

Exercise walk-through

Spectroscopy and the Electromagnetic Spectrum ■ 3.11

eXercise

You must be able to

- order the **electromagnetic spectrum** 电磁波谱 by energy/wavelength
- link the type of transition to the region (microwave, IR, UV-Vis)
- explain how absorption reveals structure

Method — The spectrum by energy

From low to high energy (long to short wavelength): radio < microwave < **infrared (IR)** < visible < **ultraviolet (UV)** < X-ray. Higher energy means shorter wavelength and higher frequency.

Method — Matching region to transition

Each region excites a different kind of change:

- **Microwave** — molecular rotation;
- **Infrared** — bond vibration;
- **UV-Visible** — electron transitions between energy levels.

Method — Absorption reveals structure

A molecule **absorbs** the wavelengths whose energy matches one of its transitions. The pattern of absorptions is a fingerprint of the bonds and electrons present.

Method — Energy-wavelength relationship

Energy and wavelength are **inversely** related: $E = \frac{hc}{\lambda}$. Shorter wavelength more energetic photon.

Practice 2.1 ■ 1 mark

Which has more energy: UV or infrared radiation?

Solution 2.1

Worked steps

UV **B1**.

Practice 2.2 ■ 1 mark

Which region of the spectrum causes bond **vibration**?

Solution 2.2

Method: Matching region to transition

Worked steps

Infrared **B1**.

Practice 2.3 ■ 1 mark

As wavelength decreases, what happens to photon energy?

Solution 2.3

Method: Energy-wavelength relationship

Worked steps

It increases **B1**.

Exam-style 3.1 ■ 1 mark

Electron transitions between energy levels are typically caused by

A microwaves

B infrared

C UV-visible light

D radio waves

Solution 3.1

Method: Matching region to transition

A microwaves

B infrared

C UV-visible light



D radio waves

Worked steps

C — UV-visible light drives electron transitions.

Exam-style 3.2 ■ 1 mark

A molecule absorbs strongly in the infrared region.

- (a) What kind of molecular motion is being excited?
- (b) Explain what “absorption” means at the particle level.

Solution 3.2

Method: Matching region to transition

Worked steps

(a) Bond vibration **B1**. (b) The molecule takes in a photon whose energy exactly matches an allowed transition, raising it to a higher-energy state **M1 A1**.

Exam-style 3.3 ■ 2 marks

Arrange these in order of increasing energy: infrared, X-ray, visible, microwave.

Solution 3.3

Worked steps

microwave < infrared < visible < X-ray **M1** **A1**.