# 7th Analytical Sp-II Past Papers

## (2017)

### (i)

### Advantages of FTIR over dispersive IR:

- Improved frequency resolution
- Improved frequency reproducibility
- Higher energy throughput
- Faster operation
- Computer based
- Easily adapted for remote use

### (ii)

| Internal conversion | Fluorescence |
|---|---|
| Internal conversion is the radiationless transition between energy states of the same spin state (compare with fluorescence - a radiative process). | Fluorescence is the ability of certain chemicals to give off visible light after absorbing radiation which is not normally visible, such as ultraviolet light. |

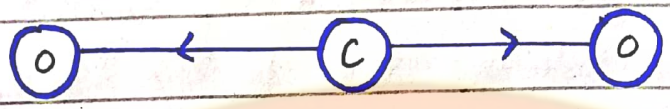
### (iii)

### Vibrational modes of $CO_2$:

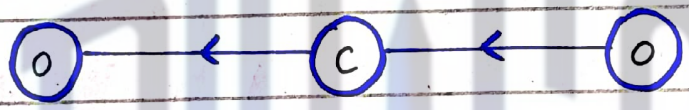
It is a linear triatomic molecule having

3N-5, 3x3-5 = 4, fundamental modes of vibrations. These are:

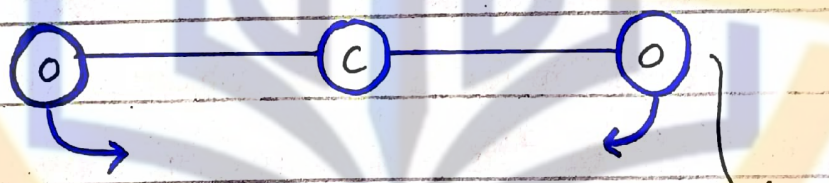
1- Symmetric stretching ($v_1$)




2- Asymmetric stretching ($v_3$)




3- Bending (in plane)




4- Bending (out of plane)


The bending motion of $CO_2$ is IR active because there is a change in the net molecular dipole. ASymmetric stretching is also IR active vibration and Raman inactive. Symmetric stretching is Raman

active and IR inactive.

(iv)

| Rotational Raman Spectroscopy | Vibrational Raman spectroscopy |
| --- | --- |
| • Rotational spectroscopy is the measurement of the energy of the transitions that take place between quantized rotational states of molecules in the gas phase. | • Vibrational spectroscopy is the measurement of the interaction of IR radiation with matter through absorption, emission or reflection. |
| • Rotational studies show that a molecule must possess permanent dipole moment to exhibit pure rotational spectrum. But a large molecule such as $H_2$, $N_2$, $C_2H_2$ which lack permanent dipole moment give rotational Raman spectra. | • Raman spectrum can be obtained by transition between vibrational states. In vibrational spectra also, it is polarizability that determines the scattering |

(v)

## Role of solvent in UV spectroscopy:

Many solvents are available for use in the UV region. Three common solvent are cyclo-hexane, 95% ethanol and 1,4-dioxane. Solvents play an important role in UV spectra.

Compound peak could be obscured by the solvent peak. So, a most suitable solvent is one that does not itself get absorbed in the region under investigation. A solvent should be trans-parent in a particular region.

(vi)

## Gas used to make plasma in ICP:

Argon gas is used to make plasma in ICP (inductively coupled plasma).

## Advantages of Argon gas:

- Argon prevents the oxidation of the surface as the plasma breaks the oxygen bond with the metal surface and carries it out of the chamber.
- Argon is chemical inert is comparably

easy to ionize.

- It is the cheapest of all nobel gases.
- Argon is a heavier gas than H or He, its ions have more energy to treat the surface of the substrate that needs to be treated.

(vii)

## Steps in ICP analysis:

ICP analysis requires the use of liquified sample solutions, so solid samples and biological samples are often digested prior to analysis. Once the sample is liquid, the ICP uses argon (Ar) carrier gas to aerosolize the sample sending only the smallest droplets through the chamber and into the argon plasma torch.

(viii)

## Advantages of IR over Raman spectroscopy:

- Raman spectroscopy is a much more expensive technique to use than IR, since high powered lasers and amplification sources are needed to get sensitive results.

- IR spectroscopy has been an understood established technique for much longer than Raman, so the techniques provid a greater sensitivity and reliability compared to
- Raman techniques such as surface-enhanced Raman spectroscopy.

(ix)

## Quantum yield of fluorescence:

It is defined as the ratio of the number of photons emitted by fluorescence to the total number of photons absorbed, i.e

### Characteristics:

High fluorescent substances have $\Phi$ values approximately equal to 1 which indicates that most of the absorbed energy is re-emitted as fluorescence. For example fluorescence in 0.1M Sodium hydroxide has $\Phi$ value of 0.85 at 23°C.

