

CHAPTER 7

Chemical Quantities

How do we measure matter?

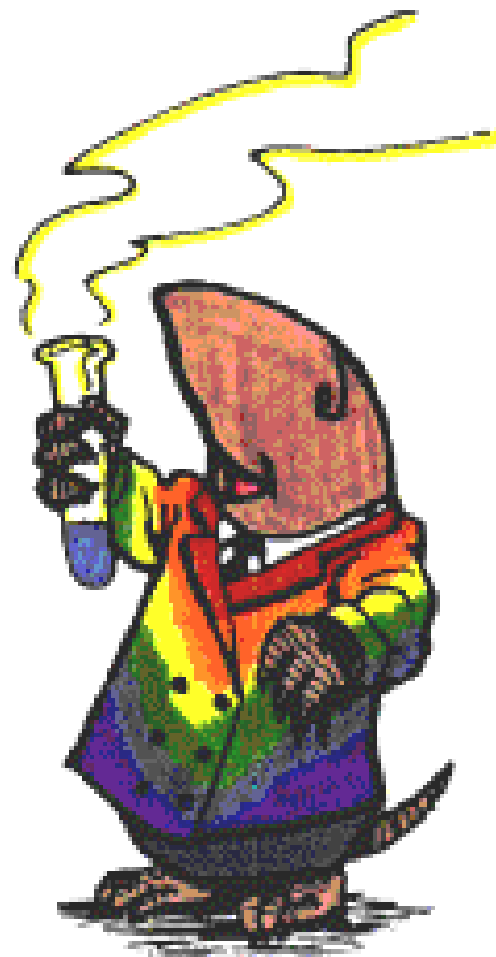
- Counting
- Weight (Mass)
- Volume

Chemical Quantities

Mole: the SI unit that measures the amount of a substance

It can be related to:

- The number of particles
- Mass
- Volume



So What is a Mole?

A mole (mol) of a substance represents:

6.02×10^{23} representative particles of a substance and is called *Avogadro's* number

Avogadro's number

Named in honor of
Amedeo Avogadro
di Quaregna
(1776-1856)



Avogadro:

He proposed:

- Equal volumes of different gases at the same temperature and pressure, contain the same number of particles.

Representative Particle

Refers to the species present

- Atoms
- Molecules
- Formula units
- Ions

Representative Particles

Substance	Representative Particle	Chemical Formula	Particles in 1 mole
Pure carbon	Atom	C	6.02×10^{23}
Pure iron	Atom	Fe	6.02×10^{23}
Nitrogen gas	Molecule	N ₂	6.02×10^{23}
Water	Molecule	H ₂ O	6.02×10^{23}
Calcium ion	Ion	Ca ²⁺	6.02×10^{23}
Calcium fluoride	Formula Unit	CaF ₂	6.02×10^{23}
Sucrose	Molecule	C ₁₂ H ₂₂ O ₁₁	6.02×10^{23}

Atomic Mass Units

In previous chapters we expressed atomic mass in atomic mass units

- Atomic mass of atoms is relative
- Carbon is 12 times the size of Hydrogen
 - This still holds true when we express atomic mass in grams

Gram Atomic Mass (GAM)

Gram atomic mass is the atomic mass of an element expressed in grams

□ Example:

■ Carbon- atomic mass = 12.011

■ Gram atomic mass = 12.011 grams

Atomic mass & Avogadro's Number

12.01 grams of Carbon and 1.008 grams of Hydrogen contain the same number of atoms

- 6.022×10^{23} atoms
- The gram atomic mass of any two elements must contain the same number of atoms

Molar mass:



Molar mass is the mass in grams of one mole of a substance

- Molar mass can be the equivalent of:
 - gram atomic mass(gam),
 - gram molecular mass(gmm), or
 - gram formula mass(gfm).

It depends on what the substance is: is it an element, a molecular or ionic substance?

Molar Mass:



Gram molecular mass is the mass that contains 1 mole of a compound

- May be calculated from gram atomic masses
 - $GMM =$ the sum of the masses of the elements in a compound
 - $GMM =$ the molecular mass expressed in grams

Molar Mass

GMM example:

Calculate the molar mass of C_2H_6 (ethane)

$$2 \times C = 2 \times 12.01 = 24.02$$

$$6 \times H = 6 \times 1.008 = \underline{6.048}$$

$$30.068 = 30.07 \text{ g/mole}$$

Molar Mass

GFM = gram formula mass used for ionic compounds

- Ionic compounds = formula units
- GFM = the mass of one mole of an ionic compound
 - GFM is calculated the same way as a GMM
 - GFM = the sum of the atomic masses of the ions in the formula of the compound

Molar Mass

GFM example:

Calculate the formula mass of NaCl

$$1 \times \text{Na} = 1 \times 23.00$$

$$1 \times \text{Cl} = \underline{1 \times 35.45}$$

$$58.45 \text{ g/mole}$$

Molar Volume

The volume of mole of a gas is much more predictable than that of a liquid or solid

That is, under the same physical conditions (STP), a mole of any gas occupies a volume of 22.4 L

- Standard temperature and pressure
 - Standard Temperature is 0°C (273 K)
 - Standard Pressure is 1 atm (760 mm; 101.3 kPa)

Molar Volume

At STP, one mole of any gas will have a volume of 22.4 L

- ▣ 22.4 L is known as the **molar volume** of a gas

What does it mean?

- ▣ It means that 22.4 L of any gas at STP contains 6.02×10^{23} representative particles of that gas.

THE MOLE ROAD MAP

