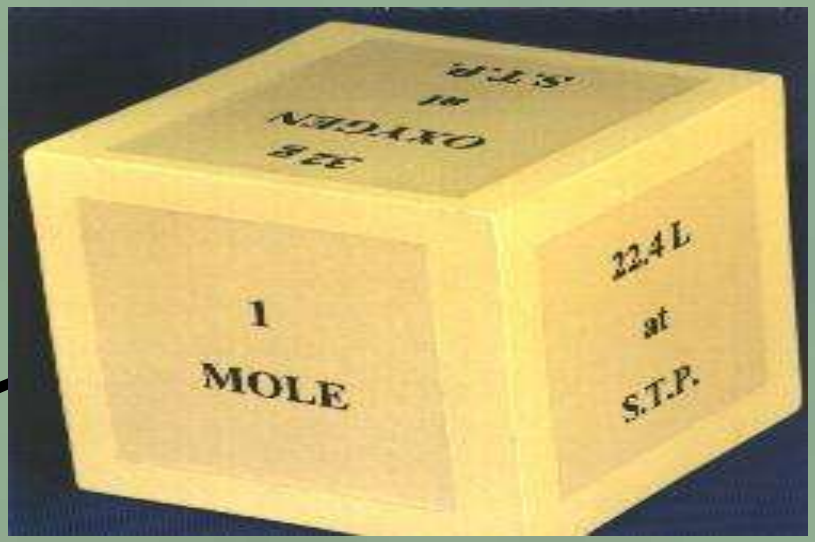
The Mole Concept



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•Introduction

- Everyone is familiar with the use of a word description of a definite number of items, for example a *dozen* doughnuts refers to 12 doughnuts.
- Likewise, a fraction of a *dozen* is easily recognized:

  one half dozen = (1/2)(12) = 12/2 or 6 doughnuts and *one fourth dozen* = (1/4)(12)= 12/4 or 3 doughnuts
- Finally, multiples of our quantity word are also easily recognized.
- If a *gross* is equivalent to *twelve* dozen, then a *gross* of doughnuts, pencils, firecrackers or anything else is: *(12)*(12) = 144 items.

What is Mole ?

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- A **MOLE** of any items is precisely defined as 602,213,367,000,000,000,000,000 items[1] or in exponential notation, 6.023 x 10^{23} items... six hundred billion trillion items!

- A **mole** is the amount of pure substance containing the same number of chemical units as there are atoms in exactly 12 grams of carbon-12 (i.e., 6.023 X 10^{23}).

- " Current usage tends to apply the term "mole" to an amount containing **Avogadro's number** of whatever units are being considered.

- Thus, it is possible to have a mole of atoms, ions, radicals, electrons. This usage makes unnecessary such terms as "gram-atom," "gram-formula weight," etc.

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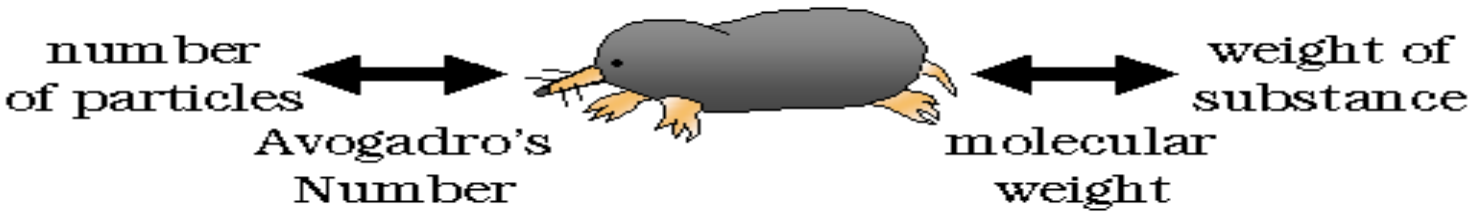
The Mole

