1)

**(a) (i)** Define the terms *wavelength, frequency* and *speed* used to describe a progressive wave.

*wavelength, λ* .....

.....

*frequency, f* .....

.....

*speed, v* .....

..... **[3]**

**(ii)** Hence derive the wave equation $v = f\lambda$ which relates these terms together.

**[2]**

**(b) (i)** Explain what is meant by *infra-red radiation*.

.....

.....

..... **[2]**

**(ii)** For infra-red radiation emitted at a frequency of $6.7 \times 10^{13}$ Hz, calculate

**1** its wavelength

wavelength = ..... m **[2]**

**2** its period of oscillation.

period = ..... s **[2]**

**(iii)** Infra-red radiation is absorbed by molecular ions in a crystal causing them to vibrate at a frequency of $6.7 \times 10^{13}$ Hz. The amplitude of oscillation of the ions is $8.0 \times 10^{-12}$ m.

On the grid of Fig. 5.1 sketch a graph showing the variation with time of the displacement of an ion.

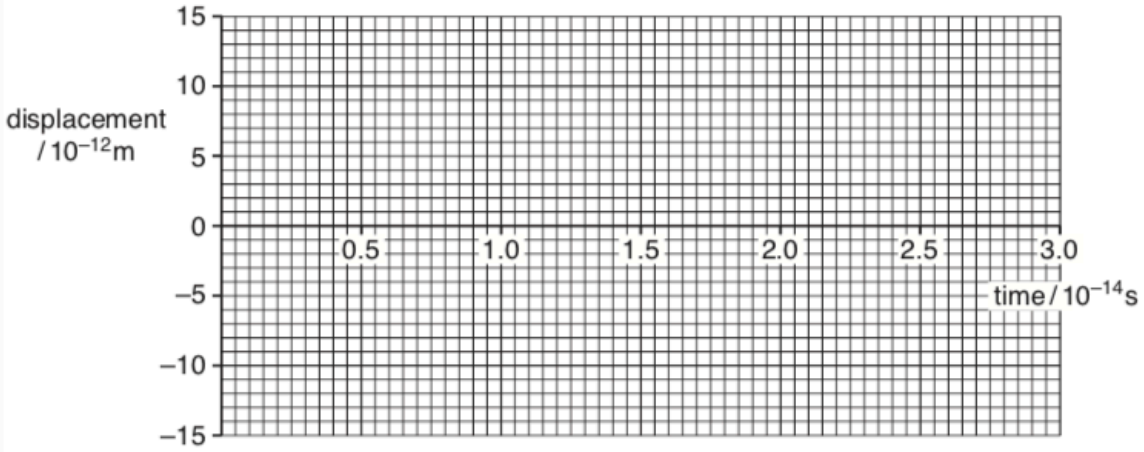



**Fig. 5.1**

**[3]**

**[Total: 14]**

2)

In 1927 it was shown by experiment that electrons can produce a diffraction pattern.

**(a) (i)** Explain the meaning of the term *diffraction*.

.....

.....

..... **[1]**

**(ii)** State the condition necessary for electrons to produce observable diffraction when passing through matter, e.g. a thin sheet of graphite in an evacuated chamber.

.....

.....

.....

..... **[2]**

**(b)** Show that the speed of an electron with a de Broglie wavelength of $1.2 \times 10^{-10}$ m is $6.0 \times 10^{6}$ m s$^{-1}$.

3)

The tungsten filament of a 12V 24W lamp glows white hot emitting photons across a continuous spectrum of energies. The intensity variation with wavelength of the electromagnetic radiation from the filament is shown in Fig. 7.1.

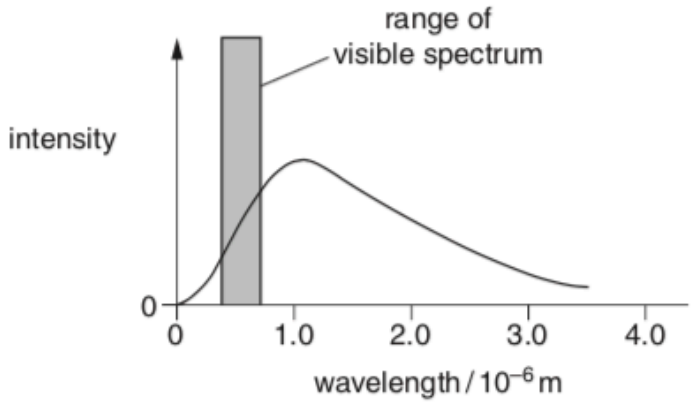



**Fig. 7.1**

**(a)** Explain what is meant by

**(i)** a *photon*

.....

