Atomic Spectroscopy

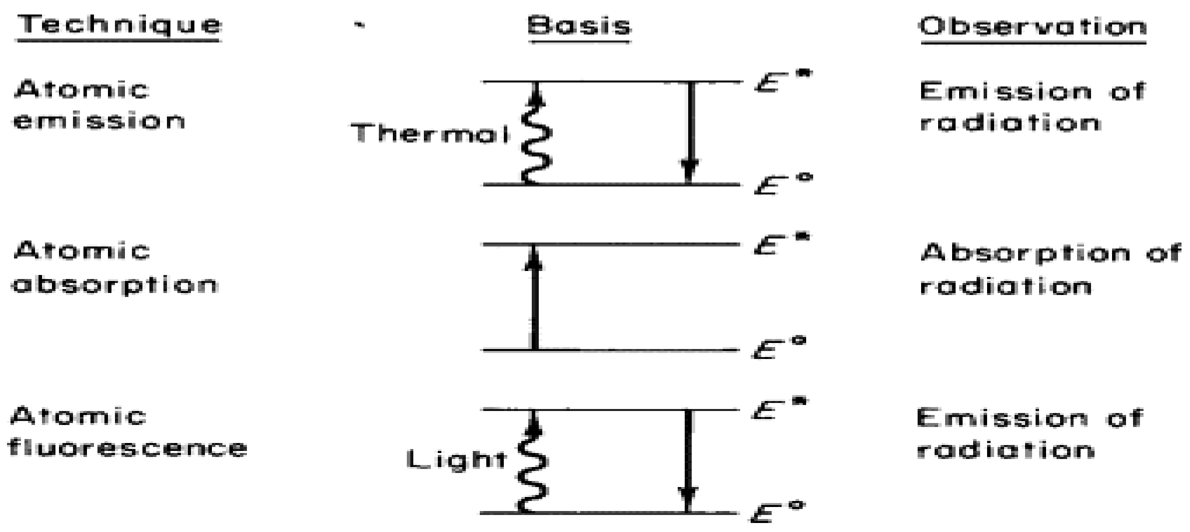
Atomic spectroscopy is the study of the electromagnetic radiation absorbed and emitted by atoms. It is an excellent analytical tool used for the detection and measurement of elements in a sample with high precision and confidence. It is typically based on the analysis of the electromagnetic radiation emitted by the atoms in an element.

Principle:

The **atoms (and ions) can absorb light at a specific, unique wavelength**. When this specific wavelength of light is provided, the energy (light) is absorbed by the atom, then electrons in the atom move from the ground state to an excited state.

Types: Atomic Spectroscopy is of 3 types.

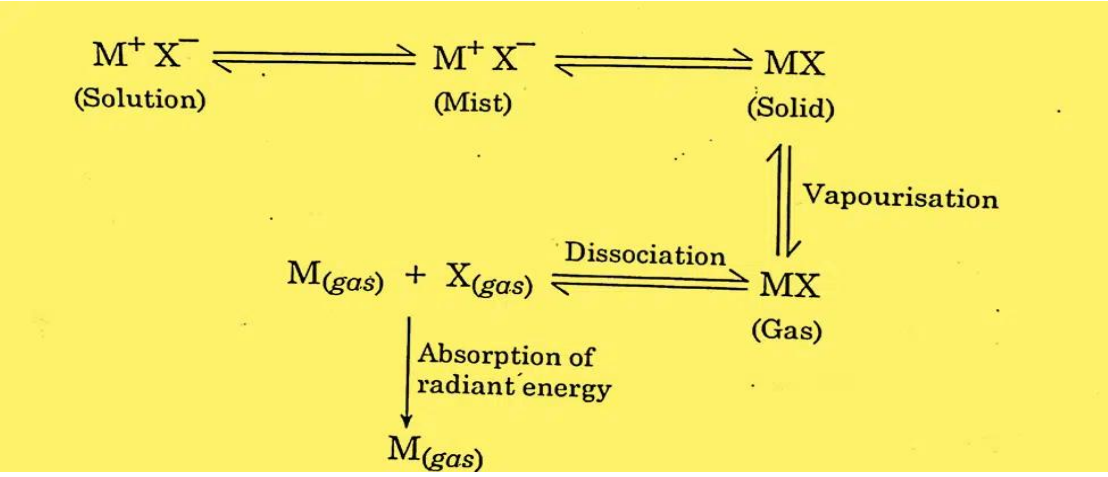
1.Atomic absorption Spectroscopy
2.Atomic emission Spectroscopy
3.Atomic Fluoroscence Spectroscopy:



