



Chapter 13 Electromagnetic Waves

Name: _____

Class: _____

Date: _____

Time: **140 minutes**

Marks: **140 marks**

Comments:

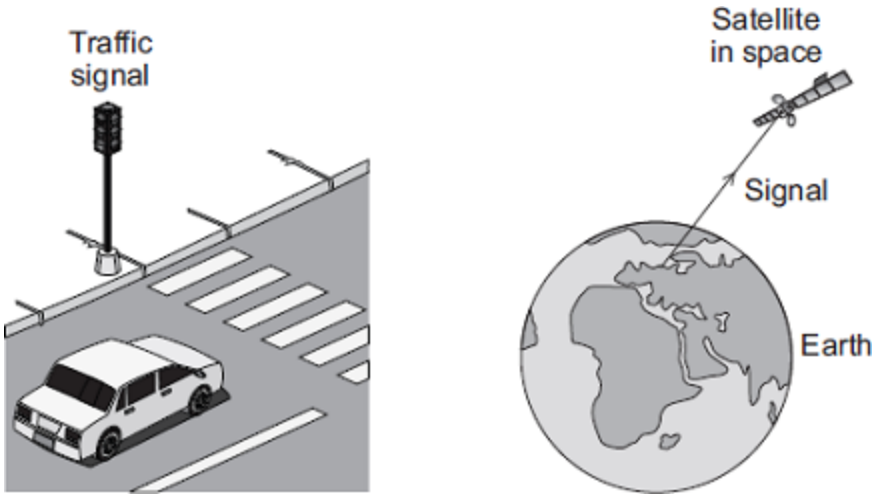
1

Diagram 1 shows four of the seven types of wave in the electromagnetic spectrum.

Diagram 1

J	K	L	Visible light	Infrared	Microwaves	Radio waves
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(a) The **four** types of electromagnetic wave named in **Diagram 1** above are used for communication.



(i) Which type of electromagnetic wave is used when a traffic signal communicates with a car driver?

.....

(1)

(ii) Which type of electromagnetic wave is used to communicate with a satellite in space?

.....

(1)

(b) Gamma rays are part of the electromagnetic spectrum.

Which letter, **J**, **K** or **L**, shows the position of gamma rays in the electromagnetic spectrum?

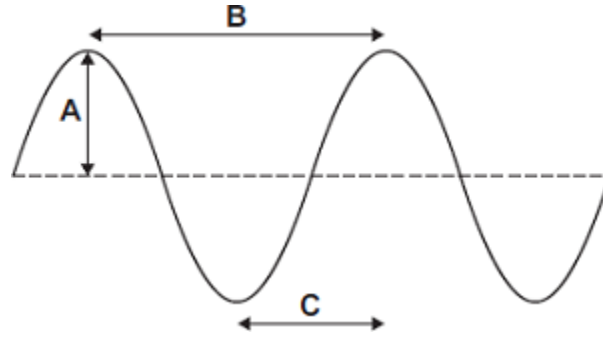
Draw a ring around the correct answer.

J K L

(1)

(c) **Diagram 2** shows an infrared wave.

Diagram 2



(i) Which **one** of the arrows, labelled **A**, **B** or **C**, shows the wavelength of the wave?

Write the correct answer, **A**, **B** or **C**, in the box.

(1)

(ii) Draw a ring around the correct answer to complete the sentence.

The wavelength of infrared waves is

shorter than
the same as
longer than

the wavelength of radio waves.

(1)

- (d) Mobile phone networks send signals using microwaves. Some people think the energy a person's head absorbs when using a mobile phone may be harmful to health.
- (i) Scientists have compared the health of people who use mobile phones with the health of people who do not use mobile phones.

Which **one** of the following statements gives a reason why scientists have done this?

Tick (✓) **one** box.

- To find out if using a mobile phone is harmful to health.
- To find out if mobile phones give out radiation.
- To find out why some people are healthy.

(1)

- (ii) The table gives the specific absorption rate (SAR) value for two different mobile phones.

The SAR value is a measure of the maximum energy a person's head absorbs when a mobile phone is used.

Mobile Phone	SAR value in W/kg
X	0.28
Y	1.35

A parent buys mobile phone **X** for her daughter.

Using the information in the table, suggest why buying mobile phone **X** was the best choice.

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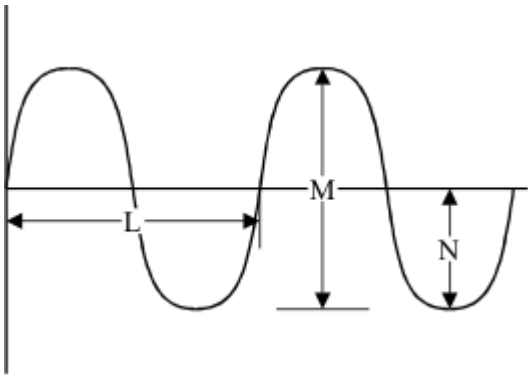
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(2)

(Total 8 marks)

2

(a) The diagram shows a wave pattern.



Which letter, **L**, **M** or **N** shows:

- (i) the wavelength?
- (ii) the amplitude?

(2)

(c) Describe how you could show that visible light travels in straight lines. You may wish to draw a diagram to help explain your answer.