When a part of the absorbed energy is lost by radiationless pathways, the quantum efficiency is less than I and we call this as

quenching of fluorescence

(x)

## Grating over prism in UV/Vis spectroscopy:

Grating is generally better than prisms. They are more efficient. They provide a linear dispersion of wavelengths and do not suffer from the absorption effects that prisms have which limits their useful wavelength range. It can produce far greater deflection between different wavelengths and so provide a greater spectral resolution. All of these reasons grating is preffered over prism.

(2018)

(i)

## Selection rule for IR absorption:

It can be seen from quantum mechanics and group theory that absorption takes place in the IR region in accordance with the following selection rules:

1- There should be change in the magnitude or direction of the dipole of a molecule as it vibrates. This creates an oscillating dipole moment which interact with electrical component of IR radiation and hence, absorption take place.

2- The second selection rule followed from the harmonic oscillator approximation states that in the absorption of radiations only transitions for which $\Delta V = \pm 1$ can occur.

(ii)

## Diff b/w internal conversion & fluorescence:

Repeated 2017 (ii)

(iii)

## Overtones:

An overtone is a result of molecular excitation to the second excited state that generates a series of integer multiples of the fundamental frequency. A higher energy compared to fundamental and few overtones is observed in case of NIR absorptions.

## Combination bands:

A combination band is an absorption whose frequency is very near the sum or difference of two or more fundamental vibrations of a molecule. Essentially two or more vibrational modes are excited by the same photon. Not all combinations are possible.

OR

## Overtones:

An overtone band is an absorption whose selection rule is a change in vibrational quantum number that is something other than $\pm 1$ (which is called the fundamental absorption).

$\therefore \Delta n = \pm 2, \pm 3$, etc for overtone band

(iv)

## Radiationless deactivation processes:

Three radiationless deactivation processes are also significant here:

### 1- Internal conversion

Internal conversion is the radiationless transition between energy states of the same spin state.

### 2- Intersystem crossing

Intersystem crossing is a radiationless transition between different spin states.

### 3- Vibrational relaxation

Vibrational relaxation, the most common of the three -- for most molecules, occurs very quickly ($< 1 \times 10^{-12}$ seconds) and is enhanced by physical contact of an excited molecule with other particles with which energy, in the form of vibrations and rotations, can be transferred through collisions.

(v)

## Advantages of photodiode detector:

- It has a lower noise level.
- It can operate at high frequencies
- It has better frequency response and spectral response compared to LDR.
- It is highly sensitive to light.
- It requires no high voltage.

## Disadvantages of photodiode detector:

- It has a small active area.
- It needs offset voltage.
- There is a necessity for amplification at low irradiances.
- Change in current is very small, hence may not be sufficient to drive the circuit.

(vi)

## Principle of ICP-AES:

The ICP-AES is an analytical technique based on the principles of atomic spectroscopy for the determination of more than 70 elements with detection limits in

the parts per billion to parts per million range. Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES) is an emission spectrophotometric technique, exploiting the fact that excited electrons emit energy at a given wavelength as they return to ground state after excitation by high temperature Argon plasma. The fundamental characteristics of this process is that each element emits energy at specific wavelengths peculiar to its atomic character. The energy transfer for electrons when they fall back to ground state is unique to each element as it depends upon the electronic configuration of the orbital. The energy transfer is inversely proportional to the wavelength of electromagnetic radiation.

$$E = \frac{hc}{\lambda}$$

Where, "h" is Planck's constant

"c" is velocity of light

"$\lambda$" is wavelength.

(vii)

| Stokes transition | Anti-stokes transition |
| --- | --- |
| • Stokes lines represents radiation of particular wavelengths present in the lines spectra that is associated with fluorescence and the Raman effect. | • Anti-stokes lines represent the radiation of particular wavelengths present in fluorescence and in Raman spectra when the atoms or molecules of the material exist in an excited state. |
| • Not in the excited state. | • Already in the excited state. |
| • Reduction of energy of the scattered photons is usually proportional to the energy of vibrational level of the molecules. | • Increasing of the energy of scattered photons is proportional to the energy of the vibrational levels of the molecule. |

(viii)

## Role of beam splitter in FTIR:

The beam splitter is made of a special material that transmits half of the

radiation striking it and reflect the other half. Radiation from the source strikes the beam splitter and separates into two beams.

(ix)

## Resonance fluorescence:

Resonance fluorescence is a sesitive and selective analytical technique used to detect and quantify the abundances of atoms and some small molecules in the atmosphese. The method relies on the absorption of a photon by the species of interest and re-emission of radiation at same wavelength.

