Al-Mustaqbal University

College of Science

Analytical Chemistry I

First Year Students / 1st Semester

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Introduction to analytical chemistry, importance and applications

By

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References:

1- Skoog, D. A., West, D. M., Holler, F. J., & Crouch, S. R. *Fundamentals of Analytical Chemistry, 10th ed. 2022.*
https://dl.konkur.in/2025/03/Analytical-Chemistry2021-%5Bwww.konkur.in%5D.pdf

2- David Harvey, Modern Analytical Chemistry, 2000, McGraw-Hill Companies, Inc.
https://pharmacy.attahadi.edu.ly/uploads/topics/17144756855079.pdf

3- Skoog, D. A., West, D. M., Holler, F. J., & Crouch, S. R. *Fundamentals of Analytical Chemistry,* Student Solutions Manual, *9th ed. 2013.*
https://library.uniq.edu.iq/storage/books/file/Fundamentals%20of%20Analytical%20Chemistry%209th%20%20Student%20Solutions%20Manual/1671012362Fundamentals%20of%20Analytical%20Chemistry%209th%20%20Student%20Solutions%20Manual%20(%20PDFDrive%20).pdf

Chemistry: is a science concerned with the study of properties, structure, components of the materials changes occur to it and emitted or absorbed energies accompany these changes.

Chemistry science is classified according to the type of materials and the purpose of their studies into these general branches:

Analytical Chemistry,

Biochemistry,

Organic Chemistry,

Inorganic Chemistry,

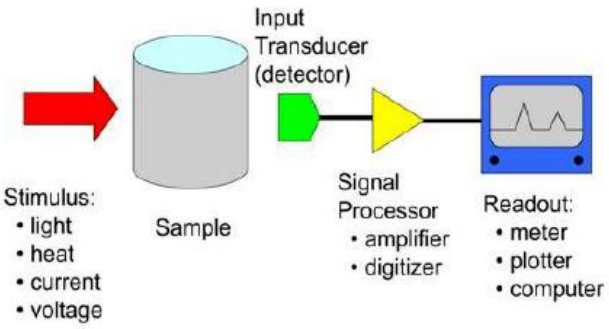
Physical Chemistry,

and Industrial Chemistry.

Other branches are Theoretical Chemistry, Quantum Chemistry, and Nuclear Chemistry etc.

What is analytical chemistry?