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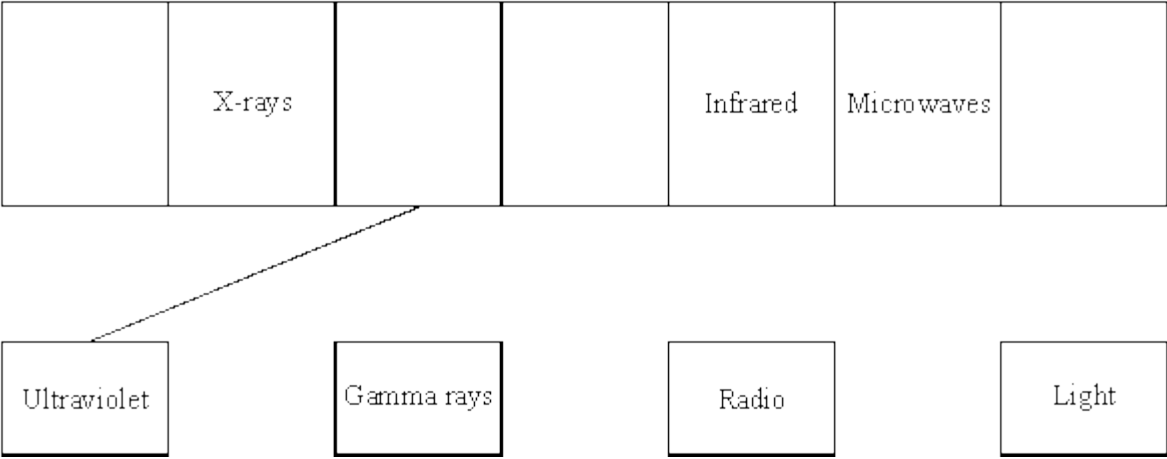
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(2)
(Total 4 marks)

3

(a) The diagram represents the electromagnetic spectrum. Four of the waves have not been named. Draw lines to join each of the waves to its correct position in the electromagnetic spectrum. One has been done for you.



(2)

(b) Complete the following sentence by choosing the correct answer and crossing out in the box the two lines which are wrong.

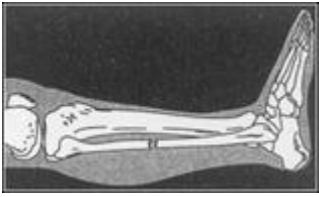
The speed of radio waves through a vacuum is

faster than
the same as
slower than

 the speed of light through a vacuum.

(1)

(d) The diagram shows an X-ray photograph of a broken leg.



Bones show up white on the photographic film. Explain why.

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.....
.....

(2)

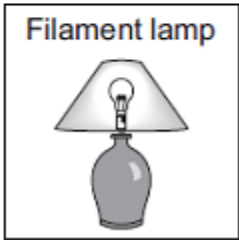
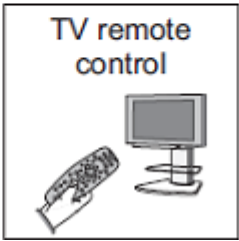
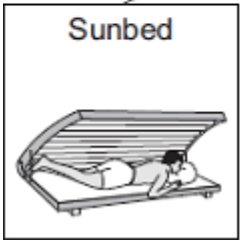
(Total 5 marks)

4

- (a) The diagram shows the electromagnetic spectrum. The pictures show four devices that use electromagnetic waves. Each device uses a different type of electromagnetic wave.

Draw a line from each device to the type of electromagnetic wave that it uses. One has been done for you.

Gamma rays	X-rays	Ultraviolet rays	Visible light	Infra red rays	Microwaves	Radio waves
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(3)

- (b) A headline from a recent newspaper article is shown below.

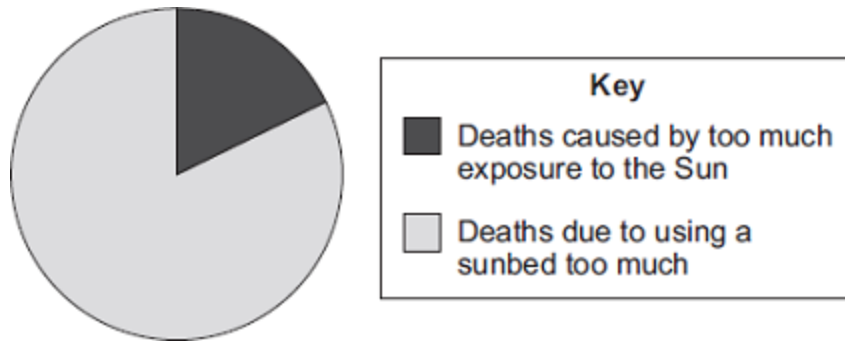


- (i) What serious health problem may be caused by using a sunbed too much?

.....

(1)

- (ii) The pie chart compares the number of deaths in Britain each year which may have been caused by using sunbeds too much, with those which may have been caused by too much exposure to the Sun.



It is difficult for a doctor to be certain that a person has died because of using a sunbed too much.

Suggest why.

.....
.....

(1)

- (iii) A spokesperson for a leading cancer charity said:

'We want people, especially young people, to know the possible dangers of using a sunbed.'

Why is it important that you know the possible dangers of using a sunbed?

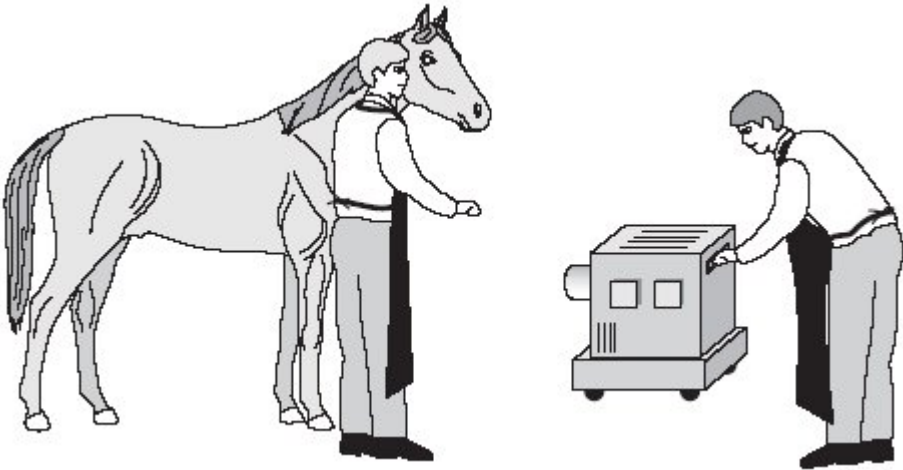
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(1)

(Total 6 marks)

5

The picture shows a horse being prepared for an X-ray.



