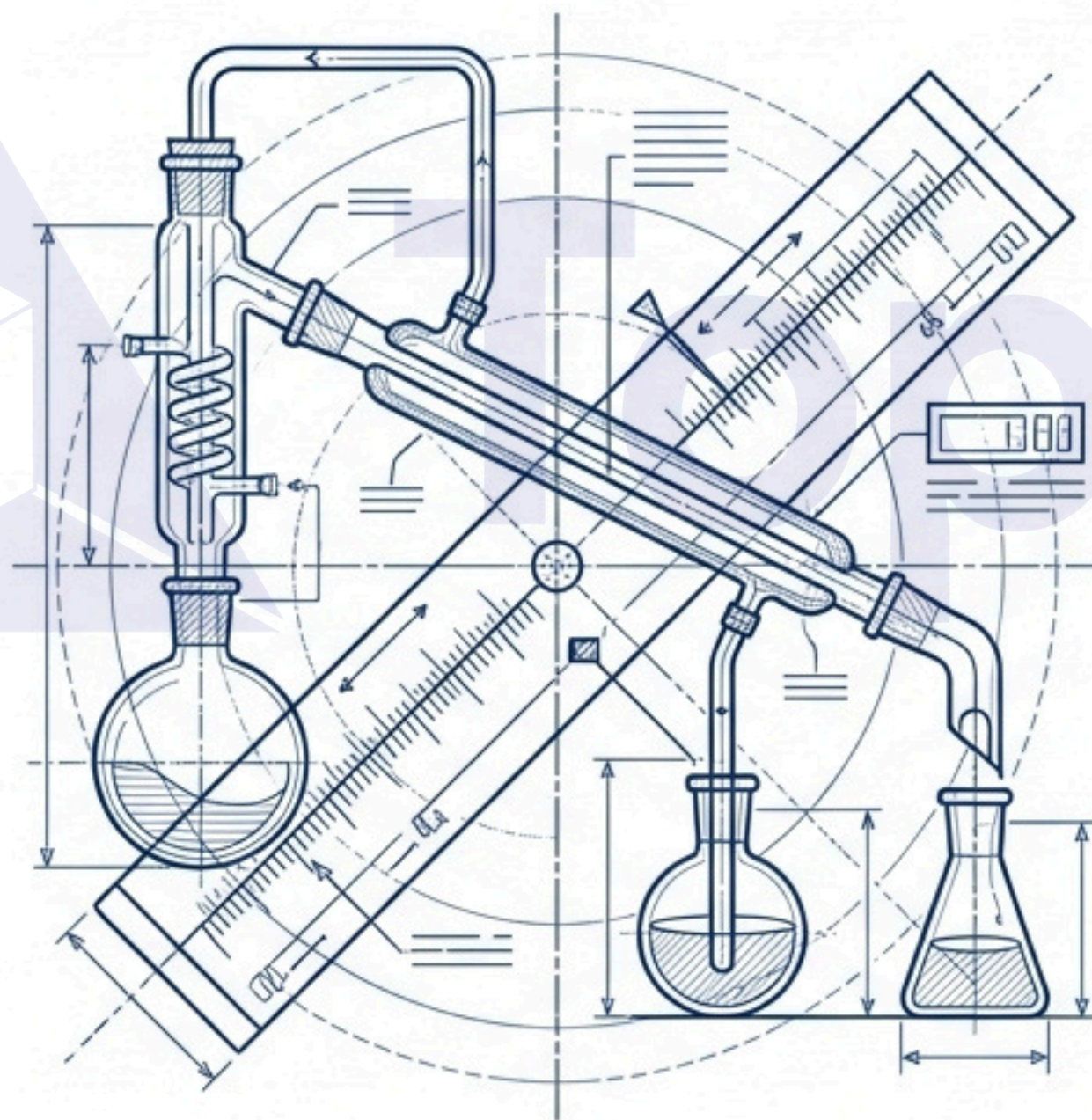


Quantitative Analysis of Organic Compounds

Moving beyond elemental detection to determine exact chemical composition.



From 'What' to 'How Much'

Before calculating empirical formulas, chemists must perform quantitative analysis. The goal is to determine exactly how much of a particular element is present by mass, not just whether it is present.

The Analytical Goal

Qualitative Analysis



- **The Question:** *Is the element there?*
- **The Output:** Yes / No
- **Example:** Lassaigne's Test reveals the presence of Nitrogen.
- **Limitation:** Gives no information on concentration or formula weight.

Quantitative Analysis



- **The Question:** *How much is there?*
- **The Output:** Percentage by mass (%)
- **Example:** Dumas Method calculates Nitrogen is exactly 17.46% of the total mass.
- **Power:** Unlocks the empirical and molecular formula of the compound.

