CHEMICAL QUANTITIES

Chapter 10

What is a mole?

- A unit of measurement in chemistry
- 1 mole of a substance = 6.02×10^{23} (Avagadro's number) representative particles of a substance
  - **Representative particle** – atoms, molecules (nonmetals), formula units (metal-nonmetal), ions.

Moles  Particles

- How many atoms are there in 0.360 moles of silver?
- How many moles of magnesium is 1.25×10^{23} atoms of magnesium?
- How many molecules are in 2.0 moles of chlorine gas?
- How many moles are in 3.7×10^{25} formula units of KCl?
- How many moles are contained in 4.65×10^{24} molecules of NO_2?

Moles  Volume

- Standard temperature & pressure (STP)
  - Temperature of 0°C
  - Pressure of 101.3 kPa or 1 atmosphere (atm)

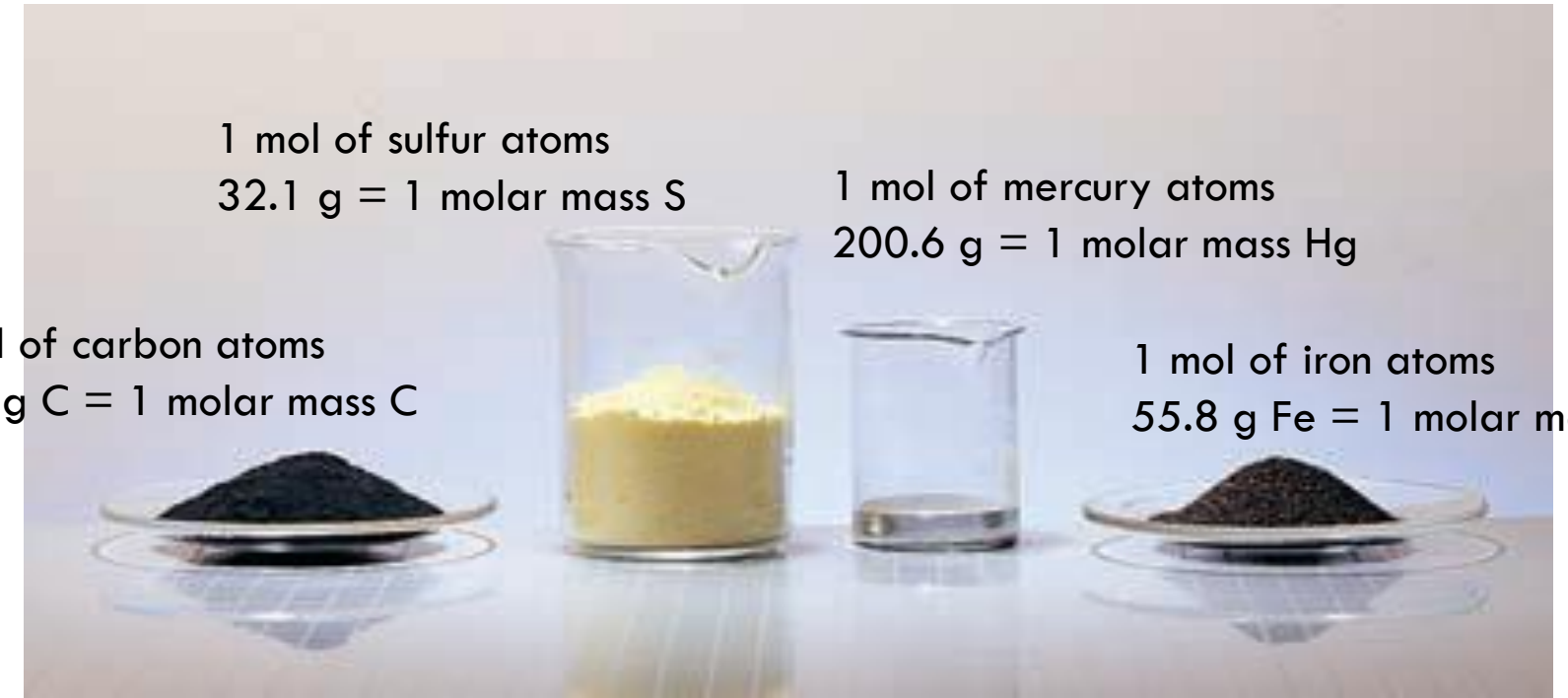
- At STP, 1 mole or 6.02×10^{23} rep. particles of any gas occupies a volume of 22.4 L.

