Section 8.1 Counting by Weighing

Average mass= total mass/ number of items

Average mass can then be used to count by weighing

If average mass is 5 grams and you want 1000 items, it is faster to weigh out 5000 grams on a scale than it is to count 1000 items.

Average mass can also be used to demonstrate ratios of different items.

If the average mass of item A is 3 times that of item B, it will take a sample with three times the weight of sample A to have the same number of items as sample B.

This demonstrates an important principle: **Two samples containing different types of components, A and B, both contain the same number of components if the ratio of the sample masses is the same as the ratio of the masses of individual components.**

For example: if item A has an average mass of 15 grams and item B has an average mass of 5 grams. If our sample of each contains 10 items, the total weight of A will be 150 grams and the total weight of B will be 50 grams. The weight ratio of A to B will always be 3:1 if the number of items of each is the same.

Have you ever purchased items in a counting by weighing situation?

Nails at a hardware store
Counting rolled coins by weighing
Candy

Section 8.2 Counting Atoms by Weighing- Atomic Masses

Grams and Kilograms are way to large to use to weigh atoms, atoms are too tiny.

AMU- atomic mass unit is used 1.66×10^{-24} grams =1 amu

Average atomic mass takes into account relative amounts of isotopes present and gives an average mass for each element- listed on periodic table.

If I have 3.00×10^{20} amu of carbon, ? atoms of carbon= 2.50×10^{19} carbon atoms

Section 8.3 and 8.4

THE MOLE

The mole = 6.022×10^{23} items

Abbreviated mol

Also known as Avogadro's number

Don't be scared by big number…
It is just a conversion like 12 = 1 dozen, 6.022×10^{23} = 1 mole

Atomic mass given on periodic table is equal to amount in grams needed to have one mole of atoms of that element.

12.01 grams of carbon = 1 mole of carbon atoms

Using this type of equality is how you convert from moles to grams and grams to moles

Can also convert from numbers of atoms to grams by first converting from number of atoms to number of moles then number of grams or the reverse direction.

MOLAR MASS

Compounds are really just a collection of atoms, gathered together according to a fixed ratio.

CH_4 is a compound, known as methane, composed of one carbon atom and four hydrogen atoms.

If I have one mole of methane, I have one mole of carbon and four moles of hydrogen.

The mass of one mole of methane can be calculating by adding the masses of the atoms present in the molecule.

1 mole of carbon = 12.01 grams of carbon
4 moles of hydrogen = 1.008 x 4= 4.032 grams of hydrogen

12.01 + 4.032 = 16.04 grams per mole of methane

This is known as the molecular mass of methane.

An old name for molecular mass is molecular weight.

It is sometimes referred to as formula weight for ionic compounds since there are no true molecules in an ionic compound. For our purposes we will call all masses for compounds molecular masses.

Here are some examples to try

Sodium Chloride
Calcium Carbonate
Sodium Sulfate
$C_7H_{14}O_2$

Once you have the molecular mass calculated you can do gram to mole and mole to gram conversions just as if you were dealing with a single element.

Be a bit careful when converting from moles to number of items, you are no longer getting number of atoms, but number of molecules. If you want true number of atoms it would require additional calculations taking into account the numbers of each atom present in each molecule. Not impossible, just time consuming. We will do one as an example in class.

Section 8.5- Percent Composition

It is often necessary to understand a compound's composition from a mass standpoint.

This is obtained by comparing the mass contributed by one component element to the mass of the entire compound.

This calculation is known as mass percent or percent composition by mass.

The calculation is performed using the following equation:

Mass Percent = (mass of one element present in one mole of the compound /the mass of one mole of the compound) x 100%

Example:

Ethanol C_2H_6O

First calculate the molecular (molar) mass of the compound

Carbon= 12.01 x 2 = 24.02

Hydrogen= 1.008 x 6 = 6.048

Oxygen= 16.00 x 1 = 16.00

Molecular mass of Ethanol= 24.02 + 6.048 + 16.00 = 46.07

Mass Percent of Carbon in Ethanol = (24.02 / 46.07)x100%= 52.14% carbon

Mass Percent of Hydrogen in Ethanol = (6.048 / 46.07)x100%= 13.13% hydrogen

Mass Percent of Oxygen in Ethanol = (16.00 / 46.07)x100%= 34.73% oxygen

Sum of Mass Percents of all components should add to 100% will some tolerance due to rounding. 52.14 + 13.13 + 34.73 = 100

This is a good way to check your work!!!

