Flame Photometry

Introduction

Atomic spectroscopy is thought to be the oldest instrumental method for the determination of elements. These techniques are introduced in the mid of 19th Century during which Bunsen and Kirchhoff showed that the radiation emitted from the flames depends on the characteristic element present in the flame. The potential of atomic spectroscopy in both the qualitative as well as quantitative analysis were then well established. The developments in the instrumentation area led to the widespread application of atomic spectroscopy. Atomic spectroscopy is an unavoidable tool in the field of analytical chemistry. It is divided into three types which are absorption, emission, and luminescence spectroscopy. The different branches of atomic absorption spectroscopy are (1) Flame photometry or flame atomic emission spectrometry in which the species is examined in the form of atoms (2) Atomic absorption spectrophotometry, (AAS), (3) Inductively coupled plasma-atomic emission spectrometry (ICP-AES).

Theory:

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. The International Union of Pure and Applied Chemistry (IUPAC) Committee on Spectroscopic Nomenclature has recommended it as flame atomic emission spectrometry (FAES). The basis of flame photometric working is that, the species of alkali metals (Group 1) and alkaline earth metals (Group II) metals are dissociated due to the thermal energy provided by the flame source. Due to this thermal excitation, some of the atoms are excited to a higher energy level where they are not stable. The absorbance of light due to the electrons excitation can be measured by using the direct absorption techniques. The subsequent loss of energy will result in the movement of excited atoms to the low energy ground state with emission of some radiations, which can be visualized in the visible region of the spectrum. The absorbance of light due to the electrons excitation can be measured by using the direct absorption techniques while the emitting

radiation intensity is measured using the emission techniques. The wavelength of emitted light is specific for specific elements.

Parts of a flame photometer

1. Source of flame:

A burner that provides flame and can be maintained in a constant form and at a constant temperature. Same as used in AAS

It is used to convert the sample into gaseous or atomic state. The process of conversion of molecules into atoms is called atomization. In atomic fluorescence

spectroscopy it is necessary to convert molecules into atoms. Following atomization techniques are used for this purpose

The **two most common methods** of sample atomization encountered in AFS,

a)Flame atomization

b)Electrothermal atomization

•Three specialized atomization procedures are also used

c) Glow-Discharge Atomization

d) Hydride Atomization

e) Cold-Vapor Atomization

We can discussed flame and electrothermal atomizer

a)Flame atomization

It can take place by two types

1) Total consumption burner and 2) Premix burner

Total Consumption Burner/ Turbulent flow burner:

TYPES OF BURNER:-

Mainly two types of burner are used.

1- Total consumption burner / Turbulent flow burner / Diffusion burner
2- Premix burner / Laminar flow burner

1- Total consumption burner: (TCB)

Aspirates the sample

Aspirate = evaporate directly into the flame by Solvent present in "venturi effect" of fuel & solution aspirates oxidant that is rushing towards & form aerosol the tip of palladium capillary particles. tube, the other end of which is dipping into sample solution or under the flame

All the sample travelling up the capillary tube reached the flame due to this the name total consumption burner.

