Spectroscopy

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What is Spectroscopy?

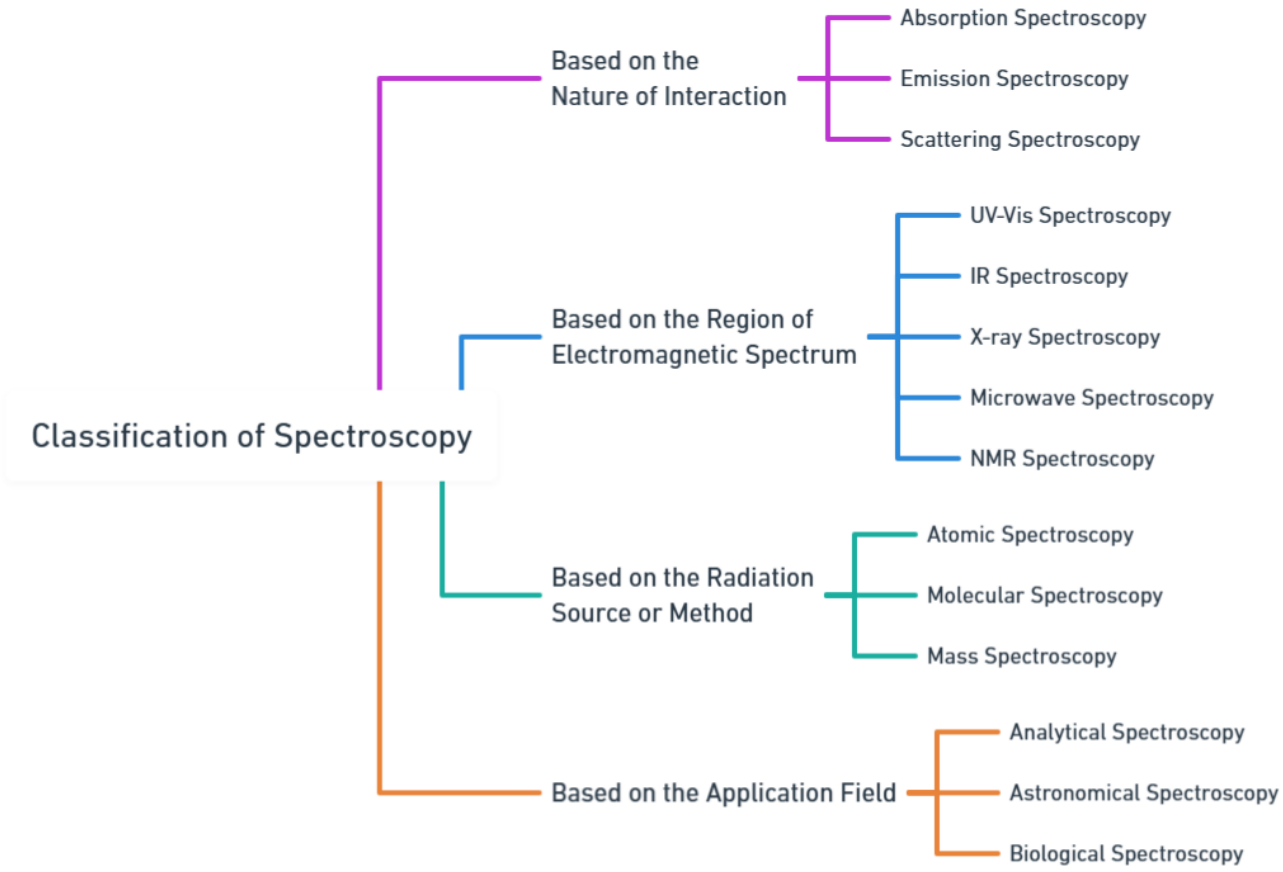
- **Spectroscopy** is a scientific technique used to study the interaction between matter and electromagnetic radiation.
- It allows scientists to analyze the structure, composition, and properties of atoms and molecules by observing the absorption, emission, or scattering of light (or other electromagnetic radiation) across various wavelengths.
- This technique is fundamental in physics, chemistry, astronomy, and biology because it provides detailed information about the energy levels, chemical bonding, and molecular structure of a sample.

Basic Principle of Spectroscopy

- When electromagnetic radiation (such as light) interacts with matter, it can cause electrons to move between energy levels.
- The specific wavelengths at which this occurs are characteristic of the elements or molecules present in the sample.
- By studying these interactions, scientists can infer the identity and properties of the substance.

Classification of Spectroscopy

Spectroscopy can be classified based on several criteria:



A. Based on the Nature of Interaction

1. **Absorption Spectroscopy**
   - Measures the amount of light absorbed by a sample at various wavelengths. Used to determine concentration and composition.
   - **Examples**: UV-Vis spectroscopy, Infrared (IR) spectroscopy.
2. **Emission Spectroscopy**
   - Measures the light emitted by a substance that has absorbed energy.
   - **Examples**: Flame emission spectroscopy, X-ray fluorescence (XRF).
3. **Scattering Spectroscopy**
   - Measures light scattered by the sample, either elastic (Rayleigh) or inelastic (Raman).
   - **Examples**: Raman spectroscopy.

B. Based on the Region of Electromagnetic Spectrum

1. **Ultraviolet-Visible (UV-Vis) Spectroscopy**
   - Studies absorption of light in the UV-visible range (200–800 nm).
2. **Infrared (IR) Spectroscopy**
   - Focuses on the vibrational transitions of molecules in the IR range (typically 2.5–25 μm).
3. **X-ray Spectroscopy**
   - Investigates core-level electronic transitions using X-ray radiation.
4. **Microwave Spectroscopy**
   - Explores rotational transitions in the microwave region.
5. **Radiofrequency (NMR) Spectroscopy**
   - Exploits radio waves and magnetic fields to study the environment of nuclei (like hydrogen) in a molecule.

C. Based on the Type of Radiation Source or Method

1. **Atomic Spectroscopy**
   - Used to analyze elemental composition; examples include Atomic Absorption Spectroscopy (AAS) and Atomic Emission Spectroscopy (AES).
2. **Molecular Spectroscopy**
   - Focuses on molecules and includes IR, Raman, and NMR spectroscopy.
3. **Mass Spectroscopy**
   - Not based on light, but often discussed with spectroscopy; identifies compounds by their mass-to-charge ratio.

D. Based on the Application Field

1. **Analytical Spectroscopy:** Used for qualitative and quantitative analysis.
2. **Astronomical Spectroscopy:** Studies composition and movement of celestial bodies.
3. **Biological Spectroscopy:** Investigates biomolecules in physiological systems.

Applications of Spectroscopy

- **Chemical analysis** (identifying compounds in a mixture)
- **Pharmaceuticals** (purity testing, drug development)
- **Environmental monitoring** (pollution detection)
- **Astronomy** (composition of stars and galaxies)
- **Forensics** (crime scene investigation)
- **Material Science** (surface analysis, nanotechnology)

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