The person who will take the X-ray and the person holding the horse are wearing special aprons. These aprons have a lead lining.

Explain why the lead lining is important.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

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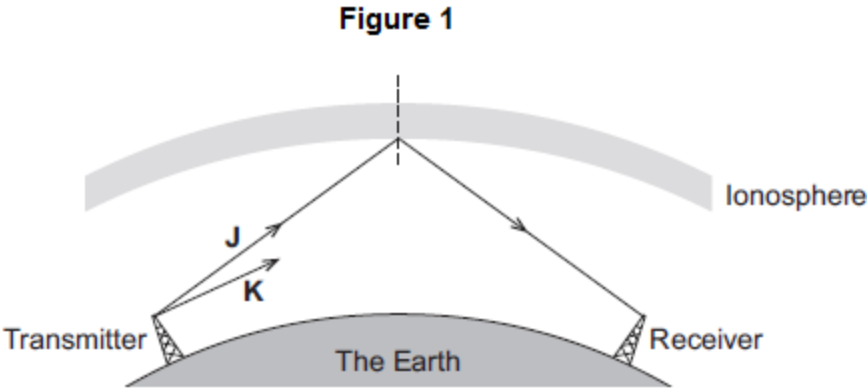
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(Total 3 marks)

6

Different parts of the electromagnetic spectrum are useful for different methods of communication.

(a) **Figure 1** shows a transmitter emitting two electromagnetic waves, **J** and **K**.



Wave **J** is reflected by a layer in the atmosphere called the ionosphere.

(i) Wave **K** will also be reflected by the ionosphere. On **Figure 1**, draw the path of wave **K** to show that it **does not** reach the receiver.

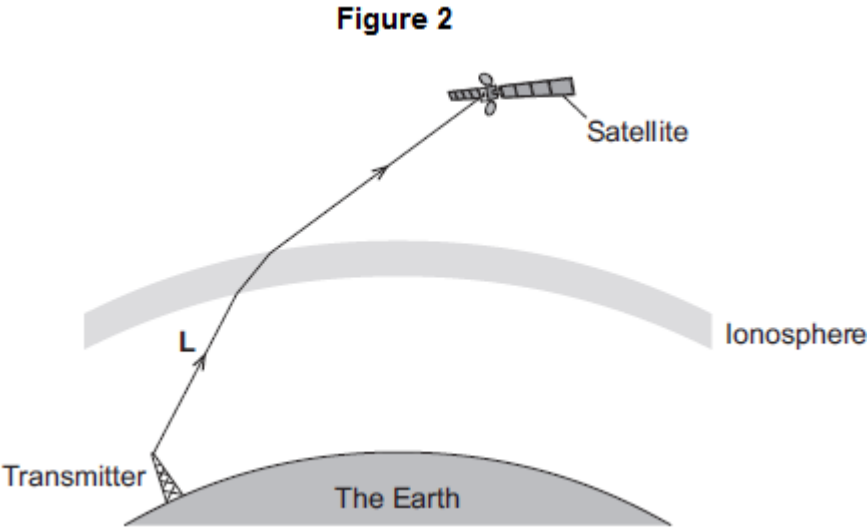
(2)

(ii) What is the name given to the dashed line in **Figure 1**?

.....

(1)

(b) **Figure 2** shows a transmitter sending a signal to a satellite orbiting the Earth.



(i) Which type of electromagnetic wave is used to send a signal to a satellite?

Draw a ring around the correct answer.

- gamma
- microwave
- ultraviolet

(1)

- (ii) What name is given to the process that occurs as wave **L** passes into the ionosphere?

Draw a ring around the correct answer.

diffraction **reflection** **refraction**

(1)

- (c) Waves **J**, **K** and **L** are electromagnetic waves.

What are **two** properties of **all** electromagnetic waves?

Tick (✓) **two** boxes.

Property	Tick (✓)
All electromagnetic waves are longitudinal.	
All electromagnetic waves are transverse.	
All electromagnetic waves are mechanical.	
All electromagnetic waves have the same speed in a vacuum.	
All electromagnetic waves have the same frequency.	

(2)

(Total 7 marks)

7

- (a) The diagram below shows six of the seven types of wave that make up the electromagnetic spectrum.

Gamma rays		Ultraviolet	Visible light	Infrared	Microwaves	Radio waves
------------	--	-------------	---------------	----------	------------	-------------

- (i) What type of electromagnetic wave is missing from the diagram?

.....

(1)

- (ii) Which of the following electromagnetic waves has the most energy?

Draw a ring around the correct answer.

gamma rays **radio waves** **visible light**

(1)

(iii) Which of the following electromagnetic waves is given out by a TV remote control?

Draw a ring around the correct answer.

infrared

microwaves

ultraviolet

(1)

(b) Draw a ring around the correct answer in the box to complete the sentence.

Microwaves travel through a vacuum at

a slower speed than

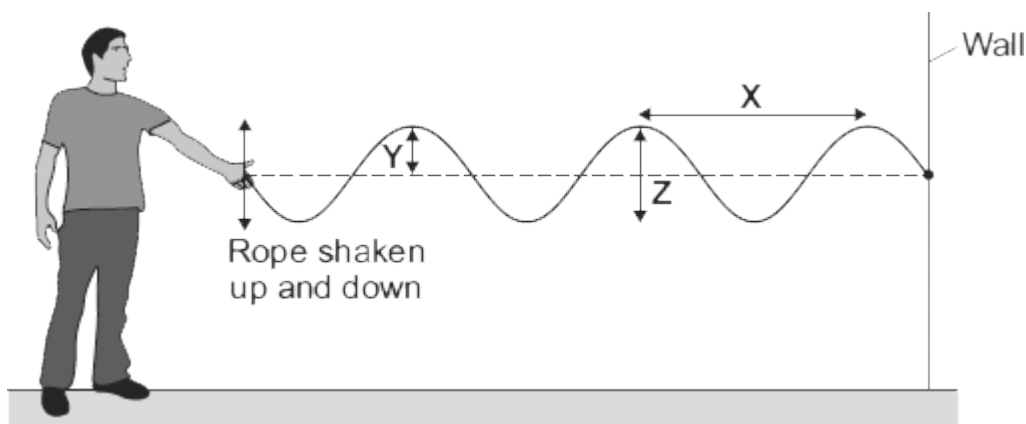
the same speed as

a faster speed than

radio waves.

