Chem 261 September 1, 2022

Definitions

- Chemistry: Study of matter
- Organic Chemistry: Study of compounds containing carbon. Chemical symbol of carbon is C
- Chemical symbol: Code for chemical element
- Atom: Is the smallest possible particle that defines a complete chemical element. Fundamental building blocks of chemistry.
    - They are composed of neutrons, protons (+), and electrons (-)
- Every atom is composed of a nucleus and one or more electrons bound to the nucleus
- Molecules: Discrete (bonded) arrangement of atoms. Bonds can be covalent or ionic.
    - Changing the arrangement or connections changes the molecule and its physical properties
- Compound: Collection of molecules of the same type
    - Water (H_2O), Cholesterol (27 carbons, white crystalline powder, average male contains 80 g)
- Atomic Number: Number of protons in the nucleus of an atom (Z)
- Atomic Weight: Mass of protons (p^+) and neutron (N) (unit: amu)
    - ^1H = Hydrogen = $1p^+ + 1e^-$
    - ^2H = Deuterium = $1p^+ + 1N + 1e^-$
    - ^3H = Tritium = $1p^+ + 2N + 1e^-$
    - $^{12}C = 6p^+ + 6N$ (^{12}C : 12 amu atomic weight, atomic No. 6)
    - $^{13}C = 6p^+ + 7N$ (Isotope of Carbon, Stable, 1.1% abundance)
    - $^{14}C = 6p^+ + 8N$ (Radioactive isotope with long half-life, $T_{1/2}$ = 5740 yrs) - $1N \rightarrow 1p^+ + 1e^-$ to become ^{14}Nitrogen
- Molecular Weight (MW): Mass of atoms in a molecule
    - H_2O: MW = [(2 x 1 g/mol)H + (1 x 16 g/mol)O] = 18 g/mol

Basic Principles

1. Like charges repel, unlike charges attract.
2. Atoms want inert gas configuration of electrons
   - Same configuration as Helium, Neon, Argon, Xenon, and Krypton.

Mole Concept

- 1 mole = 6.02×10^{23} (Avogadro's number) (can be atoms, molecules etc.)
- 1 mole H = 1 g
- Mole concept relates to MW and Atomic weight
- 18 g of H_2O is 6.02×10^{23} molecules = 1 mole of H_2O or 6.02×10^{23} molecules of water
- Carbon has 12 grams per mol, Oxygen has 16 g per mol, so for CO_2 we can calculate that it has 44 g/mol

- D = ^2H, $1p^+ + 1N$ = 2 g/mol, it's an isotope
- D_2O = 20g/mol, known as heavy water.

Typical Molecule

- A few Angstroms (Å) in length: Bond length C-H is 1 Å, C-C is 1.5 Å
- 1 Å = 10^{-8} cm
- 1 Å = diameter of 1 hydrogen atom

Example: Cholesterol is 17 Å across. If you lined all of the cholesterol molecules in an 80 g bottle end to end it would wrap around the earth roughly 5,000,000 times.....

Physical Properties

- Defined by chemical structure
- Melting point (mp) and boiling point (bp): Each compound has a characteristic mp and bp.
- Taste, appearance, odour, and biological properties (how it interacts with other molecules).
- Light Absorption (hν)
- Density (symbol is ρ, rho) (unit = g/cm^3)
- Density of water is 1g/cm^3, compounds that are less dense than water will float on top if they are not miscible (infinitely soluble)
- Absorption of radiation (light)
- Solubility

Purity of Compounds

- 1 mole of H_2O (6.02 x 10^{23} molecules) = 18 g, then add 1 x 10^6 other molecules (e.g. sugar) → the purity of the water would be 99.999 999 999 999 999%.
- Purity: A pure compound shows no change in physical properties upon attempts to further purify (purity is a relative term).
- Purity: A pure compound has a discrete and unique physical properties.

Qualitative Test for Inorganic or Organic Compound

Qualitative: Determine if you have the compound of interest

Note that the structure of a molecule defines its physical properties

Organic	Inorganic
- Contains carbon - Low mp < 200 °C, low bp - Burns frequently in air - Soluble in non-polar solvents	- No carbon - High mp & bp (due to ionic bonding) - "Does not burn" - Soluble in H_2O

Non-Polar solvent: Hexane, Benzene, Diethyl ether etc

THERE ARE MANY EXCEPTIONS!!!

E.g. Common table sugar is an organic molecule, however it dissolves in water

Quantitative Analysis

Quantitative: How much of the compound of interest (quantity)
Amounts of atoms in a compound