3. Waves

3.3 Electromagnetic spectrum

Paper 3 and 4

Question Paper

Paper 3

Questions are applicable for both core and extended candidates

1 **(c)** The chart in Fig. 6.2 shows the main regions of the electromagnetic spectrum.

radio waves	microwaves	infrared	visible light	ultraviolet	X-rays	gamma rays

Fig. 6.2

(i) State the name of **one** region in Fig. 6.2 that has longer wavelengths than visible light.

..... [1]

(ii) Describe **one** use of ultraviolet radiation.

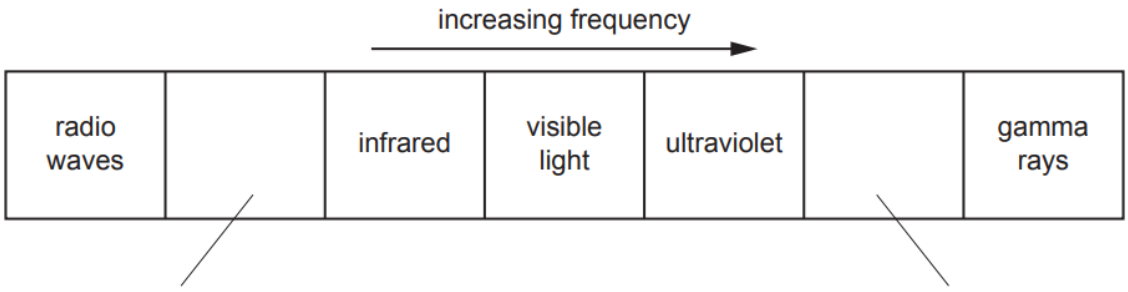
..... [1]

(iii) Compare the speed of radio waves with the speed of gamma rays as they both travel through a vacuum.

..... [1]

[Total: 9]

2 Fig. 5.1 shows the main regions of the electromagnetic spectrum in order of increasing frequency.



....

Fig. 5.1

(a) Two of the regions are unlabelled.

Add the correct label to each of the unlabelled regions in Fig. 5.1. [2]

(b) State **one** use of infrared radiation and **one** use of ultraviolet radiation.

infrared radiation

.....

ultraviolet radiation

.....

[2]

(c) Describe possible harmful effects of excessive exposure to:

infrared radiation

.....

ultraviolet radiation

.....

[2]

3 **b)** Visible light is a region of the electromagnetic spectrum.

State **one** region of the electromagnetic spectrum which has waves of longer wavelength than waves of visible light.

..... [1]

(c) Gamma rays are another region of the electromagnetic spectrum.

(i) Describe **one** use of gamma rays.

..... [1]

(ii) Describe **one** harmful effect on people of excessive exposure to gamma rays.

..... [1]

4 **(d)** The chart in Fig. 5.2 shows the regions of the electromagnetic spectrum.

Two of the regions are not labelled.

.....	X-rays	.....	visible light	infrared	microwaves	radio waves

Fig. 5.2

(i) Complete the labelling in Fig. 5.2. [2]

(ii) Compare the speed of radio waves and visible light. Complete the sentence.

In a vacuum, radio waves travel ..... visible light. [1]

(e) The different regions of the electromagnetic spectrum have different uses.

State the region of the electromagnetic spectrum that is used for:

(i) the remote control for a television ..... [1]

(ii) the signal for satellite television broadcasting ..... [1]

[Total: 9]

5 **(a)** Fig. 6.1 shows the main regions of the electromagnetic spectrum. Two of the regions are unlabelled.

radio waves	.....	.....	visible light	ultraviolet rays	X-rays	γ (gamma)-rays

Fig. 6.1

(i) Complete the labelling in Fig. 6.1. Write the name of the radiation in each unlabelled region. [2]

(ii) State the name of **one** region of the electromagnetic spectrum that has wavelengths shorter than those of ultraviolet rays.

..... [1]

(c) A student incorrectly writes some sentences about electromagnetic waves. His teacher circles a mistake in each sentence.

In Table 6.1, write a suitable correction for each mistake. The first one has been done for you.

Table 6.1

student's sentences	correction
The speed of light is (slower than) the speed of radio waves in a vacuum.	the same as
(Ultraviolet rays) are used in signals for satellite television and mobile phones.	
(Radio waves) are used to scan patients for broken bones.	

[2]

6 **(c)** Visible light is one part of the electromagnetic spectrum. X-rays are also part of the electromagnetic spectrum.

(i) Visible light and X-rays are travelling through a vacuum.

Compare their speed and frequency by completing the sentences.

The speed of visible light is ..... the speed of X-rays.