- SI unit for amount of substance

1 mole = 6.02×10^{23} particles

1 mole = 1 gram-molecular weight

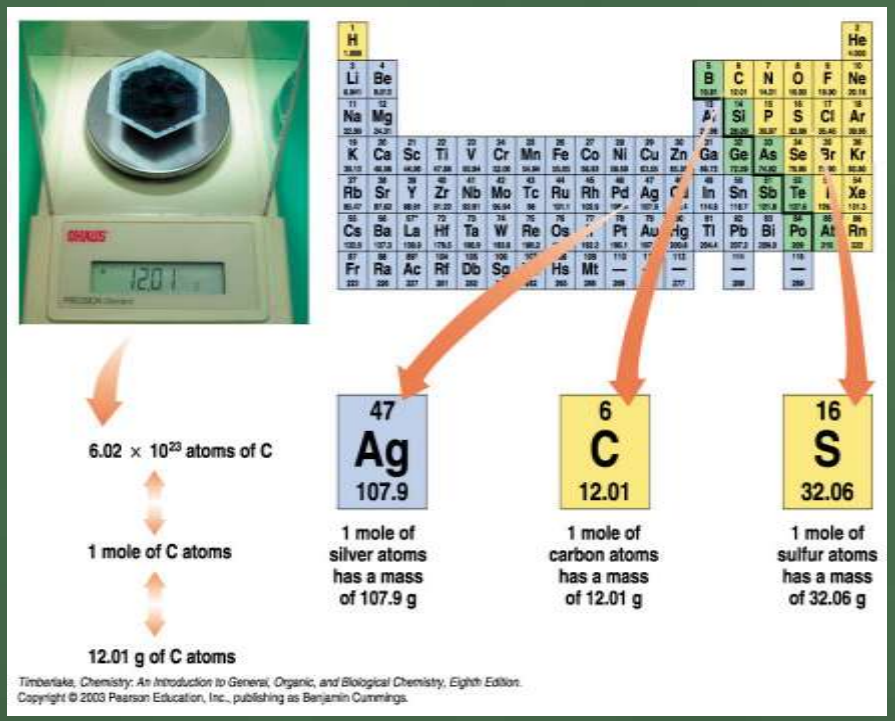


•Significance of the Mole

- The ***mole*** is the critical "Rosetta Stone" translator number that enables chemistry students to convert an atomic scale microscopic quantity, such as ***atomic mass units*** or amu, to a laboratory-measurable quantity,
- ***eg.- grams;*** the number below any element symbol on the periodic chart in grams is 6.023×10^{23} [**Avogadro's Number**] of that element.

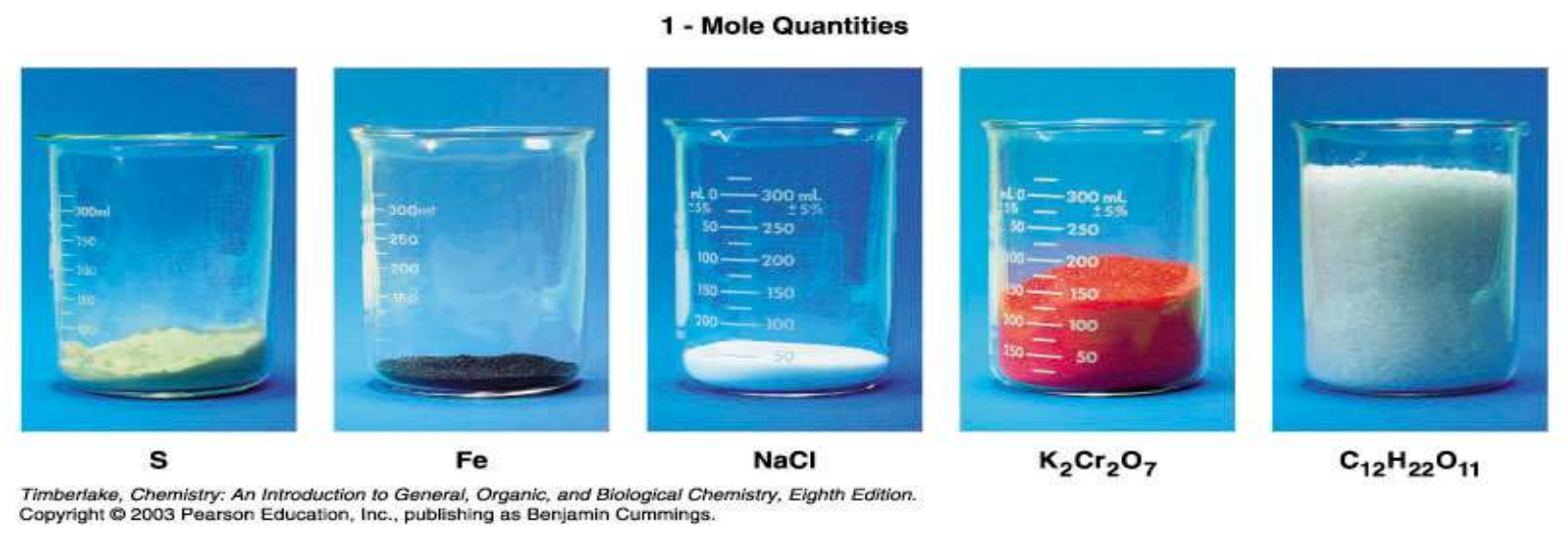
•Examples of Elemental Molar Masses: carbon, sulfur or silver

