Spectrometry and spectroscopy differences

Spectrometry is the spectroscopic technique used to assess the concentration or amount of a given chemical (atomic, molecular, or ionic) species. In this case, the instrument that performs such measurements is a spectrometer, spectrophotometer, or spectrograph.

Spectroscopy or spectrometry is often used in physical and analytical chemistry for the identification of substances through the spectrum emitted from or absorbed by them.

Spectroscopy or spectrometry is also heavily used in astronomy and remote sensing.

Basic Difference between Spectrometry and Spectroscopy:-

SPECTOMETRY

A method based on designation of the wavelengths within a particular portion of a range of radiations or absorptions, for example, ultraviolet (UV), emission, or absorption spectrometry .

SPECTROSCOPY

The study of the interaction between radiation and matter as a function of wavelength (λ). spectroscopy referred to the use of visible light dispersed according to its wavelength, e. g. by a prism. Later the concept was expanded greatly to comprise any measurement of a quantity as a function of either wavelength or frequency.

Spectrometric methods are subdivided, as a whole, into two main categories:-

Radiation spectrometry –

Comprising of absorption spectrometry, emission spectrometry, raman scattering spectrometry, and nuclear magnetic resonance spectrometry – and mass spectrometry

Absorption spectrometry –

Those spectroscopy methods that rely on absorption make use of the Beer-Lambert law, setting out the proportional relation between the intensity of light absorbed, and the amount of absorbing matter:

$A = \log (I0/I) = \varepsilon\ l\ C$,

Where A stands for the absorbance of the medium traversed,

I0 for incident light intensity,

I for transmitted light intensity,

ε is the characteristic molar extinction coefficient, for a given wavelength, for the substance

It is expressed in Lmol- 1cm- 1 – while l stands for the thickness passed through, expressed in centimeters, and C is the concentration, in moles per liter.

In an absorption spectrum, as recorded by means of a spectrometer, absorption peaks correspond to the wavelengths the medium is able to absorb.

Example:- Just as the spectrum from the Sun's light is obtained by making it pass through a prism, which breaks it up, spectrometers analyze the spectral distribution of the whole range of electromagnetic radiations, separating them out according to wavelength, by means of a reflection diffraction grating. Spectra exhibit peaks, each one corresponding to a specific wavelength.

Note

Depending of the type of sample to be analyzed, and the performance level being sought, in the laboratory, absorption spectrometry is used either on molecules in liquid or gaseous phase, or on atomic vapor, obtained through thermal breakdown of liquid or solid samples.

Molecular absorption spectroscopy, in the UV-visible region, affords simplicity of use, however it is only applicable to samples of moderate complexity, since, owing to the width of molecular absorption bands.

Emission spectrometry:-

Atoms or molecules brought to an excited state may de excite by emitting radiation, known as emission radiation. When the excitation is caused by selective absorption, by the atoms or molecules to be analyzed, of electromagnetic radiation, this represents a fluorescence emission (or a phosphorescence emission, depending on the electron excitation start involved).

Note

As with absorption, fluorescence may be applied, in the UV-visible radiation region, to molecules, or atoms.

X-ray fluorescence spectrometry:-

X radiation emitted by atoms excited by absorption of X-radiation. Fluorescence techniques are more complex to implement than is the case for absorption techniques, since they entail that the particle subjected to analysis be selectively excited by a monochromatic radiation.

On the other hand, since the radiation emitted is likewise specific to the particle, fluorescence spectrometry involves a double selectivity , resulting in very low background noise.

Thus making it peculiarly well suited for the measurement of very low concentrations.

Note

Emission of radiation may also occur when atoms are thermally excited, in an environment brought to high temperatures.

Emission spectroscopy is based on the fact that atoms, or molecules excited to high energy levels deexcite to lower levels, by emitting radiation (emission, or luminescence).

This differs from fluorescence spectrometry in that excitation is not applied selectively, rather it involves indiscriminately all of the particles making up the medium. Emission lines

Mass spectrometry:-

Mass spectrometry is a highly sensitive detection and identification technique, allowing determination of molecular structures, and thus of a sample's composition.

It is a form of spectrometry, since it is not concerned with discrete energy levels.

Its principle

A compound introduced into the device is vaporized, and subsequently ionized by an electron bombardment source (at 70 eV). The ion thus obtained, termed a molecular ion, allows the compound's molar mass to be determined. Breaking chemical bonds within the compound may yield characteristic fragment ions. These are then sorted according to their mass/charge ratio in an analyzer, through application of a magnetic and or electric field, then collected by a detector, which amplifies the signal associated to the ions, which arrive with varying delays.

