## 3.3 Electromagnetic spectrum

01. 0625_s23_qp_41 Q: 6

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

The speed of microwaves in air is $3.0 \times 10^8$ 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.

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.



.....

.....

.....

..... [3]

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

1 .....

.....

2 .....

.....

[2]

02. 0625_s23_qp_43 Q: 5

**(a)** Two types of electromagnetic radiation are used in glass optical fibres for high-speed broadband.

**(i)** State the type of electromagnetic radiation, other than visible light, which is used in glass optical fibres.

..... [1]

**(ii)** Give **two** reasons why these two types of electromagnetic radiation are used in glass optical fibres for high-speed broadband.

1 .....

.....

2 .....

.....
[2]

**(b)** **(i)** The critical angle of the glass in an optical fibre is 45°.

Calculate the refractive index of the glass.



refractive index = ..... [2]

**(ii)** Fig. 5.1 shows an optical fibre made of the glass described in **(i)**.

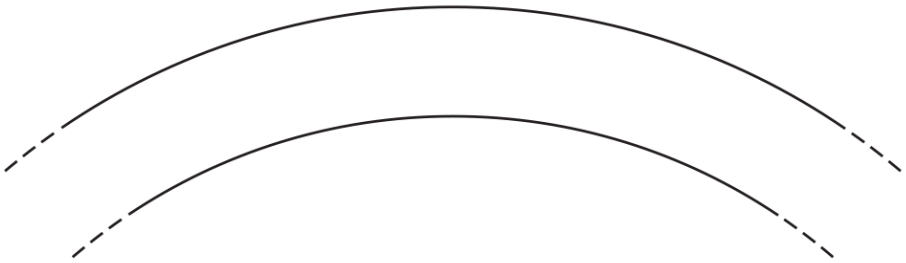

**Fig. 5.1**

On Fig. 5.1, draw carefully a ray of light in the fibre undergoing total internal reflection.
[2]

03. 0625_w23_qp_41 Q: 4

A radio transmitter is a very tall, thin cylinder. It is prevented from falling over by wires which have one end fixed to the transmitter and the other end fixed in the ground. The ends of the wires in the ground are a long distance from the transmitter.

Fig. 4.1 shows the transmitter and two of the wires.

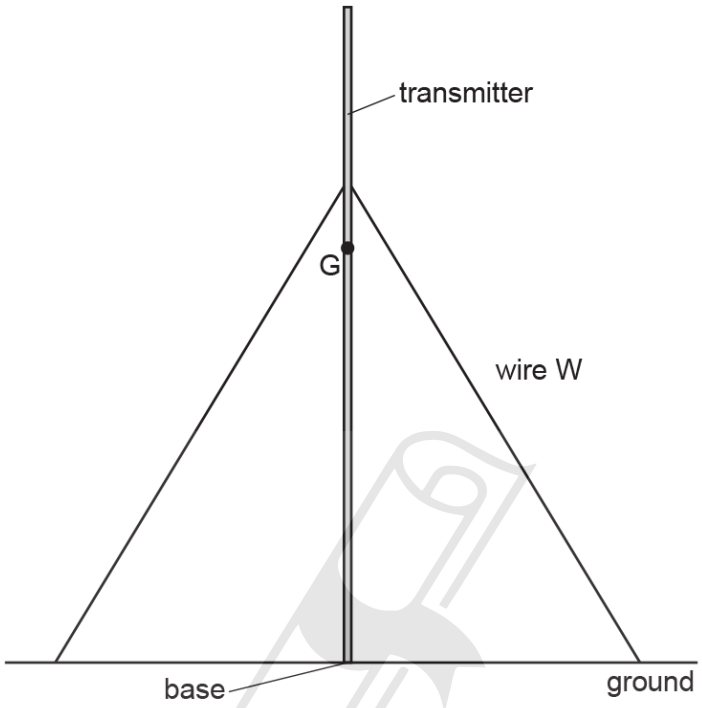


**Fig. 4.1**

**(a)** The centre of gravity G is shown on Fig. 4.1.

**(i)** State what is meant by centre of gravity.

.....

.....

[1]

**(ii)** Explain why the radio transmitter without the wires is a very unstable structure.

.....

.....