**Example:** $NO_2$ is an example, which fluorescences when excited by blue light, such as 488nm light from an argon lasers.

(x)

## Grating over prism:

Repeated 2017 (x)

## (2019)

(i)

| Raman Scattering | Rayleigh Scattering |
| --- | --- |
| Raman scattering is an optical process where incoming excitation light interacting with a sample produces scattered light that is lessened in energy by the vibrational modes of the chemical bonds of the specimen. | A quantum of radiation $h\nu_0$ of incident light collide with the molecule. If it is scattered without any energy loss, the scattered light will have the same frequency as the incident light. The phenomenon is called Rayleigh scattering. |

(ii)

| Vibrational deactivation | Internal conversion |
| --- | --- |
| Vibrational deactivation is the change in the occurrence of an electron between two vibrational energy levels. | Internal conversion is the radiationless transition between energy state of the same spin state (compare with fluorescence - a radiative process). |

(iii)

| Axial torch | Radial torch |
| --- | --- |
| • Axial view plasma looks down the central channel of the plasma. this provides the best sensitivity and lowest detection limits. | • Radial plasma looks through the side of the plasma and is best suited for high matrix tolerance and concentration. |
| • Axial design<br>• Environmental<br>• Chemical | • Radial design for Robust, fewer interferences<br>• Petrochemical<br>• Metallurgy |

(iv)

**Allowed transition:**

These are transitions having molar coefficient $10^4$ or more. These are generally designated as $\pi \rightarrow \pi$ transitions.

**For example** in 1,3 - butadiene which exhibits absorption at 217nm has $\epsilon_{max}$ value 21000 represents an allowed transition. These transitions are mainly favoured due to symmetry relationship.

## Forbidden transition:

These are the transitions for which $\epsilon_{max}$ is generally less than $10^4$.

**For example** transition of saturated aldehyde showing weak absorption near 290nm and having $\epsilon_{max}$ 100 has been a forbidden transition.

(v)

## Advantages of ICP-AES:

- Very rapid (1-2 min) simultaneous multielement analysis.
- Freedom from chemical interference and matrix effect.
- Low detection limit of 0.2-25 ng $ml^{-1}$ for most elements.
- Good precision and accuracy.
- Capable of determining over 70 elements.

## Disadvantages of ICP-AES:

- The technique is destructive.
- Some elements (Cs, Rb) have very poor sensitivity and therefore cannot be determined.
- Sample preparation could be time consuming.

- Relatively high running costs

(vi)

## Disadvantages of coloured glass filters:

- They are only available in a relatively small number of colour variants.
- Not sensitive to angle of incidence of incoming light.
- Not suitable for high power applications.
- Effectiveness over a wide range of wavelengths based on choice of filter.
- Effectiveness dependent on thickness and therefore may need additional polishing.

(vii)

| IR spectrum | Raman spectrum |
|---|---|
| • IR spectrum is the result of IR spectroscopy where IR radiation is used to analyze a sample. | • Raman spectrum is an analytical technique that lies upon the inelastic scattering of photons in the sample. |
| • Light absorption. | • Ligh scattering |

| | |
|---|---|
| • Vibrational modes active if it causes a change in dipole moment. | • Vibrational modes active if it causes a change in polarizability. |
| • Cannot use water as a solvent. | • Can use water as a solvent. |
| • Comparatively inexpensive | • Highly expensive method |

(viii)

## IR active vibrational modes are Raman inactive & vice versa?

The bands are IR active (Raman inactive) for asymmetric vibrations. In asymmetric vibrations, the vibration must change the dipole moment of the molecule. This change indicates that the mode is IR active and Raman inactive.

The bands are Raman active (IR inactive) for symmetric vibrations. In symmetric vibrations, the vibration must change the polarizability of the molecule. This change indicates that the mode is Raman active and IR inactive.

(ix)

| Operation of thermal detector in FTIR | Operation of photon detector in FTIR |
| --- | --- |
| Thermal detector is based on temperature change of the measured object through the absorption of electromagnetic radiation. The change in temperature causes a change in temperature dependent property of the thermal detector, which is evaluated electrically and is a measure of the absorbed energy. | Photon detectors count photons of light. A photon detector has some surface that absorbs photons and produces some effect (current, voltage) proportional to the number of photons absorbed. A photon detector converts the energy of an incoming photon to some other form of energy. This energy is then detected using electronic devices. |

(X)

## Kasha's Rule

- Kasha's rule is a principle in the photochemistry of electronically excited molecules.
- The rule states that photons emission (fluorescence or phosphorescence) occurs in appreciable yield only from the lowest excited state of a given multiplicity.