The frequency of visible light is ..... the frequency of X-rays. [2]

(ii) Describe **one** use of X-rays.

..... [1]

[Total: 8]

7 A narrow beam of white light enters a glass prism and splits into the colours of the visible spectrum, as shown in Fig. 7.1.

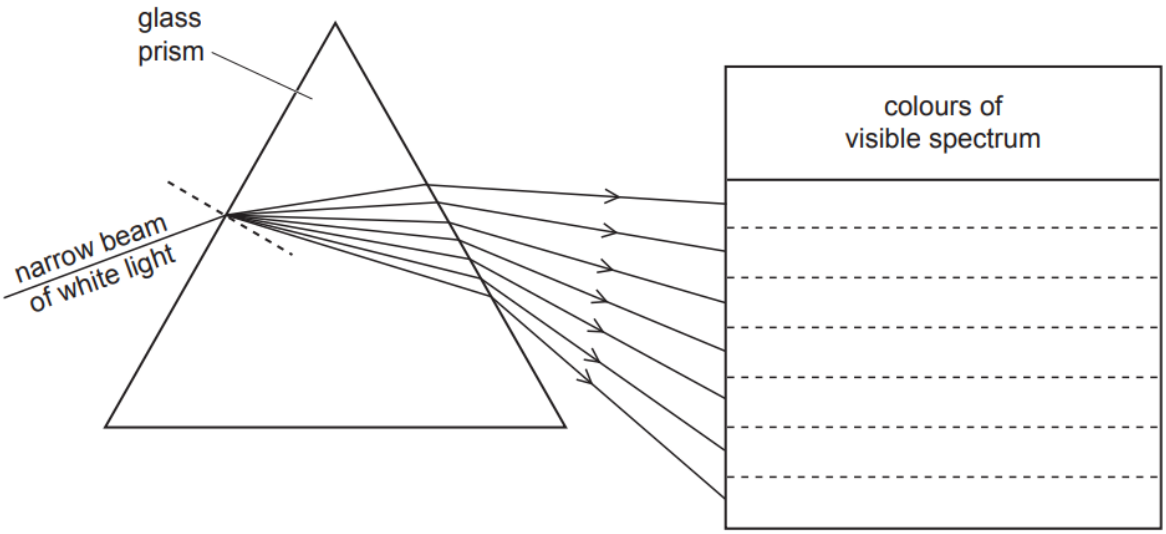


Fig. 7.1

(a) The rays leaving the prism represent the seven main colours of the visible spectrum.

Complete the labelling on Fig. 7.1 by writing the colours of the visible spectrum in the table. [2]

(b) State the term used to describe:

(i) the bending of the light as it enters the prism

..... [1]

(ii) the different amounts of bending that produce the spectrum.

..... [1]

(c) A student incorrectly writes some sentences about electromagnetic waves. His teacher circles a mistake in each sentence.

In the table, write a suitable correction for each mistake. The first one has been done for you.

student's sentences	correction
the speed of light is (faster than) radio waves in a vacuum	the same as
(X-rays) are used in television remote controllers	
(radio waves) have the highest frequencies in the electromagnetic spectrum	

[2]

[Total: 6]

8 **(a)** Both radio waves and γ-rays (gamma) are radiations in the electromagnetic spectrum. Fig. 7.1 shows the main regions of the electromagnetic spectrum. Most regions are labelled.

radio waves	microwave radiation	infrared radiation	visible light	....	....	γ-rays

Fig. 7.1

(i) On Fig. 7.1, write the names of the radiations in the other **two** parts of the electromagnetic spectrum. [2]

(ii) State **one** use of γ-rays.

..... [1]

(iii) A star emits radio waves and γ-rays at the same time. They all travel across the vacuum of space to the Earth's atmosphere.

State whether the radio waves or the γ-rays, if either, arrive first at the Earth's atmosphere. Give a reason for your answer.

statement .....

reason ..... [2]

9 Fig. 7.1 shows a diagram of the main regions of the electromagnetic spectrum. Two labels are missing.

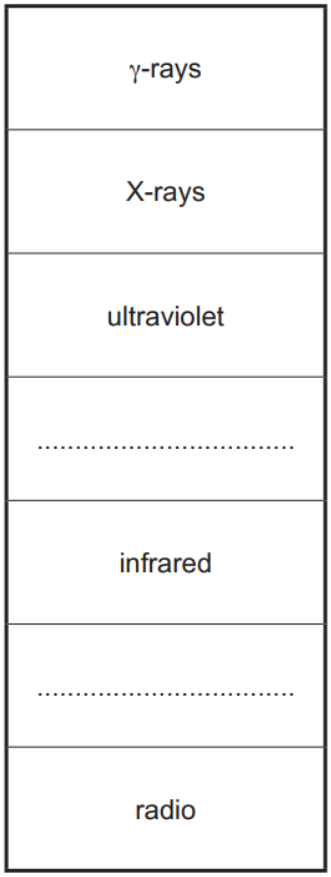


Fig. 7.1

(a) **(i)** Complete the labels on Fig. 7.1. [2]

(ii) State **two** properties that are the same for all waves in the electromagnetic spectrum.