Note:-

A data processing system converts the information from the detector into a mass spectrum, readout of which, by comparing it with reference spectra, allows the identity details of the molecule to be drawn up mass spectrometer, the exact mass of the compound may be determined, together with isotope percentages for each constituent atom.

SPECTROMETER:-

A spectrometer is an instrument used to measure properties of light over a specific portion of the electromagnetic spectrum. . The variable measured is most often the light's intensity but could also, for instance, be the polarization state.

Note:-

1* The independent variable is usually the wavelength of the light or a unit directly proportional to the photon energy, such as wavenumber or electron volts,

2*. A spectrometer is used in spectroscopy for producing spectral lines and typically used in spectroscopic analysis to identify materials.

If the region of interest is restricted to near the visible spectrum, the study is called spectrophotometres.

Types of Spectrometers:-

Colorimeters

In a colorimeter, a sample is exposed to a single wavelength of light, or is scanned with many different wavelengths of light.

The light is in the visible band of the electromagnetic spectrum.

Colored liquids reflect, transmit (let pass) or absorb different colors of light to different degrees.

Colorimetry is useful for determining the concentration of a known substance in solution, by measuring a sample's transmittance or absorbance at a fixed wavelength and comparing the result to a calibration curve.

A calibration curve is obtained by analyzing a series of standard solutions of known concentration.

UV Spectrometers

Ultraviolet (UV) spectroscopy works on a principle similar to that of colorimetry, except the light applied to the sample is in the ultraviolet range.

UV spectroscopy is also called electronic spectroscopy, because the absorbance characteristics of a sample depends on the configuration of electrons in the chemical bonds of the sample compound.

UV spectrometers are used to study chemical bonding and to determine the concentrations of substances (nucleic acids for example) that do not interact with visible light.

IR Spectrometers

It measure the response of a sample when exposed to infrared light.

A range of IR wavelengths are passed through the sample to record the absorbance.

IR spectroscopy is also called vibrational or rotational spectroscopy because the vibrational and rotational frequencies of atoms bonded to each other, are the same as the frequencies of IR radiation.

IR spectrometers are used to identify unknown compounds or to confirm their identity since the IR spectrum of a substance is essentially unique.

Atomic Spectrometers

Atomic spectrometers are used to analyze the elemental composition of samples and to determine the concentrations of elements of interest.

There are two basic types of atomic spectrometers—emission and absorbance.

In either case a liquid or gaseous sample is sent to a flame where the sample is decomposed into atoms or ions of the elements present in the sample.

In an emission instrument, the wavelengths of light released by the ionized atoms are detected.

In an absorbance instrument, light of specified wavelengths is passed through the energized atoms to a detector.

The wavelengths of the emissions or absorbances are characteristic of the elements present.

Mass Spectrometers

Mass spectrometers are used to analyze and identify the chemical structure of molecules, especially large and complex ones.

A sample is injected into the instrument and ionized (either chemically or with an electron beam) to knock off electrons and create positively charged ions.

Sometimes the sample molecules are broken into smaller ionized fragments in the process.

The ions are passed through a magnetic field, causing the charged particles to follow a curved path to strike a detector at different locations.

Heavier particles follow a different path than lighter ones, and the sample is identified by comparing the result to those produced by standard samples of known composition.

SOME OTHER SPECTROMETERS:-

A. Two-arm Spectrometers :-

The basic spectrometer has a light source S illuminating a slit that acts as an object for lens C. This produces a parallel beam of light illuminating the prism P. After refraction by the prism, the light is focussed by lens O on cross-hairs R. The eyepiece lens E is then used to examine the various images of the slit in the various colors present in the source. The cut is from Wm. S. Franklin and Barry MacNutt, Light and Sound (Bethlehem, PA, 1909)

This is the main principle on which Two arm Spectrometers are work. Some examples are:-

This small, unmarked spectroscope at Kenyon College in Gambier, Ohio has lost its eyepiece.

The telescope tube can be adjusted through a small angular range with a tangent screw.

This incomplete spectrometer at Denison is by John Browning of London

Note:-

Many physics departments used to have a small cardboard box filled with eyepieces that had come adrift from their original apparatus.

This instrument is listed at $38 in the 1888 Queen Catalogue of Instruments for Physical Optics; the cut clearly shows how the arms are threaded into their holders.