Fig: Total consumption burner

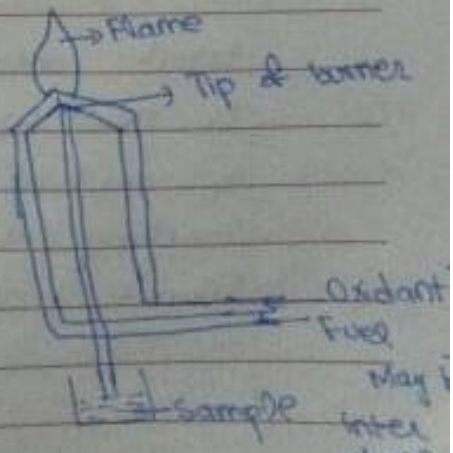


Fig: Total consumption burner

Premix Burner/Laminar Flow Burner

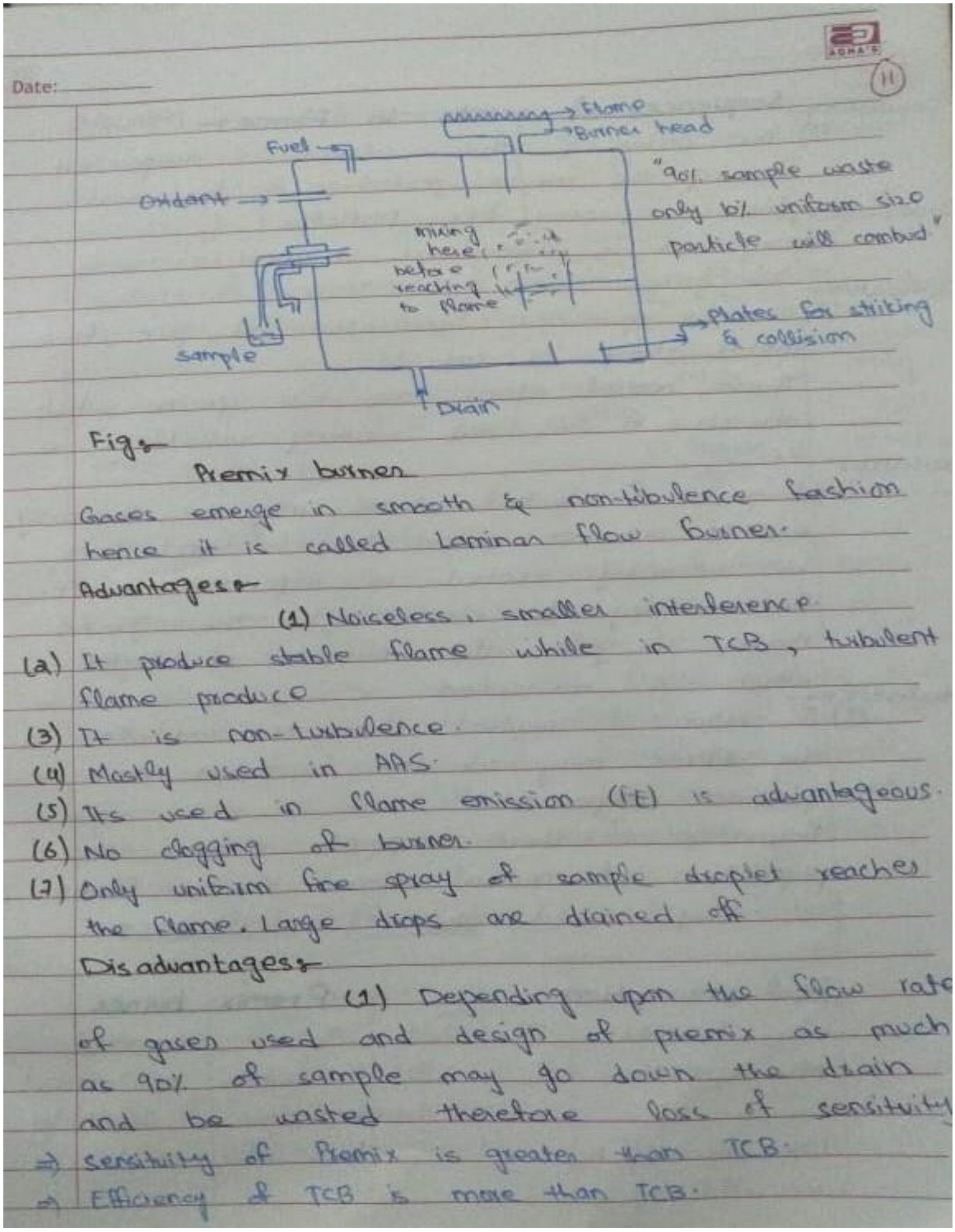


Fig:- Premix burner

Gases emerge in smooth & non-tibulence fashion hence it is called Laminar flow burner.

Advantages:-

(1) Noiceless, smaller interference.

(2) It produce stable flame while in TCB, turbulent flame produce

(3) It is non-turbulence.

(4) Mostly used in AAS.

(5) Its used in flame emission (FE) is advantageous.

(6) No clogging of burner.

(7) Only uniform fine spray of sample droplet reaches the flame. Large drops are drained off

Disadvantages:-

(1) Depending upon the flow rate of gases used and design of premix as much as 90% of sample may go down the drain and be wasted therefore loss of sensitivity

⇒ Sensitivity of Premix is greater than TCB.

⇒ Efficiency of TCB is more than TCB.

Fig Premix Burner

b) Electrothermal Atomization

An electrothermal atomizer is defined as a device which is heated to the temperature required for analyte atomization by the passage of electrical current through its body.

