Flame Photometry (Part 1)

- ✓Basic Introduction
- ✓Principle
- ✓Equations
- ✓Interferences

Spectroscopy
Instrumental Analysis

Flame Photometry

Introduction:

- Atomic spectroscopy is thought to be the oldest instrumental method for the determination of elements.
- These techniques are introduced in the mid of 19th Century during which Bunsen and Kirchhoff showed that the radiation emitted from the flames depends on the characteristic element present in the flame
- It is divided into three types which are absorption, emission, and luminescence spectroscopy.

Flame Photometry

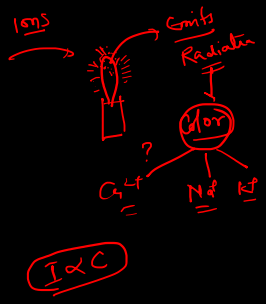
Introduction:

- The different branches of atomic absorption spectroscopy are
  - (1) Flame photometry or flame atomic emission spectrometry in which the species is examined in the form of atoms
  - (2) Atomic absorption spectrophotometry, (AAS),
  - (3) Inductively coupled plasma-atomic emission spectrometry (ICP-AES).

Flame Photometry

Introduction:

- Flame-Photometry also known as Flame Atomic Emission Spectroscopy.
- It is a branch of spectroscopy in which the species examined in the spectrometer are in the form of atoms
- **Flame Photometer:** used to examine the inorganic metal ions like Na+, K+, Ca2+, Li+.
- It is based on the measurement of intensity of the light emitted when a metal is introduce to a flame
- The Wavelength of color tell us what the element is (qualitative)
- The color intensity tell us how much of the elemenet present (Quantitative)



Flame Photometry

Introduction:

- Color produce by Ions

Element	Wavelength (nm)	Color of flmae
K+	766	Violet
Na+	589	Yellow
Ca2+	622	Orange
Li+	670	Red
Ba2+	554	Lime Green

Flame Photometry

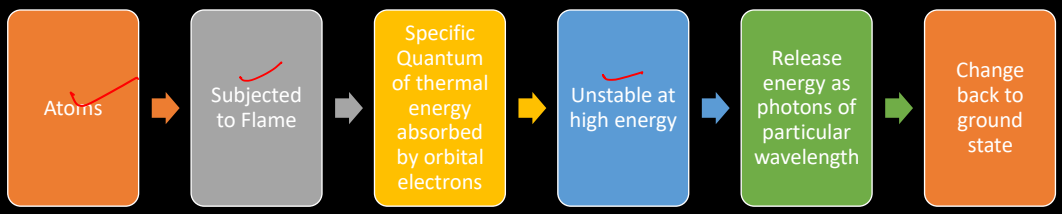
Principle & Theory

- The basis of flame photometric working is that, the species of alkali metals (Group 1) and alkaline earth metals (Group II) metals are dissociated due to the thermal energy provided by the flame source.
- Due to this thermal excitation, some of the atoms are excited to a higher energy level where they are not stable.
- The absorbance of light due to the electrons excitation can be measured by using the direct absorption techniques.
- The subsequent loss of energy will result in the movement of excited atoms to the low energy ground state with emission of some radiations, which can be visualized in the visible region of the spectrum.

Flame Photometry

Principle & Theory

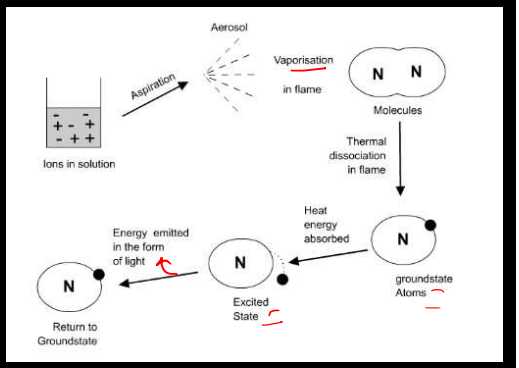
- The absorbance of light due to the electrons excitation can be measured by using the direct absorption techniques while the emitting radiation intensity is measured using the emission techniques.
- The wavelength of emitted light is specific for specific elements.