[1]

**(b)** Wire W is under tension and it exerts a force *T* on the transmitter.

**(i)** On Fig. 4.1, mark an arrow to show the force *T* exerted by wire W on the transmitter. [1]

**(ii)** The force *T* produces a moment on the transmitter about its base.

Describe how the moment produced by *T* is calculated and indicate on Fig. 4.1 what is meant by any other terms in the description.

.....

.....

[3]

**(c)** The radio transmitter uses radio waves to transmit radio and television programmes.

State **one** other use of radio waves.

.....

..... [1]

04. 0625_w23_qp_42 Q: 7

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

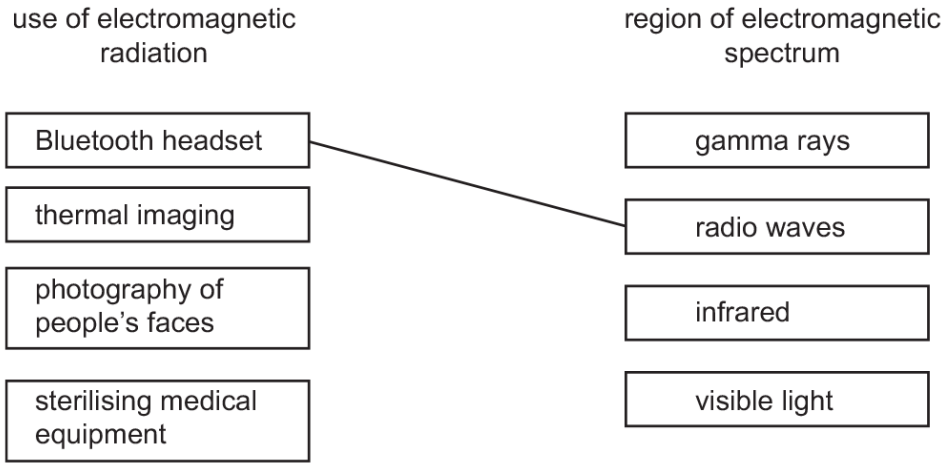


**Fig. 7.1**

**(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.

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.

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.

.....

..... [1]

05. 0625_s22_qp_41 Q: 9

Combinations of logic gates are used when digital signals are processed.

**(a)** Describe the difference between a digital signal and an analogue signal. You may include a diagram if it helps your answer.

.....

.....

..... [2]

**(b)** Fig. 9.1 is the truth table for a logic gate X.

| input A | input B | output |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

**Fig. 9.1**



State the name of logic gate X and draw the symbol that represents it.

name .....

symbol

[1]

**(c)** Logic gate Y is identical to logic gate X.

Draw a combination of logic gates X and Y that behaves like an OR gate. Label the inputs A and B and label the output Q.

[2]

06. 0625_s22_qp_43 Q: 7

**(a)** Fig. 7.1 shows a plan view of a room. There is a plane mirror on one wall and a picture across the whole of wall AB.

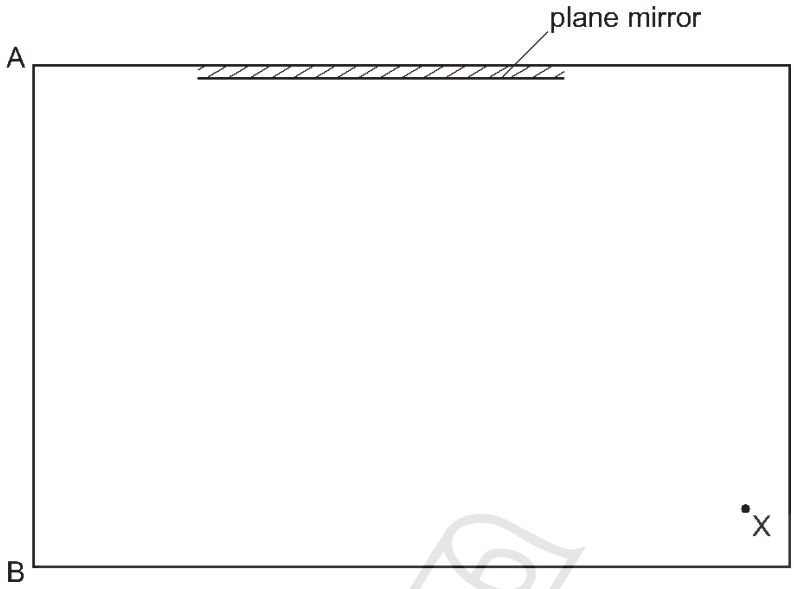


**Fig. 7.1** (plan view)

A person is standing at point X and is looking at the mirror. The person cannot see all of the picture on wall AB reflected in the mirror.

