FLAME PHOTOMETRY

Photoelectric flame photometry, a branch of atomic spectroscopy is used for inorganic chemical analysis for determining the concentration of certain metal ions such as,

- sodium,
- potassium,
- lithium,
- calcium,
- Cesium, etc.

In flame photometry the species (metal ions) used in the spectrum are in the form of atoms.
It is based on the intensity of light that is emitted when metal is placed in a flame

- ❖ The intensity of wavelength provides information about the concentration of element and
- ❖ The color of wavelength gives information about the elements present in the sample.

Flame Photometry Principle

The neutral atom spectra are of primary interest in flame photometry; spectra from the ions may be formed at high temperatures and at high atom concentrations in the flame.

Under steady and controlled conditions, the number of emitting atoms and the concentration of the substance of interest in the sample is precisely proportional to the light intensity of the characteristic wavelength emitted by each atom.

Different colors of lights are observed when the metals are heated.

Element	Emitted wavelength (nm)	Colour of flame
Lithium	670	Red
Sodium	589	Yellow
Potassium	766	Violet
Calcium	662	Orange
Barium	554	Lime green

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The wavelength of the radiation emitted is given by the following equation :-

$$\lambda = hc/ E_2-E_1$$

Where,

h = Planks constant

c= Velocity of light

E2,E1= Energy levels of exited and ground state respectively

BOLTZMAN LAW

The fraction of free atom that are thermally exited is governed by a Boltzman Distribution

$$N^* / N = Ae^{-\Delta E/kT}$$

- N* =Number of exited atom
- n = Number of atom remaining in the ground state
- Ae = Difference in energies levels
- k = The Boltzman constant
- T = Temperature

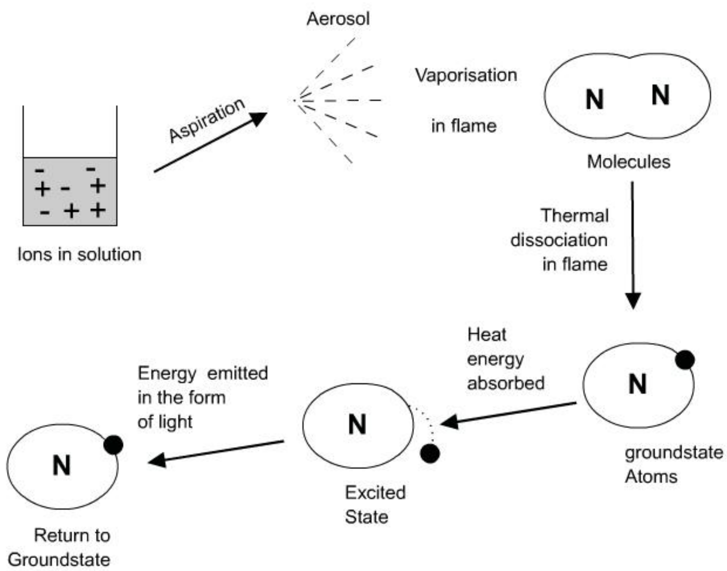
Mechanism of working:

The working of the flame photometer involves a series of steps which is discussed in the following sections.

Nebulisation: The solution of the substance to be analyzed is first aspirated into the burner, which is then dispersed into the flame as fine spray particles.

A brief overview of the 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.



INSTRUMENTATION

Basic Components of a Flame Photometer are,

1.Flame Source: The flame source provides the necessary heat to excite the atoms or ions in the sample. It is typically a propane or natural gas flame. This is a part that produces excited atoms. Here the sample solution is sprayed into fuel and oxidant combination. A homogenous flame of stable intensity is produced. There are different types of burners like Total consumption burner, Laminar flow and Mecker burner.

2.Atomizer: The atomizer is responsible for introducing the sample solution into the flame in a controlled manner. This can be achieved using a nebulizer or an aspirator.