Atomic absorption spectroscopy (AAS) is an absorption spectroscopic method that uses the absorption of light by free atoms in a gaseous state to determine the quantitative composition of chemical components. It is used to determine the concentration of metals present in a sample to be analyze

Principle: If a solution containing metal salt (M^+X^-) is aspirated to the flame, a vapor that contains atoms of metal may be formed. A large number of the gaseous metal atom remains in the ground state, and are capable of absorbing radiant energy of their specific wavelength. If the light of resonance wavelength is passed through the flame containing the atoms which are analyte, the part of the light will be absorbed and the extent of absorption will be directly proportional to the number of ground state atoms present in the flame.

The process by which gaseous metal atoms are produced into the flame can be illustrated as:



When a metal atom is changed into gas and light is passed from the sources, the ground state of the atom gets excited by absorbing the radiation of a particular wavelength. The absorbance is given by **Beer-Lambert's law**; the logarithmic ratio of the intensity of incident light to the intensity of absorbing species.

$$A = \log\frac{I_o}{I_t} = KLN_o$$

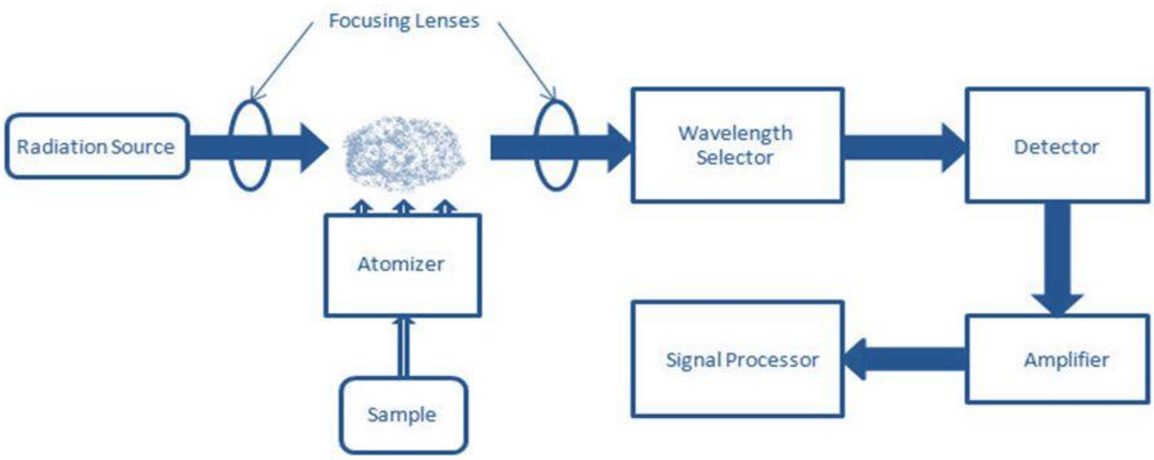
Where,

N_o = concentration of atoms in the flame

L= path length through the flame

K = constant related to absorption coefficient

Instrumentation



Atomic absorption spectrometer block diagram

Instrumentation:

1.Atomiser:
The atomizers most commonly used nowadays are flames and electrothermal (graphite tube) atomizers.
*In Flame-AAS, the atomizer is **a flame furnace**, the heat of the flame
produces the free atoms when sample introduced into atomiser.
*In Graphite-AAS, the atomizer is a graphite furnace and when sample is introduced into the atomizer,the electrical energy in the graphite furnace produces the free atoms.

* An atomizer is a device that produces a fine spray from a liquid. Most combustors employ an atomizer in which fuel is forced under high pressure through an orifice. The function of any atomizer is **to produce as homogeneous a spray as possible**.