## Mirror Image Rule

- The mirror image rule is a concept in contract law.
- The rule states that the emission spectrum of a fluorophore is the image of its absorption spectrum when the probability of the $S_1 \rightarrow S_0$ transition is identical to that of the $S_0 \rightarrow S_1$ transition.

(2020)

(i)

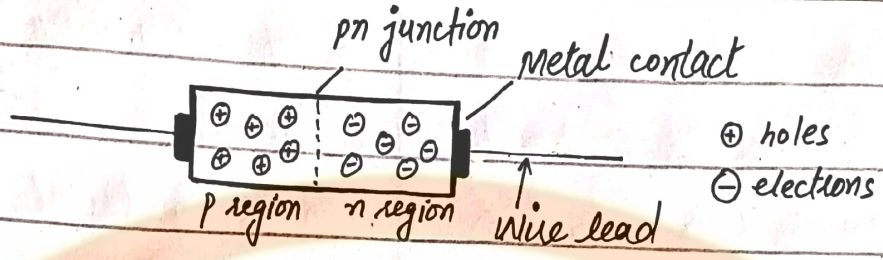
| Internal conversion | External conversion |
| --- | --- |
| • The process in which molecules that are excited returns to the ground state without emitting radiation, is known as internal conversion. It is also known as radiationless de-excitation. | • The process in which molecules pass from a higher electronic state to a lower electronic state because of the collision with other molecules is known as external conversion.<br>• There is no change in molecular spin state.<br>The excitation energy is converted to heat. |

(ii)

**Radiation detection with silicon diode transducer:**

A silicon photodiode transducer consists of a reverse-biased pn-junction formed on a silicon chip. The reverse bias creates a

depletion layer that reduces the conductance of the junction to nearly zero as shown in figure below.




If radiation impinges on the chip, however, holes and electrons are formed in the depletion layer and attracted to the appropriate electrode to produce a current that is proportional to radiant power. They require only low-voltage power supplies or can be operated under zero bias.

(iii)

| Echellete grating | Dispersive prism |
|---|---|
| • An echelle grating is a type of diffraction grating characterised by a relatively low groove density, but a groove shape which is optimized for use at | • In optics, a dispersive prism in an optical prism that is used to disperse light, that is, to separate light into its spectral components. Different wavelengths of light will be deflected by |

high incidence angles & therefore in high diffraction orders.

• Echelle gratings are like other types of diffraction gratings, used in spectrometers and similar instruments. They are most useful is cross-dispersed high resolution spectrographs such as HARPS, PARAS.

the prism at different angles. This is a result of prism material's index of refraction varying with wavelength.

• Common materials used for dispersive prisms ~~are~~ include glass and quartz which have high refractive indices and are transparent.

(iv)

## Absorptivity:

Absorptivity is a measure of the ability of a material to absorb radiation by a surface to the total radiation incident on the surface. It is represented by $\varepsilon$.

## Unit:

Its unit is liters/mole cm.

(v)

## Population inversion:

A population inversion is a state of the medium where a higher-lying electronic level has a higher population than a lower-lying level. It is often, but not always essential for laser operation.

## Light amplification:

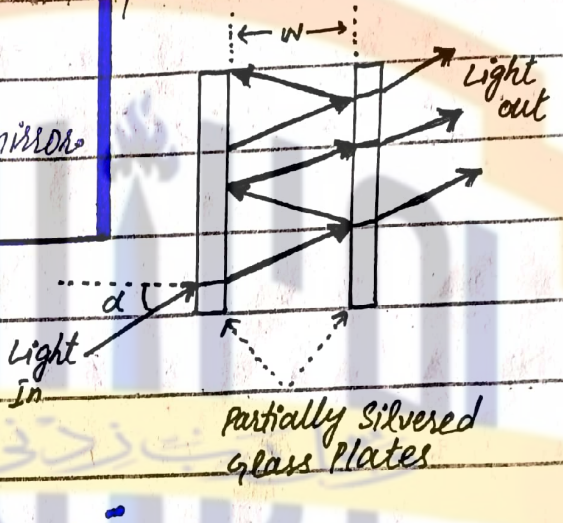
Light amplification by stimulated emission of radiation or laser is a coherent, convergent, and monochromatic beam of electromagnetic radiation with a wavelength ranging from ultraviolet to infrared.

(vi)

| Fabry perot etalon | Fabry perot interferometers |
| --- | --- |
| The Fabre-Perot etalon is the most common interferometer structure used as a fiber optic sensor, since only one | The Fabry-Perot interferometer is a high resolving power instrument, which makes use of the fringes of equal inclination, produced |

fiber is required to connect the sensor to the detector section. In a fiber sensor, a Fabry-Perot etalon can be formed using one end of the fiber itself and a separate, moveable mirror.

by transmitted light after multiple reflections in an air film between the two parallel highly reflecting glass plates.




