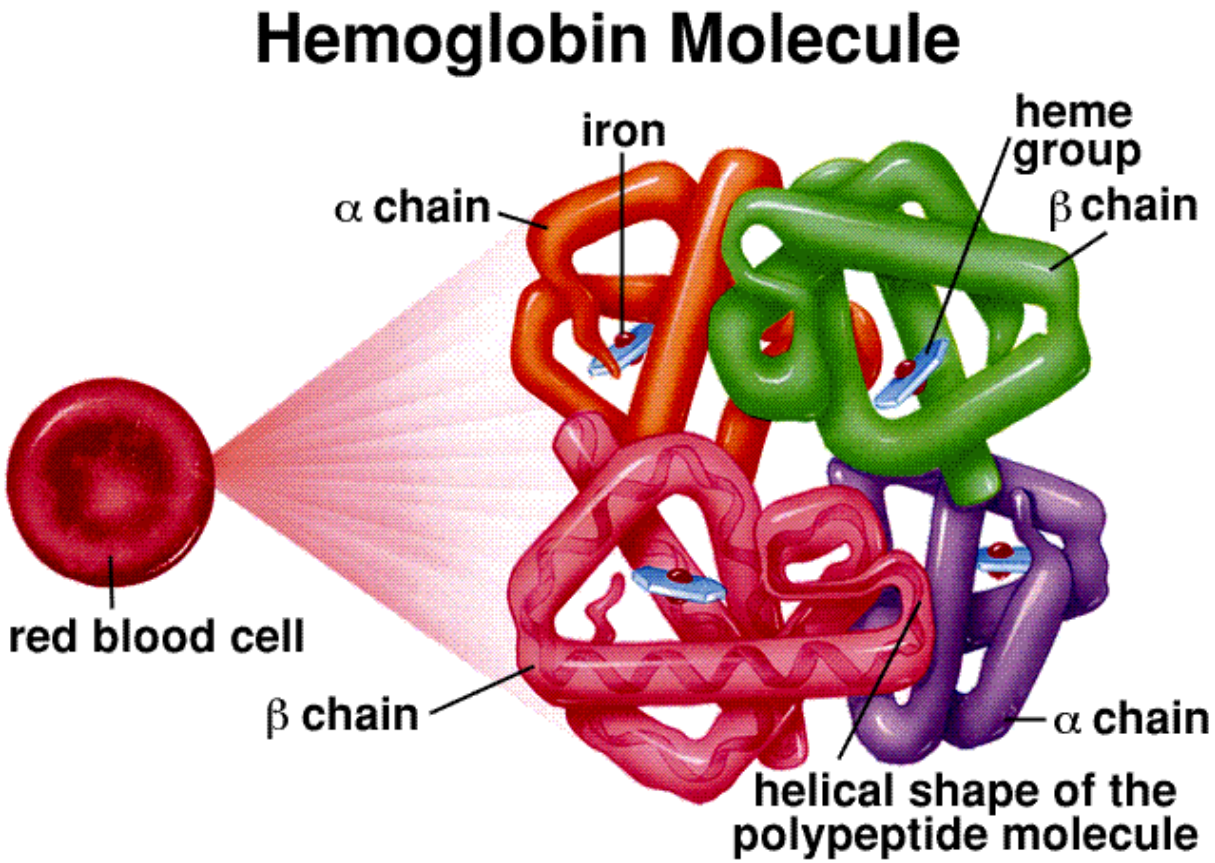
Ethylene glycol is a sweet smelling and sweet tasting liquid used in antifreeze in the cooling system in cars. Elemental analysis of ethylene glycol gives 38.7% C, 9.7% H, and 51.6% O. The molar mass of ethylene glycol is 62 g/mole. What is the chemical formula of ethylene glycol?

http://www.smbintllc.com/winter.html

See Practice Problems, Question 8.

Hemoglobin is the oxygen carrier found in red blood cells in mammals. The molecular weight of hemoglobin is 64,500. If hemoglobin contains 0.35% iron by mass, how many iron atoms are in one hemoglobin molecule?

http://fmss12ucheme.wordpress.com/2013/05/06/hemoglobin/



What are Moles Good for?

