

Infrared Spectroscopy Chemistry Questions with Solutions

Q1. Which of the following statements about infrared spectroscopy is correct?

- a.) When the frequency of infrared light matches the frequency of bond vibration in a molecule, a peak appears on the spectrum.
- b.) Infrared spectroscopy can be used to determine the size and shape of a compound's carbon skeleton.
- c.) An IR spectrometer illuminates a compound with infrared light and records the positions where the light is blocked by the compound. This results in the peaks of the spectrum.
- d.) The fingerprint region of the spectrum can be used to identify functional groups.

Correct Answer– (a.) When the frequency of infrared light matches the frequency of bond vibration in a molecule, a peak appears on the spectrum.

Q2. In an infrared (IR) spectrum, which of the following functional groups has the highest frequency?

- a.) Ketone
- b.) Aldehyde
- c.) Ester
- d.) Alcohol

Correct Answer– (d.) Alcohol.

Q3. A carbonyl group will cause a sharp dip at about ____ cm^{-1} .

- a.) 1700
- b.) 2800
- c.) 3400
- d.) 1200

Correct Answer– (a.) 1700

Q4. Which of the following causes the vibration of atoms?

- a.) The number of protons contained in a nucleus.
- b.) Electron movement to higher energy levels.
- c.) The molecule's total molecular weight.
- d.) Dipole moments between atoms.

Correct Answer– (d.) Dipole moments between atoms.

Q5. What is the range of the infrared spectrum?

Answer. The infrared spectrum extends from 700 to 1000 nm (wavelength), or 14,286 to 12,800 cm^{-1} (wavenumber).

Q6. What is the fundamental measurement in IR spectroscopy?

Answer. An infrared spectrum is a plot between measured infrared intensity versus wavelength (or frequency) of light, which is the fundamental measurement obtained in infrared spectroscopy.

Q7. Which solvent is ideal for infrared spectroscopy?

Answer. Carbon Tetrachloride (CCl_4) and Carbon Disulfide (CS_2) are the most commonly used solvents. Polar materials can be dissolved in chloroform, methylene chloride, acetonitrile, and acetone.

Q8. What are the different types of infrared spectroscopy?

Answer. The two types of infrared spectrometers are:

- The dispersive infrared spectrometer (DS)
- The Fourier transform infrared spectrometer (FTIS).

Q9. What is the region of the infrared spectrum?

Answer. The majority of the bands that indicate which functional group is present are found between 4000 cm^{-1} and 1300 cm^{-1} . Their bands can be identified and used to determine the functional group of an unknown compound functional group.

The fingerprint region, from 1300 cm^{-1} to 400 cm^{-1} , contains bands that are unique to each molecule, similar to a fingerprint. These bands are only used to compare the spectra of different compounds.

Q10. How does infrared spectroscopy works?

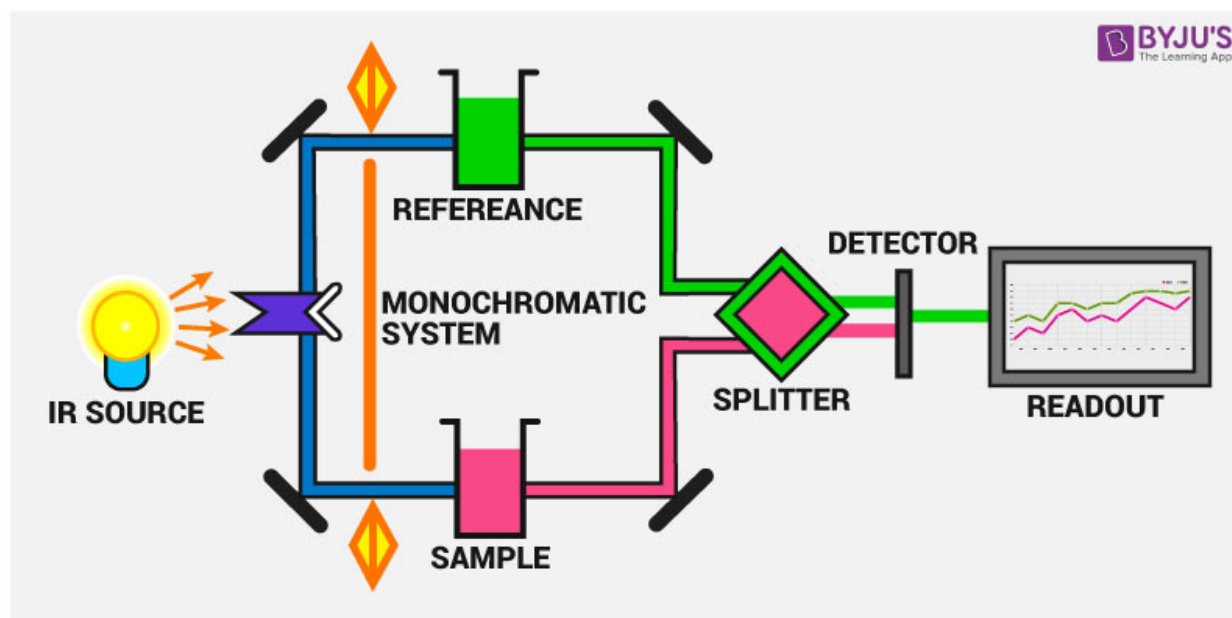
Answer. Infrared (IR) spectroscopy excites the molecules of a compound and produces an infrared spectrum of the energy absorbed by a molecule as a function of the frequency or wavelength of light. Different types of bonds react differently to IR radiation. Triple and double bonds, for example, are shorter and stiffer than single bonds and thus vibrate at higher frequencies. The types of atoms in the bonds are also important. Because O-H bonds are stronger than C-H bonds, they vibrate at higher frequencies. As a result, IR spectroscopy allows us to identify the various functional groups present in a compound.