(viii)

## Production of holographic grating:

A holographic grating is a type of diffraction grating formed by an interference-fringe field of two laser beams whose standing-wave pattern is exposed to a set of photosensitive materials.

## Advantages over master grating:

- It does not produce periodic errors, spacing errors or surface irregularities.

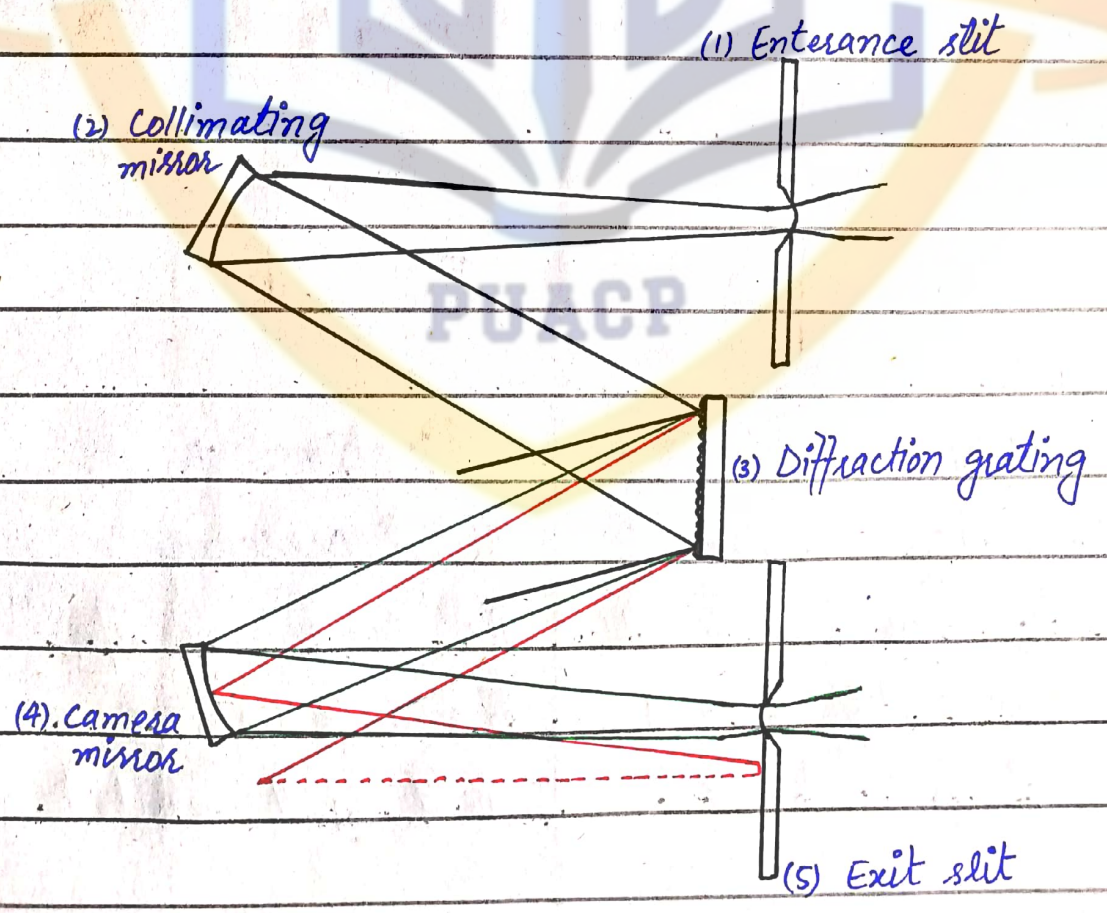
- It can produce three-dimentional images with full parallax and depth perception.
- It reduces stray light which eliminates all ghosting

(viii)

## Components of monochromators:

The basic element of monochromator are

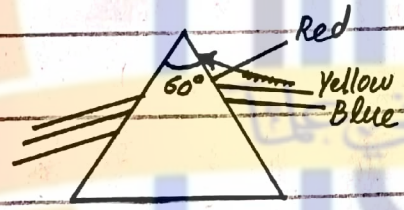
1-entrance slit  2-Collimating mirror
3-diffraction grating (dispersive element)
4-camera mirror  5-exit slit



(ix)

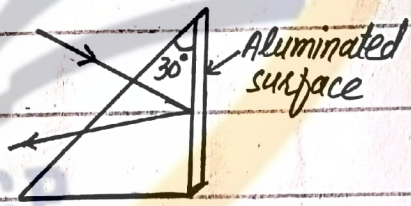
## Cornu prism

Cornu prism (refractive) has an optical angle of 60° and it is adjusted such that on rotating the emerging light is allowed to fall on exit slit.