..... **[1]**

**(ii)** a *continuous spectrum*.

.....

..... **[1]**

**(b)** **(i)** Fig. 7.1 shows that only a small percentage of the energy radiated from the filament lamp is emitted in the visible region. The majority of the energy is emitted in other regions of the electromagnetic spectrum.

**1** State the region of the spectrum in which most of the radiation from the lamp is emitted.

..... **[1]**

**2** State a simple observation which is evidence for your answer to **1**.

.....

..... **[1]**

4)

**(a)** Explain what is meant by *progressive wave*.

.....

.....

.....

..... **[2]**

**(b)** Describe how a *transverse* wave differs from a *longitudinal* wave.

.....

.....

.....

..... **[2]**

**(c)** **(i)** Explain what is meant by *diffraction* of a wave.

.....

.....

..... **[1]**

**(ii)** Describe how you would demonstrate that a sound wave of wavelength 0.10 m emitted from a loudspeaker can be diffracted.

*In your answer you should make clear how your observations show that diffraction is occurring.*

.....

.....

.....

.....

.....

.....

..... **[4]**

5)

**(a)** X-rays and radio waves are two examples of electromagnetic waves.

**(i)** Name **two** other examples of electromagnetic waves.

.....

..... **[1]**

**(ii)** State **one** similarity and **one** difference between X-rays and radio waves.

similarity .....

.....

.....

difference .....

.....

..... **[2]**

**(iii)** Explain why X-rays are easily diffracted by layers of atoms, about $2 \times 10^{-10}$ m apart, but radio waves are not.

.....

.....

.....

..... **[2]**

**(b)** On the Earth, we are all exposed to ultraviolet radiation coming from the Sun.
State **one** advantage and **one** disadvantage of UV-B radiation.

.....

.....

.....

.....

..... **[2]**

**(c)** **(i)** Circle a typical value for the wavelength of an X-ray from the list below.

$2 \times 10^{-4}$ m  $2 \times 10^{-7}$ m  $2 \times 10^{-10}$ m  $2 \times 10^{-13}$ m **[1]**

**(ii)** Use your answer to **(i)** to determine how many X-ray photons must be collected to produce an energy of $1.0 \times 10^{-6}$ J.

number of photons = ..... **[4]**

**(d)** A plane polarised radio wave is transmitted from a vertical aerial to a nearby receiving aerial as shown in Fig. 6.1.

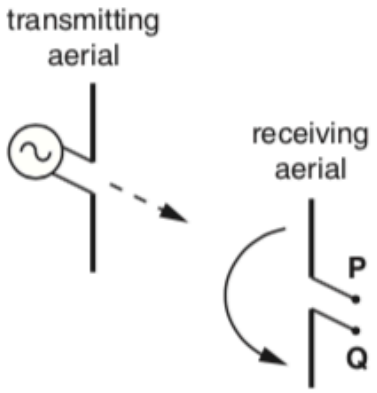



**Fig. 6.1**

A diode, resistor and ammeter are connected in series across the terminals **P** and **Q**.

**(i)** Draw the circuit between terminals **P** and **Q** on Fig. 6.1 in the space to the right of **PQ**. **[2]**

**(ii)** The entire receiving aerial is rotated slowly through 180° in the direction shown by the arrow. Explain clearly what will be observed on the ammeter and how the detected signal varies.

.....

.....

.....

.....

.....

.....

..... **[3]**

**[Total: 17]**

6)

**(a)** Name one common property of electromagnetic waves not shared by other waves.

..... **[1]**

**(b)** Fig. 5.1 shows a block diagram of the seven regions of the electromagnetic spectrum, labelled **A** to **G**.

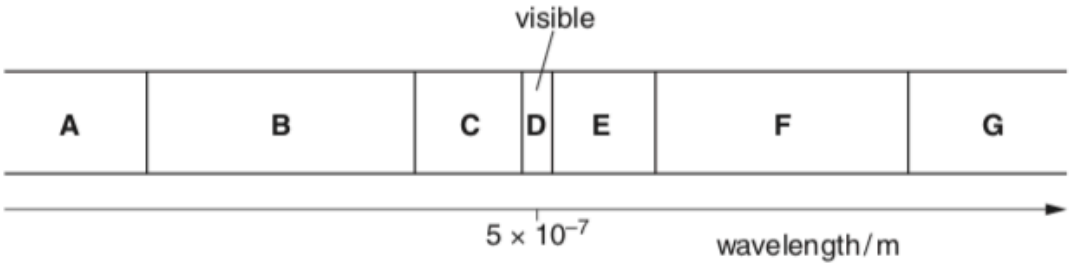



**Fig. 5.1**

Name the principal radiation in each of the regions **A**, **C** and **F**.