(1)

(c) The diagram shows waves being produced on a rope. The waves are **not** reflected by the wall.



(i) Draw an arrow on the diagram to show the direction in which the waves transfer energy.

(1)

(ii) Which **one** of the arrows, labelled, **X**, **Y** or **Z**, shows the amplitude of a wave?

Write the correct answer in the box.

(1)

(iii) The waves produced on the rope are transverse.

Name **one** other type of transverse wave.

.....

(1)

(d) The rope is shaken up and down, producing 3 waves every second.
The waves have a wavelength of 1.2 metres.

(i) State the frequency of the waves.

..... Hz

(1)

(ii) Calculate the speed of the waves.

Use the correct equation from the Physics Equations Sheet.

Show clearly how you work out your answer.

.....
.....

Wave speed = m/s

(2)

(Total 10 marks)

8

Small sailing boats can be fitted with a passive radar device. The device increases the chance that the small boat will be seen on the radar screen of a large ship.

The radar transmitter on the large ship emits microwaves.

(a) Microwaves and radio waves are both part of the electromagnetic spectrum.

How are microwaves different from radio waves?

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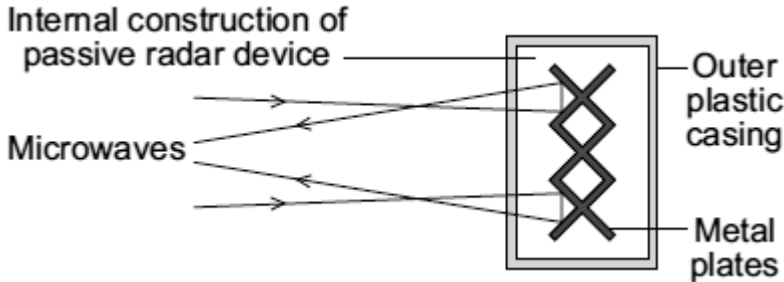
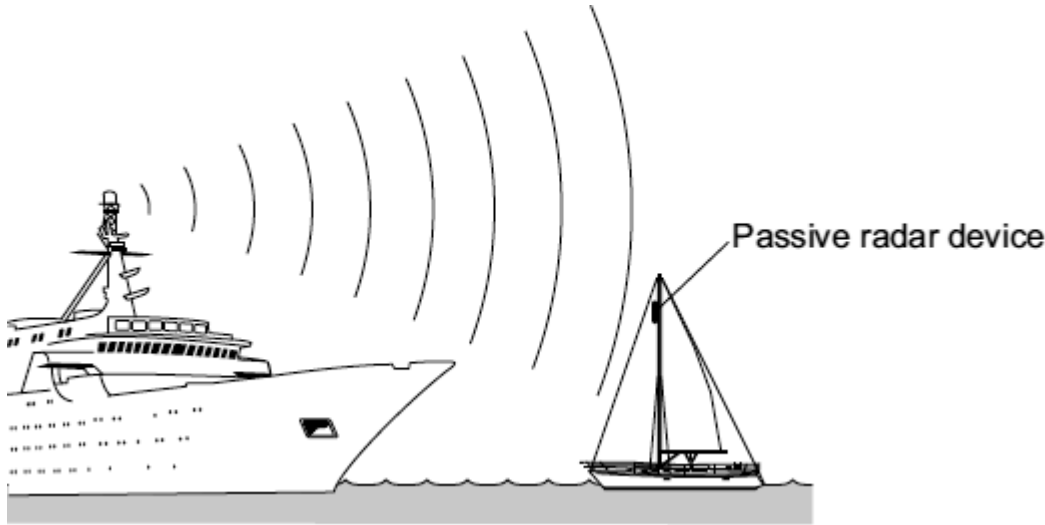
(1)

(b) How fast do microwaves travel through the air or a vacuum compared to radio waves?

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(1)

(c) The diagrams show the position of a passive radar device on a small boat and the internal construction of one type of passive radar device.



Microwaves can be absorbed, reflected or transmitted by different materials and types of surface.

Explain what happens to the microwaves from the ship's transmitter when they reach the passive radar device.

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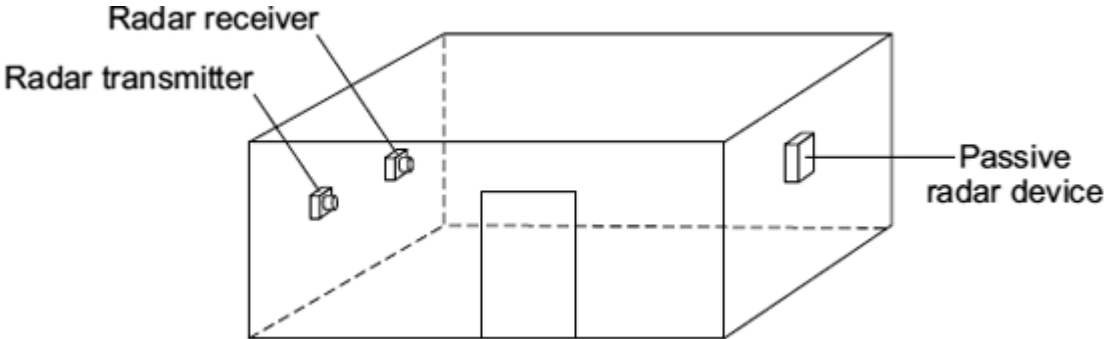
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(2)

- (d) Each type of passive radar device has an RCS value. The larger the RCS value, the easier it is for a small boat fitted with the device to be detected.