## Littrow prism

Littrow prism (reflective), which has optical angle 30° and its one surface is aluminized with reflected light back to pass through prism and to emerge on the same side of the light source i.e, light doesn't pass through the prism on other side.




(x)

## Lifetime of Phosphorescence

The phosphorescence lifetime is defined as the average time that a

## Lifetime of fluorescence

The fluorescence lifetime a fluorophore spends in the excited

molecule remains in an excited state prior to returning to the ground state by emitting a photon.

**Formula:**

$$\tau = \frac{c^3}{2(\Delta E)^2 f}$$

state before emitting a photon and returning to the ground state. FLT can vary from pico-second to hundreds of nanoseconds depending on the fluorophore.

**Formula:**

$$\tau = \frac{1}{k_f + k_{nr}}$$

$k_f$ = radioactive decay

$k_{nr}$ = non-radioactive decay

(2021)

(i)

## Molecules show IR spectra:

Unsymmetrical diatomic molecules, e.g CO, absorb in the IR spectrum. More complex molecules have many bonds, and their vibrational spectra are correspondingly more complex, i.e, big molecules have many peaks in their IR spectra.

Water, carbon dioxide & ethanol show IR spectra. A useful feature of the vibrations which occur in polyatomic molecules is that many bonds and some small groups of atoms vibrate in much the same way no matter what molecules they are in.

(ii)

## No. of vibrational modes:

In a molecule with N number of atoms, each atom has three degrees of freedom along X-, Y-, and Z- axes. Hence there should be 3N number of degree of freedom

for a polyatomic molecule consisting of N atoms corresponding to the sum of translational, rotational and vibrational motions.

**For non-linear molecule**

The number of modes for a non-linear molecule is 3N-6.

**For linear molecule:**

The number of modes for a linear molecule is 3N-5.

Each mode has a definite frequency of vibration. In such way we can determine the no. of vibrational modes.

(iii)

**Laser in Raman spectroscopy:**

In modren Raman spectrometers lasers are used as a photon source due to their highly monochromatic nature, and high beam fluxes. This is necessary as the Raman effect is weak, typically the stokes lines are ~ $10^5$ times weaker than the Rayleigh scattered component. To get sensitive results

high powered lasers and amplification sources are needed in Raman spectroscopy.

(iv)

## Modes of vibrations in IR spectroscopy:

For a molecule to absorb infrared radiations it must undergo a net change in dipole moment as a result of vibrational or rotational motion. Following vibrational modes are present in IR spectroscopy.

1- Stretching
   - Symmetric
   - Asymmetric

2- Bending
   - Bending in-plane
     - Scissoring
     - Rocking
   - Bending out of plane
     - Wagging
     - Twisting

(v)

| Chromophore | Auxochrome |
| --- | --- |
| • An atom or group of atoms whose presence is responsible for the color of a compound. | • A group of atoms attached to a chromophore that modifies the ability of that chromophore to absorb light. |
| • A part of a molecule. | • A functional group of a molecule. |
| • Gives color to a molecule. | • Increases the color of a molecule. |
| • Absorb visible light | • Modify absorption spectrum of a molecule |

(vi)

## Raman spectroscopy better than FTIR:

The key advantage of Raman spectroscopy is that it requires little to no sample preparation while the FTIR method has constraints on sample thickness, uniformity and dilution to avoid saturation.

Raman spectroscopy measures relative frequencies at which a sample scatters

radiations, unlike FTIR spectroscopy which measures absolute frequencies at which a sample absorb radiations.

FTIR is sensitive to hetero-nuclear functional group vibrations and polar bonds. Raman on the other hand is sensitive to homo-nuclear molecular bonds.

(vii)

## Electromagnetic spectrum:

The electromagnetic spectrum is the range of frequencies of electromagnetic radiation and their respective wavelengths and photon energies. The frequency of electromagnetic radiation ranges from $1Hz - 10^{25} Hz$. The most familiar electromagnetic waves are the visible light waves. There is no sharp division between different waves but the classification is based on how the waves are produced.

1- Radio wave
2- Micro wave
3- Infrared
4- Ultraviolet
5- Visible light
6- X-rays
7- Gamma-ray

(viii)

## High vibrational energy:

High vibrational energy is energy that is good and strong. It is pure in form and derived from the source energy, universe energy.

