HONORS CHEMISTRY: INTRO TO COMPOSITION MATHEMATICS DATE:_____

Objectives: SWBAT. . .
…preview mathematical expectations for composition mathematics.
…measure out a certain number of objects without counting them.

This is an extremely mathematical unit. This will be a good review of factor-label, sig figs and units.

Skills you should be able to perform by the end of this chapter:

Convert from…

… atoms to atomic mass units (u) (and vice-versa) *…atomic mass units (u) to gram (and vice-versa)*

…grams to moles (and vice-versa) *…atoms to moles (and vice-versa)*

Determine…

…an element's average atomic mass (in u) *…an elements molar mass (in g/mol)*

…the molar mass of compounds (in g/mol) *…% composition of compounds*

…a compound's empirical formula from its % composition

…compound's molecular formula from its molar mass and empirical formula

RATIOS OF CHEMICALS ARE VERY IMPORTANT IN CHEMISTRY!

For example, balance this equation: $CH_4 +$ $O_2 \rightarrow$ $H_2O +$ CO_2

WHAT DOES IT MEAN?

THE PROBLEM:

- Atoms and molecules are really, really small! (Atoms are around 1-5x10^{-10} meters or 1-5 _____)
- You cannot realistically count out enough particles to have a visible reaction.

SO HOW DO YOU COUNT OUT A CERTAIN NUMBER OF PARTICLES WITHOUT ACTUALLY COUNTING THEM?

-

Instead of looking at atoms right now, pretend that you work at a candy store. People come in and constantly ask for large, but exact numbers of different candy types. (For example, 1000 or 1,000,000 jelly beans)

1) DETERMINE THE AVERAGE MASS OF THE CANDY.

- ex.:
- Once we have this we have a factor-label conversion:

MORE ABOUT U

2) Use factor-label to convert your number to a mass.

- Example: If you needed 1000 jellybeans for a customer, what mass could you measure out?

- If you measure this out, you'll have very close to the number of candies you wanted!

THINGS TO THINK ABOUT:

- Different candies are going to have different conversion factors. ex)
- Atoms are going have the same issues. Different atoms are going to have different masses.
- Fortunately, scientists have determined the average mass of each element and put it on the periodic table.
- Atoms' masses are often measured in _____ 1 u =
- Atomic mass units are only going to be used when dealing with individual atoms and their individual masses.
- Technically, atomic mass units are actually called _____ .
- The unit _____ is interchangeable with the unit u.

TRY THESE...

1) 1 atom of carbon has an average atomic mass of 12.01 u. What is its mass (in grams)?

2) You have exactly 1 billion atoms of carbon. How many atomic mass units is that?

3) You have 1.0 mg of lead. How many Daltons is that?

4) How many lead atoms is that? (Lead's average atomic mass = 207.2 u)

"Be ashamed to die until you have won some victory for humanity." ~ Horace Mann

HONORS CHEMISTRY: THE MOLE AND ELEMENTAL MOLAR MASSES DATE:_____

Learning activities: **SWBAT. . .**

…explain the concept of a mole.

…convert between grams, moles and atoms of a substance.

TED-ED ON THE MOLE

A MOLE:

With a partner, decide which of the following statements is true:

a) *'A mole is like a cup of something.'*

b) 'A mole is like a pound of something.'

c) 'A mole is like a dozen of something.'

-

-

You can treat Avogadro's number like any other conversion in factor-label:

TRY THESE:

How many atoms are there in 2.30 moles of gold?

How many atoms are there in 2.30 moles of copper?

How many moles are exactly 1,000,000 atoms?

YOU CAN ALSO CONVERT FROM MOLES TO GRAMS AND VICE-VERSA!

Molar mass:

- The periodic table gives the molar mass of each element. It is the same number as the atomic mass.
- ex) The molar mass of carbon is 12.01 g/mol. Write this out as a factor-label conversion:

Try these:

How many grams are in 2.30 moles of gold?

How many moles are there in 25.45g of sulfur?

How many atoms are in 7.89g of Li?

DID YOU KNOW... "In 1811 the Italian chemist Amedeo Avogadro (1776–1856) hypothesized that equal volumes of gases at the same temperature and pressure contain equal numbers of molecules. Avogadro also astutely reasoned that simple gases were not formed of solitary atoms but were instead *compound* molecules of two or more atoms.