Elements:
metals and non-metals

Compounds:
ionic and molecular

Counting by weighing: **Mass <--> Moles**

Conversion Factor: Molar mass - see Periodic Table

Compounds:

- Chemical Formula - subscripts represent Moles
- Molar mass
- % composition

Reactions: predict how much reactants react and products produced

Very Common Chemical Reaction:

Light, Tasty Biscuits
Sift together 2 cups all-purpose flour, 2 1/2 teaspoons baking powder and 1/2 teaspoon salt. Cut in 1/3 cup shortening with fork until mixture resembles coarse corn meal. Add 3/4 cup of milk and blend lightly with fork until flour is moistened and dough pulls away from sides of bowl. Turn out on lightly floured board. Knead lightly (30 seconds) and roll 3/4 inch thick. Place on lightly greased pan and brush tops of biscuits with butter or margarine. Bake at 475^{o} (very hot oven) for 12 to 15 minutes.

Conversions:

flour	1/4 cup = 30 g
baking powder	1/4 teaspoon = 1.1 g
3/4 cup milk	1 cup = 240 ml = 240 g (assume density = 1 g/ml)

I’m concerned about the earth.

http://www.freepik.com/free-photos-vectors/earth

http://www.chemistryland.com/CHM107Lab/Exp02_Exhaust/Lab2Exp2Exhaust.html

How much carbon dioxide does my car make?

A chemical reaction is represented by a chemical equation.

When a chemical equation is balanced, the _____ law is obeyed. The coefficients represent _____.

Example:

1 car body (B) + 4 wheels (W) make 1 car (BW_4)

1 B + 4 W --> 1 BW_4

The # of atoms of each element is the **same** on each side of the equation

If Ford wants to make 500,000 cars next month, how many wheels are needed?

$$500{,}000\ BW_4 \times \frac{4\ W}{1\ BW_4} = 2{,}000{,}000\ W$$

Conversion Factor = coefficients in balanced chemical equation

A chemical reaction is represented by a chemical equation.
When a chemical equation is balanced, the _____ law is obeyed. The coefficients represent _____.

Example:

1 torso (T) + 1 head (H) + 2 arms (A) + 2 legs (L) make 1 body ($T_1H_1A_2L_2$)

1 T + 1 H + 2 A + 2 L --> $T_1H_1A_2L_2$

The # of atoms of each element is the **same** on each side of the equation

Dr. Frankenstein has 10 arms. How many Frankies can he make?

Conversion Factor = ?

A chemical reaction is represented by a chemical equation.
When a chemical equation is balanced, the _____ law is obeyed. The coefficients represent _____.