(ix)

## Types of laser:

Types of laser are:

1- Gas laser

A gas laser is a laser in which an electric current is sent through a gas to generate light through a process known as population inversion.

2- Semi-conductor laser

A semi-conductor laser is often refered to as a laser diode with current flowing in the forward direction of the junction.

3- Dye laser

Dye laser consist of active material in the liquid suspension. These lasers are popular

because they can be change to different wavelength by changing the chemical composition of liquor. Many of the commonly used liquor are toxic.

(x)

## Detectors of IR spectrophotometers

The two main types of detectors are used in IR spectrophotometer

### 1- Thermal detector

Thermal detector is based on temperature change of the measured object through the absorption of electromagnetic radiation. The change in temperature causes a change in temperature dependent property of thermal detector, which is evaluated electrically and is a measure of the absorbed energy.

### 2- Photonic detector

Photon detector count photons of light. A photon detector has some surface that absorbs photons and produces some effect proportional to the number of photons absorbed. A photon detector

converts the energy of an incoming photon to some other form of energy. This energy is then detected by using electronic devices.

(xi)

| Atomic absorption spectroscopy | Atomic fluorescence spectroscopy |
| --- | --- |
| AAS is a technique for measuring the concentration of metallic elements in different materials. | AFS is an analytical method used to determine the concentration of elements in samples. |
| **Principle:** AAS is based upon the principle that free atoms in the ground state can absorb light of a certain wavelength. Absorption for each element is specific, no other elements absorb this wavelength. | **Principle:** AFS is the emission of radiation energy in the UV-visible region from gas-phase atoms that have been excited to higher energy levels by absorption of radiant energy. Usuall a flame is used to obtain the atom in gaseous state. It is a radiative emission process that proceeds from the |

lowest singlet ($S_1$) to the singlet ground state ($S_0$).

(xii)

## Generation of plasma in ICP:

To generate plasma, first, argon gas is supplied to torch coil, and high frequency electric current is applied to the work coil at the tip of the torch tube. Using the electromagnetic field created in the torch tube by the high frequency current, argon gas is ionized and plasma is generated.

(xiii)

## Measurement by ICP:

ICP (Inductively coupled Plasma) spectroscopy is an analytical technique used to measure and identify elements within a sample matrix based on the ionization of the elements withing the sample.

(xiv)

## Wavelength selector used in UV/visible spectrophotometers

The wavelength selection is important and depends on the color of the suspension medium. It is customary to use 420nm wavelength if the blank is nearly colorless, and 550nm if it is yellowish. In UV-Vis, the wavelength is typically used ranges from 350-2500nm when tungsten filament lamp is used as source of visible light.

(xv)

## Material used to make sample cell:

Sample cells (cuvettes) are generally made from glass, quartz and transparent plastics. Both glass and quartz cuvettes are fragile and require care in handling and use. The choice of material depends upon nature of sample, absorbance range and inertness of material towards sample.

(2022)

(i)

## Population inversion:

Repeated 2020(V)

(ii)

## Detectors used in fluorescence:

In fluorescence spectroscopy it is common to use photo-multiplying Tubes (PMT) as detectors due to the high sensitivity and fast response of these detectors. However, silicon-based solid-state detectors can also be used.

(iii)

| Fluorescence | Phosphorescence |
|---|---|
| • The emission of light by a substance that has absorbed light or other electromagnetic radiation. | • The light emitted by a substance without combustion or perceptiable heat. |
| • Stops as soon as we take away the light | • Tends to stay little longer even after we |

| | |
|---|---|
| source. | remove the irradiating light source. |
| • Take place when excited energy is released, & the molecules come back to the ground state from the singlet excited stage. | • Take place when a molecule is coming back to the ground state form the triplet excited state. |
| • The absorbed amount of energy is released back. | • Released energy is lower than what is absorbed. |

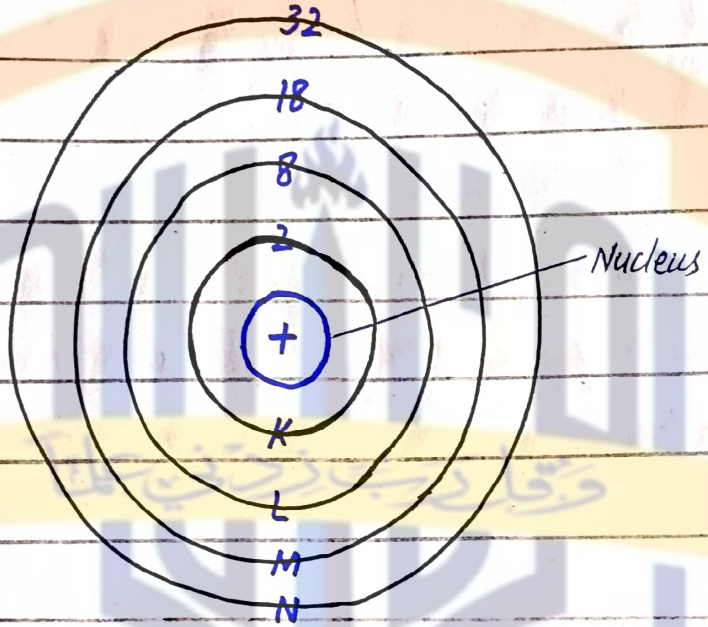
(iv)