1. .....

2. .....

[2]

(b) State which region of the electromagnetic spectrum is used in each situation.

(i) detecting objects without opening baggage at a security check

..... [1]

(ii) television remote control

..... [1]

(iii) satellite television transmissions

..... [1]

[Total: 7]

10 **(a)** Fig. 7.1 shows some devices that each use one type of electromagnetic radiation.

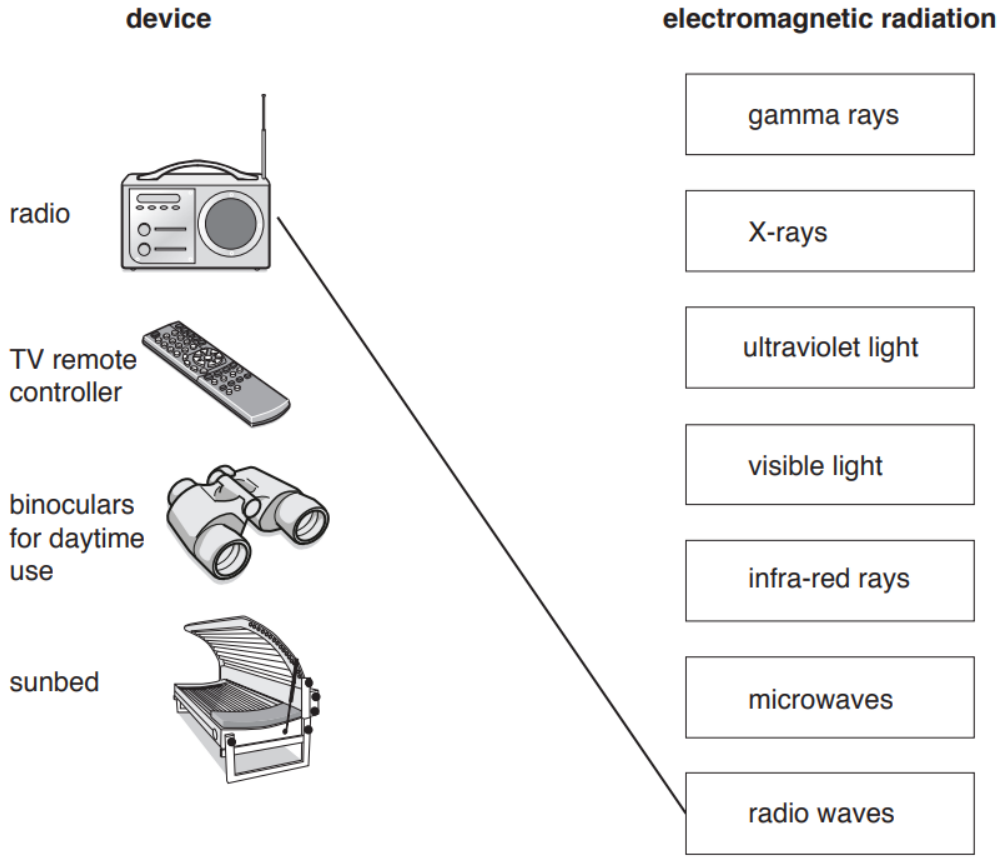


Fig. 7.1

Draw one line from each device to the correct type of electromagnetic radiation. One has been done for you. [3]

(b) **(i)** State the name of one type of radiation that has a longer wavelength than visible light.

..... [1]

(ii) Complete the sentence about electromagnetic radiation. Use a word from the box.

amplitude	frequency	speed	wavelength

All types of electromagnetic radiation travel through a vacuum with the same

..... [1]

[Total: 5]

11 Fig. 7.1 shows the electromagnetic spectrum. One type of radiation is not labelled.

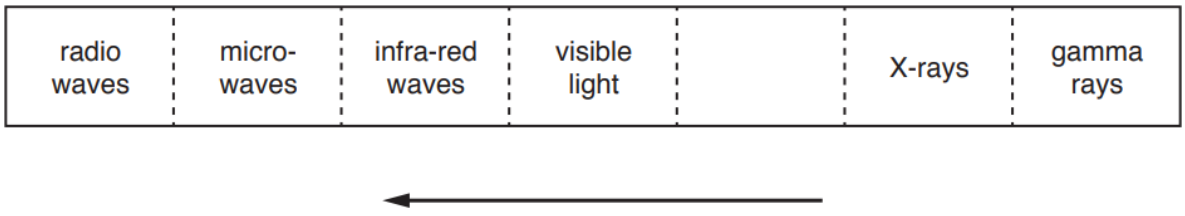


Fig. 7.1

(a) (i) On Fig. 7.1, add the label for the missing type of radiation. [1]

(ii) The arrow in Fig. 7.1 indicates a property that is increasing.

