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Flame Photometry

5.1. INTRODUCTION

It is a well known observation that several elements like sodium, potassium, calcium and barium when burned in flame emits a characteristic colour. The intensity or the colour varies with the amount or quantity of element introduced into the flame. A method of quantitative determination of a particular element using flame has been developed and it is known as **"Flame photometry"**. It is an example of emission spectroscopy. It is called as **"Flame emission spectroscopy"** or **"Flame spectrometry"**. Table 1 gives a list of some elements and their corresponding colour produced when introduced into flame.

TABLE 5.1

Flame Colour of Some Elements

Element	*Colour in Flame*
1. Sodium	Yellow
2. Potassium	Violet
3. Calcium	Brick red
4. Lithium	Crimson red
5. Barium	Apple green

When a metal or its salt is introduced into a flame, light characteristic of the metal is emitted. Since the emission of light takes place at a definite wavelength and the intensity of the emitted light is proportional to the concentration of the metal causing the emission of light, the observed wavelength gives us information about which metal is present, and the measured intensity indicates how much of the metal is present (*i.e.*, concentration).

Both qualitative and quantitative analyses can be done by this flame photometry. The alkali or alkaline earth metals which have low excitation energies, are the elements most commonly analysed by flame photometry.

5.2. THEORY

When an element is excited in a flame, a spectrum of light is emitted (colour) that is characteristic of the element. In flame photometry, a solution of a metal compound is sprayed into a flame, and the radiation emitted is compared to the radiation emitted by known concentrations of the same metal compound. This process is a simple type of **"emission spectroscopy"**. The specific wavelengths of the visible and ultraviolet radiation emitted by the elements are observed as spectral lines. Here the intensity of the spectral line is proportional to the concentration of the elements in the solution.

The various steps occuring in the process of flame photometric analysis are shown in the following scheme (Fig. 5.1) :

