

Definitions

- **Chemistry:** Study of matter
- **Science:** way of worldview
- **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.
 - o They are composed of neutrons, protons (+), and electrons (-)
- Every atom is composed of a **nucleus** (positively charged - composed of protons and neutrons) and one or more electrons bound to the nucleus
- **Molecules:** Discrete (bonded) arrangement of atoms. Bonds can be covalent or ionic.
 - o Changing the arrangement or connections changes the molecule and its physical properties (color, density, solubility, melting point, boiling point)
- **Compound:** Collection of molecules of the same type
 - o Water (H₂O), 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)
- **Molecular Weight (MW):** Mass of atoms in a molecule
 - o H₂O: MW = [(2 x 1 g/mol)H + (1 x 16 g/mol)O] = 18 g/mol

Isotopes

- Isotopes – same element that contain equal number of protons but different number of neutrons

Example 1:

- o ¹H = Hydrogen = 1p⁺ + 1e⁻
 - 90% of electron density of the hydrogen atom is within one Angstrom. Atomic number = 1, atomic weight = 1.
- o ²H = Deuterium = 1p⁺ + 1n + 1e⁻ (Isotope of Hydrogen). Atomic number = 1, atomic weight = 2.
- o ³H = Tritium = 1p⁺ + 2n + 1e⁻ (Isotope of Hydrogen, radioactive, T_{1/2} = 12.2 yrs). Atomic number = 1, atomic weight = 3.

Example 2:

- o ¹²C = 6p⁺ + 6n (¹²C : 12 amu atomic weight, atomic No. 6)
- o ¹³C = 6p⁺ + 7n (Isotope of Carbon, Stable, 1.1% abundance)
- o ¹⁴C = 6p⁺ + 8n (Radioactive isotope with long half-life, T_{1/2} = 5740 yrs; used in Carbon dating)
 - 1n → 1p⁺ + 1e⁻ to become ¹⁴Nitrogen

Typical Molecule

- Discrete connection of atoms
- Chemical Structure: Determines a molecule physical properties
- How big are molecules? A few Angstroms (Å) in length: Bond length C-H is 1 Å, C-C is 1.5 Å
- $1 \text{ Å} = 10^{-8} \text{ cm}$
- $1 \text{ Å} = \text{diameter of 1 hydrogen atom}$

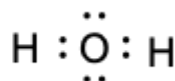
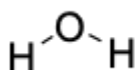
Example: Cholesterol is 17 Å across. If you lined all of the cholesterol molecules in an 80 g bottle end to end, it would wrap around the earth roughly 5,000,000 times.....

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 (hv): h stands for Planck's constant ($6.626 \times 10^{-34} \text{ Js}$; ν stands for frequency)
- Density (symbol is ρ , rho) (unit = g/cm^3)
- Density of water is 1.0 g/cm^3 , compounds that are less dense than water will float on top if they are not miscible (infinitely soluble)
- Absorption of radiation (light) (unit =)
- Solubility ~ most organic solvents dissolve in other organic solvents (like dissolves like); some organic molecules dissolve in H_2O which is inorganic (ex. Sugar)

Basic Principles

1. Like charges repel, unlike charges attract.
2. Atoms want inert gas configuration of electrons (e^-)
 - Same configuration as Helium, Neon, Argon, Xenon, and Krypton.
 - Can be attained through either ionic bonding or covalent bonding



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 CO₂ we can calculate that it has 44 g/mol
- D (deuterium) = ²H, 1p⁺ + 1n = 2 g/mol, it's an isotope
- D₂O = 20g/mol, known as heavy water.

Purity of Compounds

- o 1 mole of H₂O (18 g/mol) (1 mole = 6.02 x 10²³ molecules) = 18 g of H₂O, then add 1 x 10⁶ other molecules (e.g. sugar) → the purity of the water would be 99.999 999 999 999 999%.
- o Purity: A pure compound shows no change in physical properties upon attempts to further purify (purity is a relative term).
- o Purity: A pure compound has a discrete and unique physical properties.

Qualitative Test for Inorganic or Organic Compound

Qualitative Analysis: Determine if you have the compound of interest

Note that the structure of a molecule defines its physical properties

Organic	Inorganic
<ul style="list-style-type: none"> - Contains carbon - Low mp < 200 °C, low bp - Burns frequently in air - Non-polar - Soluble in non-polar solvents (e.g. oil) 	<ul style="list-style-type: none"> - Generally no carbon - High mp & bp (due to ionic bonding e.g. NaCl) - “Does not burn” - Polar - Soluble in H₂O