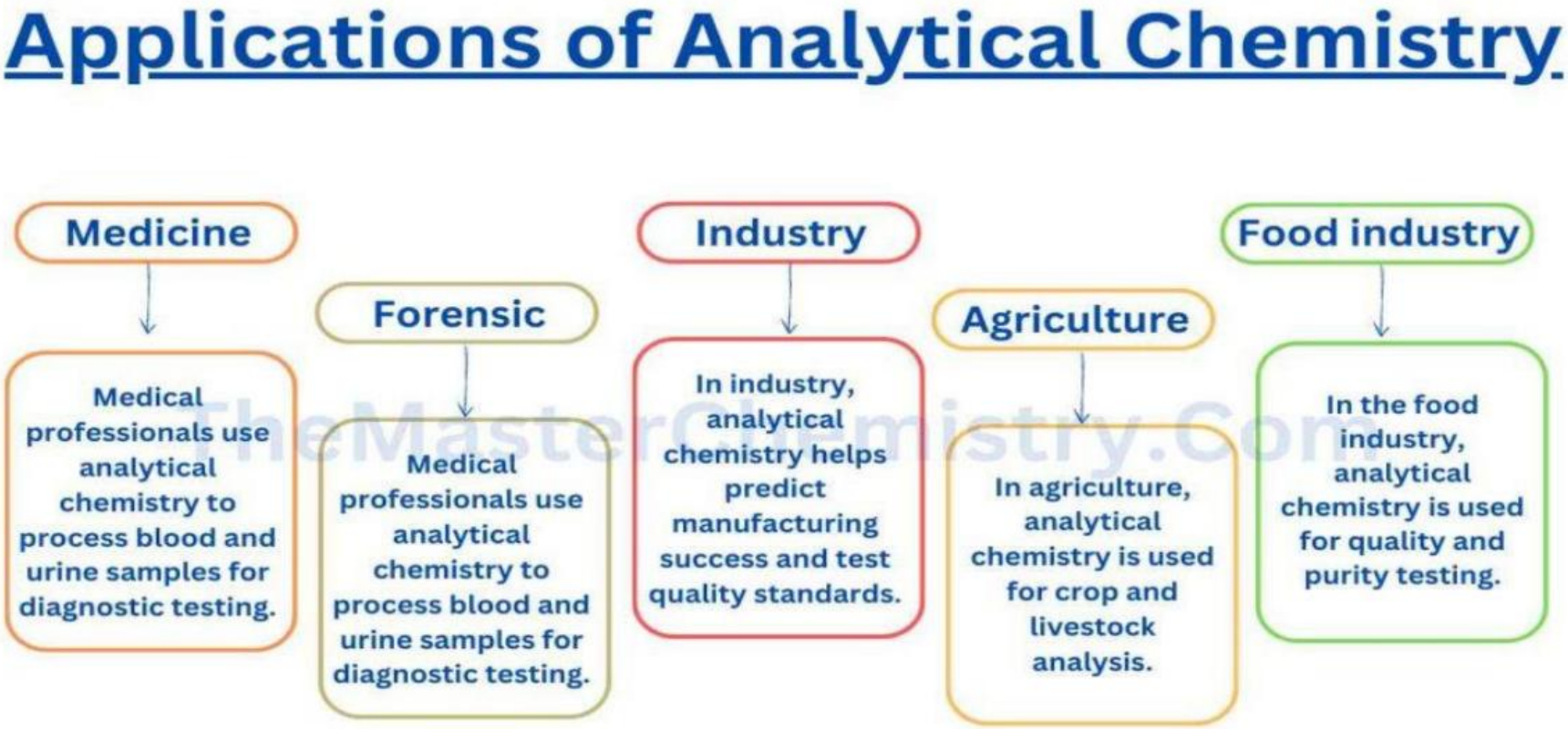
Analytical chemistry is the study of the chemical composition of natural and synthetic substances. Unlike other branches of chemistry such as inorganic chemistry or organic chemistry, analytical chemistry is not restricted to a specific type of compound or a specific type of chemical reaction. The properties studied in analytical chemistry include engineering properties such as the shape of molecules and the distribution of atoms in them into properties such as composition and identification of components of elements.



Analytical chemistry is a **measurement science** consisting of a set of powerful ideas and methods that are useful in all fields of science and medicine.

The Role of Analytical Chemistry

Figure 1
The relationship between analytical chemistry, other branches of chemistry, and the other sciences.
The central location of analytical chemistry in the diagram signifies its importance and the breadth of its interactions with many other disciplines.


Applications of Analytical Chemistry
Medicine
Medical professionals use analytical chemistry to process blood and urine samples for diagnostic testing.
Forensic
Medical professionals use analytical chemistry to process blood and urine samples for diagnostic testing.
Industry
In industry, analytical chemistry helps predict manufacturing success and test quality standards.
Agriculture
In agriculture, analytical chemistry is used for crop and livestock analysis.
Food industry
In the food industry, analytical chemistry is used for quality and purity testing.
TheMasterChemistry.Com

International system of unit
SI Units

Base quantity	**name of unit**	**symbol**
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Temperature	kelvin	K
Amount of substance	**mole**	**mol**
Luminous intensity	candela	cd

Prefixes used with units

Prefix	symbol	meaning	example
Giga	G	10^{9}	1 gigameter(Gm) = 1 x 10^{9} m
Mega	M	10^{6}	1 megamete (Mm) = 1 x 10^{6}m
Kilo	k	10^{3}	1 kilometer (km) = 1 x 10^{3} m
deci	d	10^{-1}	1 decimeter (dm) = 0.1 m
centi	c	10^{-2}	1 centimeter (cm) = 0.01 m
Milli	m	10^{-3}	1 millimeter (mm) = 0.001 m
Micro	µ	10^{-6}	1 micrometer (µm) = 1 x 10^{-6} m
Nano	n	10^{-9}	1 nanometer (nm) = 1 x 10^{-9} m
Pico	p	10^{-12}	1 picomer (pm) = 1 x 10^{-12} m

Introduction

- **Analytical chemistry** is concerned with the chemical characterization of matter and the answer to two important questions what is it (qualitative) and how much is it (quantitative).
- **So Analytical chemistry** answering for basic questions about a material sample:

- **· What?**
- **· Where?**
- **· How much?**
- **· What arrangement, structure or form?**

Introduction

Some important terms

❖ **Analyte**-

- The component of the sample to be studied by quantitative measurements or identified qualitatively.