- For Example, carbon has an atomic mass of 12.01. If 12.01 grams of carbon, 107.9 g of silver or 32.06 g of sulfur were weighed out on a gram scale, those masses would be
- 6.023 x 10^{23} atoms of carbon, sulfur or Ag



What is Molecular Mass ?

•The Molar Mass of a Molecular Compound Equals the Sum of Its Atoms' Masses



Timberlake, Chemistry: An Introduction to General, Organic, and Biological Chemistry, Eighth Edition.

For Example :

- S = 32.1g Fe = 58.9 g NaCl = 23.0 + 35.5 = 58.5g
- $K_2Cr_2O_7$ = 2(39.0)+2(52.0)+7(16.0) = 294g
- $C_{12}H_{22}O_{11}$ = 12(12.0)+22(1.00)+11(16.0) = 342g

Conversions Using The Mole.

Converting Mass To Moles.

General Equation:

$$\text{No. of Moles} = \frac{\text{Given mass (g) of elements or compound}}{\text{Mass of 1 mole (g mol}^{-1}\text{) of element or compound (molar mass)}}$$

Converting Moles To Mass.

General Equation:

Mass of a compound = The mass of 1 mole x number of moles

•Fractions and Multiples of Moles Related to Molar Mass and Avogadro's Number

- 1/4 or 0.25 of a mole of potassium dichromate = (0.25)(294g) = 73.5g of $K_2Cr_2O_7$ which represents the same fraction of Avogadro's number of the salt
- $0.25(6.02 \times 10^{23}) = 1.505 \times 10^{23}$ formula units of potassium dichromate, $K_2Cr_2O_7$
- Likewise, two moles of sucrose($C_{12}H_{22}O_{11}$ is 2(342g) = 684g and represents 12.04×10^{23} molecules of sucrose.

Q. Calculate the number of moles in 6 g of Na.

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Solution :

23 g Na contains 1 mole of sodium atom

1 g Na contains $\frac{1 \text{ mole}}{23 \text{ g Na}}$

6 g Na contains $\frac{1 \text{ mole}}{23 \text{ g Na}} * 6\text{g}$

= 0.261 moles

- **Q. How many moles are there in 45 g of nitrogen.**

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Solution:

14 g N contains 1 mole of N atom

1 g contains $\frac{1 \text{ mole}}{14 \text{ g N}}$

45 g contains $\frac{1 \text{ mole}}{14 \text{ g N}} * 45 \text{ g}$

= 3.12 moles

Q. Calculate the mass of 0.34 moles of sodium chloride.

Solution:

Step 1

RMM of NaCl = 23 + 35.5

= 58.5 g mol^{-1}

Step 2

1 mol NaCl contains 58.5 g mol^{-1}

0.34 moles contains 58.5 g mol^{-1} * 0.34 moles

1mole

= 19.89 g

Mole - Mass Relationships of Elements

Element	Atomic Mass	Molar Mass	Number of Atoms
1 atom of H = **1.008 amu**		1 mole of H = **1.008 g**	= 6.022×10^{23} atoms
1 atom of Fe = **55.85 amu**		1 mole of Fe = **55.85 g**	= 6.022×10^{23} atoms
1 atom of S = **32.07 amu**		1 mole of S = **32.07 g**	= 6.022×10^{23} atoms
1 atom of O = **16.00 amu**		1 mole of O = **16.00 g**	= 6.022×10^{23} atoms

Molecular mass:

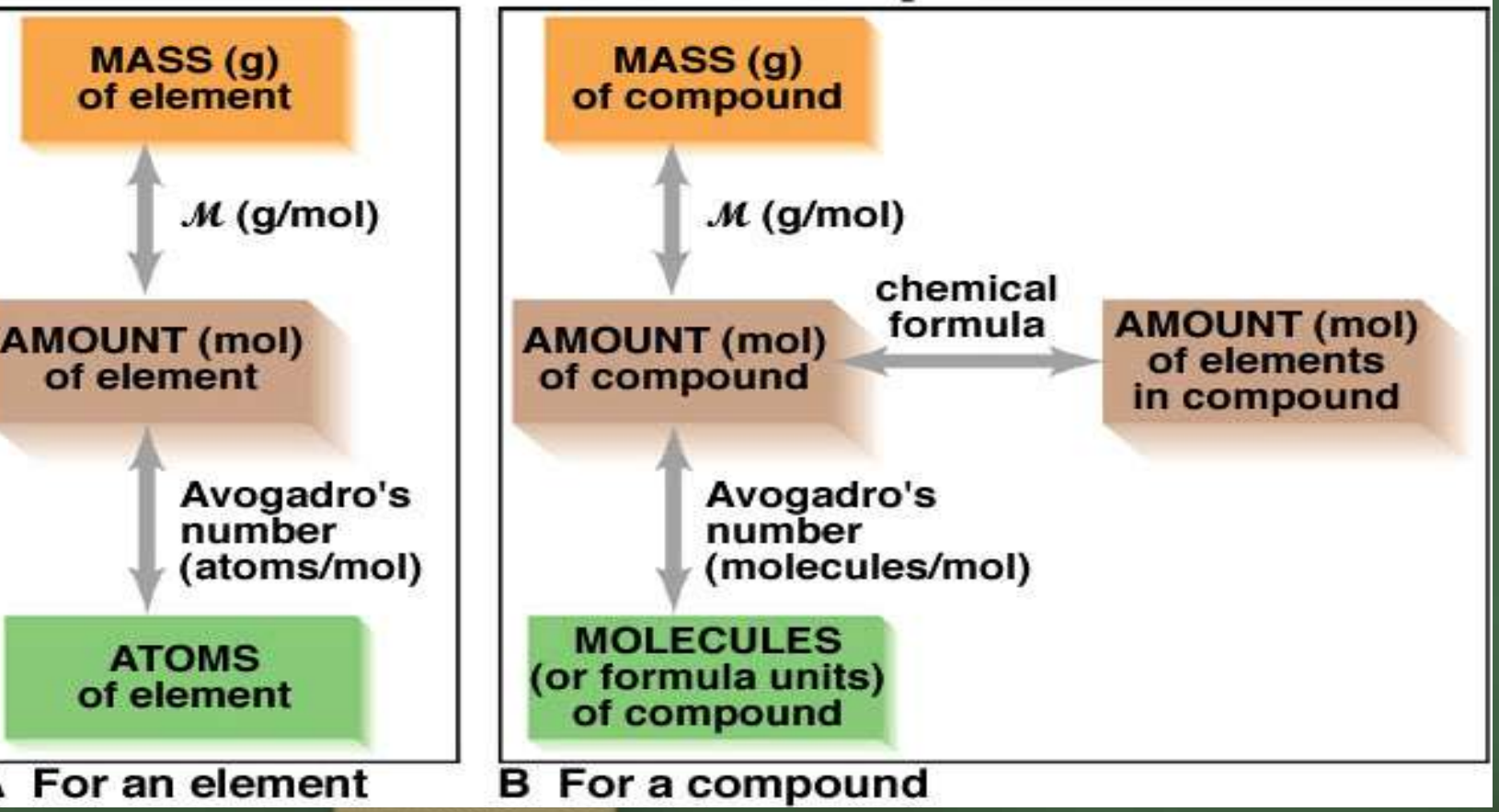
1 molecule of O_2 = 16.00 x 2 = **32.00 amu**

1 mole of O_2 = **32.00 g** = 6.022 x 10^{23} molecule

1 molecule of S_8 = 32.07 x 8 = **256.56 amu**

1 mole of S_8 = **256.56 g** = 6.022 x 10^{23}molecules

Summary of the Mass-Mole-Number Relationships



A For an element B For a compound

•Molar Volume

The volume of one mole of a gas at STP (0°C and 1 atm) is 22.4 L. This gives another way to determine numbers of moles for a gas.