An independent group of scientists measured the RCS values of 4 different types of device. The RCS value for each device was measured in the same room using the same equipment.



- (i) Why are the walls of the room covered in a material that absorbs the waves emitted by the radar transmitter?

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(1)

- (ii) Why is it important to use the same room and the same equipment?

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(1)

- (iii) Why is it important that the measurements are made by an independent group of scientists?

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(1)

- (e) The movement of a small boat causes the mast and device to lean over, therefore the RCS values were measured at different angles.

The table gives the RCS values obtained by the scientists.



Device	Angle X			
	0 °	5 °	10 °	15 °
A	1.4	1.6	1.7	1.8
B	4.7	2.6	2.3	1.9
C	9.3	3.3	1.9	1.1
D	4.5	4.8	5.0	4.6

- (i) Describe how the RCS values for **device A** are different to the RCS values for **device B**.

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.....

(2)

- (ii) The scientists recommended that a passive radar device fitted to a small boat should have:

- the largest possible RCS value
- an RCS value consistently above 2.0

Which **one** of the devices, **A**, **B**, **C** or **D**, would you recommend that someone fits to their boat?

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Give a reason for your answer.

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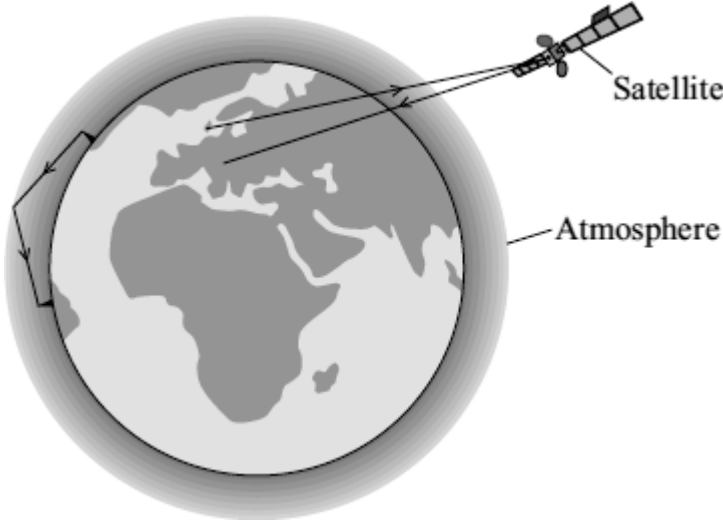
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(1)

(Total 10 marks)

9

(a) Electromagnetic waves have many uses. The diagram shows two ways of sending information using electromagnetic waves.



(i) What type of wave is used to send information to and from satellites?

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(1)

(ii) What property of this type of wave makes it suitable for satellite communications?

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(1)

(b) The diagram shows two types of signal that can be used to send information. One of the signals is an analogue signal. The other is a digital signal.

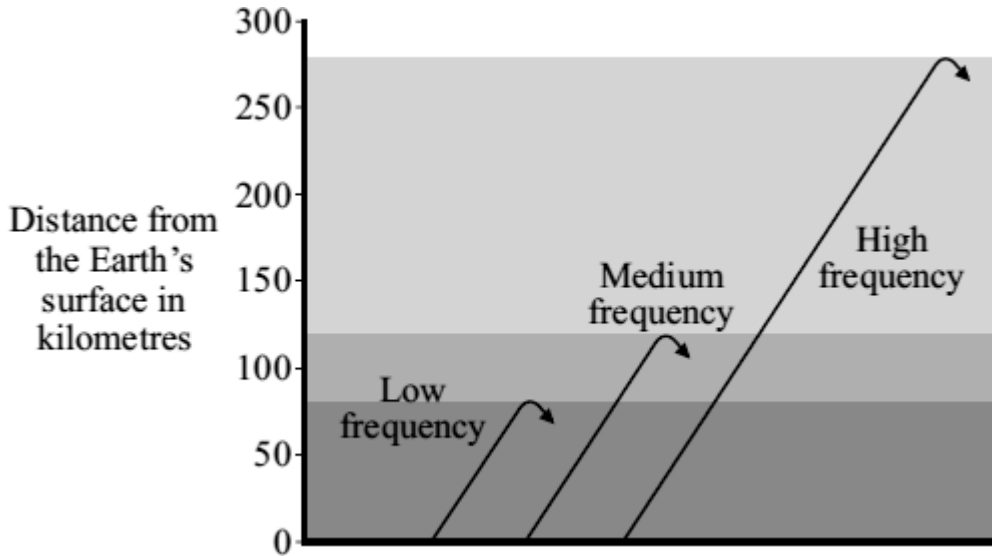


Describe the differences between an analogue signal and a digital signal.

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.....

(2)

- (c) Different frequency radio waves travel different distances through the atmosphere before being reflected.



Use the information in the diagram to describe the connection between the frequency of a radio wave and the distance the radio wave travels through the atmosphere before it is reflected.

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(1)

- (d) Electromagnetic waves travel at a speed of 300 000 000 m/s.

A radio station transmits waves with a wavelength of 20 metres.

Use the equation in the box to calculate the frequency, in kilohertz (kHz), of these waves.

$$\text{wave speed} = \text{frequency} \times \text{wavelength}$$

Show clearly how you work out your answer.

.....

Frequency = kHz

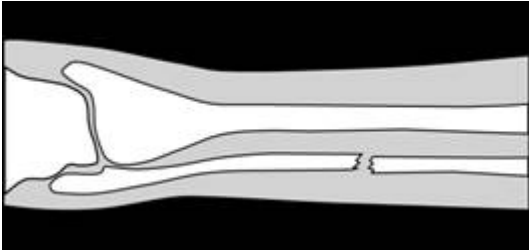
(2)

(Total 7 marks)

10

Both X-ray machines and CT scanners are used to produce images of the body.

(a) The diagram shows an X-ray photograph of a broken leg.



Before switching on the X-ray machine, the radiographer goes behind a screen.

Explain why the radiographer does this.

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(3)

(b) The following is an extract from a newspaper article.

