M.Sc. Chemistry
Practical Inorganic Chemistry (Paper- 4106)
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Flame Atomic Emission Spectroscopy

Flame atomic emission spectrometry has been used for the determination of alkali and alkaline earth metals like, sodium, potassium, lithium, strontium, etc.

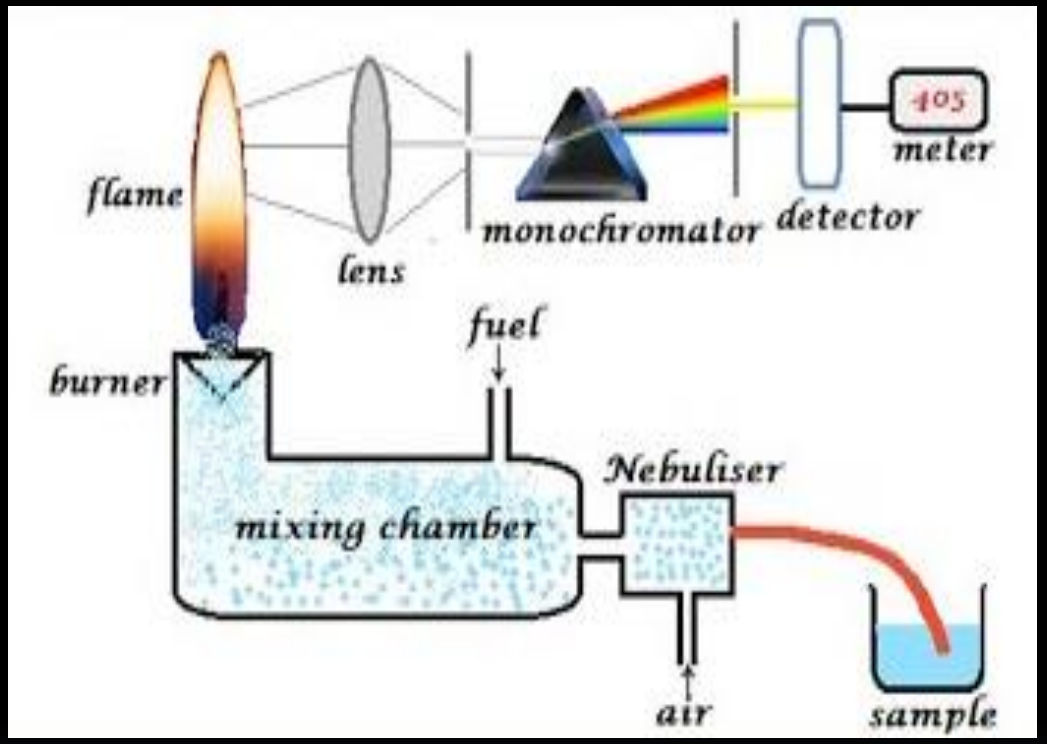
Now, ***why is flame atomic emission is important?*** Because you will have to imagine several situations, where sodium determination is very very essential; it is required in the analysis of seawater, body fluids, soils, plants, and then in chemicals and several other samples, where the determination of sodium, potassium, lithium, etc. become very important and routine. *So, routinely in body fluids, sodium as well as other elements are also determined like potassium, etc.*

Basic Principle:

In flame emission, the system is emission phenomenon. Compounds containing an alkali or alkaline earth metals (Group II) dissociate into atoms when introduced into the flame. Some of these atoms further get excited to even higher levels. But these atoms are not stable at higher levels. Hence, these atoms emit radiations when returning back to the ground state. These radiations generally lie in the visible region of the spectrum. Each of the alkali and alkaline earth metals has a specific wavelength.

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.

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.

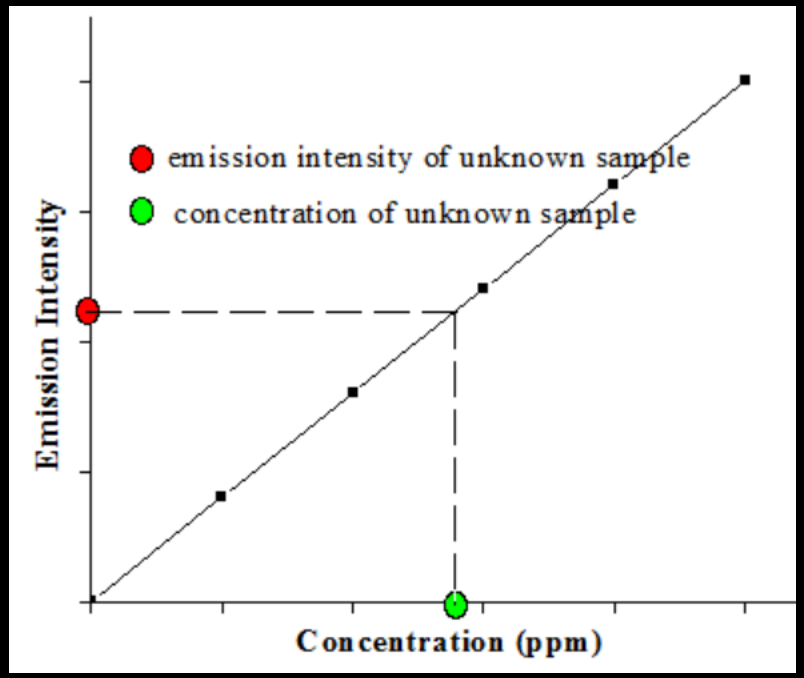
Simple colour filters: The reflections from the mirror pass through the slit and reach the filters. Filters will isolate the wavelength to be measured from that of irrelevant emissions.