Moles  Volume

- Determine the volume, in liters, of 0.60 mol SO_2 gas at STP.
- 75 L of N_2 gas is how many moles?
- Determine the number of moles in 33.6 L of helium gas.
- What is the volume of 3.20×10^{-3} mol CO_2 gas at STP?
- What volume, in liters, is 2.5 moles of CO_2 at STP?

Formula Mass (Molar Mass)

- The atomic mass (amu) of an element expressed in grams is the mass of a mole of the element.
- The molar mass of any element contains 1 mol or 6.02×10^{23} atoms of that element.



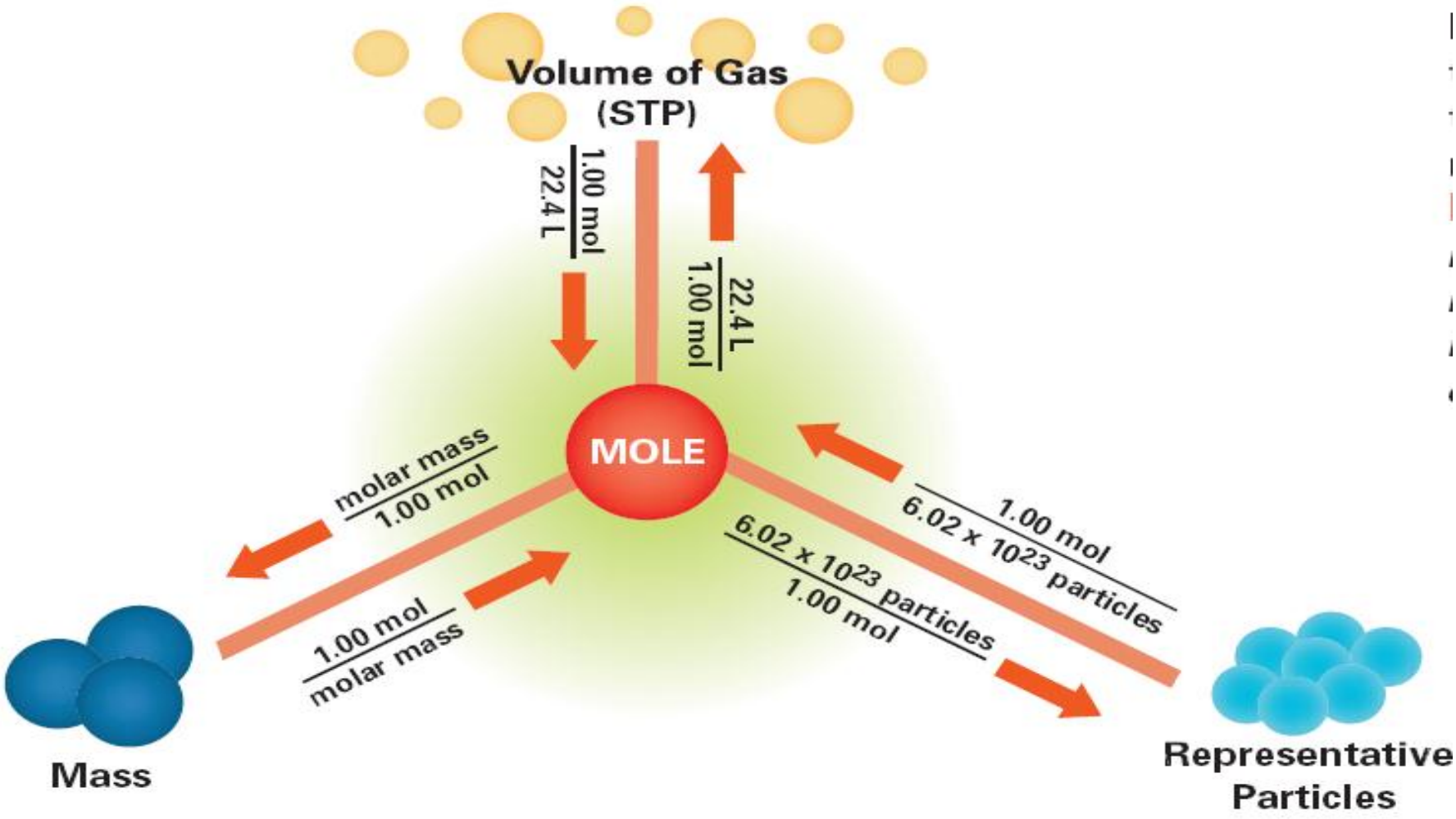
Formula Mass (Molar Mass)

- What is the molar mass of iron?
- Determine the molar mass of the following compounds:
  - Water
  - Carbon dioxide
  - Sodium bicarbonate
  - Calcium fluoride
  - Phosphorus trichloride
  - Calcium sulfate

Moles  Grams

- **Must know molar mass!**
- How many grams are in 7.20 mol of N_2O_3?
- How many moles is 28 grams of ammonium phosphate?
- What is the mass of 9.45 mol of aluminum oxide?
- How many moles of iron(III) oxide are contained in 92.2 g of pure iron(III) oxide?
- How many grams is 0.29 mol of K_2S?