**A** ..... **C** .....

**F** ..... **[3]**

**(c)** An aerial mounted vertically transmits vertically polarised radio waves of frequency $1.0 \times 10^9$ Hz. The waves are detected by a receiving aerial some distance away. Initially the receiving aerial is also mounted vertically as shown in Fig. 5.2.


**Fig. 5.2**

The length of each aerial is half the wavelength of the radio waves.

**(i)** Calculate the wavelength of the waves.

wavelength = ..... m **[2]**

**(ii)** Calculate the length of an aerial.

length = ..... m **[1]**

**(iii)** The receiving aerial is rotated through 180° about the axis joining the centres of the two aerials. See Fig. 5.2. Describe and explain how the output signal from the receiving aerial changes with the angle of rotation.

.....

.....

.....

.....

.....

..... **[3]**

**(d)** Ultra-violet radiation from the Sun is often divided into three regions UV-A, UV-B and UV-C.

**(i)** Describe the characteristics and dangers of UV-A, UV-B and UV-C radiations.

.....

.....

.....

.....

.....

..... **[3]**

**(ii)** Explain how sunscreen protects the human skin.

.....

.....

..... **[1]**

**(e)** Explain why electrons can be emitted from a clean metal surface illuminated with bright ultra-violet light but never when infra-red light is used, however intense.

.....

.....

.....

..... **[2]**

**[Total: 16]**

7)

**(a)** State **two** properties shared by all electromagnetic waves which distinguish them from all other waves.

.....

.....

.....

..... **[2]**

**(b)** The two columns below list four regions of the electromagnetic spectrum and four orders of magnitude of wavelength in m.

| region | wavelength/m |
|---|---|
| microwaves | $10^{-12}$ |
| ultra violet light | $10^{-8}$ |
| gamma rays | $10^{-6}$ |
| infra red light | $10^{-4}$ |

Draw a straight line from each **region** box to the corresponding **wavelength** box. **[2]**

**(c)** Fig. 8.1 shows a microwave receiver **R** placed between a microwave transmitter **T** and a flat metal sheet.

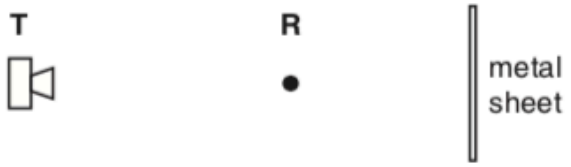



**Fig. 8.1**

**(i)** Explain why **R** receives two signals of different amplitude but of the same frequency.

.....

.....

.....

.....

..... **[2]**

8)

**(a) (i)** Explain what is meant by a *progressive wave*.

.....

.....

.....

..... **[2]**

**(ii)** State **two** differences between a *progressive* and a *stationary* wave.

1 .....

.....

2 .....

.....

**[2]**

**(b)** Fig. 4.1 shows, at time $t = 0$, the shape of a section of stretched cord along which a transverse wave is **travelling** from left to right. **W**, **X**, **Y** and **Z** are four marked points on the cord.

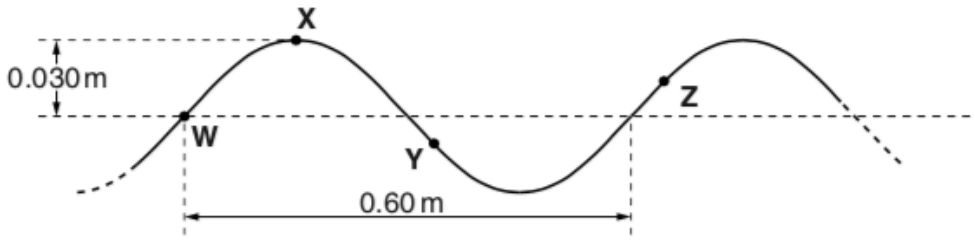
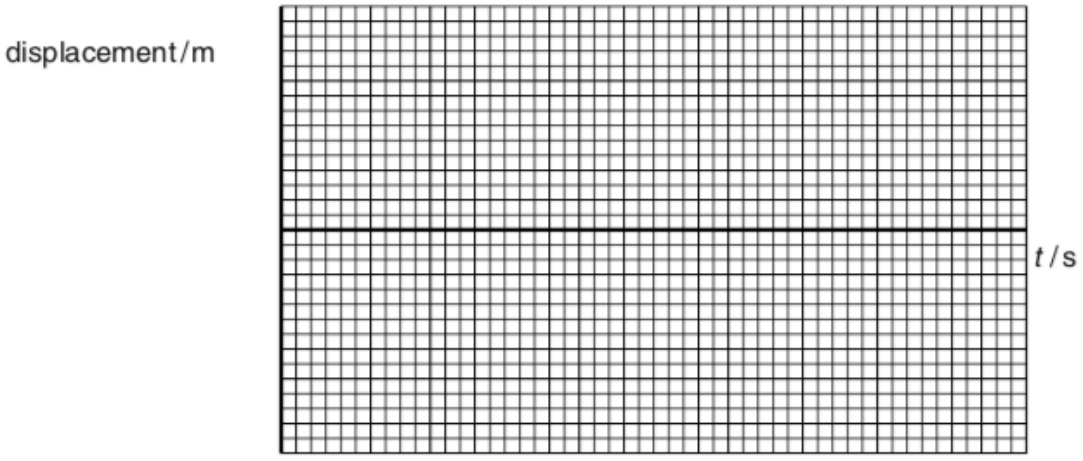