Flame Photometry

Process

- 1. The solvent is first evaporated leaving fine divided solid particles.
- 2. This solid particles move towards the flame, where the gaseous atoms and ions are produced.
- 3. The ions absorb the energy from the flame and excited to high energy levels.
- 4. When the atoms return to the ground state radiation of the characteristic element is emitted.
- 5. The intensity of emitted light is related to the concentration of the element.



Flame Photometry

Basic Equation

intensity of the light emitted could be described by the Scheibe-Lomakin equation:

$$I = K C^n$$

I- Intensity of emitted light

C- Conc. Of element

K- constant of Proportionality

n-1 (at the linear part of calibration curve

$$I = K C$$

is the intensity of emitted light is directly related to the concentration of the sample.

Flame Photometry

Interferences

- Other element present on sample can affect or interfere with observation of specific element.
- There are mainly 3 type of interferences:
  1. **Spectral line/Cationic/Molecular Interferences**
  2. **Anionic/Vaporization Interference**
  3. **Ionization Interferences**
  4. **Physical Interference**

Flame Photometry

Interferences

1. Spectral Line Interferences/Cationic Interference/Molecular spectral interference

- This is occurs due to presence of interfering substance like Cations, these can emit radiation in same region of analyte. Examples
  - Orange band of Ca2+ (543-622) can interfere with Na+ doublet 589/589.6 nm and Ba2+ line at 553.6nm
  - Na+ & K+ mixture interfere with each other
- Remedy-
  - The use of Grating type monochromator
  - Extraction of interfering material
  - Use of Pure substanes, Plotting a standard curve of interfering matarial

Flame Photometry

Interferences

2. Anionic/Vaporization Interference

- Anions do not emit radiation, but polyvalent anions, depresses the emission of certain cations by forming less volatile salt in flame.
- Ex- $Ca_3(PO_4)_2$ or CaSO4 emits less intense radiation than CaCl2
- Remedy- Supressing agent may be added like few ppm of Lanthanum Chloride or Stronium Chloride that may suppress the PO_4^{3-}

Flame Photometry

Interferences

3. Ionization Interferences

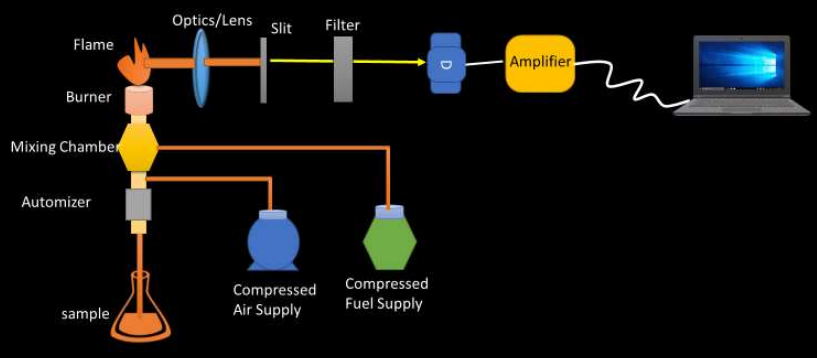
- A very hot flames can provoke partial ionization of certain elements which decreases the concentration of free atoms in the flame hence decrease the sensitivity of the method
- Remedy-
  - Addition of ionization suppresser like K, Cs, Stronium

4. Physical Interferences

- Viscosity of the solution may also interfere with the radiation by altering flow rate, drop size etc.
- Ex. Sugar increase the viscosity while alcohol lowers the surface tension

Flame Photometry (Part 2)

