Spectroscopy Chemistry Questions with Solutions

Q1: During the motion, if the centre of gravity of the molecule changes, the molecule possesses _____

a) Rotational energy
b) Electronic energy
c) Vibrational energy
d) Translational energy

Answer: d) Translational energy

Explanation: If the molecule's centre of gravity shifts during motion, the molecule has translational energy. The term "translational" refers to horizontal or vertical movement.

Q2: The different types of energies associated with a molecule are _____
a) Electronic energy
b) Vibrational energy
c) Rotational energy
d) All of the mentioned

Answer: d) All of the mentioned

Explanation: Electronic energy, vibrational energy, rotational energy, and translational energy are the different forms of energies connected with molecules.

Q3: Select the correct statement from the following option.
a) Spectroscopic methods require less time and more amount of sample than classical methods
b) Spectroscopic methods require more time and more amount of sample than classical methods
c) Spectroscopic methods require less time and less amount of sample than classical methods
d) Spectroscopic methods require more time and less amount of sample than classical methods

Answer: c) Spectroscopic methods require less time and less amount of sample than classical methods

Q4: The transition zone for Raman spectra is _____
a) Between electronic levels
b) Between vibrational and rotational levels
c) Between magnetic levels of nuclei
d) Between magnetic levels of unpaired electrons

Answer: b) Between vibrational and rotational levels

Explanation: Raman spectra have a transition zone between vibrational and rotational levels. Raman spectroscopy is a spectroscopic technique for observing low-frequency vibrational, rotational, and other modes in a system.

Q5: The region of electromagnetic spectrum for nuclear magnetic resonance is _____
a) Microwave
b) UV-rays
c) Infrared
d) Radio frequency

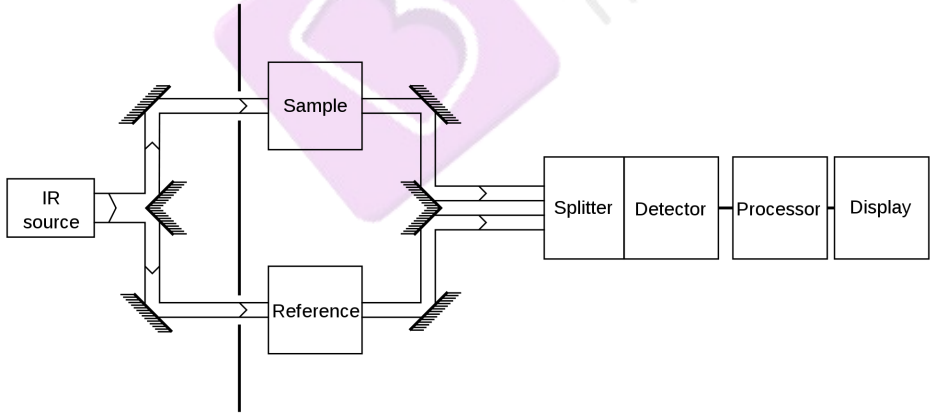
Answer: d) Radio frequency

Explanation: Nuclear magnetic resonance occurs in the radio frequency range of the electromagnetic spectrum.

Q6: Define Infrared Spectroscopy.

Answer:

Infrared (IR) Spectroscopy is a form of spectroscopy that deals with the infrared part of the electromagnetic spectrum. The infrared region's rays have a longer wavelength than light but a lower frequency. Absorption spectroscopy is the foundation of infrared spectroscopy.