There is a point P on wall AB which is the closest point to A that the person can see reflected in the mirror.

On Fig. 7.1, draw a reflected ray and an incident ray to show the position of the point P. [2]

**(b)** State **two** properties of the image formed by the mirror.

1. .....

2. .....

[2]

**(c)** Visible light is an electromagnetic wave.

State the name of **one** region of the electromagnetic spectrum in which the waves have:

**(i)** shorter wavelengths than visible light

..... [1]

**(ii)** longer wavelengths than visible light.

..... [1]

07. 0625_w22_qp_41 Q: 5

Fig. 5.1 shows a heater in a bathroom.

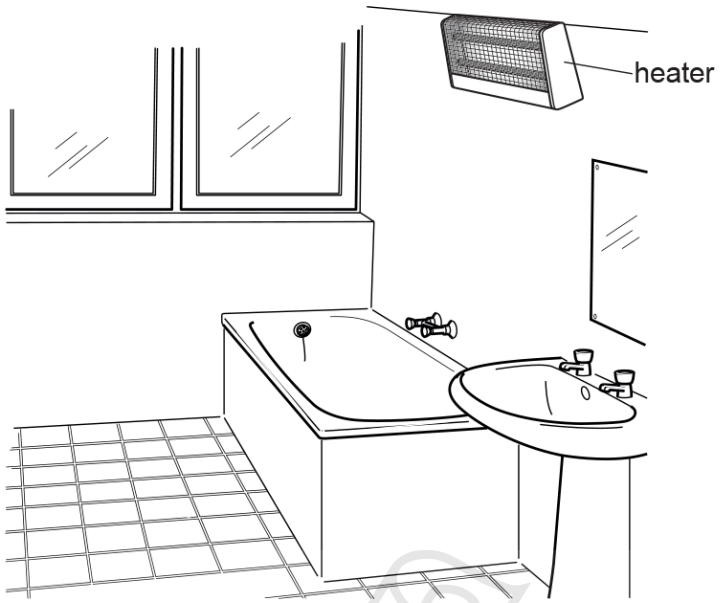


**Fig. 5.1**

The heater is at a very high temperature and it glows red. The manufacturer states:

> "The heater emits light and radiation and it transfers thermal energy by radiation."

**(a)** State the part of the electromagnetic spectrum that transfers thermal energy.

..... [1]

**(b)** State:

**(i)** **one** way in which visible light and the radiation identified in **(a)** are similar

.....

..... [1]

**(ii)** **one** way in which visible light differs from the radiation identified in **(a)**.

.....

..... [1]

**(c)** Some surfaces are better at emitting radiation than others.

**(i)** Describe an experiment to show whether a black surface or a white surface is the better emitter of radiation. You may draw a diagram.

.....

.....

.....

.....

..... [3]

**(ii)** To ensure that the conclusion reached in the experiment in **(c)(i)** is correct, several details of the experiment must be identical when testing the two different surfaces.

State **two** quantities in the experiment that you described that must be identical during the test.

1. .....

.....

2. .....

.....

[2]

08. 0625_s21_qp_43 Q: 8

**(a)** State the difference between an analogue signal and a digital signal. You may draw a diagram to help explain your answer.

.....

..... [2]

**(b)** Draw the symbol for a NOR gate.

[1]

**(c)** Fig. 8.1 shows a combination of logic gates X, Y and Z. The gates are not represented by the standard symbols.

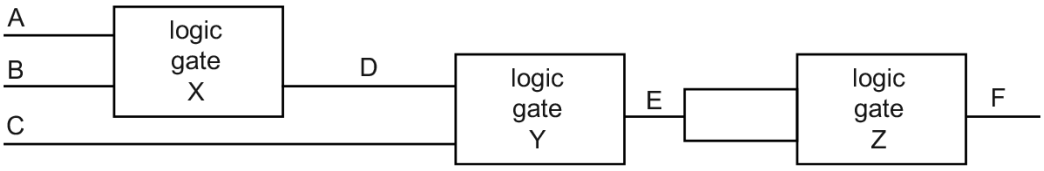


**Fig. 8.1**

Table 8.1 shows a partly completed truth table for this combination of logic gates.

