**Chapter 7: Quantitative Composition of Compounds** Name: _____

## 7.1: The Mole

The mass of a single atom ($1.673 \times 10^{-24}$ grams) is far too small to measure on a laboratory balance.
Chemists need a unit to count the number of atoms in a sample...and so the MOLE is born!

The mole is a unit for counting atoms just as the following examples are used as units for measuring:

| | |
|---|---|
| 1 dozen = 12 objects | ex: 1 dozen eggs is 12 eggs |
| 1 ream = 500 objects | ex: 1 ream of paper is 500 sheets of paper |
| 1 mole = $6.022 \times 10^{23}$ objects | ex: 1 mole of iron atoms is $6.022 \times 10^{23}$ atoms of iron |

**Avogadro's Number** =

1 mole of atoms = _____ atoms and 1 mole of molecules = _____ molecules

Define **Molar Mass:**

The unit for a molar mass is: _____

**Ex**: What is the molar mass of Iron?

## 7.2: Molar Mass of Compounds

If the formula of a compound is known, its molar mass can be determined by adding the molar masses of all the atoms in the formula. If more than 1 atom of any element is present in the compound, its mass must be added as many times as it appears.

**Example Problems:**
1.) What is the molar mass of sodium chloride?

2.) What is the molar mass of calcium sulfate?

## Mass → Mole → Atoms/Molecule Conversions

### I. Mass → Mole Conversions:

**Example Problems:**
1.) How many moles of iron are in 25.0 g of iron?

2.) How many moles of calcium chloride are there in 275 g of calcium chloride?

### II. Mole → Mass Conversions:

**Example Problems:**
1.) What is the mass of 0.365 mol of tin?

2.) What is the mass of 1.25 mol of water?

**III. Mole → Atom/Molecule Conversions:**

**Example Problems:**
1.) How many atoms of lithium are contained in 0.160 mol of lithium?

2.) How many molecules of potassium sulfate are contained in 2.15 mol of potassium sulfate?

**IV. Mass → Atom/Molecule Conversions:**

**Example Problems:**
1.) How many iron atoms are contained in 25.0 g of iron?

2a.) How many molecules of hydrochloric acid are there in 16.5 g of hydrochloric acid?

2b.) How many hydrogen atoms are in the quantity from 2a?

2c.) How many chlorine atoms?

3.) What is the mass of one atom of magnesium?

4.) What is the mass of $4.5 \times 10^{22}$ molecules of magnesium oxide?

**In dealing with the **7 diatomic elements**, distinguish between one mole of atoms and one mole of molecules.

1.) 56.04 g of $N_2$ contains how many $N_2$ molecules?

2.) 56.04 g of $N_2$ contains how many individual nitrogen atoms?

## 7.3: Percent Composition of Compounds

Define the **Percent Composition** of a compound:

**Steps to determine the Percent Composition from the CHEMICAL FORMULA:**

1. Calculate the total molar mass of the compound
2. Divide the total mass of each element in the formula by the molar mass and multiply by 100.

***How do you perform a check of your answer?:**

**Example Problems:**

1.) What is the percent composition of sodium fluoride?

2.) What is the percent composition of lithium nitrate?

**Steps to determine the Percent Composition from EXPERIMENTAL DATA:**

1. Calculate the total mass of the compound formed
2. Divide the total mass of each element by the total mass of the compound and multiply by 100.

**Example Problem:**

1.) Zinc oxide is a compound with many uses from preventing sunburn to a pigment in white paint. When heated in air, 1.63g of zinc combines with 0.40 g of oxygen to form zinc oxide. Calculate the percent composition of the compound formed.

## 7.4: Empirical Formula versus Molecular Formula

Define the following terms:

- **Empirical Formula:**

  Example:

- **Molecular Formula:**

  Example:

**Two compounds can have the same empirical formula and different molecular formulas.

**Ex:** molecular formula = $C_2H_2$ = "acetylene" molecular formula = $C_6H_6$ = "benzene"
empirical formula = _____ empirical formula = _____

## 7.5: Calculating Empirical Formulas

**Steps for calculating the empirical formula of a compound:**

1. If not given, assume a definite starting quantity **(100.0 g)** of the compound and express the mass of each element in grams.

2. Convert grams of each element into moles using each element's molar mass. This will give the number of moles of atoms of each element in the quantity assumed in Step 1. These numbers will not be whole numbers.

3. Divide each number of moles from Step 2 by **the smallest value of moles listed**. If the numbers obtained are whole numbers, use them as subscripts and write the empirical formula. If the numbers obtained are not whole numbers, continue to Step 4.

4. Multiply the values obtained in Step 3 by the smallest number that will convert them to whole numbers. Then, use these whole numbers as the subscripts in the empirical formula. For example, if the ratio of A to B is 1.0 to 1.5, multiply both numbers by 2 to obtain a ratio of 2 to 3. The empirical formula would then be $A_2B_3$.

**Example Problems:**
1.) Calculate the empirical formula of a compound containing 11.19% hydrogen (H) and 88.79% oxygen (O).

2.) The analysis of a salt shows that it contains 56.58% potassium (K); 8.68% carbon (C); and 34.73% oxygen (O). Calculate the empirical formula for this substance.

## 7.6: Calculating the Molecular Formula from the Empirical Formula

If the molar mass of the compound is known, the molecular formula can be calculated from the empirical formula. The molecular formula will be equal either to the empirical formula or some multiple of it.

**n = _____ =**

**Ex:** If the empirical formula of a compound of calcium and oxygen is CaO, the molecular formula can be expressed as $(CaO)_n$, where n = 1, 2, 3, … and this n means that the molecular formula could be CaO, $Ca_2O_2$, $Ca_3O_3$, and so on.

**Example Problems:**
1.) A compound of nitrogen and oxygen with a molar mass of 92.00 g/mol was found to have an empirical formula of $NO_2$. What is its molecular formula?

2.) Fructose is a very sweet natural sugar that is present in honey, fruits, and fruit juices. It has a molar mass of 180.1 g/mol and a composition of 40.0% C, 6.7% H, and 53.3% O. Calculate the molecular formula of fructose.