✓Instrumentation
✓Application

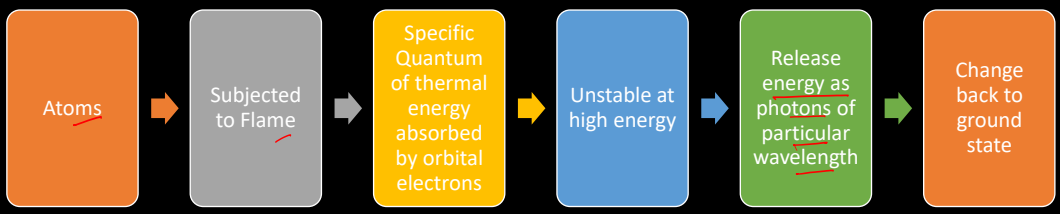


Spectroscopy
Instrumental Analysis

Flame Photometry

Basic Principle

- Flame photometer, used to examined the metal ions like Na+, K+, Ca2+, Li+, Ba2+ by using Flame



- The concentration of element directly proportional to intensity of emitted radiation.
- Colour of emitted radiation describe the presence of element type

Flame Photometry

Element	Wavelength (nm)	Color of flmae
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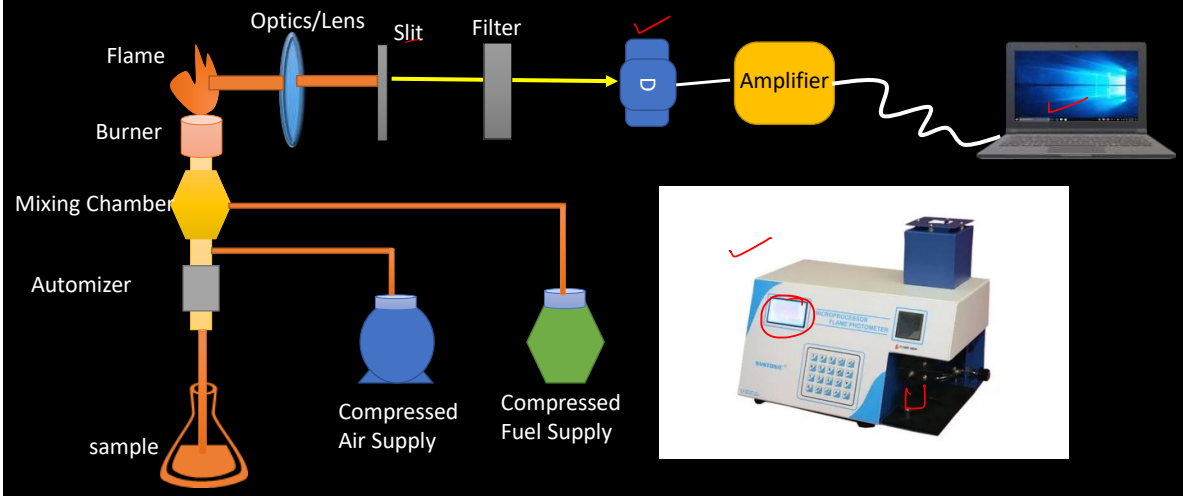
Flame Photometry

Instrumentation:-



Flame Photometry

Instrumentation

- A simple flame photometer consists of the following basic components
- **Source of flame:** A Burner in the flame photometer is the source of flame. It can be maintained in at a constant temperature. The temperature of the flame is one of the critical factors in flame photometry

Fuel-Oxidant mixture	Temperature (°C)
Natural gas-Air	1700
Propane-Air	1800
Hydrogen-Air	2000
Hydrogen-Oxygen	2650
Acetylene-Air	2300
Acetylene-Oxyen	3200
Acetylene-Nitrous oxide	2700
Cyanogen-Oxygen	4800

Flame Photometry

Instrumentation

- **Nebuliser:** Nebuliser is used to send homogeneous solution into the flame at a balanced rate.
- **Optical system:** The optical system consists of convex mirror and convex lens. The convex mirror transmits the light emitted from the atoms. Convex mirror also helps to focus the emissions to the lens. The lens helps to focus the light on a point or slit.
- **Simple colour filters:** The reflections from the mirror pass through the slit and reach the filters. Filters will isolate the wavelength to be measured from that of irrelevant emissions.