Advantages of Electrothermal Atomization

1)electrothermal atomizers offer the advantage of unusually high sensitivity for small volumes of sample.

2)Absolute detection limits lie in the range of 10-10 to 10-13 g of analyte.

3)The relative precision of electrothermal methods is generally in the range of 5% to 10% compared with the 1% or better that can be expected for flame or plasma atomization.

2. Nebuliser and mixing chamber:

Helps to transport the homogeneous solution of the substance into the flame at a steady rate. Same as used in AAS and AFS.

1) Pneumatic Nebulizers (most common)

In this nebulizer, the liquid sample is sucked through a capillary tube by a high pressure jet of gas flowing around the tip of the capillary as shown in figure.

2) Cross-flow Nebulizers:

The jet stream flows at right angles to the capillary tip. The sample is sometimes pumped through the capillary.

3) Babington Nebulizers:

Jet is pumped through a small orifice in a sphere on which a thin film of sample flows. This type is less prone to clogging and used for high salt content samples.

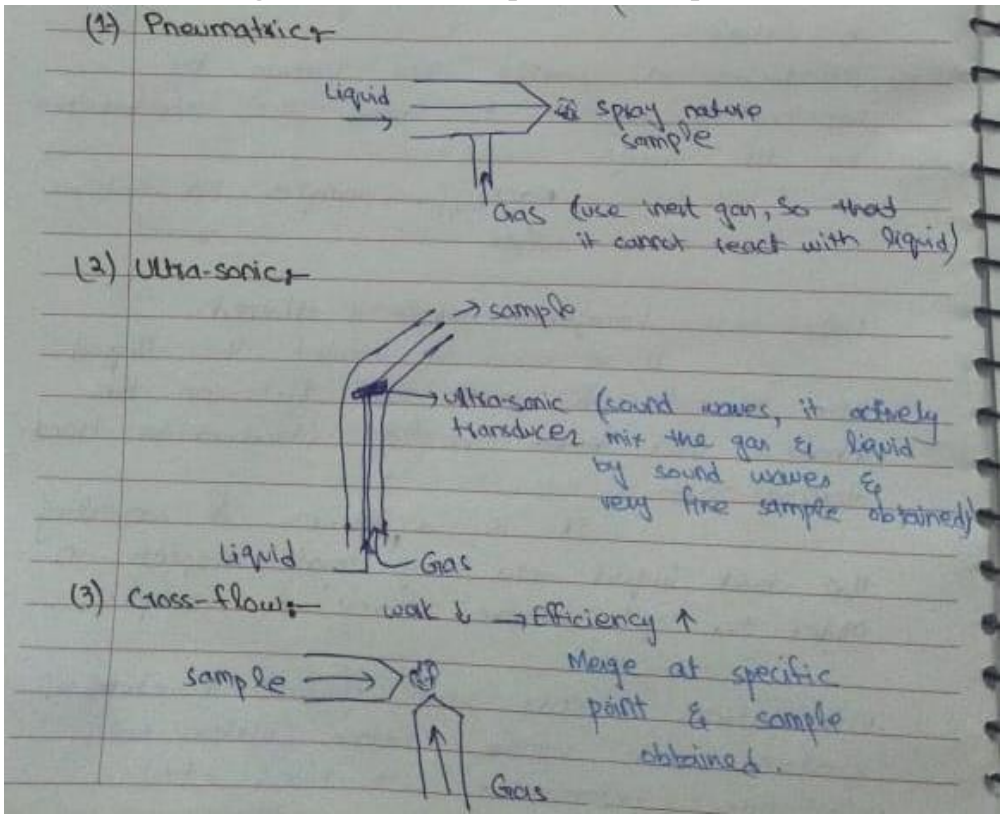
4) Ultrasonic Nebulizers:

• The sample is pumped onto the surface of a vibrating piezoelectric crystal.

• The resulting mist is denser and more homogeneous than pneumatic nebulizers.

