Introduction to Physical Science

Formula Mass and the Mole Concept

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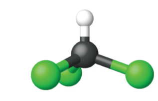
Formula Mass

- Sum of the average atomic masses of the component atoms
- Covalent substances
  - Formula represents the number and type of atoms making a single molecule
  - Molecular mass

Element	Quantity		Average atomic mass (amu)		Subtotal (amu)
C	1	×	12.01	=	12.01
H	1	×	1.008	=	1.008
Cl	3	×	35.45	=	106.35
				Molecular mass	119.37



Example

- What is the formula mass of ibuprofen (   )?

C: 13 atoms x 12.01 amu
H: 18 atoms x 1.008 amu
O: 2 atoms x 16.00 amu

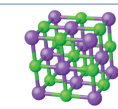
C: 156.13 amu
H: 18.144 amu
O: 32.00 amu

156.13 amu + 18.144 amu + 32.00 amu
= 206.27 amu

Formula Mass (2)

- Sum of the average atomic masses of the component atoms
- Ionic substances
  - Sum the average atomic masses of all atoms in the compound's formula
  - NOT a molecular mass

Element	Quantity		Average atomic mass (amu)		Subtotal
Na	1	×	22.99	=	22.99
Cl	1	×	35.45	=	35.45
				Formula mass	58.44



Example

- What is the formula mass of Aluminum sulfate (   )?

$Rewrite: Al_2S_3O_{12}$

Al: 2 atoms x 26.98 amu
S: 3 atoms x 32.06 amu
O: 12 atoms x 16.00 amu

Al: 53.96 amu
S: 96.18 amu
O: 192.00 amu

53.96 amu + 96.18 amu + 192.00 amu
= 342.14 amu

The Mole

- A mole of a substance is the amount in which there are 6.022×10^{23} discrete entities (atoms or molecules)
  - Avogadro's Number: 6.022×10^{23} =
- One mole of any element contains the same number of atoms as a mole of any other atom
  - Molar mass: Mass in grams of one mole of a substance

The Mole (2)

- Molar Mass: numerically equivalent to its atomic or formula weight in amu
  -        = 12.00 g/mol
- Atomic mass and molar mass are equivalent numerically
  - The represent different things

Element	Average Atomic Mass (amu)	Molar Mass (g/mol)	Atoms/Mole
C	12.01	12.01	6.022×10^{23}
H	1.008	1.008	6.022×10^{23}
O	16.00	16.00	6.022×10^{23}
Na	22.99	22.99	6.022×10^{23}
Cl	35.45	35.45	6.022×10^{23}

Example

- Moles from grams: Nutritional guidelines for potassium are 4.7 g/day/ What would this be in moles?

$m = 4.7\ g\ K$
Molar mass of potassium = 39.10 g/mol

$$4.7\ g\ K\left(\frac{mol\ K}{39.10\ g\ K}\right)$$

$$= 0.12\ mol\ K$$

Example

- Grams from moles: If a liter of air contains $9.2x10^{-4}$ mol Ar. What is the mass of Ar in one liter of air?

$moles : 9.2x10^{-4} mol\ argon$

Molar mass of argon = 39.95 g/mol

$$9.2x10^{-4} mol\ Ar(\frac{39.95\ g\ Ar}{mol\ Ar})$$

$$= 0.037\ g\ Ar$$

Example

- Moles from grams: How many moles of glycine molecules are contained in 28.35 g of glycine (   )?

Find molar mass

C: 2 x 12.01 = 24.02 g/mol glycine

H: 5 x 1.088 = 5.040 g/mol glycine

O: 2 x 16.00 = 32.00 g/mol glycine

N: 1 x 14.007 = 14.007 g/mol glycine

24.02 + 5.040 + 32.00 + 14.007 = 75.07 g/mol glycine

$$28.35\ g\ glycine(\frac{mol\ glycine}{75.07\ g\ glycine})$$

$$= 0.378\ mol\ glycine$$

Percent Composition

- Percent composition:
  - The percentage by mass of each element in the compound
- Example: a compound of hydrogen and carbon
  -
  -

Example

- A 12.04g sample of a liquid is found to contain 7.34 gC, 1.85 g H, and 2.85 g N. What is the percent composition of the compound?

7.34 g C ; 1.85 g H ; 2.85 g N

$$\%C = \frac{7.34\ g\ C}{12.04\ g\ compound} x100\% = 61.0\%$$

$$\%H = \frac{1.85\ g\ H}{12.04\ g\ compound} x100\% = 15.4\%$$

$$\%N = \frac{2.85\ g\ N}{12.04\ g\ compound} x100\% = 23.7\%$$

Percent Composition from Formula

- Can use the molecular or empirical formula to determine percent composition
- Example: ; Molecular weight: N: 1 x 14.01 amu and H 3 x 1.008 amu = 17.03 amu
  -
  -

Example

- What is the percent composition of aspirin ( )?

Molar mass: C: 9 x 12.01 = 108.09 ; H: 8 x 1.008 = 8.064 ; O: 4 x 16.00 = 64.00 = 180.154 g/mol

$$\% C = \frac{108.09\ g/mol}{180.154\ g/mol} x100\,\% = 60.00\,\% C$$

$$\% H = \frac{8.064\ g/mol}{180.154\ g/mol} x100\,\% = 4.476\,\% H$$

$$\% O = \frac{64.00\ g/mol}{180.154\ g/mol} x100\,\% = 35.52\,\% O$$

Summary

- The formula mass is the sum of the masses of the individual atoms composing a compound
- One mole is defined to be the amount of a substance containing $6.022x10^{23}$ atoms/molecules
- The molar mass of an atom or compound is numerically equal to the the atomic or formula weight in amu