Ch 100: Fundamentals for Chemistry

Ch 7: Quantitative Composition of Compounds
Lecture Notes
(Sections 7.1 to 7.3)

The Mole

- The mole is a counting unit (analogous to the dozen unit)
  - A large unit used to describe large quantities such as number of atoms

$$1 \text{ mole} = 6.022 \times 10^{23} \text{ units}$$

- 6.022×10^{23} is known as Avogadro's number (N_A)
- Relationship between the mole & the Periodic Table
  - The atomic mass is the quantity (in grams) of 1 mole of that element
  - The units of atomic mass are grams/mole
  - Mass is used by chemists as a way of "counting" number of atoms/molecules of a substance
- Mole calculations

Got mole problems?

Call Avogadro at 602-1023.

What do you get if you have Avogadro's number of donkeys?

Answer: molasses (a mole of asses)

Molar Mass

- Molar mass is the mass in grams of 1 mole of a substance
- Molar mass refers to both atoms & molecules

1. Elements (atoms)

   Examples:

   1 mole of Na has a mass of 22.99 g

   1 mole of Cl has a mass of 35.45

   1 mole of Cl_2 has a mass of 70.90 g

2. Compounds (molecules)

   Examples:

   1 mole of NaCl has a mass of 58.44 g
   - Mass of Na (22.99 g) + Mass of Cl (35.45 g)

   1 mole of CO_2 has a mass of 44.01 g
   - Mass of C (12.01 g) + 2 x Mass of O (16.00 g)

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Mole Calculations

1. To convert from atoms (or molecules) to moles, divide the # of atoms (or molecules) by Avogadro's #

Example: How many moles are 1.0×10^{24} atoms?

$$(1.0\times10^{24}\text{atoms})\left(\frac{1\text{ mol}}{6.022\times10^{23}}\right)= 1.7\text{ mol}$$

2. To convert from moles to atoms (or molecules), multiply the # of atoms (or molecules) by Avogadro's #

Example: How many molecules are in 2.5 moles?

$$(2.5\text{ mol})\left(\frac{6.022\times10^{23}}{1\text{ mol}}\right)=1.5\times10^{24}\text{ molecules}$$

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Mole-Mass Calculations

1. To convert from moles to grams, multiply the # of moles by atomic mass

Example: How many grams in 2.5 moles of carbon?

$$(2.5\text{ mol})\left(\frac{12.01\text{ g}}{1\text{ mol}}\right) = 30.\text{ g (or } 3\times10^{1})$$

2. To convert from grams to moles, divide the mass in grams by atomic mass

Example: How many moles are in 2.5 g of lithium?

$$(2.5\text{ g})\left(\frac{1\text{ mol}}{6.941\text{ g}}\right) = 0.36\text{ mol (or } 3.6\times10^{1})$$

Percent Composition

- Percent composition is the percentage of each element in a compound (by mass)
- Percent composition can be determined from either:
  1. the formula of the compound
  2. the experimental mass analysis of the compound

$$\%\ \text{Composition} = \left(\frac{\text{part}}{\text{whole}}\right) \times 100\%$$

Note: *The percentages may not always total to 100% due to rounding*

Percent Composition Calculations

To determine % Composition from the chemical formula:

1. Determine the molar mass of compound
2. Multiply the molar mass of the element of interest by the number of atoms per molecule then
3. Divide this value by the molar mass of the compound

$$\%\ \text{Composition of A} = \left(\frac{(\#\ \text{atoms of A})(\text{atomic mass of A})}{\text{molar mass of compound}}\right) \times 100\%$$

Example: The % Composition of sodium in table salt

1. The molar mass of NaCl is 58.44 g/mol
2. There is 1 atom of Na in each NaCl molecule
3. The atomic mass of Na is 22.99

$$\%\ \text{Composition of Na} = \left(\frac{1 \times 22.99}{58.44}\right) \times 100\% = 39.33\%$$

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Percent Composition Calculations

Perform the following % Composition calculations:

1. The % composition of carbon in carbon monoxide

2. The % composition of oxygen in water

3. The % composition of chlorine in sodium hypochlorite

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Amadeo Avogadro

(1743-1794)

- Italian lawyer turned chemist
- Major contributions included:
  1. Established difference between atoms & molecules:
     - Oxygen & nitrogen exist as molecules O_2 & N_2
  2. Reconciled the work of Dalton & Guy-Lussac
  3. Establishing Avogadro's Principle: *equal volumes of all gases at the same temperature and pressure contain the same number of molecules.*
- Note: Avogadro did not determine Avogadro's number nor the mole (these concepts came later)
  1. Avogadro is honored because the molar volume of all gases should be the same
  2. Much of Avogadro's work was acknowledged after he died, by Stanislao Cannizarro