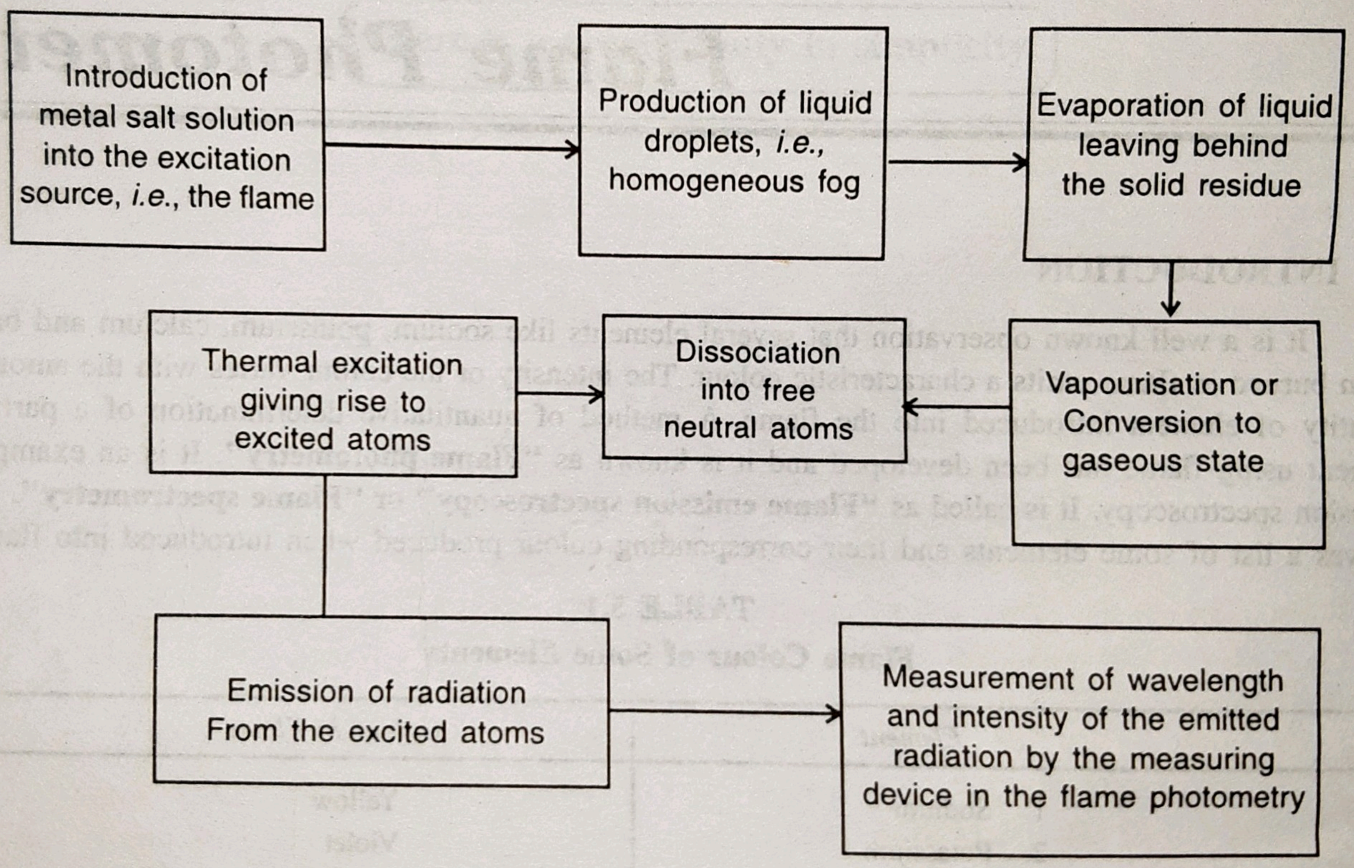

Fig. 5.1. Summary of flame photometry.

5.3. INSTRUMENTATION

The instrument used in flame photometry is known as flame photometer or flame spectrometer. The following is the schematic diagram (Fig. 5.2) of a flame photometer.

The various components of a flame photometer are :

