

7.4 Electromagnetic spectrum

Name: _____ Class: _____ Date: _____ **Total: 13 marks**

KEY WORDS electromagnetic spectrum 电磁波谱 • wave 波 • electromagnetic wave 电磁波
• vacuum 真空 • infrared 红外线

Objective

Build the skills to answer exam questions on the **electromagnetic spectrum** 电磁波谱.

You must be able to:

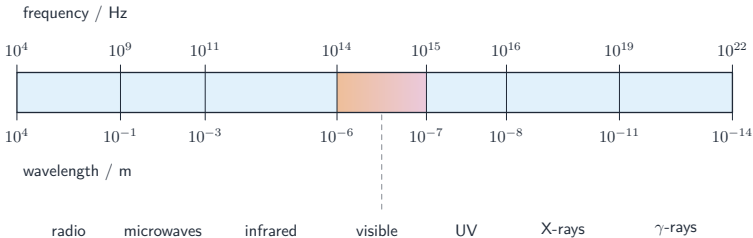
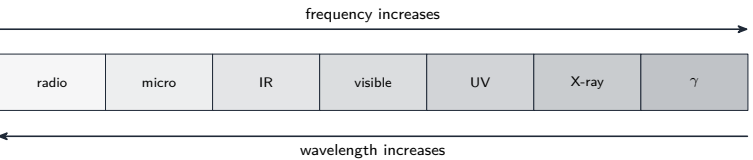
- state that all EM waves are **transverse** and travel at c in a vacuum
- order the regions from **radio** to **γ -rays** by wavelength/frequency
- use $c = f\lambda$ and recall visible light is 400–700 nm

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ EM waves and the spectrum

All EM waves are **transverse** and travel in a vacuum at $c = 3.00 \times 10^8 \text{ m s}^{-1}$. In order:



The electromagnetic spectrum

Approximate wavelengths (learn the orders of magnitude): radio $> 10^{-1}$ m; microwaves 10^{-3} – 10^{-1} m; IR up to $\sim 7 \times 10^{-7}$ m; **visible** 400–700 nm; UV $\sim 10^{-8}$ – 4×10^{-7} m; X-rays $\sim 10^{-11}$ – 10^{-8} m; γ -rays $< 10^{-11}$ m.

Use $c = f\lambda$ to convert between wavelength and frequency.

2 Practice

Now apply the methods above.

2.1 State **two** properties common to **all** electromagnetic waves. [2]

2.2 State the speed of EM waves in a **vacuum**. [1]

2.3 State the wavelength range of **visible** light. [1]

2.4 Put these in order of **increasing frequency**: X-rays, radio waves, visible light. [1]

3 Exam-style questions

3.1 Which EM wave has the **shortest** wavelength? [1]

- A radio waves
- B infrared
- C ultraviolet
- D γ -rays

3.2 A radio wave has frequency 100 MHz. Find its wavelength. ($c = 3.0 \times 10^8 \text{ m s}^{-1}$.) [2]

3.3 A surveyor points a laser rangefinder at the far wall of a valley. The reflected pulse returns $8.4 \mu\text{s}$ after it was sent. **Determine** the width of the valley, and **state** the assumption you make about the path of the light. [3]

3.4 State whether **infrared** or **ultraviolet** has the higher frequency, and explain using the spectrum. [2]

Solutions

Each answer shows the steps, then the **result**.

2.1

- any two: they are **transverse**; they travel at the **same speed** c in a vacuum; they can travel through a vacuum

2.2

- $c = 3.0 \times 10^8 \text{ m s}^{-1}$

2.3

- **400 nm** to **700 nm**

2.4

- radio waves < visible light < X-rays

3.1 D

- γ -rays have the highest frequency (shortest wavelength) on the EM spectrum

3.2

- $\lambda = c/f$

$$\lambda = \frac{3.0 \times 10^8 \text{ m s}^{-1}}{100 \times 10^6 \text{ Hz}} = \mathbf{3.0 \text{ m}}$$

3.3

- the pulse covers the width **twice** (there and back)

$$d_{\text{total}} = ct = (3.0 \times 10^8 \text{ m s}^{-1})(8.4 \times 10^{-6} \text{ s}) = 2520 \text{ m}$$

$$\text{width} = \frac{1}{2} \times 2520 \text{ m} = \mathbf{1.3 \times 10^3 \text{ m}}$$

- assumption: light travels in a straight line at c through air (air treated as a vacuum)

3.4

- **ultraviolet** has the higher frequency
- on the spectrum UV is **closer to the high-frequency end** (shorter λ) than infrared