5) Electro-thermal Vaporizers (Etv):

An electro thermal vaporizer contains an evaporator in a closed chamber through which an inert gas carries the vaporized sample into the atomizer

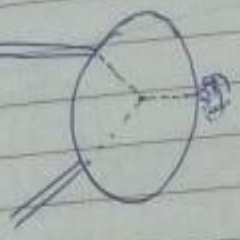


Date:

(15)

(4) Babington / V-Groove Nebulizer:- bcoz V-series is used.

extra effect ↓ Efficiency ↓ less than class flow



Specialities:-

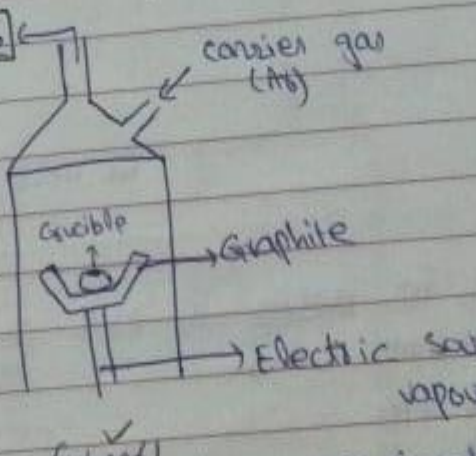
(1) Very viscous sample can be used

(2) contaminated samples can be used.

It is in circular form. Heavy substance or contaminated things remain in the bottom of circle & sample moves with the gas.

Liquids can be used. In liquids, solvent is present in large amount. After passing through the nebulizer, it passes through vaporizer then pass through the atomizer then it pass through extra to evaporate extra water.

Vaporization Chamber / Furnace:-



(Solvent) Remove extra water by vaporization. Sample is placed in the crucible. Electric source is applied & extra water evaporate and bit dense sample is obtained.

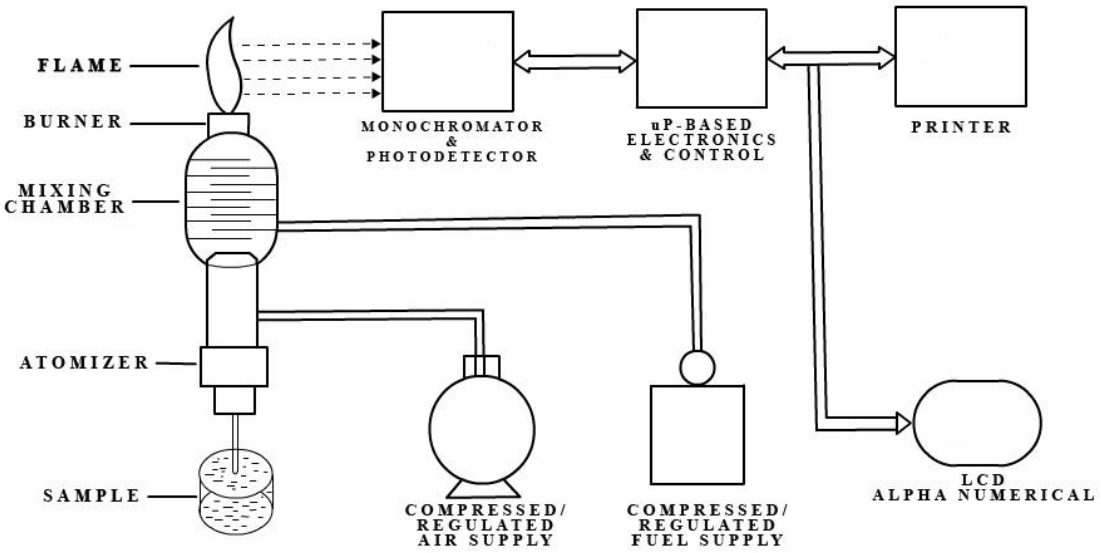
3. Optical system (optical filter):

The optical system comprises three parts: convex mirror, lens and filter. The convex mirror helps to transmit light emitted from the atoms and focus the emissions to the lens. The convex lens help to focus the light on a point called slit. The reflections from the mirror pass through the slit and reach the filters. This will isolate the wavelength to be measured from that of any other extraneous emissions. Hence it acts as interference type colour filters.

4. Photo detector:

Detect the emitted light and measure the intensity of radiation emitted by the flame. That is, the emitted radiation is converted to an electrical signal with the help of photo detector. The produced electrical signals are directly proportional to the intensity of light.

A schematic representation of flame photometer is shown in figure 1,



Flame emissions of the alkali and alkaline earth metals in terms of the emission wavelength and the characteristic color produced by each element is shown in table 1

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