Flame Photometry

Instrumentation

- **Photo-detector:** The intensity of radiation emitted by the flame is measured by photo detector. Here the emitted radiation is converted to an electrical signal with the help of photo detector. These electrical signals are directly proportional to the intensity of light.

Flame Photometry

Events in the Flame

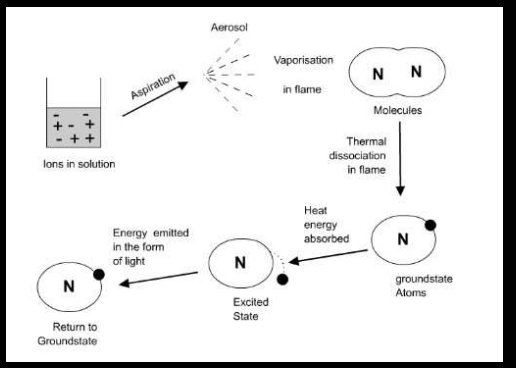
1.Desolvation: The metal particles in the flame are dehydrated by the flame and hence the solvent is evaporated.

2.Vapourisation: The metal particles in the sample are dehydrated. This also led to the evaporation of the solvent.

3.Atomization: Reduction of metal ions in the solvent to metal atoms by the flame heat.

4.Excitation: The electrostatic force of attraction between the electrons and nucleus of the atom helps them to absorb a particular amount of energy. The atoms then jump to the exited energy state.

5.Emission process: Since the higher energy state is unstable the atoms jump back to the stable low energy state with the emission of energy in the form of radiation of characteristic wavelength, which is measured by the photo detector.



Flame Photometry

Application

- Flame photometer can be applied both for quantitative and qualitative analysis of elements.
- The presence of some group II elements is critical for soil health. We can determine the presence of various alkali and alkaline earth metals in soil sample by conducting flame test and then the soil can be supplied with specific fertiliser.
- The concentrations of Na+ and K+ ions are very important in the human body for conducting various metabolic functions. Their concentrations can be determined by diluting and aspirating blood serum sample into the flame.
- Soft drinks, fruit juices and alcoholic beverages can also be analysed by using flame photometry to determine the concentrations of various metals and elements.

Flame Photometry

Advantages

- Simple quantitative analytical test based on the flame analysis.
- Inexpensive
- The determination of elements such as alkali and alkaline earth metals is performed easily with most reliable and convenient methods.
- Quite quick, convenient, and selective and sensitive to even parts per million (ppm) to parts per billion (ppb) range.

Disadvantages

- The concentration of the metal ion in the solution cannot be measured accurately.
- A standard solution with known molarities is required for determining the concentration of the ions which will corresponds to the emission spectra
- The information about the molecular structure of the compound present in the sample solution cannot be determined.
- The elements such as carbon, hydrogen and halides cannot be detected due to its non radiating nature.

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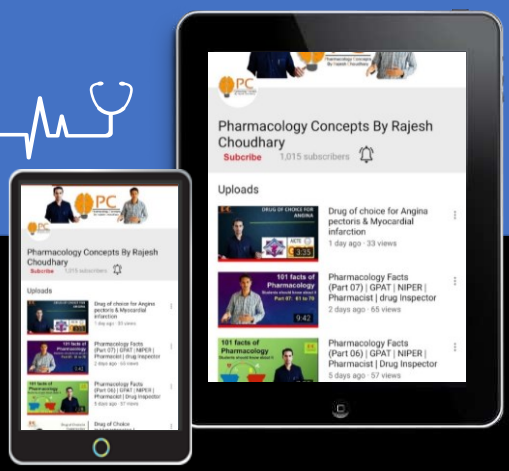

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