Definitions

- Chemistry: Study of matter
- Science: way of worldview /repeatable phenomenon
- **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** (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.
 - 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
 - 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)

Isotopes

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

Example 1:

 \circ ¹H = Hydrogen = 1p⁺ + 1e⁻

- 90% of electron density of the hydrogen atom is within one Angstrom
- \circ ²H = Deuterium = 1p⁺ + 1n + 1e⁻ (Isotope of Hydrogen)
- \circ ³H = Tritium = 1p⁺ + 2n + 1e⁻ (Isotope of Hydrogen, radioactive, T_{1/2} =
- 12.2 yrs) note: approximately 30 decompositions per minute Example 2:
 - \circ ¹²C = 6p⁺ + 6n (¹²C : 12 amu atomic weight, atomic No. 6)
 - \circ ¹³C = 6p⁺ + 7n (Isotope of Carbon, Stable, 1.1% abundance)
 - \circ ¹⁴C = 6p⁺ + 8n (Radioactive isotope with long half-life, T_{1/2} = 5740 yrs;
 - used in Carbon dating)
 - $\ln \rightarrow 1p^+ + 1e^-$ to become ¹⁴Nitrogen
- Molecular Weight (MW): Mass of atoms in a molecule

 \circ H₂O: MW = [(2 x 1 g/mol)H + (1 x 16 g/mol)O] = 18 g/mol

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 x 10⁻³⁴ Js; v stands for frequency
- Density (symbol is ρ , rho) (unit = g/cm³)
- Density of water is 1.0 g/cm³, compounds that are less dense than water will float on top if they are not miscible (infinitely soluble)
- Absorption of radiation (light)
- Solubility ~ most organic solvents dissolve in other organic solvents (like dissolves like); some organic molecules dissolve in H₂O which is inorganic (ex. Sugar)

Typical Molecule

- A few Angstroms (Å) in length: Bond length C-H is 1 Å, C-C is 1.5 Å
- \circ 1 Å = 10⁻⁸ cm
- \circ 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.....

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.
 - 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.)
- $1 \mod H = 1 g$
- Mole concept relates to MW and Atomic weight
- 18 g of H₂O is 6.02×10^{23} molecules = 1 mole of H₂O 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) = 2 H, 1p⁺ + 1n = 2 g/mol, it's an isotope
- $D_2O = 20g/mol$, known as heavy water.

Purity of Compounds

- 1 mole of H₂O (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.

Pure compound: Collection of molecules of the same type **Oualitative 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		
- Contains carbon	- Generally no carbon		
- Low mp $< 200 ^{\circ}$ C, low bp	- High mp & bp (due to ionic bonding e.g.		
- Burns frequently in air	NaCl)		
- Non-polar	- "Does not burn"		
- Soluble in non-polar solvents	- Polar		
(e.g. oil)	- Soluble in H ₂ O		

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

Organic compound
$$\longrightarrow$$
 CO₂ + H₂O [H] = Reduction
 $Organic compound \longrightarrow$ CO₂ + H₂O + NO₂
MW (g/mol): 44 18
Compound (4.34 mg) \longrightarrow 10.35 mg 3.42 mg 0 mg
Contains C, H, O CO₂ H₂O NO₂

Note: Matter cannot be created or destroyed in a chemical reaction; therefore the amount of carbon in the CO_2 is equal to the amount of carbon in the starting sample.

<u>Percent Composition</u> – how much of each atom is present in the sample

Weight of carbon (in sample) = $\frac{12 \text{ g/mol of C}}{44 \text{ g/mol CO}_2}$ x 10.35 mg of CO₂ = 2.82 mg of C

Molecular Weight (MW) of $CO_2 = 12 (C) + 2 \times 16 (O) = 44 \text{ g/mol}$

Weight of hydrogen = 2(1 g/mol of H) x 3.42 mg of H₂O = 0.383 mg of H 18 g/mol of H₂O

NB: H₂O contains two hydrogen. MW of H₂O = $(2 \times 1) + 16$ H₂ O

Weight of oxygen = 4.34 mg sample - (2.82 mg of C + 0.383 mg of H) = 1.14 mg of O

Now one can calculate percentage composition:

% Composition:

% C = <u>Mass of carbon</u> x 100%	=	<u>2.82 mg of C</u> x 100%	= 65.1%
Mass of sample		4.34 mg	

% H = <u>0.383 mg of H</u> = 8.83% 4.34mg % O = 100% - 65.1% - 8.83% = 26.1%