Carbon & Hydrogen: Liebig's Combustion Method

A known mass of the organic compound is burnt in the presence of excess copper(II) oxide and oxygen.



Step 1 – Complete Oxidation

- **Reaction:** C and H in the compound are oxidized.
- **Products:** Yields CO_2 and H_2O .
- **State:** Products pass as gases into specialized absorption tubes.



Step 2 – Hydrogen Measurement

- **Absorber:** U-tube containing anhydrous **Calcium Chloride**.
- **Action:** Absorbs exclusively H_2O .
- **Math:** The increase in mass gives the mass of water, allowing calculation of % Hydrogen.



Step 3 – Carbon Measurement

- **Absorber:** U-tube containing **Potassium Hydroxide (KOH)**.
- **Action:** Absorbs exclusively CO_2 .
- **Math:** The increase in mass gives the mass of carbon dioxide, allowing calculation of % Carbon.



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$$E=mc^2$$



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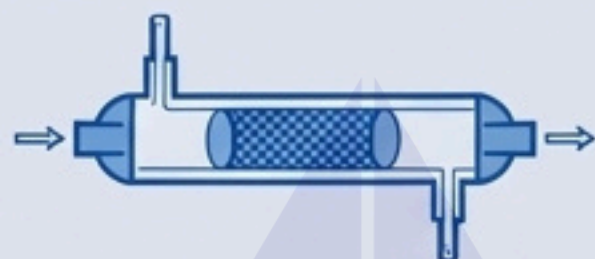
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Quantifying Nitrogen: Two Approaches

Nitrogen analysis requires breaking down the organic framework to isolate the element.



Dumas Method

Principle: Combustion. Heated with CuO in an atmosphere of CO_2 .

Isolated Form: Free Nitrogen gas N_2 .

Measurement: Volumetric. The volume of N_2 collected over aqueous KOH is measured at Standard Temperature and Pressure (STP).

Scope: Works for almost all nitrogen-containing organic compounds.



Kjeldahl's Method

Principle: Digestion. Heated with concentrated H_2SO_4 .

Isolated Form: Ammonium Sulphate $(\text{NH}_4)_2\text{SO}_4$, then converted to Ammonia gas NH_3 .

Measurement: Titrimetric. Ammonia is passed into standard acid. Unreacted acid is estimated by back-titration with standard alkali.

Scope: Limitation: Cannot be used for compounds containing nitrogen in ring structures (e.g., pyridine) or nitro/diazo groups.

The Carius & Precipitation Methods

For halogens, sulphur, and phosphorus, the organic compound is oxidized, converted to an inorganic precipitate, and carefully weighed.



Underlying Pattern: Oxidation → Precipitation → Gravimetry

Halogens (Carius Method)

- **Oxidizer:** Heated with fuming HNO_3 .
- **Reagent Added:** Silver Nitrate (AgNO_3).
- **The Reaction:** Halogens are converted into silver halides.
- **Precipitate Weighed:**

AgX (where $\text{X} = \text{Cl}, \text{Br}, \text{or I}$)

Sulphur

- **Oxidizer:** Heated with fuming HNO_3 or sodium peroxide.
- **Reagent Added:** Barium Chloride (BaCl_2).
- **The Reaction:** Sulphur is oxidized to sulphuric acid, then precipitated.
- **Precipitate Weighed:**

BaSO_4 (Barium Sulphate)

Phosphorus

- **Oxidizer:** Heated with fuming HNO_3 .
- **Reagent Added:** Magnesia mixture.
- **The Reaction:** Oxidized to phosphoric acid, precipitated as MgNH_4PO_4 , then ignited.
- **Precipitate Weighed:**

$\text{Mg}_2\text{P}_2\text{O}_7$ (Magnesium Pyrophosphate)

Exam Master Guide: Quantitative Analysis

A rapid-review matrix for elemental quantification.

Element	Primary Method	Key Reagent/Process	Final Measured Form
Carbon	Liebig's Combustion	Passed through KOH	Mass of CO_2
Hydrogen	Liebig's Combustion	Passed through Anhydrous CaCl_2	Mass of H_2O
Nitrogen	Dumas Method	Combusted with CuO	Volume of N_2 (gas)
Nitrogen	Kjeldahl's Method	Digested in conc. H_2SO_4	Volume of Acid neutralized by NH_3
Halogens	Carius Method	Fuming $\text{HNO}_3 + \text{AgNO}_3$	Mass of AgX
Sulphur	Carius Variant	Fuming $\text{HNO}_3 + \text{BaCl}_2$	Mass of BaSO_4
Phosphorus	Ignition	Fuming $\text{HNO}_3 + \text{Magnesia}$	Mass of $\text{Mg}_2\text{P}_2\text{O}_7$

 **Oxygen Calculation:** Oxygen is typically calculated by difference: $\% \text{O} = 100 - (\text{Sum of \% of all other elements})$.



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