X-rays cause 700 new cancers each year in the U.K.
Each year there are about 125 000 new cancer cases in the UK, of which, about 700 may be due to the use of X-rays to diagnose illness.

The article was reporting on a scientific research project first published in a medical journal.

What evidence would the scientists have collected to come to the conclusion that X-rays can cause cancer?

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(2)

(c) Explain the advantage of a CT scan compared to an X-ray.

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(2)

(Total 7 marks)

11

Ultrasound and X-rays are waves used in hospitals to create images of the inside of the human body. To produce the images below, the waves must enter the human body.

Ultrasound scan of an unborn child



© Isabelle Limbach/Thinkstock

X-ray of a broken bone



© itsmejst/iStock

(a) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

Describe the features of ultrasound and X-rays, and what happens to each type of wave after it has entered the human body.

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(6)

(b) It would **not** be safe to use X-rays to produce an image of an unborn child.

Explain why.

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.....
.....
.....

(2)

(c) Ultrasound can be used for medical treatments as well as for imaging.

Give **one** use of ultrasound for medical treatment.

.....
.....

(1)

(Total 9 marks)

12

(a) Some scientists think that there is a link between using a mobile phone and some types of illness. Other scientists disagree. They say that the evidence is limited and unreliable.

(i) Suggest what scientists could do to show a link between using a mobile phone and illness.

.....
.....

(1)

(ii) How could scientists improve the reliability of the evidence?

.....
.....

(1)

- (iii) Complete the following passage by drawing a ring around the word in the box that is correct.

There has been little or no experimental research into the health of children who use mobile phones.

This is partly because of the

economic
environmental
ethical

issues involved in using

children in scientific research.

(1)

- (b) Before being sold, new mobile phones must be tested and given a SAR value. The SAR value is a measure of the energy absorbed by the head while a mobile phone is being used.

The table gives the SAR value for three mobile phones made by different companies. To be sold in the UK, a mobile phone must have a SAR value lower than 2.0 W/kg.

Mobile phone	SAR value in W/kg
J	0.18
K	0.86
L	1.40

- (i) All companies use the same test to measure a SAR value.

Why is using the same test important?

.....
.....

(1)

- (ii) Would the companies that make the mobile phones, **J**, **K** and **L**, be correct to claim that these three phones are totally safe to use?

Answer yes or no.

Give a reason for your answer.

.....
.....

(1)

- (c) Devices designed to protect a mobile phone user from microwave radiation are now available.

Why is it important that these devices are tested by scientists who are **not** working for the company that makes the devices?

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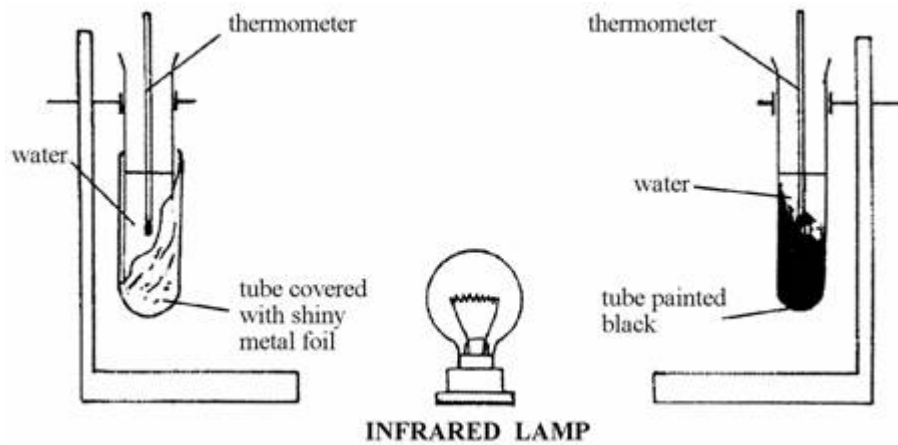
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(1)

(Total 6 marks)

13

The diagram shows an experiment to find out what happens to infrared waves when they strike different surfaces.



- (a) The water in the black tube gets hotter than the water in the shiny tube. Choose words from the list to complete the sentences below.

absorbs conducts convects radiates reflects

The infrared lamp energy to the tubes of water.