- **Or the analyte** is the substance to be identified, detected, or separated in some manner.

- **The analyte** can be a pure substance or one component in a multi-component sample.

Introduction

- **Sample**- is anything that comes to mind in the air, water, soil, food and living organisms such as a piece of rock or a piece of meat or some water from the tank of the house or from a river or a lack or a sea or some tissue or blood from humans or animals or some vegetables .... etc.
- Sample – is a portion of material selected from a larger quantity of material

Introduction

- **Matrix-** The remainder of the sample of which the analyte forms a part.
- **Or the "matrix"** refers to all the other components of a particular sample, other than the analyte or compound you are interested in.
- **Matrix**- all other components in a sample except for the analyte.

Sample = (analyte + matrix)

Major Areas of Analytical Chemistry

1. **Qualitative Analysis:** This analysis detects (identify) the type of all or some of the substances present in the sample (elements or ions or compounds) . In other words it gives an answer to the question:

   What substances are present in a sample ?

2. **Quantitative Analysis:** This analysis gives knowledge of the amount of all or some of the substances present in the sample and uses two types of analysis depending on the concentration of the substance in the sample.

Major Areas of Analytical Chemistry

Main branches of analytical chemistry

- Qualitative

provides information about the identity of species or functional groups in the sample

What ?

- Quantitative

Determine the amount of certain component in a sample

How much ?

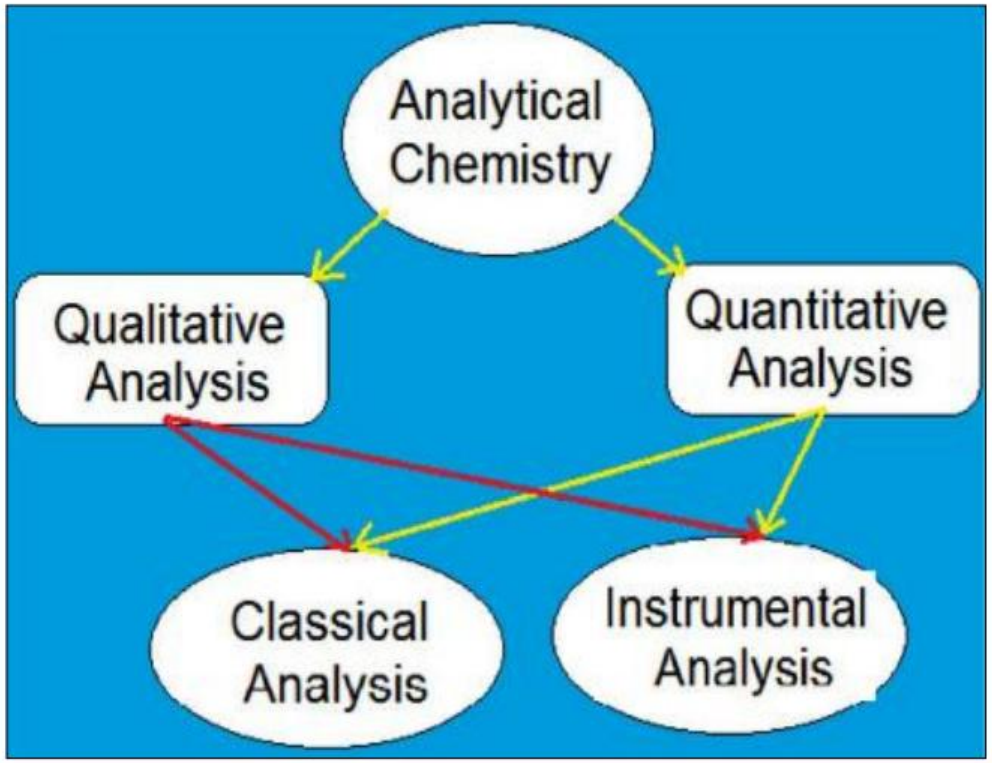
Major Areas of Analytical Chemistry

- **Each one of these two types (Qualitative analysis and Quantitative Analysis) can be either**

