Flame Photometry (or) Flame Emission Spectroscopy

Flame photometry is a method in which, a atomized metal is introduced into a flame and the intensity of the light emitted is measured. The wave length of the colour tells us what the element is, and the intensity of the colour tells how much of the element is present.

Theory (or) Principle

When a metallic salt solution is introduced into a flame, the following processes will occur.

1. The solvent is evaporated leaving behind the solid particle.
2. The salt is vapourised into the gaseous state and dissociated into atoms.
3. Some of the atoms from the ground state are excited to higher energy state by absorbing thermal energy from the flame.

The excited atoms which are unstable, quickly emit photons of different wave lengths and return to the lower energy state. Then the emitted radiation is passed through the filter, which permits the characteristic wave length of the metal under examination. It is then passed into the detector, and finally into the recorder.

M^+X^- ⟷ MX ⟷ MX ⟷ X + M

Evaporation Solid *Vapourisation* Gas *Dissociation* Gas

Thermal excitation ↓

M ⟵ M*

(Ground state) *Emission* Gas (excited state)

Instrumentation

Components

The various components of the flame photometer are described as follows:

Burner

The flame must possess the following functions:

i) it should evaporate the solvent from the sample solution

(ii) it should decompose the solid into atoms

(iii) it should excite the atoms and cause them to emit radiant energy.

Mirror

The radiation from the flame is emitted in all directions in space. In order to increase the amount of radiation reaching the detector, a concave mirror is used which is set behind the burner.

Slits

Entrance slits: It is kept between the flame and monochromator. It permits only the radiation coming from the flame & mirror.

Exit slits: It is kept between the monochromator and detector. It prevents the entry of interfering lines.

Monochromator

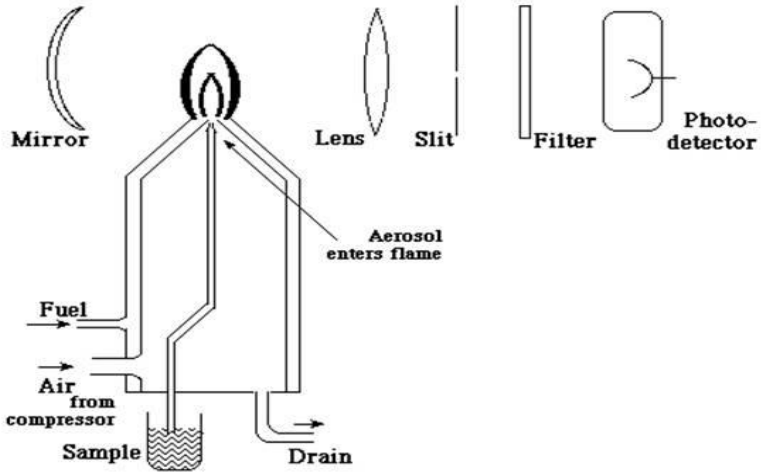
It allows the light of the required wavelength to pass through but absorbs the light of other wavelength.

Detector

The radiation coming from the filter is allowed to fall on the detector, which measures the intensity of the radiation falling on it. Photo cell or photo multiplier is used as detector, which converts the radiation into an electrical current.

Amplifier & Recorder

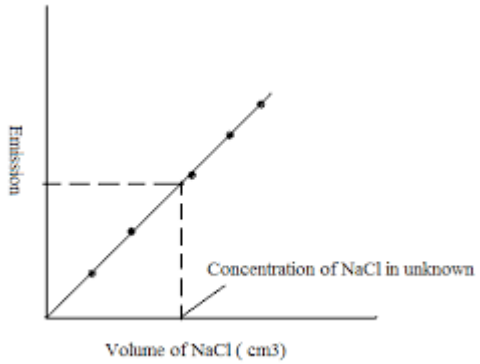
The current coming out from the detector is weak, so it is amplified and recorded.



Working of the Flame photometer:

Air, at a given pressure, is passed into an atomiser. The suction so-produced draws some solution of the sample into the atomiser. Air+sample solution is then mixed with fuel gas in the mixing chamber. The Air+sample solution +fuel gas mixture is then burnt in the burner. The radiation, emitted by the burner flame, is passed successively through the lens, filter, detector, amplifier and finally into a recorder.

The above experiment is first carried out using a series of standard solutions and the reading for each solution is noted. The graph is drawn between the concentration against intensity of emitted light. The test solution is taken and similar experiment is carried out. From the graph the concentration of the unknown sample can be determined.



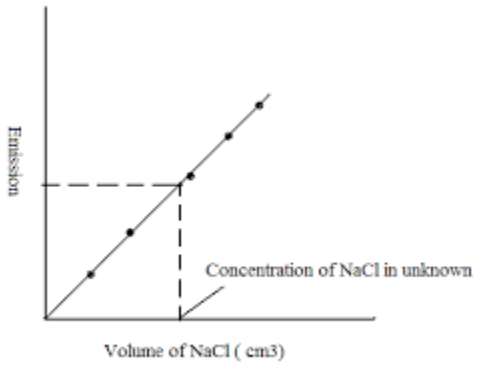
Applications of flame photometry

1. **Estimation of sodium by flame photometry**

The instrument is switched on. Air supply and gas supply are regulated. First distilled water is sent and ignition is started. After the instrument is warmed up for 10 min, the instrument is adjusted for zero reading in the disply. Since sodium produces a characteristic yellow emission at 589 nm, the instrument is set at λ_{max}= 589 nm and the readings are noted.

A series of standard NaCl solution (1, 2, 3, 4, 5, ……ppm) is prepared and is sent one by one and the readings are noted. The calibration graph is drawn between the concentration vs intensity of the emitted light. A straight line is obtained.

Now the unknown sodium solution is sent and the reading is noted. Then the concentration of sodium in the water sample is determined from the calibration curve.



2. **Qualitative analysis**

a) The elements of group I & II (K, Na, Li, Ca, Mg, etc) can be detected visually from the colour of the flame.

Example

Element	λ_{max}	Colour of the flame
Ca	422 nm	Brick red
K	766 nm	Red
Na	586 nm	Yellow
Li	670 nm	Scarlet red

b) Non radiating elements such as carbon, hydrogen and halides cannot be detected using this method.

3. Quantitative analysis

a) The amount of elements of group I & II (alkali & alkaline earth metals) can be determined from the sample.

b) Certain transition elements, such as Cu, Fe & Mn can also be determined.

4. Other applications

1. The measurement of these elements is very useful in medicine, agriculture and plant science.
2. Flame photometry is extensively used in the analysis of biological fluids and tissues.
3. In soil analysis the elements like Na, K, Al, Ca, Fe, etc are determined.
4. Industrial and natural waters, petroleum products, cement, glass, and metallurgical products can also be analysed by this method.

Limitations of flame photometry

1. It cannot be used for the determination of all metal atoms and inert gases.
2. Only liquid samples must be used.
3. It does not provide information about the molecular form of the metal present in the original sample.