Curiously, Avogadro's hypothesis was neglected for half a century after it was first published. Many reasons for this neglect have been cited, including some theoretical problems. In addition, Avogadro was not part of an active community of chemists: the Italy of his day was far from the centers of chemistry in France, Germany, England, and Sweden.

It was not until 1860, after Avogadro's death, that another chemist, Stanislao Cannizzaro, used Avogadro's hypothesis to determine the molar mass of several compounds; validating the correctness of Avogadro's idea. The number of particles in a mole of a substance was named Avogadro's Number in honor of his contributions to chemistry. (http://www.chemheritage.org)

"He who can take no great interest in what is small will take false interest in what is great." ~ John Ruskin

EVERYTHING YOU WANTED TO KNOW ABOUT MOLES BUT WERE AFRAID TO ASK!

No, I don't mean those little rodents! As you've learned from your text and class, a mole is:

- a unit of measurement for the amount a substance
- A subjective number which chemists picked out to help manage very large amounts of very small particles.
- equal to the number of carbon atoms in exactly 12 grams of pure ^{12}C.
- equal to 6.022×10^{23} particles (that's 602.214.000.000,000,000,000,000!)
- also known as Avogadro's number.

So you're saying that's a big, big number! **But just how big is it?** Well if you had a mole of…

- …drops of water going over Niagara falls, it would take 134,000 years!
- …seconds, you'd have a time 4 million times longer than the earth's existence!
- … tons, you'd have a little over 1% of the earth's mass! (the earth is big too…)
- …dollars, seven billion people could spend a million dollars an hour for their entire lives and they and use up about 1% of that money. (you could stack a mole of dollar bills the distance of the earth to the moon… over 170 billion times.)

Now this is getting out of control! **Why do chemists need such a large number?** Well, atoms and molecules are small. Real small. These particles are so small, in fact, that even tiny samples we can see are composed of enormous quantities of particles.

Since chemical reactions depend on ratios of particles, chemists came up with Avogadro's number. For example, a mole (abbreviation, by the way, is mol) of copper only equal about two dozen pennies (compare that to the example of pennies given above) and a mole of water is only around three teaspoons! That makes planning and running chemical experiments a lot easier.

In fact, if you take a look at your periodic table, you'll soon discover that the numeric value of an element's atomic mass is equal to its molar mass (how many grams of the element would be needed to obtain a mole of it). So what is the mass of a mole of gold? Helium? Uranium?

Boy, moles sure are fun!

HONORS CHEMISTRY: Determining Compound Molar Masses DATE:_____

Learning activities: **SWBAT. . .** …determine the molar mass of a compound.

REMEMBER THE LAW OF CONSERVATION OF MASS:

So the mass of a compound…

Determining a compound's molar mass is only slightly harder than looking up an element's molar mass.

ex) What is the molar mass of barium nitrate?

Step 1) Determine the chemical formula, if necessary.

Step 2) Count the number of each element in the compound formula

Step 3) Do a series of one-step factor label problems to determine the mass of each element present.

Step 4) Add up the parts to determine the molar mass of the compound (grams per one mole).

Try determining the molar mass of $C_{10}H_6O_3$.

"To be great we have to win the games we aren't supposed to win" ~ Julius Ervin

HONORS CHEMISTRY: PERCENT COMPOSITION DATE:_____

Learning activities: **SWBAT. . .** …determine the percent composition of a compound.

DETERMINING THE ELEMENTAL PERCENT COMPOSITION OF A COMPOUND:

EX) WHAT IS THE PERCENT COMPOSITION OF SODIUM CARBONATE?

Step 1) Determine the chemical formula, if necessary.

Step 2) Determine compound's molar mass.

Step 3) Solve for percent composition of each element.

FORMULA = TOTAL ELEMENT MASS/COMPOUND MOLAR MASS X 100%

Step 4) Double check work by making sure all components add up to 100%

Occasionally you will run into a **HYDRATE:**

- Part of mass of compounds can come from bound water. ex) $SrCl_2 \cdot 6H_2O$.
- Often used as **DESICCANT:**

Determine the percent composition of $SrCl_2 \cdot 6H_2O$

HYDRATES IN ACTION

"Out of the lowest depths, there is a path to the loftiest height." ~ Carlyle

HONORS CHEMISTRY: DETERMINING EMPIRICAL FORMULAS DATE:_____

Learning activities: **SWBAT. . .**

…determine the empirical formula of a compound.

DETERMINING THE EMPIRICAL FORMULA OF A COMPOUND:

Ex) A compound in 63% manganese and 37% oxygen. What is its empirical formula?

