Focus

- Calculations with Molecular and molar masses
- Calculations of Percent Compositions
- Determination of Empirical Formula
- Determination of Water of crystallization

Atoms, Molecules and The Mole

1 dozen atoms = 12 Atoms
1 dozen molecules = 12 molecules
1 mole Atoms = 6.022 x 10^{23} Atoms
1 mole molecules = 6.022 x 10^{23} Molecules

Particles in a Mole

Avogadro’s Number

1 mole = 6.0221367 x 10^{23} particles

Named in honor of Amedeo Avogadro 1776-1856

There is Avogadro’s number of particles in a mole of any substance.
Molar Mass of elements

1 mol of Al atoms = 6.022 x 10^{23} atoms of Al
Mass of 1 mole of Al atoms = 26.9815 g/mol

Find molar mass from periodic table

<table>
<thead>
<tr>
<th>Atomic Number</th>
<th>Symbol</th>
<th>Atomic Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Al</td>
<td>26.9815</td>
</tr>
</tbody>
</table>

MOLECULAR WEIGHT AND MOLAR MASS

Molecular weight is the sum of the atomic weights of all atoms in the molecule.

What is the molar mass of ethanol, C_{2}H_{6}O?
Tylenol
What is the molar mass of Tylenol?

- Formula = C₈H₉NO₂

How many moles of alcohol are there in a “standard” can of beer if there are 21.3 g of C₂H₆O?

How many moles of alcohol are there in a “standard” can of beer if there are 21.3 g of C₂H₆O?
How many molecules of alcohol are there in a “standard” can of beer if there are 21.3 g of C₂H₆O?

How many molecules of alcohol are there in a “standard” can of beer if there are 21.3 g of C₂H₆O?

How many atoms of C are there in a “standard” can of beer if there are 21.3 g of C₂H₆O?
How many atoms of C are there in a “standard” can of beer if there are 21.3 g of C₂H₆O?

Device for Remembering How to Do Mass/Mole Calculations

An Alternative Device for Molar Mass Calculations

- Use molar mass (mol/g)
- Use Avogadro's Number (Molecules/mol)
- Use Avogadro's Number (Atoms/molecule)
- No. of Atoms of a particular element per molecule

Mass, (g) → Moles (mol) → Molecules → Molecules
**Percent Composition**

Law of constant composition:
A pure compound always consists of the same elements combined in the same proportions by weight.
Therefore, we can express molecular composition as PERCENT BY WEIGHT

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**Example:**
Calculate the percent composition of each element in ethanol (C₂H₅O)

**Answer:**
1. First calculate the mass contributed by each element to the molecule and hence the molar mass of the molecule

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**Example:**
Calculate the percent composition of each element in ethanol (C₂H₅O)

**Answer:**
2. Next calculate the percent composition of each element in the molecule
Consider NO₂, Molar mass = ?
What is the weight percent of N and of O?

Determining Formulas

In chemical analysis we determine the % by weight of each element in a given amount of pure compound and derive the EMPIRICAL or SIMPLEST formula.
Determining Formulas

Determining Empirical Formula From Percent Composition

PROBLEM: A compound of B and H is 81.10% B. What is its empirical formula?

ANS:

Step 1:
Calculate the percent composition of other elements in the compound if not given:

Step 2:
Convert weight percent of each element to mass by assuming 100g of the compound.

Step 3:
Convert mass of each element to moles.
Determining Empirical Formula From Percent Composition

PROBLEM: A compound of B and H is 81.10% B. What is its empirical formula?

ANS:

Step 4:
Now, recognize that atoms combine in the ratio of small whole numbers. Find the mole ratio of elements.
Determination of Molecular formula From Empirical Formula

Problem:
If the empirical formula of a compound was found to be $B_2H_5$ and its molar mass is 53.3 g/mol, what is the molecular formula of the compound?

Ans:
Step 1
Calculate the mass of one unit of the empirical formula

Determination of Molecular formula From Empirical Formula

Problem:
If the empirical formula of a compound was found to be $B_2H_5$ and its molar mass is 53.3 g/mol, what is the molecular formula of the compound?

Ans:
Step 2
Find the ratio of these masses

Determination of Empirical Formula From Mass Data

Example:
Excess tin metal was reacted with iodine to form a tin iodide compound of an unknown formula $Sn_xI_y$. The following data was obtained from the experiment:

• Mass of Sn in the beginning = 1.056 g
• Mass of iodine (I$_2$) used = 1.947 g
• Mass of Sn remaining unreacted = 0.601 g
Determine the formula of the tin compound.
Tin and Iodine Compound

Find the mass of Sn that combined with 1.947 g I₂.

Mass of Sn initially = 1.056 g
Mass of Sn recovered = 0.601 g
Mass of Sn used =
Find moles of Sn used:

Tin and Iodine Compound

Now find the number of moles of I₂ that combined with 3.83 x 10⁻³ mol Sn. Mass of I₂ used was 1.947 g.

Tin and Iodine Compound

Now find the ratio of number of moles of moles of I and Sn that combined.
Tin and Iodine Compound

Now find the ratio of number of moles of moles of I and Sn that combined.

Hydrated Compounds:
Determining Formula of Hydrated Compounds

See Lab # 2