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.

Working Procedure

1. Both the standard stock solution and sample solution are prepared in fresh distilled water.
2. The flame of the photometer is calibrated by adjusting the air and gas. Then the flame is allowed to stabilize for about 5 min.
3. Now the instrument is switched on and the lids of the filter chamber are opened to insert appropriate colour filters.
4. The readings of the galvanometer are adjusted to zero by spraying distilled water into the flame.
5. The sensitivity is adjusted by spraying the most concentrated standard working solution into the flame. Now the full scale deflection of the galvanometer is recorded.
6. Again distilled water is sprayed into the flame to attain constant readings of galvanometer. Then the galvanometer is readjusted to zero.
7. Now each of the standard working solutions is sprayed into the flame for three times and the readings of galvanometer are recorded. After each spray, the apparatus must be thoroughly washed.
8. Finally sample solution is sprayed into the flame for three times and the readings of galvanometer are recorded. After each spray, the apparatus must be thoroughly washed.
9. Calculate the mean of the galvanometer reading.
10. Plot the graph of concentration against the galvanometer reading to find out the concentration of the element in the sample.

Flame Photometer Graph



The oxidants in flame photometer are mainly air, oxygen or nitrous oxide. The temperature of the flame depends on the ratio of fuel and oxidant.

Modus Operandi

The processes occurring during flame photometer analysis are summarized below:

Desolvation: Desolvation involves drying a sample in a solution. The metal particles in the solvent are dehydrated by the flame and thus solvent is evaporated.

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

Atomization: Atomization is the separation of all atoms in a chemical substance. The metal ions in the sample are reduced to metal atoms by the flame.

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 higher energy state when excited.

Emission: Since the higher energy state is unstable the atoms jump back to the ground state or low energy state to gain stability. This jumping of atoms emits radiation with characteristic wavelength. The radiation is measured by the photo detector.

Emitted Wavelength and Flame Colors of Various alkali Earth Metals

Name of the element	Emitted wavelength range (nm)	Observed colour of the flame
Potassium (K)	766	 Violet
Lithium (Li)	670	 Red
Calcium (Ca)	622	 Orange
Sodium (Na)	589	 Yellow
Barium (Ba)	554	 Lime green

Applications of flame photometer

1. Flame photometer can be applied both for quantitative and qualitative analysis of elements. The radiations emitted by the flame photometer are characteristic to particular metal. Hence with the help of Flame photometer we can detect the presence of any specific element in the given sample.

2. 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 fertilizer.

3. 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.

4. Soft drinks, fruit juices and alcoholic beverages can also be analysed by using flame photometry to determine the concentrations of various metals and elements.

Advantages/Disadvantages of flame photometer

Advantages	Disadvantages
1. The method of analysis is very simple and economical.	In spite of many advantages, this analysis technique has quite a few disadvantages:
2. It is quick, convenient, selective and sensitive analysis.	The accurate concentration of the metal ion in the solution cannot be measured.
3. It is both and qualitative and quantitative in nature.	It cannot directly detect and determine the presence of inert gases.
4. Even very low concentrations (parts per million/ppm to parts per billion/ppb range) of metals in the sample can be determined.	Though this technique measures the total metal content present in the sample, it does not provide the information about the molecular structure of the metal present in the sample.
5. This method compensates for any unexpected interfering material present in the sample solution.	Flame photometry cannot be used for the direct determination of each and every metal atom. A number of metal atoms cannot be analyzed by this method. The elements such as carbon, hydrogen and halides cannot be detected due to their non-radiating nature.
6. This method can be used to estimate elements which are rarely analyzed.	Only liquid samples may be used. Also sample preparation becomes lengthy in some cases.

Recommended Books:

1. Bibliography on Flame Spectroscopy, Analytical Applications, R. Mavrodineanu. Philips Laboratories (1800-1966).

2. Vogel's Quantitative inorganic analysis, 6th edition.

3. Quantitative Chemical Analysis, 9th edition, D.C. Harris.