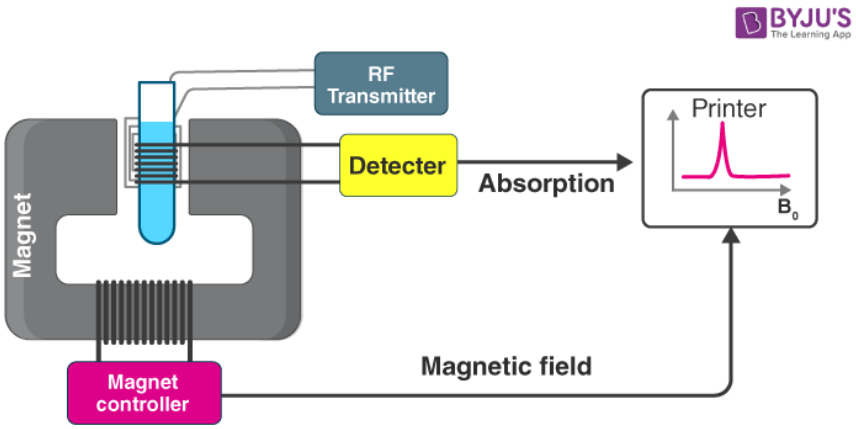
Infrared spectroscopy (IR Spectroscopy) identifies infrared light frequencies absorbed by a molecule. Because these specific frequencies of light correspond to the frequency of the vibration of bonds in the molecule, molecules tend to absorb them.

Q7: Explain Nuclear Magnetic Resonance (NMR) spectroscopy.

Answer:

The study of molecules by recording the interaction of radiofrequency (Rf) electromagnetic radiations with the nuclei of molecules placed in a strong magnetic field is known as nuclear magnetic resonance (NMR) spectroscopy.

It's a study method that takes advantage of the magnetic characteristics of specific atomic nuclei. The physical and chemical properties of atoms or molecules are determined using NMR spectroscopy.



NMR Spectroscopy Instrumentation

It uses the nuclear magnetic resonance phenomena to offer extensive information on a molecule's structure, dynamics, reaction state, and chemical environment.

Q8: Briefly explain the Absorption Spectrum.

Answer:

- When a ray of white light strikes a prism, it is refracted twice.
- It does this twice: once when it goes from a rarer medium (air) to a denser medium (glass), and then again when it travels from a denser medium (glass) to a rarer medium (air).
- Finally, we see a spectrum, which is a band of colours created by a ray of white light. If we look carefully at this spectrum, the colour with the shortest wavelength deviates the most, and vice versa.
- As a result, a spectrum of colours ranging from red to violet can be seen, with red suffering the least variation due to its longest wavelength.
- As violet merges into blue, blue into green, and so on, this type of spectrum is known as a continuous spectrum.

Q9: What are the advantages of Mass Spectrometry?

Answer:

Mass spectrometry (MS) is an analytical technique that identifies the molecular weight of compounds and thus allows for the identification of individual elements. When used in conjunction with other

identification techniques like carbon and proton NMR and IR spectroscopy, mass spectrometry can be extremely helpful in identifying unknown compounds.

MS can also tell you whether a compound contains particular elements like bromine or chlorine. These halogens can be easily detected by comparing the intensity ratios of ions with atomic mass units (m/z) that differ by two.

Q10: Briefly explain Proton magnetic resonance spectroscopy.

Answer:

Because most organic compounds contain numerous hydrogen atoms, and the hydrogen atoms absorb the energy of different wavelengths depending on their bonding environment, proton NMR spectra provide a plethora of data about molecular structure.

Nuclear magnetic resonance with respect to hydrogen-1 nuclei within a substance's molecules is known as proton nuclear magnetic resonance (proton NMR, hydrogen-1 NMR, or ^{1}H NMR). In samples containing natural hydrogen (H), the isotope ^{1}H makes up nearly all of the hydrogen (hydrogen-1; i.e., having a proton for a nucleus).

Q11: Mention the differences between Spectrometry and Spectroscopy.

Answer:

The science of spectroscopy is the study of the interaction between matter and radiated energy. It's the study of matter's absorption properties or absorption behaviour when exposed to electromagnetic radiation. Spectroscopy is a theoretical method of science that does not produce any results.

Spectrometry, on the other hand, is a technique for obtaining a quantitative spectrum measurement. It is the practical application in which results are obtained, assisting in quantifying absorbance, optical density, and transmittance, for example.

In a summary, spectroscopy is a theoretical science, and spectrometry is a practical measurement in the atomic and molecular balances of matter.

Q12: Give the molecular formula of hydrocarbon cation with an m/z value of 91.