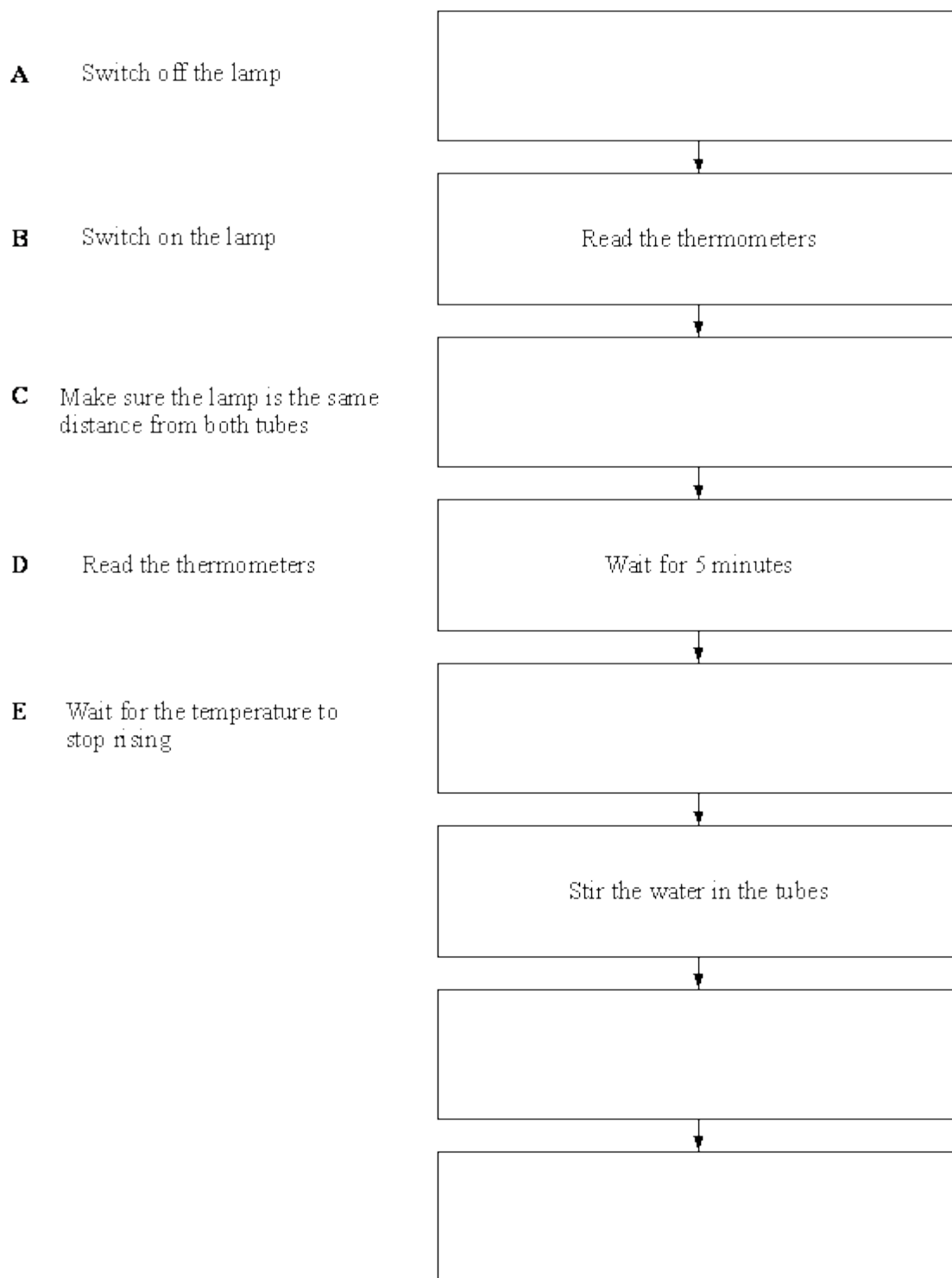
The black surface most of the energy that reaches it.

The shiny surface most of the energy that reaches it.

(3)

(b) Put the sentences A- E below into the correct boxes on the flow diagram so that they tell you how to do the experiment

(You may use just the letters if you want to.)

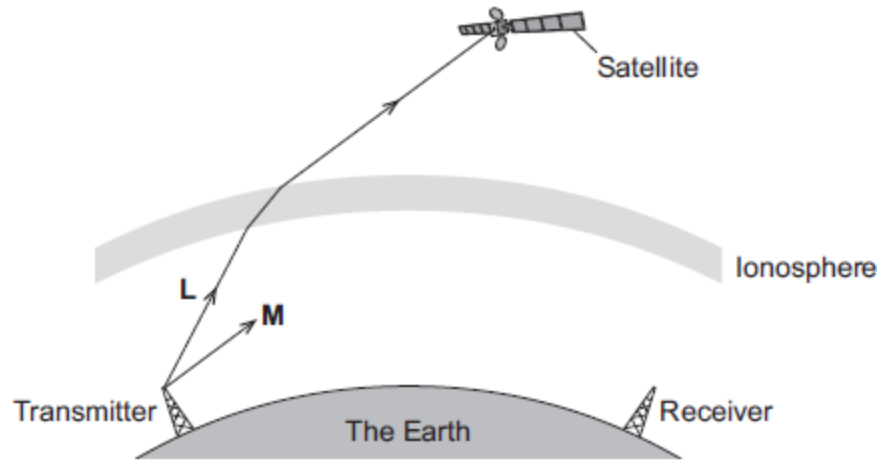


(5)
(Total 8 marks)

14

Different parts of the electromagnetic spectrum are useful for different methods of communication.

The diagram shows a transmitter emitting two electromagnetic waves, **L** and **M**.



(a) (i) Wave **L** is used to send a signal to a satellite.
Which part of the electromagnetic spectrum does wave **L** belong to?
..... (1)

(ii) What name is given to the process that occurs as wave **L** passes into the ionosphere?
..... (1)

(b) Wave **M** is **reflected** by the ionosphere.

(i) On the diagram above, draw the path of wave **M** until it reaches the receiver. (2)

(ii) On the daigram above, draw a line to show the normal where wave **M** meets the ionosphere. Label the line **N**. (1)

(c) Give **two** properties of all electromagnetic waves.

- 1.....
-
- 2.....
-

(2)
(Total 7 marks)

15

Radio waves and microwaves are two types of electromagnetic wave.

Both waves:

- can be used for communications
- travel at the same speed through air.

(a) Give **two** more properties that are the same for both radio waves and microwaves.

1

.....

2

.....

(2)

(b) Some satellites are used to transmit television programmes. Signals are sent to, and transmitted from, the satellites using microwaves.

What is the property of microwaves that allows them to be used for satellite communications?

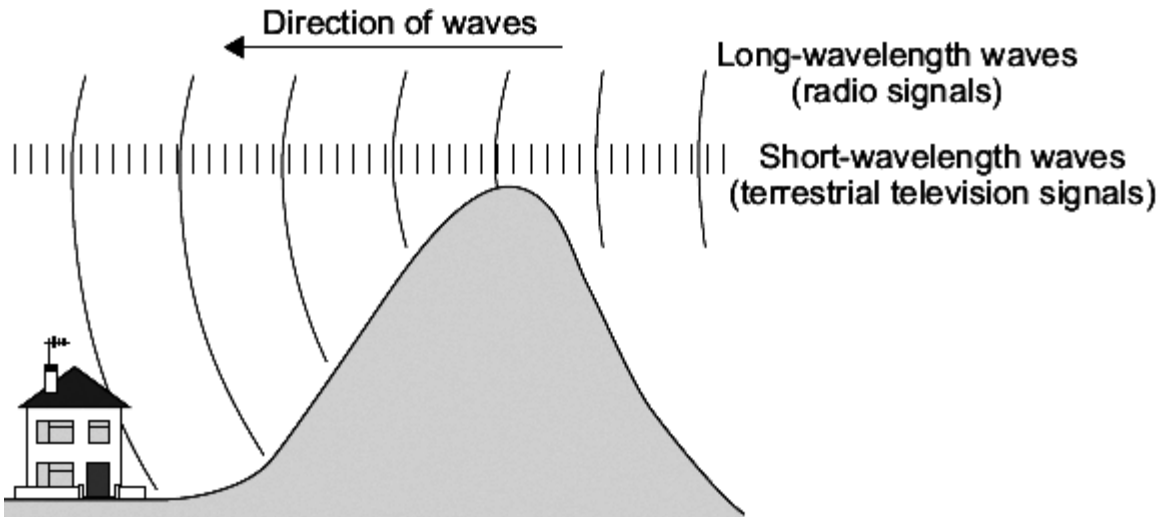
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(1)