3.Fuel and oxidants: Fuel and oxidant are required to produce the flame such that the sample converts to neutral atoms and get excited by heat energy. The temperature of the flame should be stable and also ideal. If the temperature is high, the elements in the sample convert into ions instead of neutral atoms. If it is too low, atoms may not go to the excited state. So a combination of fuel and oxidants is used such that there is the desired temperature.
The following combination of fuel and oxidants are commonly used.

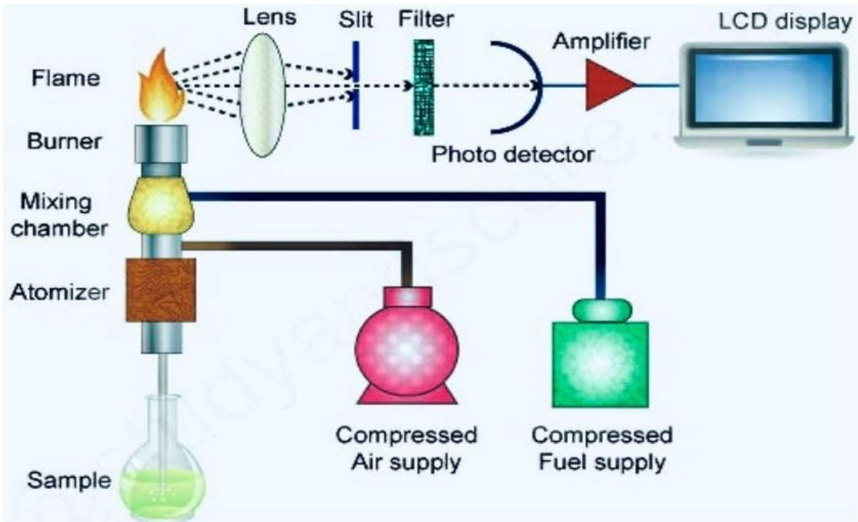
Fuel	Oxidant	Temperature of Flame
Propane +	Air	2100 Degree C
Propane +	Oxygen	2800 Degree C
Hydrogen+	Air	1900 Degree C
Hydrogen+	Oxygen	2800 Degree C
Acetylene+	Air	2200 Degree C
Acetylene+	Oxygen	3000 Degree

4.Monochromator: The monochromator is an optical device that selects a specific wavelength of light emitted by the sample. It helps eliminate unwanted background radiation and enhances the accuracy of measurements. They are needed to isolate the light of a specific wavelength from the remaining light of the flame. For this simple filters are sufficient as we study only a few elements like Ca, Na, K and Li. So a filter wheel with a filter for each element is taken. When a particular element is analyzed, the particular filter is used so that it filters all other wavelengths.

5.Detector: The detector captures the selected wavelength of light and converts it into an electrical signal. flame photometric detector is similar to that used in spectrophotometry. The emitted radiation is in the visible region, i.e., 400nm to 700nm. Further, the radiation is specific for each element, so simple detectors are sufficient for the purpose of photovoltaic cells, phototubes, etc.

6.Signal Processor: The signal processor amplifies and processes the electrical signal from the detector, allowing for quantitative analysis.

Working of Flame photometer involves several essential steps:



1. **Sample Introduction**: The sample solution is introduced into the flame through the atomizer. The solution is typically aspirated or nebulized, ensuring a fine spray for efficient atomization.
2. **Atomization and Desolvation**: As the sample enters the flame, the solvent evaporates, leaving behind the dissolved elements in the form of atoms or ions. The high temperature of the flame further excites these atoms or ions.
3. **Emission of Light**: The excited atoms or ions in the flame emit light at specific wavelengths characteristic of the elements present in the sample.
4. **Wavelength Selection**: The monochromator selects the desired wavelength of light emitted by the sample, while blocking out other unwanted wavelengths.
5. **Detection and Measurement**: The detector captures the selected wavelength of light and converts it into an electrical signal. The signal processor then measures the intensity of the signal, which is proportional to the concentration of the element in the sample.
6. **Quantitative Analysis**: The measured signal is compared to calibration curves or standards to determine the concentration of the element in the sample solution. This allows for the quantitative analysis of the specific element of interest.

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