**Table 8.1**

| inputs | | | intermediate points | | output |
|---|---|---|---|---|---|
| A | B | C | D | E | F |
| 0 | 0 | 0 | 0 | 0 | |
| 0 | 1 | 0 | 0 | 0 | |
| 1 | 0 | 1 | 0 | 1 | |
| 1 | 1 | 1 | 1 | 1 | |
| 0 | 0 | 0 | 0 | 0 | |
| 0 | 1 | 0 | 0 | 0 | |
| 1 | 0 | 1 | 0 | 1 | |
| 1 | 1 | 1 | 1 | 1 | |

**(i)** From Table 8.1, deduce:

**1.** the name of logic gate X

..... [1]

**2.** the name of logic gate Y.

..... [1]

**(ii)** Logic gate Z is a NAND gate.

Complete column F of Table 8.1. [2]

[Total: 7]

09. 0625_w21_qp_41 Q: 6

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

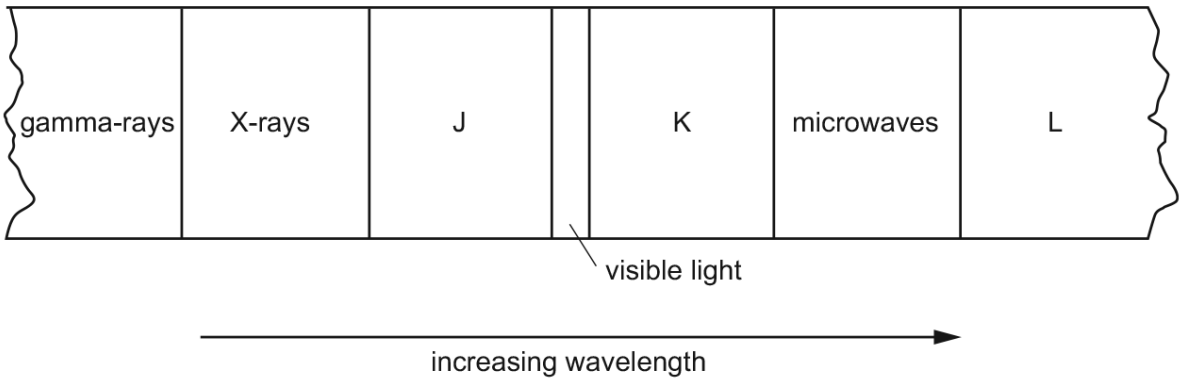


**Fig. 6.1**

**(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 $1.2 \times 10^{-9}$ 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]

10. 0625_s19_qp_43 Q: 6

**(a)** Fig. 6.1 shows wavefronts of a wave approaching a narrow gap and passing through the gap. The wavelength is $\lambda$.

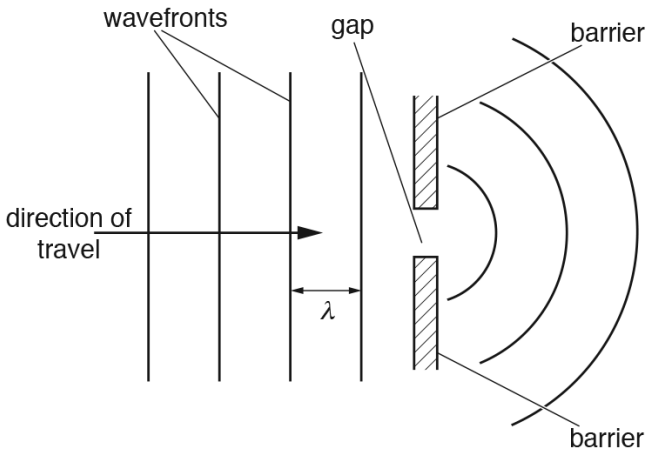


**Fig. 6.1**

**(i)** State the name of the process that occurs as the wave passes through the gap.

..... [1]

**(ii)** A wave with a wavelength $\frac{\lambda}{2}$ approaches the same gap.

On Fig. 6.2, draw three wavefronts for this wave as it approaches the gap and three more wavefronts as the wave continues beyond it. [3]

**Fig. 6.2**

**(b)** Table 6.1 shows 5 different types of electromagnetic wave.

In the blank column in Table 6.1, write the numbers 1 to 5 to show the order of wavelength. Write 1 for the wave with the shortest wavelength and 5 for the wave with the longest wavelength. [2]