1. The pressure regulators and flow meters for the fuel and the oxidant gases.
2. Atomiser
3. The optical system

4. The photosensitive detector
5. Amplifier and readout system.

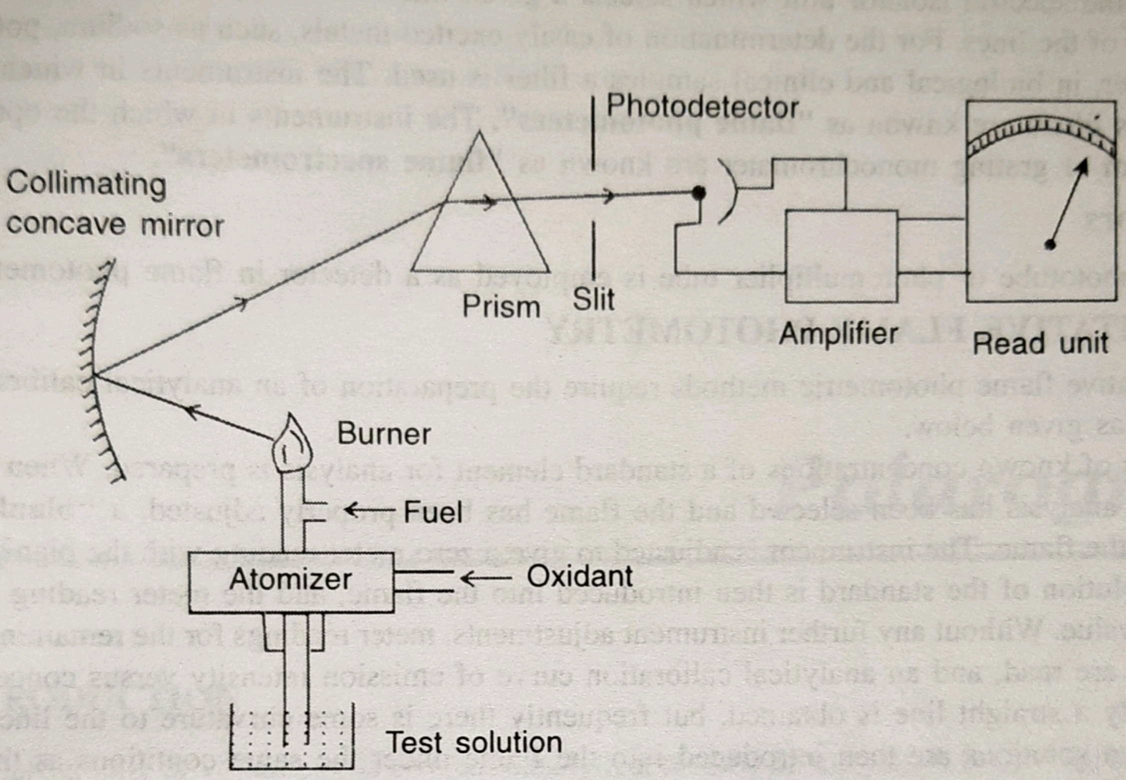

Fig. 5.2. Schematic diagram of flame photometer.

5.3.1. Pressure Regulators and Flow Meters

In order to maintain the temperature of the flame constant over a period of time, the gas pressure and gas flow to the flame excitation system should be kept constant. The fuel gas is usually contained in a cylinder under pressure. The oxidant, which is air, may be used directlry from a compressor. To maintain a constant flow, double diaphragm pressure regulating valves are usually used.

5.3.2. Atomizer and Burner

In atomizer the test solution is converted into atomic vapour. The atomizer produces an aerosol of the test solution. The mixture of atomic vapour, fuel and oxidant gas passes up the burner tube and burns at the burner tip producing a flame temperature above 2000 K. The following Table 5.2 gives some fuel gases, oxidants commonly used in flame photometry.

TABLE 5.2

Flame Temperatures

Fuel	*Oxidant*	*Temperature (°C)*
1. Hydrogen	Air	2100
2. Hydrogen	O_2	2750
3. Acetylene	Air	2150
4. Acetylene	O_2	3100
5. Propane	Air	1900
6. Propane	O_2	2800

5.3.3. The Optical System

This is the spectral isolator unit which selects a given line in the emission spectrum and isolates it from the rest of the lines. For the determination of easily excited metals, such as sodium, potassium and calcium in water, in biological and clinical samples a filter is used. The instruments in which the optical system includes filters are knwon as "**flame photometers**". The instruments in which the optical system includes a prism or grating monochromater are known as "**flame spectrometers**".

5.3.4. Detectors

Either phototube or photomultiplier tube is employed as a detector in flame photometer.

5.4. QUANTITATIVE FLAME PHOTOMETRY

Quantitative flame photometric methods require the preparation of an analytical calibration curve. It is described as given below.

A series of known concentrations of a standard element for analysis is prepared. When the correct wavelength for analysis has been selected and the flame has been properly adjusted, a **"blank"** solution is sprayed into the flame. The instrument is adjusted to give a zero meter reading with the blank. The most concentrated solution of the standard is then introduced into the flame, and the meter reading is adjusted to a maximum value. Without any further instrument adjustments, meter readings for the remaining solutions of the standard are read, and an analytical calibration curve of emission intensity versus concentration is prepared. Ideally a straight line is obtained, but frequently there is some curvature to the line.

Unknown solutions are then introduced into the flame under the same contitions as those of the standard solutions used for the preparation of the analytical curve. Meter readings for the unknown are read, and the standard curve is used to obtain the concentrations of the unknown solutions.

5.5. APPLICATIONS

Flame photometry is useful to determine

1. – **Ca** and **K** content in soils, plant material food and beverages
   – **Ca** in Wine

   In **Food and Agriculture**

2. – **Na, K and Li** electrolytes in serum
   – **Na and K** in body fluids (blood, urine, perspiration and Saliva)

   In **Pathological, Medical, Clinical and Bio-Medical Investigation**

3. – **Alkali and Alkali earth metals**
   In Mining and Metallurgy

4. – **Alkali and Alkali earth metals** in presence of each other or in any other material
   – **Na, K and Ca** nutrient solutions for cultivation of antibiotics

   in **Pharmaceuticals**

5. – **Na, K and Ca** in natural, spring, river, sea, boiler feed, rinse and waste water
   in **Pollution Monitoring and Control**

6. – Solubility, absorption and corrosion
   – **Alkali and Alkali earth metals** in pastes, Soda Glass, Ceramic and Chemical Industries
   – **Na, K and Ca** in cement and its raw materials

   in **Research Laboratories and Industires**

When you imagine that you have attained perfection, your decline begins.