Example:
2 moles of H_2 reacts with 1 mole of O_2 to produce 2 moles of H_2O

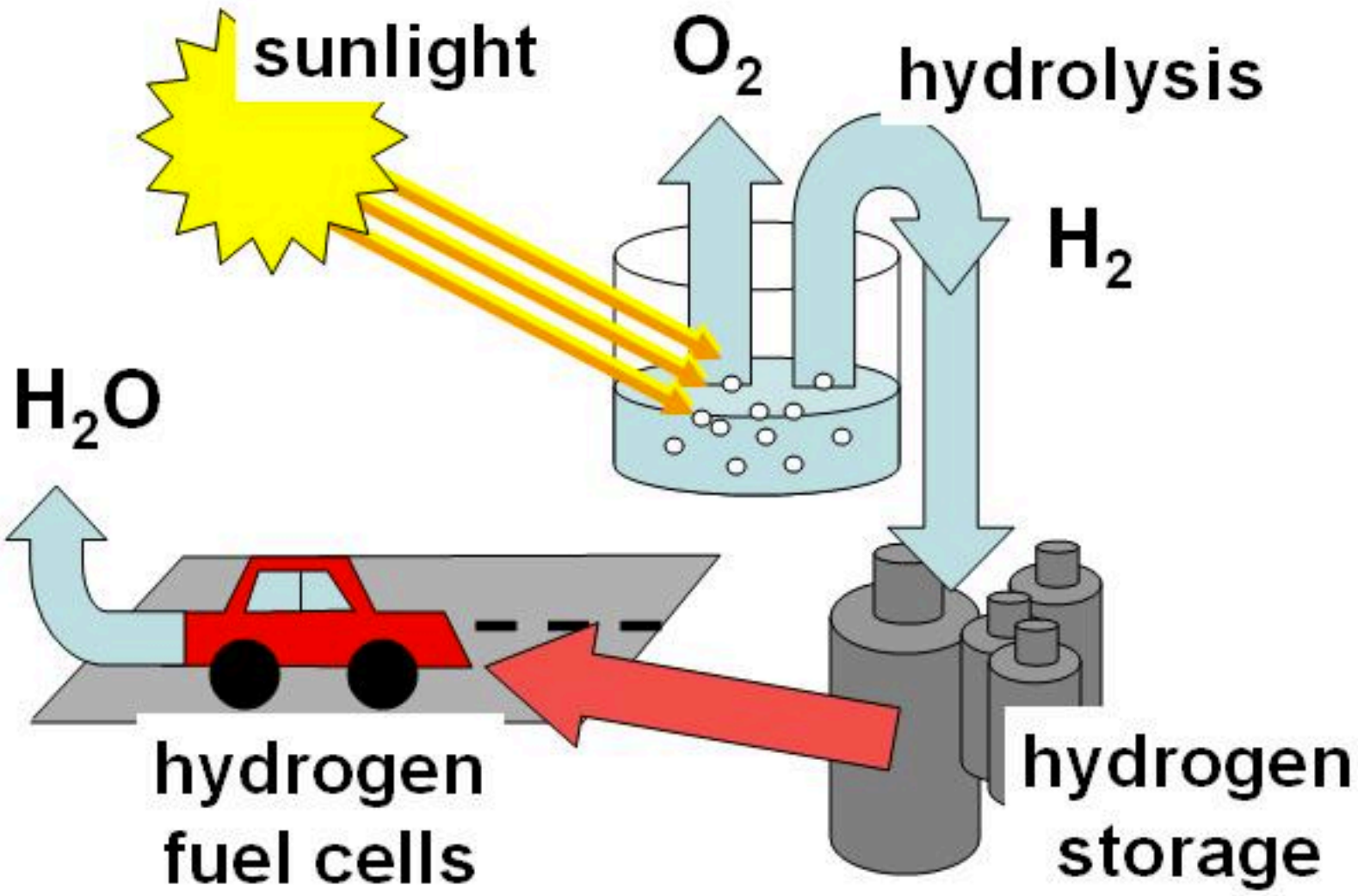
$$2\ H_2 + O_2 \text{ --> } 2\ H_2O$$

The # of atoms of each element is the **same** on each side of the equation.

If you burn 10 moles of H_2, how many moles of H_2O are produced?

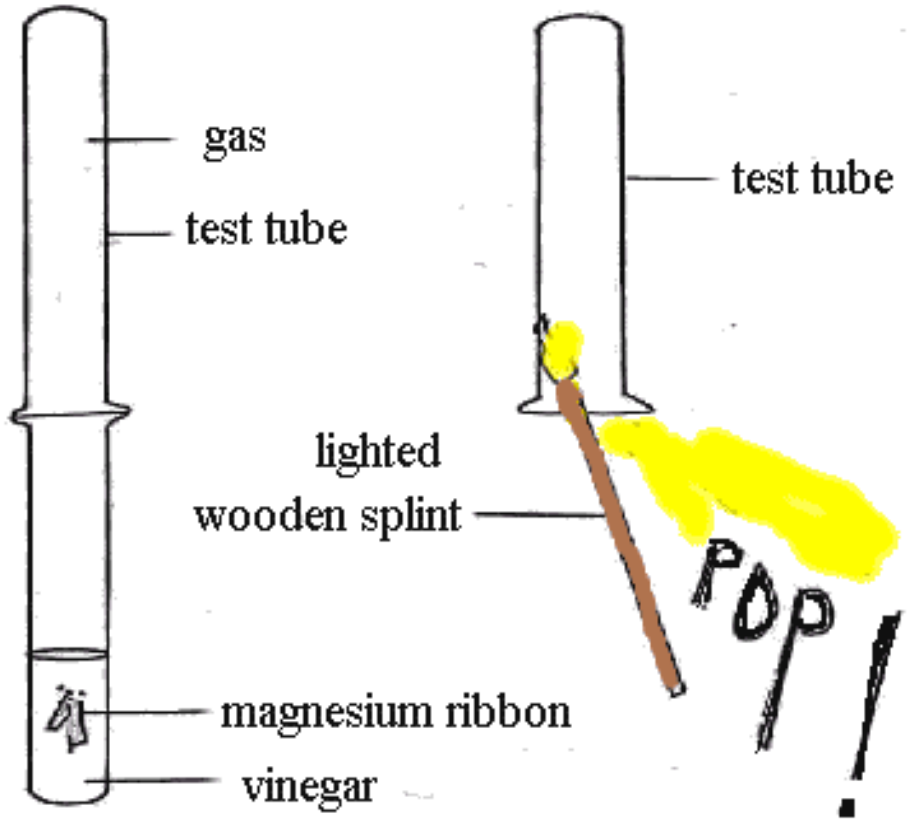
If 450 moles of O_2 are available, how many moles of H_2 can burn?