**Table 6.1**

| type of electromagnetic wave | order of wavelength |
|---|---|
| gamma rays | |
| light | |
| microwaves | |
| ultraviolet | |
| X-rays | |

**(c)** **(i)** State the speed of radio waves in air.

..... [1]

**(ii)** A radio station transmits radio waves with a frequency of 96 MHz.
Calculate the wavelength of these radio waves.



wavelength = ..... [3]

[Total: 10]

11. 0625_m18_qp_42 Q: 6

**(a)** Fig. 6.1 represents the electromagnetic spectrum.

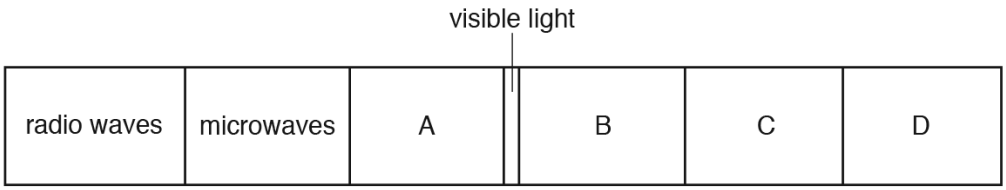


**Fig. 6.1**

State the radiation in each of the regions represented by A, B, C and D in Fig. 6.1.

A .....

B .....

C .....

D .....

[2]

**(b)** A source emits visible light.

Fig. 6.2 shows a ray of red light from the source incident on the face XY of a glass prism at point S.

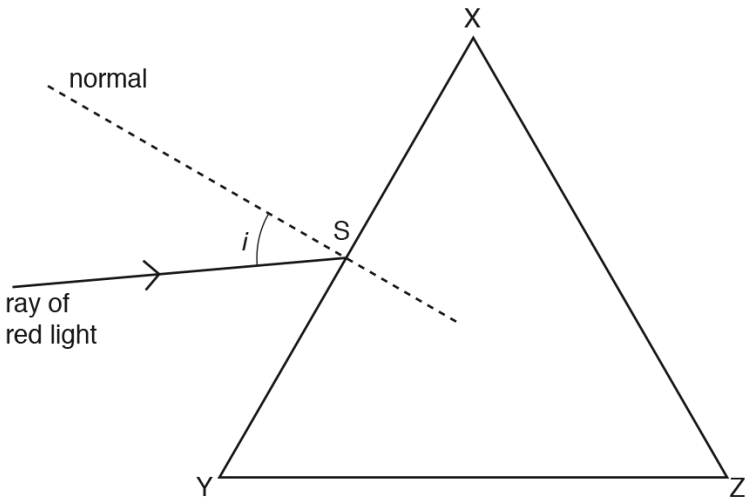


**Fig. 6.2**

The angle of incidence *i* of the ray is 35°. The refractive index of the glass for red light is 1.5.

**(i)** Calculate the angle of refraction in the glass at S.

angle of refraction = ..... [2]

**(ii)** On Fig. 6.2, draw the refracted ray at face XY and the ray emerging from face XZ of the prism. Label this ray R. [2]

**(iii)** A ray of blue light follows the same path as the ray of red light incident on the face XY.

On Fig. 6.2, draw the path of this ray in the prism and emerging from the prism.

Label this ray B. [2]

[Total: 8]

12. 0625_w17_qp_43 Q: 6

Visible light is one component of the electromagnetic spectrum.

**(a)** **(i)** In the table, place a tick in the box next to the approximate value of the speed of light in air. [1]

| speed / m/s | |
|---|---|
| $3.0 \times 10^{10}$ | |
| $3.0 \times 10^{8}$ | |
| $3.0 \times 10^{6}$ | |
| $3.0 \times 10^{4}$ | |
| $3.0 \times 10^{2}$ | |

**(ii)** The frequency of a light wave is $4.8 \times 10^{14}$ Hz.

Calculate the wavelength of this light in air.

wavelength = .....[2]

**(b)** Light is travelling in an optical fibre that is made of glass.

**(i)** The glass has a refractive index of 1.5.

**1.** Explain why the quantity *refractive index* does **not** have a unit.

.....

.....[1]

**2.** Calculate the speed of light in the glass.



speed = .....[2]

**(ii)** Describe **one** use of optical fibres in communication technology.

.....

.....

.....

.....

.....[3]

[Total: 9]