Electronics And Instrumentation

8th Semester

Subject: Analytical Instrumentation
Subject code: BT 808

Unit-3

Flame Photometers

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1. INTRODUCTION

In this course you have so far learnt about the spectroscopic methods of analysis based on the molecular spectroscopies. In the present and the next few units, you would learn about spectroscopic methods based on atomic spectroscopies. In atomic spectroscopy, the element present in a sample is converted to gaseous atoms or elementary ions in a process called atomisation which may be brought about by any of the available methods. The absorption of the radiation by the vapourised atoms in the ground state, or emission or fluorescence emission of suitably excited state forms the basis of different types of atomic spectroscopies. Collectively, the atomic spectroscopic methods can be used for the qualitative and quantitative determination of about 70 elements in a wide variety of samples of clinical, biological, and environmental origin. These methods are quite quick, convenient, and selective and offer sensitivities in the parts per million (ppm) to parts per billion (ppb) range. This unit concerns flame photometry which refers to the measurement of the EM radiation in UV-VIS range emitted by the vapourised atoms after they are electronically excited by the thermal energy of the flame. It is a simple, rapid and inexpensive method for routine analysis of alkali and alkaline earth metals like, sodium, potassium, lithium, calcium and barium in environmental, clinical and biological samples especially in biological fluids and tissues. The convenience, speed and

relative freedom from interferences has made flame photometry a method of choice for the determination of these elements, which are otherwise difficult to determine. With the help of more sophisticated instruments, the method has also been applied to the determination of many other elements, with varying degree of success. We begin the unit with an understanding of the origin and classification of different types of atomic spectroscopic methods. Then we will take up the principle of flame photometry which is followed by the instrumental aspects of flame photometry. In the end we will take up some qualitative and quantitative applications of flame photometry. In the next unit you would learn about atomic fluorescence spectrometry.

Objectives

After studying this unit, you will be able to:

• define atomic spectroscopic methods and classify them,
• explain different characteristics of atomic spectrum and contrast them with that of the molecular spectrum,
• explain the principle of flame photometry,
• draw a schematic diagram illustrating different components of a flame
photometer,
• enlist the applications of flame photometry,
• discuss the factors affecting flame photometric determinations, and
• state the merits and limitations of the flame photometric technique.

2. ORIGIN AND CLASSIFICATION OF ATOMIC SPECTROSCOPIC METHODS

As a chemist you would have performed a flame test for the dentification of some elements especially the alkali and alkaline earth metals in their salts. You would have observed the beautiful colours imparted by the elements to the flame. The colour is a consequence of

the emission of radiation by the gaseous atoms / ions in the excited state. The emitted radiation can be analysed in terms of the wavelength and the intensity and can be used for the identification and quantification of the element. This forms the basis of atomic emission or flame emission spectroscopy-one of the types of atomic spectroscopy.

Atomic spectroscopy is the oldest instrumental method of elemental analysis. The origin of these techniques dates back to the times of Bunsen and Kirchhoff in the mid 19th Century wherein they showed that the optical radiation emitted from flames is characteristic of the elements present in the flame gases or the ones introduced into the burning flame by different means. It was also demonstrated during the same time that the intensities of the radiation, characteristic of different elements, present in the spectra, were dependent on the amount of elemental species present. Thus, the potential of atomic spectroscopy both as qualitative as well as quantitative analysis was established. It was also shown that the wavelength emitted by a given element in the analyte was absorbed by cold vapours (atoms in their ground state) of the same element. Further developments facilitated by the developments in the area of instrumentation led to the widespread application of atomic spectroscopy. Today, atomic spectroscopic methods or atomic spectrometry is indispensable tools in the hands of analytical chemists. Let us understand the origin of atomic spectroscopy in terms of the transitions amongst different atomic energy levels.

2.1 Origin of Atomic Spectrum

You would recall from your earlier knowledge that an atom contains a set of quantised energy levels that can be occupied by the electrons depending on the energy. The energy level with the minimum energy is called **ground state** while the ones of higher energy are referred to as the **excited states**. Further, electron in an energy level can undergo a transition to another level of a higher energy by absorbing a photon of appropriate energy equal to the difference in the energies of the two levels. On the other hand the transition of an electron from a higher energy level to a level of lower

energy is accompanied by the **emission** of the difference in energy in the form of a radiation of appropriate wavelength. A spread of the wavelengths of the photons absorbed or emitted versus their intensities is called a **spectrum**. The atomic spectroscopic methods are based on the transitions amongst the quantised electronic energy levels caused by the absorption of radiation by the atoms in ground state or by the emission of radiation by the excited atoms in vapour phase. You have learnt in details about the molecular spectroscopic methods in Blocks 1 and 2 of this course. In what way do you think that the transitions in the molecular systems are different from that in atomic systems? Try to answer this question in the space given below, before you go further. Yes, you are right. In molecular systems the rotational and vibrational motions are also quantised besides the electronic energies. Different types of electromagnetic radiation (microwave, IR, UV-VIS) are required to cause transitions amongst these levels. On the other hand, in case of atomic systems only electronic energies are quantised; the transitions being brought about by UV-VIS radiation. Let us learn the different ways in which the transitions amongst the atomic energy levels can be exploited for the identification and analytical determination of different elements.