Step 1) If given in percents, assume you have 100 grams total and convert directly to grams.

(Note: if in grams already, start at step #2)

2. Using molar masses, determine the moles of each element present.

3. Identify the smallest mole amount. Divide all mole amounts by this. (This will clean up your ratio.)

4. Manipulate ratio to get it to the smallest whole number ratio (a.k.a. the empirical formula).

This part gets easier with experience.

Try to tweak the ratio; not just round it to the nearest whole number!

When tweaking, look for decimals which can be converted into easily manipulated fractions:

Batman finds an unknown substance. After running it through the Batcomputer, he finds it to be 66.75% copper, 10.84% phosphorus and 22.41% oxygen. What's the chemical formula?

"Pick battles big enough to matter, small enough to win." ~ Jonathan Kozol

HONORS CHEMISTRY: DETERMINING MOLECULAR FORMULAS DATE:_____

Objectives: **SWBAT**…determine the molecular formula for a compound given mass ratio and the molar mass.

DETERMINING MOLECULAR FORMULAS:

Remember, there is a difference between the empirical formula and the molecular formula.

***EMPIRICAL FORMULA*:**

(All ionic compounds are written as empirical formulas due to the differing sizes of the lattices.)

***MOLECULAR FORMULA*:**

(Many covalent compounds have similar empirical formulas, but different molecular formulas.)

EX) A COMPOUND IS FOUND TO BE 78.14% BORON AND THE REST IS HYDROGEN. THE MOLAR MASS IS DETERMINED TO BE AROUND 27.7 G/MOL. WHAT IS ITS MOLECULAR FORMULA?

Step 1) Determine the empirical formula, if necessary. ***(For now, ignore the molar mass information.)***

Step 2) Determine the molar mass of the empirical formula.

Step 3) Determine the molecular formula using the 'x-factor' equation:

x = molecular molar mass (given) / empirical molar mass (you solved)

Multiply the subscripts of the empirical formula by the 'x-factor' to get the molecular formula.

Determine the molecular formula of benzene. (Molar mass = 78.11 g/mol. %C = 92.3 %H = 7.7)

MORE ABOUT BENZENE

"Nothing is particularly hard if you divide it into small jobs." ~ Henry Ford

HONORS CHEMISTRY — COUNT WITHOUT COUNTING MINI-EXPERIMENT

NAMES: _____ & _____

BACKGROUND:

In case you haven't noticed yet, atoms are small. Chemical reactions demand a certain proportion of reactants by amount. And while we can scale up the ratio to an amount for appropriate than a couple molecules, we cannot realistically count out the proper amount of each reactant.

So how do we keep the ratio consistent? In this activity, you will practice counting items by determining the average mass of the items and then using factor-label to determine the mass of any amount desired.

MATERIALS:

Balances Uncooked Lentils Popcorn Kernels

PROCEDURE:

1. Find the mass of 5 individual lentils to the proper number of significant figures. Then obtain the other 10 mass samples from other groups. Repeat for kernels.

INDIVIDUAL LENTIL MASS (G)		

INDIVIDUAL KERNELS MASS (G)		

2. Determine the average mass of both types of particles. Show work and watch sig figs!

AVERAGE LENTIL MASS: AVERAGE KERNEL MASS:

3. Write the factor-label conversions for grams per unit for each:

4. Use factor-label to determine the mass of 100 lentils.

5. Measure out that mass of lentils on your balance. Then count how many are there and determine your percent error (assuming the true value was supposed to be 100 lentils). Do this twice.

TRIAL ONE: TRIAL TWO:

6. Use factor-label to determine the mass of 100 popcorn kernels.

7. Measure out that mass of kernels on your balance. Then count how many are there and determine your percent error (assuming the true value was supposed to be 100 popcorn kernels). Do this twice.

Trial One: Trial Two:

Questions:

1. Which item had the biggest error? Can you determine why that happened?

2. What are the lentils and kernels in this experiment analogous to in chemistry? What is the average mass of the items analogous to in chemistry?

3. Determine the mass (in grams) of one mole of lentils and one mole of popcorn kernels. Then convert this to pounds. Show all work!

4. Convert the mass of an average lentil and popcorn kernels to Daltons. Show all work.

5. Determine the approximate number of atoms in your (or someone else's) body. Explain your assumptions and show your work.

"Don't be afraid to take a big step if one is indicated.
You can't cross a chasm in two small jumps." ~ David Lloyd George