State the name of the property that is increasing in the direction of the arrow.

.....[1]

(iii) Compare the speeds of radio waves and visible light in a vacuum.

.....[1]

(b) (i) Describe how X-rays are used for security in airports.

.....

.....

.....[2]

(ii) Explain the properties of X-rays that make them useful in airport security.

.....

.....

.....[2]

[Total: 7]

12 **(a)** A ray of white light is incident on a glass prism. It forms a spectrum that is visible on the screen. Fig. 7.1 shows the arrangement.

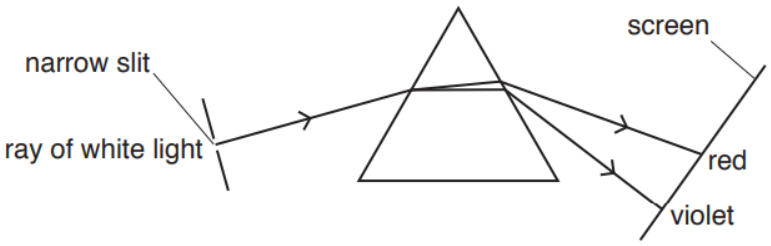


Fig. 7.1

Two of the colours in the visible spectrum are listed in the box below.

Complete the box. List the five missing colours of the visible spectrum, in the correct order.

red .... violet

[2]

(b) Electromagnetic radiation has many uses.

(i) Draw a line from each use to the type of radiation it requires.

use	**type of radiation**
	radio waves
detecting an intruder at night	microwaves
	infra-red
communicating by satellite for a telephone	visible light
	ultraviolet
detecting broken bones in the body	X-rays
	gamma rays

[3]

(ii) The types of radiation listed in **(b)(i)** form the electromagnetic spectrum.

amplitude	frequency	velocity

Complete the sentence. Choose a word from the box.

The position of each type of radiation in the electromagnetic spectrum depends on its

..... . [1]

[Total: 6]

13 Fig. 9.1 shows a partially-labelled diagram of the electromagnetic spectrum.

Fig. 9.1

(a) **(i)** On Fig. 9.1, add the names of the missing radiations at **A** and at **B**. [2]

(ii) Indicate the radiation that has the lowest frequency. On Fig. 9.1, draw a ring around the radiation. [1]

(b) State two safety precautions when handling sources that emit gamma radiation.

1 .....

2 .....
[2]

[Total: 5]

14 Fig. 7.1 shows some parts of the electromagnetic spectrum.

radio waves		infra-red waves	visible light	ultraviolet waves	X-rays	γ-rays

Fig. 7.1

(a) (i) In Fig. 7.1, one part of the electromagnetic spectrum is not labelled.

State the name of this part.

.....[1]

(ii) The speed of visible light waves in a vacuum is 3.0×10^8 m/s.

Suggest a value for the speed of infra-red waves in a vacuum.

speed = ... m/s [1]

(iii) Some parts of the electromagnetic spectrum have a wavelength shorter than that of visible light.

State one example.

.....[1]

(b) (i) X-rays and γ-rays are used in hospitals.

Describe one medical use for X-rays and one use for γ-rays.

X-rays .....

.....

γ-rays .....

.....

[2]

(ii) Explain why γ-rays are dangerous to living things.

.....

.....

.....[2]

[Total: 7]

Paper 4

Questions are applicable for both core and extended candidates unless indicated in the question