Classical Analysis

or

Instrumental Analysis



Classical chemical analysis :

- **Depends on the chemical reaction, such as volumetric analysis and gravimetric analysis.**
- **It uses simple equipment such as burettes , balances , flame , furnace .**
- **It is used to estimate high concentrations (more than 0.001 M).**

Classical chemical analysis :

Using Classical Methods (Earliest Techniques)

a.) Separations: precipitation, extraction, distillation

b.) Qualitative: boiling points, melting points, color, odor, solubility

c.) Quantitative: titrations, gravimetric analysis

Instrumental Analysis :

- It uses instruments
- It depends on the physical and physico-chemical properties of the substance being analyzed (analyte) such as absorption or emission of electromagnetic radiation (spectroscopic methods of analysis) or electrical properties of the substance being analyzed such as voltage or current intensity or electrical conductivity..etc.
- It is used to estimate low concentrations of the analyte (less than 0.001 M).
- Most of the instrumental analysis methods require expensive instruments.

Instrumental Analysis :

Using Instrumental Methods (~post-1930's)

a.) separations: chromatography, electrophoresis, etc.

b.) Qualitative or Quantitative: spectroscopy, electrochemical methods, mass spectrometry, NMR, radiochemical methods, etc.

Analytical chemistry

Analytical chemistry is the study of the separation, identification, and quantification of the chemical components of natural and artificial materials. Qualitative analysis gives an indication of the identity of the chemical species in the sample, and quantitative analysis determines the amount of certain components in the substance.
The separation of components is often performed prior to analysis.

Analytical methods can be separated into **classical and instrumental**.

Classical methods (also known as **wet chemistry methods**) use separations such as precipitation, extraction, and distillation and qualitative analysis by color, odor, or melting point.
Classical quantitative analysis is achieved by measurement of weight or volume.
[Note: It is called “wet chemistry” since most analyzing is done in the liquid phase.]

Instrumental methods use an apparatus to measure physical quantities of the analyte such as light absorption, fluorescence, or conductivity.

The separation of materials is accomplished using chromatography, electrophoresis or field flow fractionation methods.

Classification of Analytical Methods

Classical

Qualitative - identification by color, indicators, boiling points, odors

Quantitative - mass or volume (e.g. gravimetric, volumetric)

Instrumental

Qualitative - chromatography, electrophoresis and identification by measuring physical property (e.g. spectroscopy, electrode potential)

Quantitative - measuring property and determining relationship to on concentration (e.g. spectrophotometry, mass spectrometry)

Dr.Usharani RK

Qualitative Analysis *vs.* Quantitative Analysis

- **Qualitative** analysis reveals the identity of the elements and compounds in a sample.

- **Quantitative** analysis indicates the amount of each substance in a sample.

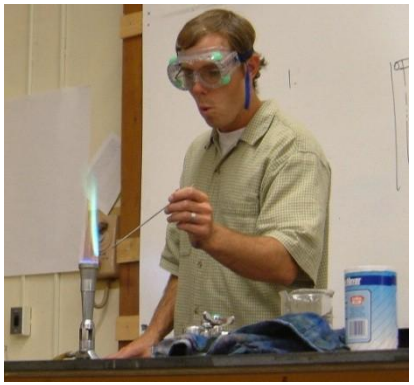
Qualitative analysis

A qualitative analysis determines the presence or absence of a particular compound, but not the mass or concentration. By definition, qualitative analyses do not measure quantity.

Chemical tests

There are numerous qualitative chemical tests, for example, the acid test for gold and the Kastle-Meyer test for the presence of blood.

Flame/color test



Blood test Kastle-Meyer test - A drop of phenolphthalin reagent is added to the sample.

The presence of copper in this qualitative analysis is indicated by the bluish-green color of the flame. Yellow flame for Na.

Classical Analytical Chem.

→ Modern Instrumentation

Although modern analytical chemistry is dominated by sophisticated instrumentation, the roots of analytical chemistry and some of the principles used in modern instruments are from traditional techniques many of which are still used today.