Answer:

To find the number of carbon atoms in the chemical formula of a hydrocarbon cation with a m/z value of 91, divide the given value by 12. Hydrogens account for the remaining mass. As a result, the parent hydrocarbon cation's molecular formula is $C_7H_7^+$.

Q13: Give the applications of Mass Spectrometry.

Answer:

Mass spectrometry has a wide range of applications. Mass spectrometry is utilised in practically every branch of science for both qualitative and quantitative study of macromolecules and low molecular weight substances, whether in pure or applied research. Some of the most important uses of mass spectrometry are listed below.

- Biomolecules such as proteins, carbohydrates, and nucleic acids have molecular masses that may be determined.
- Biopolymer sequences, such as nucleic acids, oligosaccharides, and polypeptides, are determined.
- To ascertain the structure of a protein.
- Elements and their isotopes are identified.
- Toxins and pesticide residues in food are tested.
- Monitoring the environment and climate change by analysing air, water, and soil quality.
- During surgery, monitoring the metabolic gas exchange of patients.
- Carbon dating of samples and determining the composition of rock and soil.
- Quality control in the chemical and petrochemical sectors is examined.
- Particles in aerosols, such as perfumes, are being studied.
- Analyzing drug misuse metabolites in saliva, urine, and blood to determine drug abuse cases.

Q14: On which factors does the vibrational stretching frequency of a diatomic molecule depend?
a) Atomic population
b) Force constant
c) Temperature
d) Magnetic field

Answer: b) Force constant

Explanation: If the force constant of a bond changes with its electronic structure, the value of the vibrating stretching frequency shifts. Working with the same chemical in different states also causes frequency alterations (solids, liquids, and gas). Compared to liquid and solid forms, a substance absorbs at a greater frequency in the gaseous state.

Q15: The intensity of an absorption band is always proportional to which of the following factor?
a) Atomic population
b) Temperature
c) Molecular population of the final state
d) Molecular population of the initial state

Answer: d) Molecular population of the initial state

Explanation: The most important factor influencing the intensity of an observed I line is the probability of a transition occurring in the initial state. The population of the initial state engaged in the transition determines this probability.

Practise Questions on Spectroscopy

Q1: Mention the different types of Spectroscopy.

Answer:

- Acoustic resonance
- X-ray photoelectron
- Time-resolved
- Photoemission
- Circular Dichroism
- Raman spectroscopy
- IR Spectroscopy (Infrared spectroscopy)

Q2: Define Carbon-13 Magnetic Resonance Spectroscopy.

Answer:

Natural carbon is almost entirely made up of the carbon-12 isotope, which has no magnetic moment and cannot be detected by NMR techniques. However, carbon-13 (^{13}C) atoms, which account for around 1% of all carbon atoms, absorb radio-frequency waves similarly to hydrogen.

Q3: Mention the applications of NMR Spectroscopy.

Answer:

NMR spectroscopy is a spectroscopic technique used by chemists and biochemists to study the characteristics of organic molecules, while it can be applied to any sample with spin-containing nuclei.

The NMR, for example, can examine mixtures containing known substances quantitatively. NMR can be used to compare unknown chemicals to spectral libraries or to derive their basic structure directly.

NMR can be used to assess molecule conformation in solutions and examine physical features at the molecular level, such as conformational exchange, phase shifts, solubility, and diffusion, once the basic structure is understood.

Q4: Name the type of radiation used in mass spectrometry.

Answer:

Photoionization can be utilised in mass spectrometry investigations to address chemical kinetics processes and branching in isomeric materials. In certain circumstances, a high-energy photon, such as UV or X-ray, is employed to separate stable gaseous molecules from Argon or Helium carrier gas.

Q5: What is the use of ionizer in mass spectrometry?

Answer:

Positively charged ions are created in an ionizer by hitting materials with an electron beam. The ionizer's electrons travel between the cathode and the anode. The high-energy electrons knock away the electrons from the sample as it passes through the electron stream between the cathode and anode, resulting in the creation of ions.