15 Fig. 7.1 shows some uses of electromagnetic radiation and different regions of the electromagnetic spectrum.

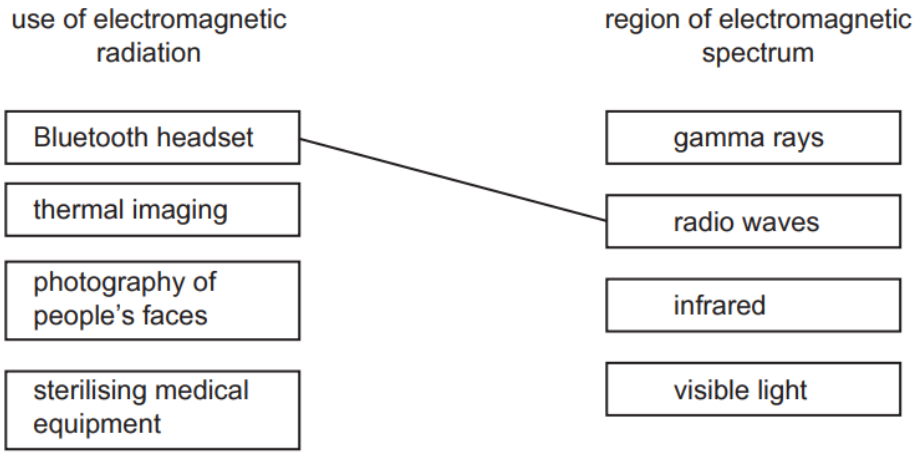


Fig. 7.1

(a) Draw a line from each use to the correct region of the spectrum. Each region of the spectrum is used once. One line has been completed for you. [2]

(b) State the speed of electromagnetic waves in a vacuum. **(extended only)**

speed = ... [1]

(c) A Bluetooth headset can be used to listen to music on a mobile (cell) phone without the need for wires to connect the headset to the phone.

(i) The headset uses frequencies in the range 2.40–2.48 GHz. **(extended only)**

Calculate the wavelength of the radio waves when the frequency is in the middle of the frequency range.

wavelength = ... [3]

(ii) Suggest why a Bluetooth headset only works well over short distances. **(extended only)**

.....

..... [1]

[Total: 7]

16 A mobile phone (cell phone) network uses microwaves of frequency 1.9×10^9 Hz to transmit and receive signals.

The speed of microwaves in air is 3.0×10^8 m/s.

(a) Calculate the wavelength of these microwaves in air.

wavelength = ... [2]

(b) State **two** reasons why microwaves are used for mobile phone (cell phone) signals.
(extended only)

1 .....

.....

2 .....

.....
[2]

(c) All mobile phone (cell phone) networks use digital signals to communicate with the phone.

(i) Describe, with the aid of a diagram, how a digital signal differs from an analogue signal.
(extended only)

.....

.....

.....

..... [3]

(ii) State **two** advantages of using digital signals rather than analogue signals.
(extended only)

1 .....

.....

2 .....

.....
[2]

[Total: 9]

17 X-rays are electromagnetic waves. Fig. 6.1 shows the position of X-rays in the electromagnetic spectrum arranged according to increasing wavelength.

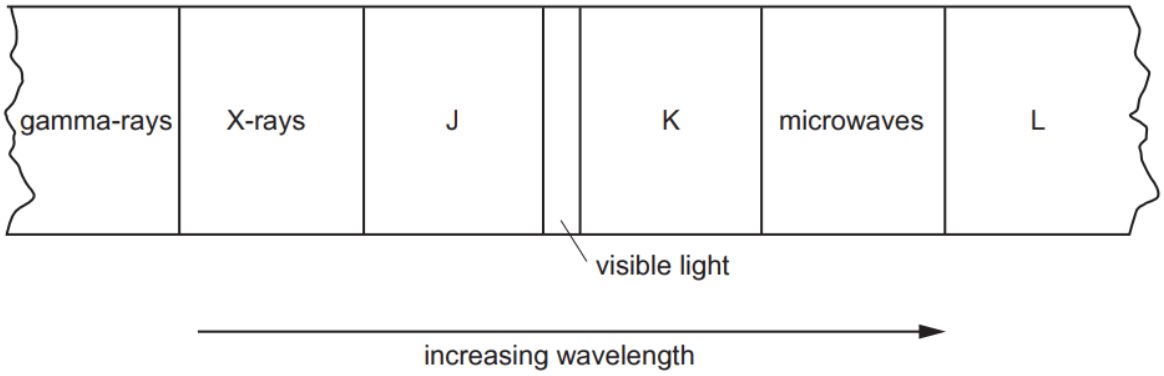


Fig. 6.1

(a) Three components of the spectrum are unnamed but labelled J, K and L.

(i) State the names of these three components.

J .....

K .....

L .....

[2]

(ii) State which of these three components has the lowest frequency.

..... [1]

(b) Calculate the frequency of X-rays that have a wavelength of 1.2×10^{-9} m in a vacuum.

frequency = ... [3]

(c) **(i)** Describe **one** medical use of X-rays.

.....

.....

.....

.....

..... [3]

(ii) State **one** reason why it is necessary to take safety precautions when X-rays are used.

.....

..... [1]

[Total: 10]