Hydrogen – Fuel of the 21st Century?



http://www.keepbanderabeautiful.org/hydrogen.html

Usually, you know the mass. Use MASS to MOLES in a Chemical Reaction to Predict (*calculate*) the Amounts of Reactants and Products



10 g of H_2 reacts with O_2 to produce H_2O. Calculate the mass of O_2 that reacts.

a. 5 g
b. 10 g
c. 40 g
d. 80 g
e. 90 g

You did this in CHM 22 lab!

https://sites.google.com/site/internationalgcsechemistry/year-9-topics/hydrogen-and-water/3---water-from-hydrogen

Objective: Use MASS to MOLES in a Chemical Reaction to Predict (*calculate*) the Amounts of Reactants and Products

10 g of H_2 reacts with O_2 to produce H_2O.
Calculate the mass of O_2 that reacts.

Step 1. balance chemical equation: $2\ H_2 + O_2 \rightarrow 2\ H_2O$

Step 2. given the mass of one reactant or product, calculate moles:

10 g H_2 x (_____) = _____ moles H_2

Step 3. Convert moles from Step 2 to moles of another reactant or product. The Coefficients tell us _____ and the *RATIO* in _____ of reactants to products.

$$\text{_____ moles } H_2 \times \frac{1 \text{ mole } O_2}{2 \text{ moles } H_2} = \text{_____ moles } O_2$$

Step 4. Convert moles in Step 3 to mass:

$$\text{_____ moles } O_2 \times \frac{32 \text{ g } O_2}{1 \text{ mole } O_2} = \text{_____ g } O_2$$

Calculate the mass of H_2O produced.

If you know the mass of one substance, you can calculate (predict) the mass of every other substance.

Step 1. balance chemical equation. Check chem formulas. Check charge.

Step 2. given the mass of one reactant or product, calculate moles:

_____ g _____ x (_____) = _____ moles

Conversion Factor = Molar Mass

Step 3. Convert moles from Step 2 to moles of another reactant or product. The Coefficients tell us _____ and the *RATIO* in _____ of reactants to products.

_____ moles ___ x = _____ moles ___

Step 4. Convert moles in Step 3 to mass:

_____ moles ___ x = _____ g ___

Conversion Factor = Molar Mass

In an experiment, you can calculate the mass of product produced = *Theoretical Yield*.

But you'll measure the actual mass of product produced = *Actual Yield*.

Ideally, you want the *% Yield* = $\frac{\text{actual yield}}{\text{theoretical yield}} x100$

to be _____%.

Some reasons % yield < ____ % are _____

Objective: Use mass/moles to calculate yield.

Experiment: 10 g of H_2 reacts with O_2 to produce 2.5 g of water.
Calculate the % yield of water.
Steps:
(i) Calculate the theoretical yield (TY) of water.
(ii) Calculate the % yield of water.

% yield =

a. 3%
b. 25%
c. 50%
d. 100%

Objective: Use mass/moles to calculate yield.

Experiment: 10 g of H_2 reacts with O_2 to produce 2.5 g of water.

Calculate the % yield of water.

Steps:

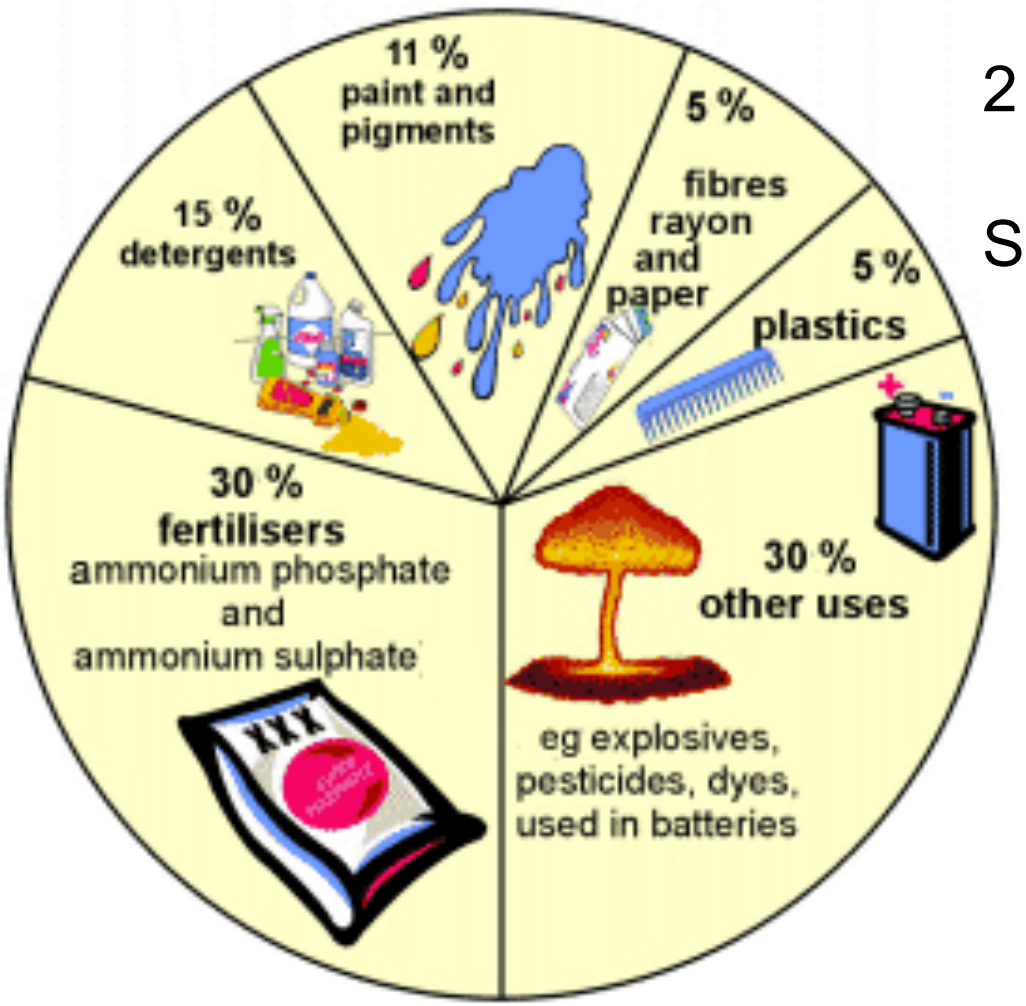
(i) Calculate the theoretical yield (TY) of water.

(ii) Calculate the % yield of water.

$$\text{TY of } H_2O = \frac{10 \text{ g } H_2}{} \times \frac{1 \text{ mole } H_2}{2 \text{ g } H_2} \times \frac{2 \text{ mole } H_2O}{2 \text{ mole } H_2} \times \frac{18 \text{ g } H_2O}{\text{mole } H_2O} =$$

$$\% \text{ yield} = \frac{2.5 \text{ g } H_2O}{\text{\_\_\_\_ g } H_2O} \times 100 =$$

A Lot (200 million tons) of Sulfuric Acid is Produced Annually



$$S\ (s) + O_2\ (g) \rightarrow SO_2\ (g)$$

$$2\ SO_2\ (g) + O_2\ (g) \rightarrow SO_3\ (g)$$

$$SO_3\ (g) + H_2O\ (l) \rightarrow H_2SO_4\ (l)$$

http://www.mindset.co.za/resources//0000022611/0000029697/0000029637/default.htm

Objective: Use mass/moles to determine % yield.

In the first step of the industrial production of sulfuric acid, sulfur, S_8, is burned in air to give SO_2 (g).

_____S_8 (s) + _____ O_2 (g) -------> _____SO_2 (g).

450 g of S_8 (s) is burned in excess air to produce 750 g of SO_2 (g). Calculate the % yield of SO_2 (g).

Objective: Use mass/moles and % yield to determine mass of reactant.

In the first step of the industrial production of sulfuric acid, sulfur, S_8, is burned in air to give SO_2 (g).

_____S_8 (s) + _____ O_2 (g) -------> _____SO_2 (g).

You need to produce 1.0 kg of SO_2 (g) at 75% yield. Calculate the mass of S_8 (s) to produce 1.0 kg of SO_2 (g).