This small, unmarked spectroscope at Kenyon College in Gambier, Ohio has lost its eyepiece.

Note:-

The telescope tube can be adjusted through a small angular range with a tangent screw.

In modern spectrographs, the spectrum is generally given in the form of photon number (in the UV, visible, and near-IR spectral ranges) or Watts (in the mid- to far-IR) and is displayed with an abscissa given in terms of wavelength, wavenumber, or eV.

Note:-

A comparison of the three abscissa types typically used for visible spectrometers

This large, unmarked spectrometer is at Denison University in Granville, Ohio.

It dates from ca. 1900,

Note:-

Student-type spectrometers like this one have been in common use since 1900, although computer-based devices are beginning to take their place. Verniers allow the angular positions of the arm to be read to the nearest minute or two.

This incomplete spectrometer at Denison is by John Browning of London.

Note:-

The prism clamp can be clearly seen and the collimating arm exists, but the telescope has been lost over the years

This instrument is listed at $38 in the 1888 Queen Catalogue of Instruments for Physical Optics; the cut clearly shows how the arms are threaded into their holders.

This spectrometer is in the Museum at St. Patrick’s College at Maynooth, County Kildare, Ireland. It was made by Adam Hilger of London, stands on its own trolley, and the divided circle has a diameter of 45. 7 cm. It was used by Walter Hartley (1846-1913) for his research on the spectra of elements. In 1883 he established that the relationships exist between the wavelengths in the spectrum of an element and its position in the periodic table.

This Max Kohl spectroscope at the University of Vermont rather resembles Jamin’s Divided Circle in its overall form.

Note:-

It is used for more accurate experiments on reflection, refraction and colour-dissipation, for determining the angles of prisms and refractive indices by

Fraunhofer's, Meyerstein's or Listing-Abbe's Method, as a Goniometer and Spectrum Apparatus.

This spectrometer is of the Galway physics department.

Note:-

The spectrometer was made by Max Kohl of Chemnitz, Germany,

It equipped with a 14438 line per inch diffraction grating ruled by Rowland of Johns Hopkins University on a blank figured by Brashear.

The apparatus is listed at 725 marks in the Kohl catalogue published ca. 1900.

B. Three-Arm Spectrometers

A present-day user of a spectrometer employs a diffraction grating; if the grating spacing of the grating is known with precision the wavelengths may be obtained directly from the angle at which the particular lines appear.

For most of the nineteenth century the typical spectroscope used a prism to separate the spectral lines. Calibration was obtained by projecting the lines of a known spectral source onto the same plane as the unknown lines.

The Queen spectrometer at the right in in the collection of Kenyon College in Gambier, Ohio.

The Queen spectrometer at the left is approximately the same as the one at the right above.

It is at Westminster College in western Pennyslvania. It has suffered the fate of many older spectrometers and has lost its eyepiece.

Irish National Inventory of Historic Scientific Instruments (Samton Limited, Dublin, 1995), pg 362. The third arm, used to project the image of the linear scale, projects to the rear. A hollow glass prism for holding

APPLICATIONS OF DIFFERENT TYPES OF SPECTROMETERY:-

There are so many application of spectrometry ; generally they used to measure the wave length of the radiation produced by different types of material.

Some applications are:-

*Mass spectrometry (MS) is an analytical technique for the determination of the elemental composition of a sample or molecule.

A sample is loaded onto the MS instrument, and undergoes vaporization.

the components of the sample are ionized by one of a variety of methods (e. g., by impacting them with an electron beam), which results in the formation of charged particles (ions)

the positive ions are then accelerated by an electric field computation of the mass-to-charge ratio (m/z) of the particles based on the details of motion of the ions as they transit through electromagnetic fields, and detection of the ions, is completed with final step.

*Liquid chromatography-mass spectrometry (LC-MS, or alternatively HPLC-MS) is an analytical chemistry technique that combines the physical separation capabilities of liquid chromatography (or HPLC) with the mass analysis capabilities of mass spectrometry.

*Atomic spectrometers are used to analyze the elemental composition of samples and to determine the concentrations of elements of interest.

*IR Spectrometers measure the response of a sample when exposed to infrared light.

*UV spectrometers are used to study chemical bonding and to determine the concentrations of substances (nucleic acids for example) that do not interact with visible light.

*Colorimetry is useful for determining the concentration of a known substance in solution, by measuring a sample's transmittance or absorbance at a fixed wavelength and comparing the result to a calibration curve.