A-LEVEL PHYSICS • EXERCISE SHEET

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:

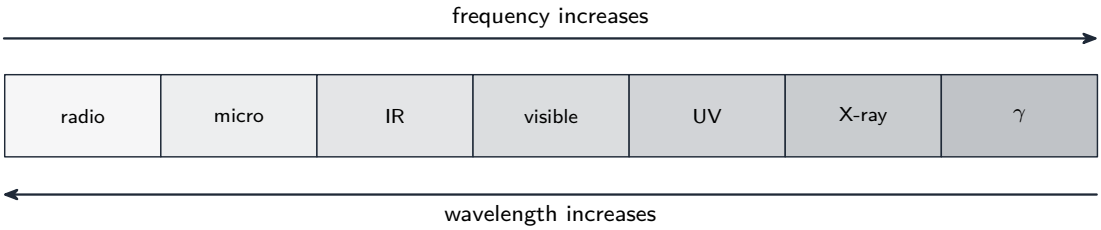
- state that all EM waves are **transverse** and travel at c in a vacuum
- order the regions from **radio** to **γ-rays** by wavelength/frequency
- use $c = f\lambda$ and recall visible light is 400–700 nm

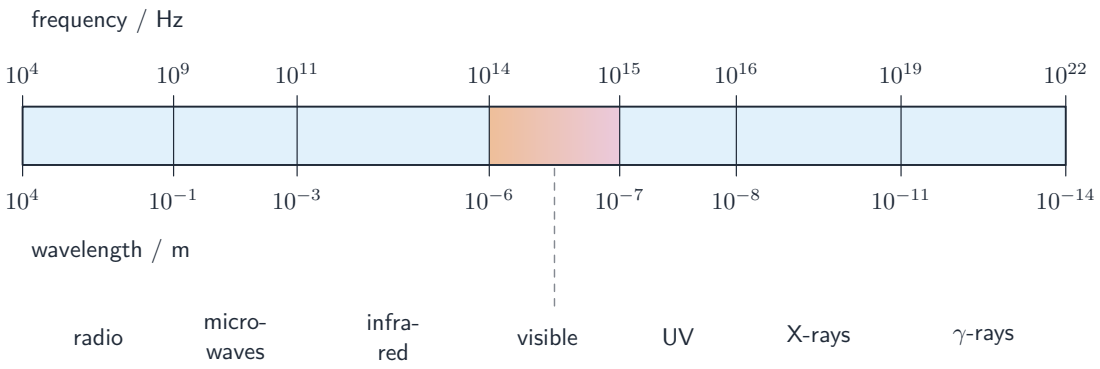
1 Worked examples

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 $c = 3.00 \times 10^8$ 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. ($c = 3.0 \times 10^8$ 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 μs 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

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 3.0×10^8 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 $\lambda = c/f = (3.0 \times 10^8)/(100 \times 10^6) = 3.0$ m.

3.3 The pulse covers the width **twice**: $d_{\text{total}} = ct = 3.0 \times 10^8 \times 8.4 \times 10^{-6} = 2520$ m; width $= \frac{1}{2} \times 2520 = 1.3 \times 10^3$ m. Assumption: the light travels in a straight line at 3.0×10^8 m s^{-1} through the air, i.e. air is treated as a vacuum.

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