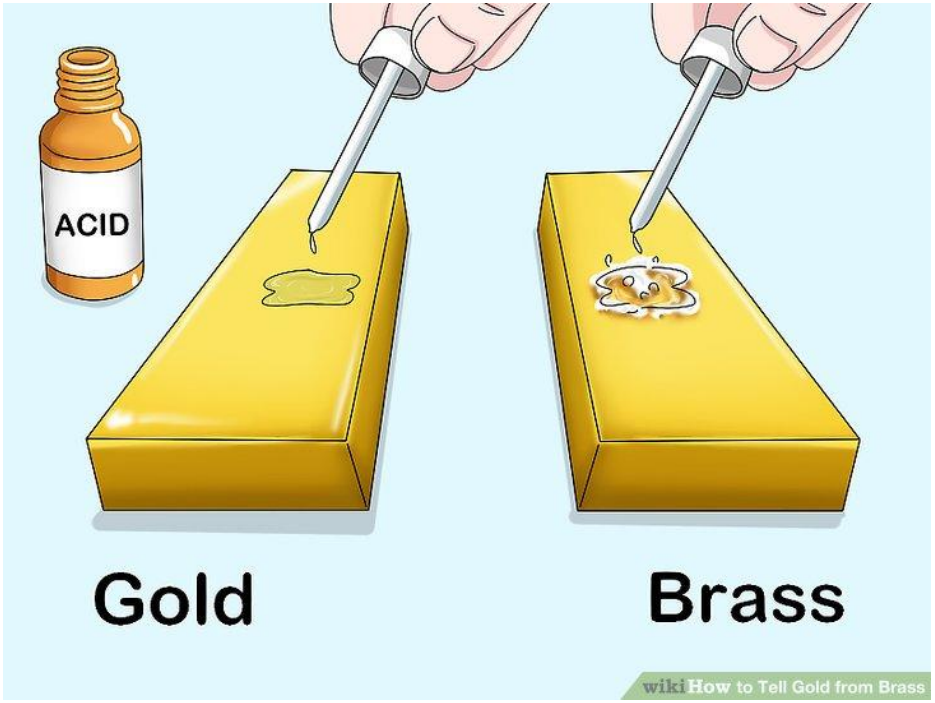
These techniques (traditional) also tend to form the backbone of most undergraduate analytical chemistry educational labs.

1. Classical Methods

There exist many classical methods of checking for the presence or absence of a particular compound in a given analyte.
These examples are of classical method of qualitative analysis:

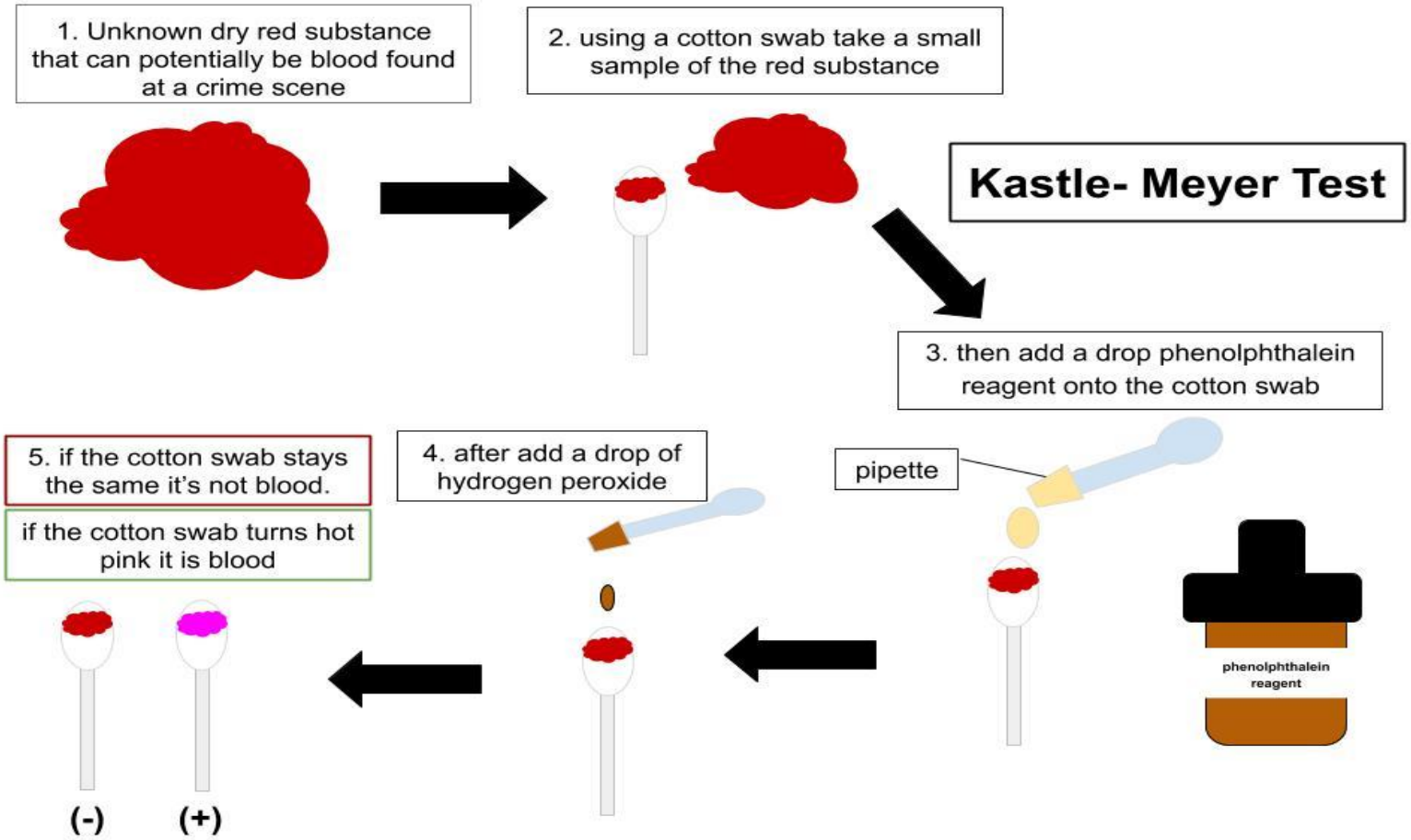
1. The acid test for gold:

The mark is tested by applying nitric acid, which dissolves the mark of any item that is not gold



2- The Kastle-Meyer test :

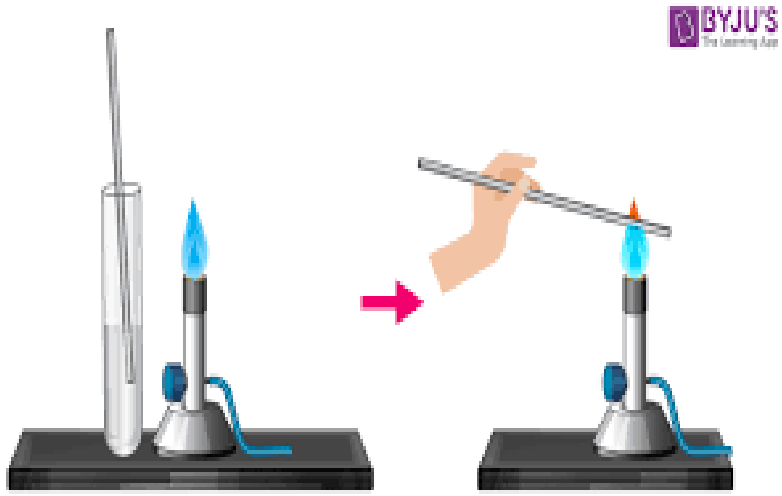
The test identifies the heme component of hemoglobin, which in the presence of hydrogen peroxide catalyzes the oxidation of the indicator phenolophthalin, turning it pink.



3-Flame tests:

These can be used to check for the presence of specific elements in an analyte by exposing it to a flame and observing the change in the color of the flame.

A flame test is a **qualitative analysis** used by the chemist to identify the metal and metalloid ion in the sample. Not all metal ions emit color when heated in the gas burner.



Flame Tests

Metals change the colour of a flame when they are heated in it, this produces a flame of a distinct colour. The colour of this flame can help us identify common metals.

Chemistry teach