Definitions

- Chemistry: Study of matter
- Organic Chemistry: Study of compounds containing carbon
- Atom: Is the smallest possible particle that defines a complete chemical element
- Molecules: Atoms connected in a particular arrangement
    - 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 80g)
- Atomic Number: number of protons in nucleus of atoms
- Atomic Weight: mass of protons and neutrons
- Molecular Weight (MW): mass of atoms in molecule
    - Hydrogen = H, Atomic number = 1, 1 proton = $p^+ = (1H^+)$
    - Deuterium = D or d, Atomic number = 1, 1 proton and 1 neutron, Atomic Weight = 2 is an Isotope of Hydrogen
    - Tritium = T, Atomic number = 1, 1 proton and 2 neutrons, Atomic Weight = 3, radioactive isotope of hydrogen (half-life = 12.2 years)

Mole Concept

- 1 mole = 6.02×10^{23} (Avogadro's number) (can be atoms, molecules etc)
- 1 mole H = 1 g
- H_2O: MW = [(2 x 1 g/mol)H + (1 x 16 g/mol)O] = 18 g/mol
- 18g of H_2O is 6.02×10^{23} molecules = 1 mole of H_2O or 6.02×10^{23} molecules of water

Typical Molecule

- A few Angstroms (Å) in length
- 1 Å = 10^{-8} cm

Example: cholesterol is 18 Å across. If you lined all of the cholesterol molecules in a 80g bottle end to end it would wrap around the earth roughly 5,000,000 times.

Purity of Compounds

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

Physical Properties

- Defined by chemical structure.
- Melting point (mp) and Boiling point (bp): Each compounds has a characteristic mp and bp.
- Biological properties: Taste, appearance, odour
- Density (g/cm^3).
- Absorption of radiation.

- Solubility

Chemical Analysis

- Qualitative Analysis
- Quantitative Analysis

Qualitative Test for Inorganic or Organic Compound

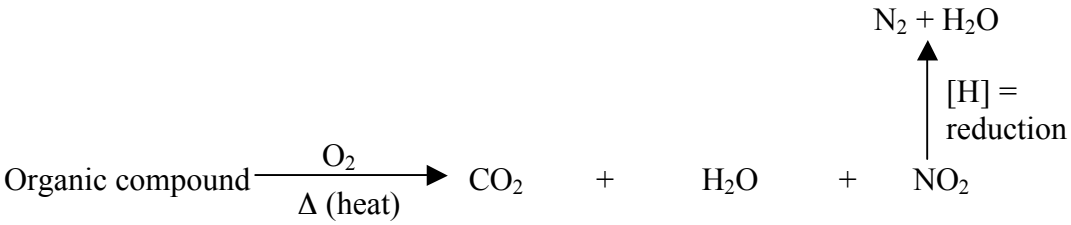
- Qualitative: Determine if you have the compound of interest.

Organic	Inorganic
- Contains carbon	- No carbon
- Low mp < 200 °C	- High mp
- Burn frequently	- "Does not burn"
- Soluble in non-polar solvents	- Soluble in H_2O

THERE ARE MANY EXCEPTIONS !!!

Quantitative Analysis

- Quantitative: How much of the compound of interest (quantity).



Example:

Compound contains C, H, O (4.34 mg) ⟶ 10.35 mg CO_2 + 3.42 mg H_2O + 0 mg NO_2

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.

$$\text{Weight of carbon (in sample)} = \frac{12 \text{ g/mol of C}}{44 \text{ g/mol } CO_2} \times 10.35 \text{ mg of } CO_2 = 2.82 \text{ mg of C}$$

$$\text{Weight of hydrogen} = \frac{2(1 \text{ g/mol of H})}{18 \text{ g/mol of } H_2O} \times 3.42 \text{ mg of } H_2O = 0.383 \text{ mg of H}$$

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

Now one can calculate percentage composition

% Composition

% C = Mass of carbon = 2.82mg of C = 65.1%
Mass of sample 4.34mg

% H = 0.383 mg of H = 8.83%
4.34mg

% O = 100% - 65% - 8.83% = 26.1%

The empirical can be determined from % composition.

Determining the empirical experimental formula:

- Definition: empirical formula is ratio of atoms to each other in a molecular formula
- Three steps to calculate the empirical formula:
  i) divide each percentage (%) by the atomic weight of element → crude ratio
  ii) divide all crude ratio by the smallest crude ratio → refined ratio
  iii) Multiply the refined ratio by an integer value to get integral ratio

% Composition	Crude ratio	Refined ratio	Integral ratio
65.1 % C	65.1 / 12.0 = 5.42	5.42 / 1.63 = 3.34	3.34 x 3 = 10
8.83 % H	8.83 / 1.01 = 8.76	8.76 / 1.63 = 5.39	5.39 x 3 = 16
26.1 % O	26.1 / 16.0 = 1.63	1.63 / 1.63 = 1.00	1.00 x 3 = 3

From the integral ratio, the empirical formula is $C_{10}H_{16}O_3$. Using this formula an empirical weight can be calculated.

C $10 \times 12 = 120$ g/mol
H $16 \times 1 = 16$ g/mol
O $3 \times 16 = 48$ g/mol

$C_{10}H_{16}O_3 = 184$ g/mol

Note: suppose the molecular weight is given as 368 g/mol, then the molecular formula is obtained by multiplying the integral ratios by a factor of 2 and it would be $C_{20}H_{32}O_6$.