



## 12

# Electromagnetic spectrum

Candidate should be able to:

- state that all electromagnetic waves are transverse waves that travel with the same high speed in vacuo and state the magnitude of this speed
- describe the main components of the electromagnetic spectrum

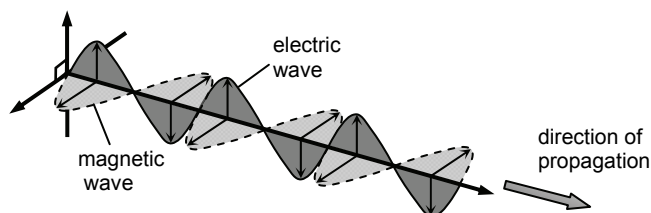
## 12.1 Properties of electromagnetic waves

### Electromagnetic waves

In terms of classical wave theory, a very hot object such as any star or sun produces a range of *electromagnetic waves*. Electromagnetic waves are often collectively referred to as *electromagnetic radiation*.

**Electromagnetic radiation** is produced by acceleration or sudden movement of electrons. The electron in motion constitutes the electric current that generates the magnetic field in the wave.

- ✎ Electromagnetic waves are transverse waves; consisting of electric and magnetic waves at right angles to each other and perpendicular to the direction of wave propagation.



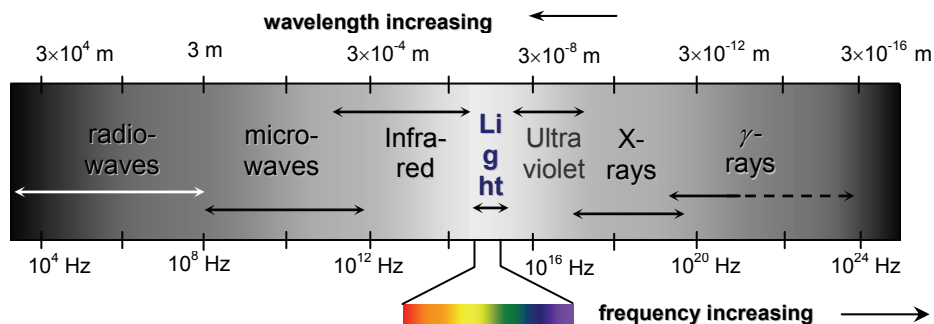
- ✎ Electromagnetic waves can travel through vacuum and do not need a medium to traverse. They can travel through solids, liquids and gases.
- ✎ All electromagnetic waves have the same speed in vacuum of  $3 \times 10^8 \text{ m s}^{-1}$  (commonly referred to as 'speed of light'). But the speed slows down in other material media.

# Electromagnetic spectrum

The spectrum of the radiation emitted by a hot body is continuous because there are many different kind of oscillators in any real lump of matter, so that in practice radiation exists at all frequencies.

The **main components** of the electromagnetic spectrum are gamma-rays ( $\gamma$ ), X-rays, ultra-violet, visible light, infra-red, micro-waves and radio-waves.

- ☞ **Gamma-rays** and **X-rays** are the highest-energy electromagnetic waves and able to penetrate matter easily. They have the shortest wavelengths and the highest frequencies.  $\gamma$ -rays may be emitted by radioactive substances, while X-rays may be produced by X-ray tubes.
- ☞ **Ultra-violet (UV)** radiation is the next highest-energy. It may be produced by very hot bodies, such as sun and particular mercury lamps. The atmosphere filters most of the UV radiation from the sun. UV radiation also causes sun-burned skin.



☺ Longer the wavelength, the less energetic is the electromagnetic radiation.

- ☞ The **visible light** is the only electromagnetic radiation that is visible to our eyes. It occupies a surprisingly small portion in the electromagnetic spectrum. Sun and other white-hot bodies emit white light, which is made up of violet, indigo, blue, green, yellow, orange and red colours (in order of reducing frequencies).
- ☞ **Infra-red** radiation (IR) may be produced by any hot bodies similar to white light, but with longer wavelengths. IR radiation is readily absorbed by matter and raises their temperature.
- ☞ Special electronic devices known as klystron valves may be used to generate **microwave** radiation. Microwave receivers can be used to detect microwaves. They are reflected by metals and partly absorbed by non-metals.
- ☞ **Radio waves** have the longest wavelengths, varying from a few centimetres to thousands of metres. These may be generated by oscillations in special electronic circuits and by electrical sparks and are detected by metal aerials.

# Worked Example

## Example 1

Compared to visible light, comment on the wavelength, frequency and speed in vacuum of radio-waves.

### Solution:

Compared to visible light, the radio-waves have longer wavelength, lower frequency and same speed in vacuo. (ans)

**Notes:**