Chem 30A

Ch 6. Chemical Composition

The Mole

The Mole

- In laboratories, large numbers of atoms are used for experiments, so scientists made up a unit to avoid using very large numbers: mole (mol)

- The mole is a unit of measure:

  1 dozen = 12

  1 gross = 144

  1 mole = 6.02214×10^{23}

  Avogadro's number (N_A)

1 dozen eggs = 12 eggs

1 mole eggs = 6.02214×10^{23} eggs → huge number!

The Mole

The mole is useful for counting atoms, molecules, and ions.

- 1 mol of ^{12}C atoms = 6.022×10^{23} ^{12}C atoms
- 1 mol of H_2O molecules = 6.022×10^{23} H_2O molecules
- 1 mol of NO_3^- ions = 6.022×10^{23} NO_3^- ions

Converting Between Moles and # of Particles

6.022×10^{23} particles/mol

moles  number of particles

(Can be atoms, ions, or molecules)

Ex Probs

Where Did Avogadro's Number Come From?

- It was measured!
- The value of the mole (Avogadro's number, N_A) is based on ^{12}C standard:

N_A = the number of atoms in exactly 12 g of ^{12}C

$= 6.02214 \times 10^{23}$

So by definition: 1 mol of ^{12}C atoms has a mass of 12 g.

Relationship Between amu/atom and g/mole

- By defn: 1 atom of ^{12}C has a mass of 12 amu.
- By defn: 1 mole of ^{12}C has a mass of 12 g.

- So, mass of ^{12}C =

$$12\ \frac{\text{amu}}{\text{atom}} \quad \text{and} \quad 12\ \frac{\text{g}}{\text{mol}}$$

atomic mass molar mass

- Molar mass: the mass of one mole of a substance [g/mol]

Relationship Between Atomic Mass and Molar Mass

$$\mathbf{1}\ \frac{\text{amu}}{\text{atom}} = 1\ \frac{\text{g}}{\text{mol}}$$

atomic mass [amu] = # molar mass [g]

Because the atomic masses of all other elements are relative to atomic mass of ^{12}C, this relationship between atomic mass and molar mass is true for every element.

Atomic Mass [amu] = Molar Mass [g]

Substance	Atomic Mass	Molar Mass
C	12.01 amu/atom	12.01 g/mol
Mg	24.30 amu/atom	24.30 g/mol
O	16.00 amu/atom	16.00 g/mol
Ag	107.87 amu/atom	107.87 g/mol
He	4.00 amu/atom	4.00 g/mol

Now we know the molar mass of an atom by looking at the periodic table!

Similarly, for molecules:
formula mass [amu] = molar mass [g]

Ex Probs

Converting Between Moles and Mass

We can use the molar mass (g/mol) to convert between the moles of particles and the mass (in g) of a substance:

molar mass
(g/mol)

grams of sample ⟷ moles of sample

Ex Probs

Grams-Moles-Number of Particles Conversions

molar mass [g/mol]

6.02×10^{23} particles/mol

grams  moles  No. of particles

Ex Probs

Amounts of an Element in a Compound

Chemical Formulas as Conversion Factors

- Find moles element in given moles of compound.
  - How many moles of carbon are in 0.245 mole of $C_6H_{12}O_6$?

- Find grams of element in given grams of compound.
  - How many grams of carbon are in 1.50 g of $C_6H_{12}O_6$?

*Must go through mole relationship: $\frac{\text{mol of element}}{\text{mol of compound}}$

Ex Probs

Mass Percent Composition of Compounds

Mass Percent Composition

- Mass fraction of an element in a compound =

$$\frac{\text{mass of an element}}{\text{mass of compound}} \quad \text{in a sample of compound}$$

- Mass percent = mass fraction x 100

- Mass percent of an element in a compound =

$$\frac{\text{mass of an element in compound sample}}{\text{mass of a compound in compound sample}} \times 100$$

Ex probs

Mass Percent from Chemical Formula

- Mass fraction of an element in a compound =

$$\frac{\text{mass of an element}}{\text{mass of compound}} \quad \text{in 1 mole of compound}$$

- Mass percent = mass fraction x 100

- Mass percent of an element in a compound =

$$\frac{\text{mass of an element in 1 mol of compound}}{\text{mass of 1 mol of compound}} \times 100$$

Ex probs

Mass Percent of an Element in a Compound

Mass of element and
Mass of compound in a
Given sample

Mass % of element
In Compound

Chemical
Formula