The Mole Road Map



Practice

- Calculate the molar mass of:
  - Sodium sulfate
  - Zinc nitrate
- Convert the following:
  - 125 g H_2SO_4 to moles
  - 1.5×10^{20} molecules of F_2 to moles
  - A sample of NH_3 gas occupies 75.0 liters at standard conditions. How many molecules is this?
  - 0.987 moles of dinitrogen trioxide to grams.
  - 10.5 L of oxygen gas to grams.

Percent Composition

- The relative amounts (%) of each element in a compound.

$$\% \text{ Mass of Element E} = \frac{\text{mass of element E (g)}}{\text{molar mass of compound (g)}} \times 100$$

Percent Composition

- Calculate the mass % of each element in the following compounds:
  - C_3H_8
  - HCN
  - Barium phosphate

Percent Composition

- When a 13.60-g sample of a compound containing only magnesium and oxygen is decomposed, 5.40 g of oxygen is obtained. What is the percent composition of each element in this compound? *Think about the formula for magnesium oxide…*

- Calculate the percent nitrogen in these common fertilizers.
  - NH_3
  - NH_4NO_3

Empirical Formulas

- Give the lowest whole number ratio of the atoms (or moles of atoms) of the elements in a compound.

What is the empirical formula of a compound that is 25.9% N and 74.1 % O?

- Steps to find:

1) Convert mass % to grams.
   (pretend you have 100 grams)
2) Divide by molar mass to
   get moles.
3) Divide answers from step 2
   by smallest # of moles.
4) Multiply to get smallest
   whole #s. (if unnecessary, jump to step 5)
5) Write the empirical formula
   by putting answers to 3 or 4
   as subscripts.

Empirical Formula Memory Device

- % to Mass
- Mass to Mole
- Divide by small
- Multiply till whole

Empirical Formula Practice

- Determine the empirical formula for the following:
  - 94.1% O, 5.9% H
  - 79.9% C, 20.1% H
  - 67.6% Hg, 10.8% S, 21.6% O
  - 27.5% C, 1.15% H, 16.09% N, 55.17% O
  - 17.1% Na, 39.7% Cr, 42.7% O

Molecular Formulas

- Either the same as the empirical formula, or a simple whole-number multiple of the empirical formula.

Comparison of Empirical and Molecular Formulas

Formula (name)	Classification of formula	Molar mass
CH	Empirical	13
C_2H_2 (ethyne)	Molecular	26 (2 × 13)
C_6H_6 (benzene)	Molecular	78 (6 × 13)
CH_2O (methanal)	Empirical and Molecular	30
$C_2H_4O_2$ (ethanoic acid)	Molecular	60 (2 × 30)
$C_6H_{12}O_6$ (glucose)	Molecular	180 (6 × 30)

Calculate the molecular formula of a compound whose molar mass is 60.0 g/mol and empirical formula is CH_4N.

- Steps to find:
  1) Calculate/determine the empirical formula.
  2) Determine the molar mass of the empirical formula.
  3) Divide the molecular molar mass (usually given in the problem) given by the empirical molar mass.
  4) Multiply the empirical formula subscripts by the value determined in step 3.

Molecular Formula Practice

- Answer the following:
  - What is the empirical formula of an unknown compound that has the percent composition as follows:
    - 47.0 % potassium
    - 14.5 % carbon
    - 38.5 % oxygen
  - If the true molar mass of the above compound is 166.22 g/mol, what is its molecular formula?
  - A compound with an empirical formula of C_2OH_4 has a molar mass of 88 grams per mole. What is the molecular formula of this compound?

Chapter 10 Practice

- Convert the following:
  - 2.0 x 10^{23} molecules of oxygen gas to liters of gas at STP.
  - 1.45 grams of calcium nitrate to formula units.
- Calculate the percent nitrogen in NH_4NO_3, a common fertilizer.
- Determine the empirical formula for the following:
  - 67.6% Hg, 10.8% S, 21.6% O
- The empirical formula of adipic acid is $H_5C_3O_2$. What is the molecular formula if the molecular mass is 146 g/mol?