ATOMIC ABSORPTION SPECTROSOPY:

*Atomic absorption spectroscopy is based on the principle of absorption of light by atoms in the gaseous state.

*Atoms absorbed light at a definite wavelength depending on the nature of chemical elements.

- Sodium is absorbed in 589 nm
- Uranium is absorbed in 589 nm
- Potassium is absorbed in 766.5 nm

*From the ground state of an atom is excited to a higher energy level by absorption of energy. The electronic transition is specific to a particular element.

*Elements with high excitation energy can be determined by atomic absorption spectroscopy.
*Atomic spectra are identified by sharp lines which can be distinguished from broadband spectra associated with molecules.

*The lines arising from the ground state are almost important in atomic absorption spectroscopy. These are called resonance lines.

ATOMIC ABSORPTION SPECTROSCOPY FLAME:

We used fuel and oxidant to create an atomic absorption spectroscopy flame.

Fuels used: natural gas, propane, butane, hydrogen, and acetylene

Oxidants: Air, oxygen, nitrous oxide, and a mixture of nitrous oxide and acetylene are used as an oxidant for flame creation in atomic absorption spectroscopy.

Atomic absorption spectroscopy flame			
Fuel	Air oxidant	Oxygen oxidant	Nitrous oxide oxidant
Hydrogen	2100 °C	2780 °C	–
Acetylene	2200 °C	3050 °C	2955 °C
Propane	1950 °C	1950 °C	–

Very high temperatures are required for the vapourisation of some metals which are not essily atomised. It is attained by using an oxidant in the flame along with fuel gas in atomic absorption spectroscopy.

*For example, we used oxyacetylene flame for the analysis of aluminum, titanium, and rare earth elements in an AAS instrument.

Any atomic absorption spectroscopy instrumentation has the following types of components,

- Atomization
- Hollow cathode lamp
- Monochromator
- Detector
- Recorder

- **Atomization**

- Atomization can be carried out either by a flame or furnace. Heat energy is utilized in atomic absorption spectroscopy to convert metallic elements to atomic dissociated vapor. The temperature should be controlled very carefully for the conversion of atomic vapor. At too high temperatures, atoms can be ionized.

*Fuel and oxidant gases are fed into a mixing chamber which passes through baffles to the burner. A ribbon flame is produced in the AAS instrument. The sample is aspirated through the air into the mixing chamber.

HOLLOW CATHODE LAMP: The hollow cathode lamp has two electrodes, one is cup-shaped and made of a specific element. Radiation from the hollow cathode lamp should not be continuous due to spurious radiations. Therefore, we used a chopping wheel between the radiation or pulsed potential.

The metal which is used in the cathode is the same as that metal that we analyzed. The lamp is filled with noble gas at low pressure. The lamp forms a glow of emission from the hollow cathode.

Multi-element hollow cathode Lamps: Such types of lamps facilitate for determination of samples without change of lamps each time. These types of lamps are widely used in atomic absorption spectroscopy instruments.

Monochromator

A monochromator is an optical device that transmits a narrow band of wavelengths of light or other radiation from a wider range of wavelengths. The atoms in the AAS instrument accept the energy of excitation and emit radiation.

A desired band of lines can be isolated with a monochromator by passing a narrow band.

Detector

A detector can convert light coming from a monochromator to a simplified electrical signal. Generally, we used a photomultiplier tube as a detector in the atomic absorption spectroscopy instrument. A detector can be tuned to respond by a specific wavelength or frequency.

Recorder

The recorder can receive electrical signals from the detector to convert them into a readable response. In atomic absorption spectroscopy instrumentation, today we used a computer system with suitable software for recoding signals coming from the detector.

Application of atomic absorption spectroscopy

Today, the atomic absorption spectroscopy technique is the most powerful tool in analytical chemistry, forensic science, environmental analysis, and food industries. It is popular for analysts due to several advantages.

- The most important advantage is the speed of analysis. It can analyze various samples within a day.
- Secondly, it is possible to determine all elements at trace concentration.
- Thirdly, it is not always essential to separate the element before analysis because AAS can be used to determine one element in presence of another.
- The atomic absorption spectroscopy principle or instrumentation can be used to analyze sixty-seven metals and several nonmetals such as phosphorus and boron.