

7.4 Electromagnetic spectrum

Name: _____ Class: _____ Date: _____

Total: 12 marks

Objective

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

You must be able to:

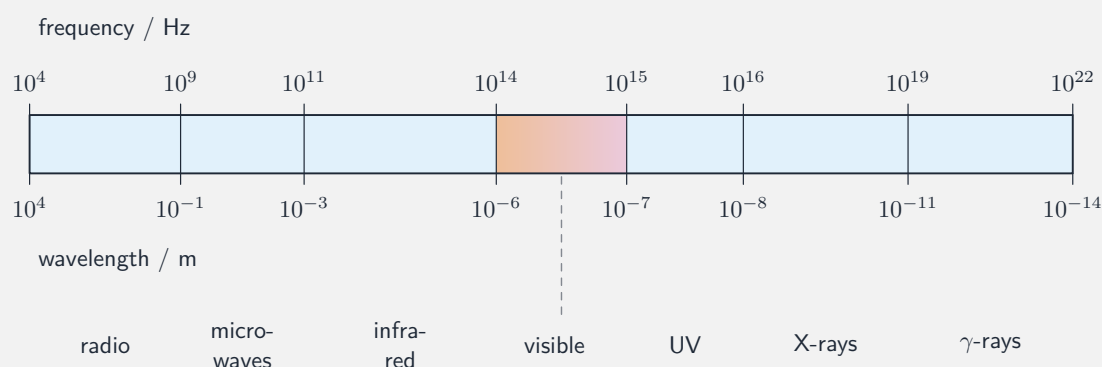
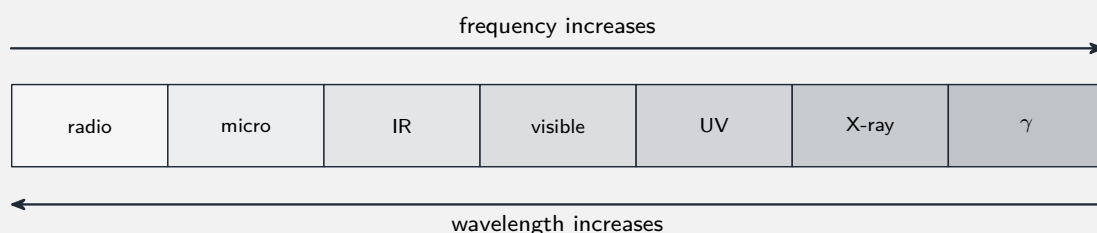
- state that all EM waves are **transverse** and travel at c in a vacuum
- order the regions from **radio** to **γ -rays** by wavelength/frequency
- use $c = f\lambda$ and recall visible light is 400–700 nm

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:



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. ($c = 3.0 \times 10^8$ m s $^{-1}$.) [2]

3.3 A device emits a pulse of light that reflects from a wall 150 m away. Calculate the **total time** for the pulse to travel there and back. [2]

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

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **7.4 Electromagnetic spectrum** past-paper sheet in the Library, or try these in **Practice mode**:

- 9702/11 J25 —Q6 (speed of light)
- 9702/13 J25 —Q27 (the electromagnetic spectrum)
- 9702/24 N25 —Q4 (EM waves and frequency)
- 9702/12 J25 —Q5 (EM wave properties)

Solutions

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

2.3 400 nm to 700 nm.

2.4 radio waves < visible light < X-rays.

3.1 D — γ -rays.

3.2 $\lambda = c/f = (3.0 \times 10^8)/(100 \times 10^6) = 3.0 \text{ m}$.

3.3 Distance there and back = $2 \times 150 = 300 \text{ m}$; $t = d/c = 300/(3.0 \times 10^8) = 1.0 \times 10^{-6} \text{ s}$.

3.4 Ultraviolet has the higher frequency; on the spectrum UV is **closer to the high-frequency end** (shorter wavelength) than infrared.