What is Infrared Spectroscopy?

Worksheet

IR spectroscopy measures the absorption of infrared light (wavelength 2.5-25 m, wavenumber 400-4000 cm) by molecular bonds, revealing functional groups present.

Questions

1. A spectrum shows a strong, sharp peak at 2150 cm. Which bond is this likely?

A) C=O
B) C=C
C) CN (nitrile)
D) O-H

2. IR peaks for O-H in carboxylic acids are typically

A) sharp and narrow
B) broad due to hydrogen bonding
C) absent
D) below 1000 cm

3. What does a C=O peak at ~1650 cm suggest, rather than 1700 cm?

A) A stronger C=O bond
B) An amide (conjugation lowers frequency)
C) No functional group
D) An ester instead of aldehyde

4. Why is the fingerprint region (below 1500 cm) useful?

A) Only this region is active
B) It is unique to each compound, aiding identification
C) It contains only one peak
D) It is independent of functional groups

5. A compound shows a strong absorption peak at 1700 cm. What functional group does this suggest?

6. Ethanol (CHCHOH) shows peaks at 2900 (C-H), 3300 (O-H), and 1050 (C-O) cm. Explain each peak.

7. Phenol (CHOH) shows a O-H peak at 3200 cm, not 3300. Why might it differ from aliphatic alcohols?

8. Define: What does IR spectroscopy measure?

9. Define: What wavenumber range is used in IR spectroscopy?

10. Define: Why do different bonds absorb IR at different frequencies?

Answer Key

1. C) CN (nitrile) - 2150 cm is characteristic of CN (nitrile/cyano) stretching.

2. B) broad due to hydrogen bonding - Hydrogen bonding in carboxylic acids broadens the O-H peak significantly.

3. B) An amide (conjugation lowers frequency) - Amides show lower C=O frequency (~1650 cm) due to C-N resonance and conjugation.

4. B) It is unique to each compound, aiding identification - Complex skeletal vibrations make the fingerprint region unique for each compound.

5. 1700 cm is in the C=O stretch region (carbonyl). This indicates an aldehyde, ketone, carboxylic acid, ester, or amide. Further analysis of other peaks (O-H at ~3300 cm for acid, or N-H) refines the identification.

6. 2900 cm: C-H stretching (alkyl groups) 3300 cm: O-H stretching (hydroxyl group, broad peak) 1050 cm: C-O stretching (alcohol C-O bond) These peaks confirm ethanol's functional groups.

7. Phenol's O-H is directly bonded to an aromatic ring. The aromatic structure shifts the O-H stretching frequency slightly. Hydrogen bonding in phenol can also broaden the peak and shift it to lower frequency.

8. The absorption of infrared light by molecular bonds, revealing functional groups.

9. Typically 400-4000 cm (2.5-25 m wavelength).

10. Each bond has a unique vibrational energy (spring constant and reduced mass), so it absorbs IR at its characteristic frequency.