## Electronic energy level:

Electronic energy levels refer to the specific energies that electrons can have in an atom or molecule. In quantum mechanics, electrons are described as existing in discrete energy levels or shells around the atomic nucleus.

Each energy level corresponding to a specific amount of energy that the electron possess, and higher energy levels are associated

with greater distances from the nucleus. Electrons can move between energy levels by absorbing or emitting energy in the form of photons which cause them to transition from one energy level to another.




(v)

## Properties of good solvent:

- It should not itself absorb radiations in the region under investigation.
- It should be transparent in a particular region.
- It should be less polar so that it has minimum interaction with solute molecules.

(vi)

## Selection rule in IR absorption:

Repeated

(vii)

## Sources used in UV-Vis spectroscopy:

Two sources are commonly used in UV-Visible spectrophotometers:

1- The deuterium arc lamp provides a good intensity continum in the UV region and useful in the visible region.

2- The tungsten-halogen lamp yields good intensity overt part of the UV-spectrum and over the entire visible range.

## Sources used in IR spectroscopy:

Following are different types of sources used in IR spectroscopy.

1- The Nernst glower is a cylinder of rare earth oxides. Platinum wires are sealed to the ends, and a currend passed through the cylinder. The Nernst glower can reach temperatures of 2200K.

2- The Globar source is a silicon carbide rod which is electrically heated to about 1500K. Water cooling of electrical contacts is needed to prevent arcing.

3- The incadescent wire source is a tightly wound coil of nichrome wire, electrically heated to 1100K. It produces a lower intensity of radiation than the Nernst or Globar source, but has a longer working life.

(viii)

## ICP:

ICP (Inductively Coupled Plasma) spectroscopy is an analytical method used to detect and measure elements to analyze chemical samples. The process is based on the ionization of a sample by an extremely hot plasma, usually made from the argon gas.

(ix)

## Determine no. of vibrational modes:

Repeated 2021 (ii)

(x)

## Electromagnetic spectrum:

Repeated 2021 (vii)

(xi)

| Raman spectroscopy | IR spectroscopy |
| --- | --- |
| • Analysis of scattered light of the vibrating molecules. | • Analysis of absorption of the vibrating molecules. |
| • Vibration is Raman active if it causes a change in polarizability. | • Vibration is IR active if a change in the dipole moment during the vibration occurs |
| • Molecules may not have a dipole moment. | • Chemical bond must have the characteristics of an electric dipole. |
| • Water can be used as a solvent | • Water cannot be used as a solvent due to intense absorption |

(xii)

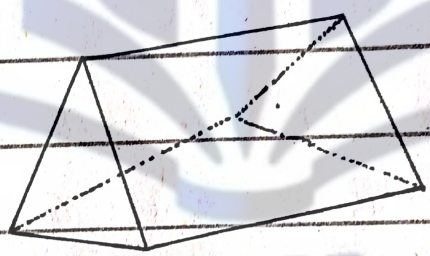
## Define allowed & forbidden transition:

Repeated

(xiii)

## Prism:

Prism is a three dimentional solid object in which the two ends are identical. It is the combination of the flat faces, identical bases and equal cross-sections. The faces of the prism are parallelograms or rectangles without the bases.



## Monochromator:

A monochromator is an optical device that separates polychromatic light (such as sun light or light coming from a lamp) into a range of individual wavelengths and allows a narrow band of these individual

wavelengths to be selected.

**Example:** The HR320 monochromator is an example of monochromator.

(xiv)

## Laser / LASER:

A laser is a device that emits light through a process of optical amplification base on the stimulated emission of electromagnetic radiation. The term "laser" originated as an acronym for light amplification by stimulated emission of radiation.

Laser has following types

1- Gas laser
2- Dye laser
3- Semi-conductor laser
4- Free-electron laser

(xv)

## Purpose of grating:

- Grating is used to separate polyatomic light into its constituent wavelengths.
- Diffraction grating determines wavelength range and partially determines the optical

resolution that the spectrometer will achieve.

- Gratings give exceptionally high resolutions of spectral lines.