**Fig. 4.1**

A mechanical oscillator is causing the wave by oscillating the end of the cord at a steady frequency of 5.0 Hz. The wave has a wavelength of 0.60 m and amplitude of 0.030 m.

**(i)** On the axes of Fig. 4.2 sketch the graph of the displacement of point **X** over the period $t = 0$ to 0.40 s. Add suitable scales to the axes. **[4]**



**(ii)** State which of the points **W**, **X**, **Y** and **Z** at $t = 0$

**1** is instantaneously at rest .....

**2** has the greatest speed .....

**3** are moving 90° out of phase with each other. .....

**[3]**

**(iii)** On Fig. 4.1 draw arrows to show the directions in which the points **Y** and **Z** are moving.

**[2]**

**(c)** The speed $v$ of the wave on the stretched cord is given by the formula

$$v = k\sqrt{T}$$

where $T$ is the tension in the cord and $k$ is a constant.

Calculate the wavelength $\lambda$ of the wave after the tension in the cord has been **quadrupled** (×4) but the frequency of oscillation is unchanged.

$\lambda$ = ..... m **[2]**

**(d)** The speed of point **W** on the cord at $t = 0$ is $0.94\,m\,s^{-1}$. With the cord at its original tension, the frequency of oscillation is now **doubled** to 10 Hz. The amplitude is kept at 0.030 m. Calculate the new speed of point **W** at $t = 0$. Explain your reasoning.

speed = ..... $m\,s^{-1}$ **[2]**

**[Total: 17]**

9)

**(a)** State **two** properties which distinguish electromagnetic waves from other transverse waves.

.....

.....

.....

..... **[2]**

**(b)** **(i)** Describe what is meant by *a plane polarised wave*.

.....

.....

.....

..... **[2]**

**(ii)** Light from a filament lamp is viewed through two polarising filters, shown in Fig. 6.1. The arrow beside each filter indicates the transmission axis of that polarising filter.

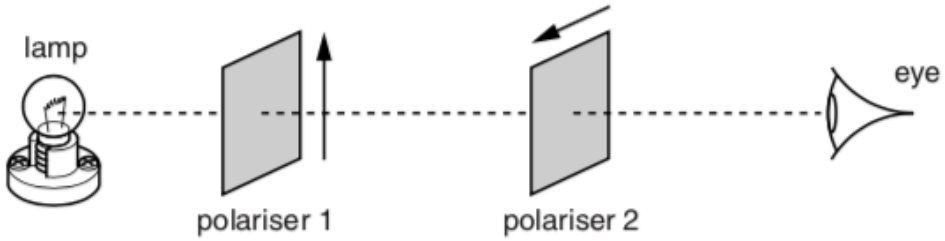



**Fig. 6.1**

Explain why the lamp cannot be seen by the eye.

.....

.....

.....

.....

.....

.....

..... **[2]**

**(iii)** A third polarising filter is placed between the first two with its transmission axis at 45° to each of the others as shown in Fig. 6.2.

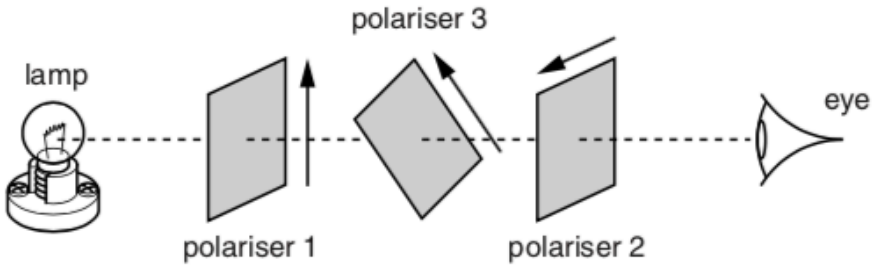



**Fig. 6.2**

Explain whether or not any light reaches the eye through the three filters.