Q11. What is the necessary condition for IR spectroscopy?

Answer. According to the selection rule for IR transitions, the change in the electric dipole moment of the functional group present in a molecule or sample during the vibration is required for a molecule or sample to show an infrared spectrum.

Q12. How does the IR spectroscopy instrument works?

Answer. The infrared spectroscopy instrumentation is shown below.



First, an IR light beam from the source is split into two and passed through the reference and sample, in that order.

Both of these beams are now reflected in order to pass through a splitter and then a detector. After the processor deciphers the data passed through the detector, the required reading is printed out.

Q13. What are some of the applications of infrared spectroscopy?

Answer. Infrared spectroscopy is widely used in both industry and research. It is a simple and dependable measurement, quality control, and dynamic measurement technique. It is also used in forensic analysis, both civil and criminal.

The following are some of the most important applications of IR spectroscopy:

- Identification of functional group and structure elucidation
- Identification of substances
- Studying the progress of the reaction
- Detection of impurities
- Quantitative analysis

Q14. What is the principle on which infrared spectroscopy works?

Answer. IR spectroscopy is based on the idea that molecules absorb specific frequencies that are unique to their structure. All atoms in molecules are in continuous vibration with respect to each other at temperatures above absolute zero. A sample's IR spectrum is recorded by passing an IR radiation beam through it.

When the frequency of a specific vibration equals the frequency of the IR radiation directed at the molecule, the radiation is absorbed. The amount of energy absorbed at each frequency is revealed by examining the transmitted light (or wavelength). IR spectrometers can accept a wide variety of sample types, including gases, liquids, and solids, by using various sampling accessories.

Q15. What are the disadvantages of IR spectroscopy?

Answer. Disadvantages of IR spectroscopy:

- Sample Constraint: Infrared spectroscopy is not applicable to water-containing samples because this solvent absorbs IR light strongly.
- Spectrum Complication: The IR spectrum is extremely complicated, and interpretation requires a great deal of experience. On the basis of a single IR spectrum, we cannot always determine the structure of a compound. Other spectroscopy techniques, such as (Mass Spectrometry) MS and (Nuclear Magnetic Resonance) NMR, are still required to fully understand the specific structure.
- Quantification: While infrared spectroscopy is effective for qualitative analysis of a wide range of samples, quantitative analysis may be limited under certain conditions, such as very high and low concentrations.

Practise Questions on Infrared Spectroscopy

Q1. Which of the following statements is correct?

- a.) The fingerprint region is most easily used to determine the molecule's functional groups.
- b.) Molecular mass can be easily determined using IR spectroscopy.
- c.) The frequency of vibrations between atoms is determined using infrared spectroscopy.
- d.) The shape of the carbon backbone is determined using IR spectroscopy.

Correct Answer– (c.) The frequency of vibrations between atoms is determined using infrared spectroscopy.

Q2. An alcohol group will cause a sharp dip at about ____ cm^{-1} .

- a.) 1700
- b.) 2800
- c.) 3400
- d.) 1200

Correct Answer– (c.) 3400

Q3. Why the IR absorption spectra is specific for a particular functional group?

Answer. When atoms in a molecule absorb electromagnetic radiation, they do so in discrete amounts of energy known as quanta. The energy levels of different frequencies of EM radiation vary. The IR spectrum's frequencies contain just enough energy to cause molecules to vibrate.

The ground vibrational state is the lowest vibrational state of a molecule, while vibrational states higher than this are referred to as excited vibrational states.

Molecules will only absorb the energy of the frequency required to move them from one vibrational state to the next.

The energy difference between different vibrational states is determined by the bond strength and mass of the elements in the bond. This is why IR absorption spectra are specific to a functional group.

Infrared spectrophotometry thus measures the energy changes required to excite a molecule from its ground vibrational state to subsequent excited vibrational states.

Q4. Classify the IR spectrum region.

Answer. The most common classification of the infrared spectrum divides it into three IR regions, which are named according to their distance from the visible light spectrum, as follows;

- The near IR region: This range, which borders the visible light region, has the most energy and the shortest wavelength of the three. It spans the $14000 - 4000 \text{ cm}^{-1}$ (wavenumber) range.
- The mid-IR region has a wavelength range of $4000 - 400 \text{ cm}^{-1}$ and is where most organic substances absorb IR radiation. It is further subdivided into two ranges: $400 - 1400 \text{ cm}^{-1}$ for the fingerprint region and $1400 - 4000 \text{ cm}^{-1}$ for the functional group region.
- The far infrared region: This region borders the microwave spectrum and has a wavelength range of $400 - 10 \text{ cm}^{-1}$. This frequency range is useful for analysing inorganic substances and gases because it is where their fundamental vibrations occur.

Q5. What are the advantages of IR spectroscopy?

Answer. Some of the advantages of IR spectroscopy are as follows:

- Information can be obtained in both qualitative (structure, presence of functional groups) and quantitative (amount of substances in sample) formats.
- Samples in various states can be studied. This includes liquids, gases, films, surfaces, pastes, powders, and solutions, among other things.
- Different IR regions can be tailored to specific applications, such as analysing inorganic substances in the far IR region, organic species in the mid-IR region, and routine quantitative analysis in the near IR region.
- The peak intensities, peak positions, peak widths, and shapes of the commonly used mid IF region can be easily read and information extracted quickly.
- The FTIR spectrometer can generate data quickly and with a higher signal-to-noise ratio.
- The sample is not damaged because IR spectrophotometry is a non-destructive method of analysis.