Try $C_{10}H_{14}O$ on your own. Remember start by calculating the molecular mass!

Section 8.6, 8.7 and 8.8

Different types of Chemical Formulas

Molecular Formulas- show the actual composition of the compound
** these are the ones we have been working with so far.

Empirical Formulas- express the smallest whole number ratio of elements (atoms) present in the compound, simplest formula, shows the relative numbers of atoms present in the compound, ratio of atoms

Example of Empirical Formula vs. Molecular formula

CH_2O = empirical formula for the following Molecular formulas- $C_2H_4O_2$, $C_3H_6O_3$, $C_4H_8O_4$, $C_5H_{10}O_5$, $C_6H_{12}O_6$, etc.

All of the above molecular formulas have the same empirical formula, the same whole number ratio of 1:2:1, Carbon: Hydrogen: Oxygen

To determine an empirical formula from a molecular formula look for a number that all subscripts can be divided by and still have whole numbers for all subscripts.

How to Calculate Empirical Formulas

There are 2 ways to calculate empirical formulas

1. From relative masses of elements present in a sample
2. From % composition by mass

Calculating Empirical Formulas from the Relative Masses of Elements Present

Remember that an empirical formula is the relative number of atoms present, so we must start by converting grams to relative numbers of atoms.

1. Convert grams to moles for each element in you compound, you can stop at moles, no need to convert to atoms, because we know 1 mole equals 6.022×10^{23} atoms, and for relative numbers we might at well keep the numbers smaller.

2. Next divide by the smallest number of moles to convert all moles relative to the smallest one, smallest number of moles should end up with a relative number of one, all others should be more than one. (remember the bean lab)

3. If all numbers are whole, STOP, these are the subscripts in your empirical formula.
4. If all numbers are not whole, you need to multiply all by the smallest whole number that will give you all whole numbers and the new set of numbers are the subscripts for you empirical formula.

It does not matter how many elements make up your compound, just make certain you calculate for all elements present.

Examples: 0.2636 g Ni and 0.0718 g O,
1.3813 g Pb, 0.00672 g H, 0.4995 g As, 0.4267 g O

Calculating Empirical Formulas from the % Composition

Same process, you just add a step on to the beginning.

If you are given % composition by mass, Step One is to assume 100 grams and convert the percentages to grams.

The 100 gram assumption is for ease of calculation. It would work no matter what gram assumption you made, but why make it more difficult.

Example: 5% by mass of 100 grams = 5 grams

After calculating the masses from % by assuming 100 grams, follow the procedure from above to calculate you empirical formula.

Calculating Molecular Formulas from Empirical Formulas

In order to calculate molecular formulas from empirical formulas you must know the molecular mass of the compound.

We do this by comparing the mass of the empirical formula to that of the molecular mass.

Remember that an empirical formula is just the basic ratio for the molecular formula which means that they are related by the formula:

Molecular Formula = (Empirical Formula) x (n), where n represents the number of empirical formulas in the molecular formula

Example: $C_6H_{12}O_6$ = CH_2O x 6

Since the molecular and empirical formulas are related in this way, so are their respective masses.

Molecular Mass = Mass of Empirical Formula x n, which can be rearranged algebraically to be Molecular Mass/ Mass of Empirical Formula = n

Once n is determined it can be used to convert the empirical formula to the molecular formula.

Multiply all subscripts in empirical formula by n to get molecular formula

Empirical formula = CH_2O , n = 6, Molecular Formula = $C_6H_{12}O_6$

It is possible for n = 1, therefore your empirical and molecular formulas would be the same.

Examples

Empirical formula = P_2O_5 , molecular mass= 141.94 g

71.65% Cl, 24.27% C, 4.07%H, molecular mass= 98.96 g