*In your answer you should state clearly the condition for light to be transmitted by a polarising filter.*

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... **[3]**

**[Total: 9]**

10)

**(a) (i)** Both electromagnetic waves and sound waves can be **reflected**. State **two** other wave phenomena that apply to both electromagnetic waves and sound waves.

1. .....

2. ..... **[2]**

**(ii)** Explain why electromagnetic waves can be polarised but sound waves cannot be polarised.

.....

..... **[1]**

**(iii)** Describe briefly an experiment to demonstrate the polarisation of microwaves in the laboratory.

*In your answer you should make clear how your observations demonstrate polarisation.*

.....

.....

.....

..... **[4]**

**(b)** A sound wave emitted by a loudspeaker consists of a single frequency. Fig. 4.1 shows the displacement against time graph of the air at a point **P** in front of the speaker.

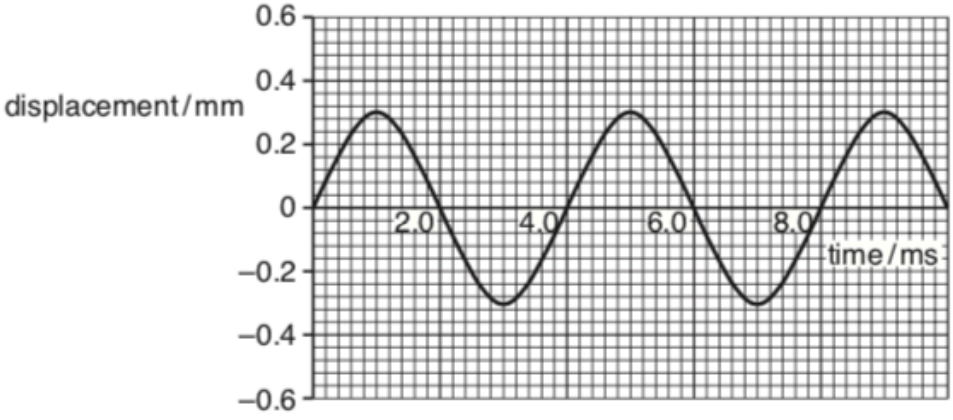



**Fig. 4.1**

**(i)** Use Fig. 4.1 to find

**1** the amplitude of the air motion

amplitude = ..... mm **[1]**

**2** the frequency of the sound wave.

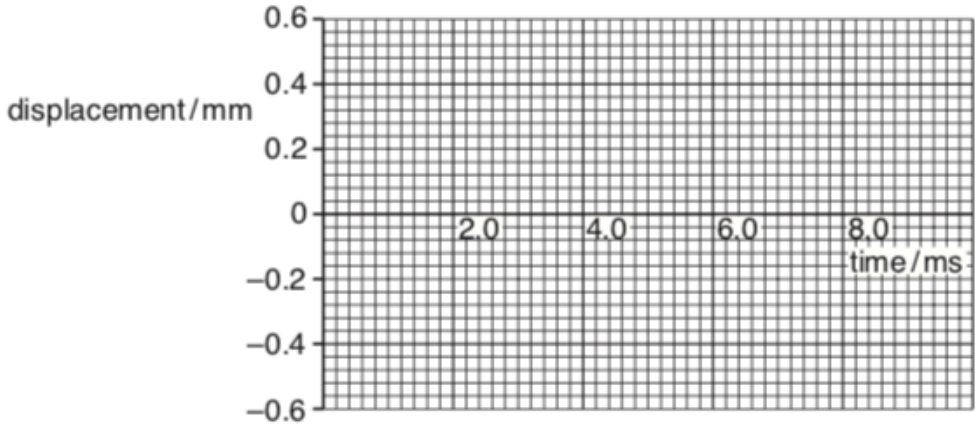
frequency = ..... Hz **[2]**

**(ii)** The sound generator is adjusted so that the loudspeaker emits a sound at the original frequency and twice the **intensity**. Sketch on Fig. 4.2 the new displacement against time graph at point **P**. Explain your reasoning.

.....

.....

.....




**[3]**

**Fig. 4.2**

**(iii)** Suggest, with reasons, the apparatus that you would choose to detect and measure the frequency of the sound wave at **P**.

.....

.....

.....

.....

.....

.....

..... **[2]**

**[Total: 15]**