(c) Terrestrial television does not use satellites.

Terrestrial television signals and radio signals both use radio waves. Radio signals are transmitted at a longer wavelength than terrestrial television signals.



In hilly areas it may be possible to receive radio signals but not receive terrestrial television signals.

Explain why.

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(3)

- (d) Electromagnetic waves travel at a speed of 3.0×10^8 m/s.

A radio station transmits waves with a wavelength of 2.5×10^2 m.

Calculate the frequency of the radio waves.

Use the correct equation from the Physics Equations Sheet.

Show clearly how you work out your answer and give the unit.

.....

.....

.....

Frequency =

(3)

(Total 9 marks)

16

- (a) Microwaves are one type of electromagnetic wave.

(i) Which type of electromagnetic wave has a lower frequency than microwaves?

.....

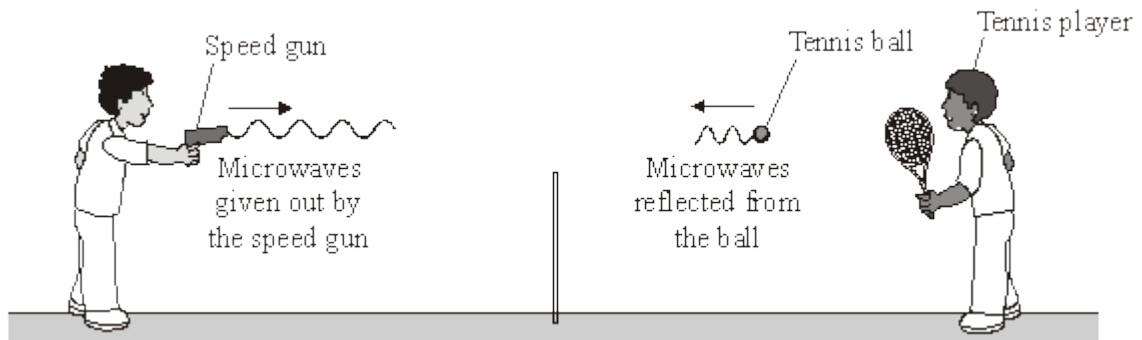
(1)

(ii) What do all types of electromagnetic wave transfer from one place to another?

.....

(1)

- (b) The picture shows a tennis coach using a speed gun to measure how fast the player serves the ball.



- (i) The microwaves transmitted by the speed gun have a frequency of 24 000 000 000 Hz and travel through the air at 300 000 000 m/s.

Use the equation in the box to calculate the wavelength of the microwaves emitted from the speed gun.

$\text{wave speed} = \text{frequency} \times \text{wavelength}$

Show clearly how you work out your answer.

.....

.....

Wavelength = m

(2)

- (ii) Some of the microwaves transmitted by the speed gun are absorbed by the ball.

What effect will the absorbed microwaves have on the ball?

.....

.....

(1)

- (iii) Some of the microwaves transmitted by the speed gun are reflected from the moving ball back towards the speed gun.

Describe how the wavelength and frequency of the microwaves change as they are reflected from the moving ball.

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.....

(2)
(Total 7 marks)

17

- (a) Electromagnetic waves form a continuous spectrum with a range of wavelengths.

What is the approximate range of wavelengths of electromagnetic waves?

Tick (✓) **one** box.

10^{-15} metres to 10^4 metres	<input type="checkbox"/>
10^{-4} metres to 10^{15} metres	<input type="checkbox"/>
10^{-6} metres to 10^6 metres	<input type="checkbox"/>

(1)

- (b) Infrared waves and microwaves are used for communications.

- (i) Give **one** example of infrared waves being used for communication.

.....
.....

(1)

- (ii) A mobile phone network uses microwaves to transmit signals through the air. The microwaves have a frequency of 1.8×10^9 Hz and travel at a speed of 3.0×10^8 m/s.

Calculate the wavelength of the microwaves.

Use the correct equation from the Physics Equations Sheet.

Give your answer to **two** significant figures.

.....
.....
.....

Wavelength = m

(3)

- (c) Some scientists suggest there is a possible link between using a mobile phone and male fertility.

The results of their study are given in the table.

Mobile phone use in hours per day	Sperm count in millions of sperm cells per cm ³ of semen
0	86
less than 2	69
2 – 4	59
more than 4	50

The results show a negative correlation: the more hours a mobile phone is used each day, the lower the sperm count. However, the results do **not** necessarily mean using a mobile phone causes the reduced sperm count.

Suggest **one** reason why.

.....
.....

(1)

(Total 6 marks)

18

Radio waves, ultra-violet, visible light and X-rays are all types of electromagnetic radiation.

(a) Choose wavelengths from the list below to complete the table.

$3 \times 10^{-8} \text{ m}$ $1 \times 10^{-11} \text{ m}$ $5 \times 10^{-7} \text{ m}$ 1500 m

TYPE OF RADIATION	WAVELENGTH (m)
Radio waves	
Ultra-violet	
Visible light	
X-rays	

(4)

(b) Microwaves are another type of electromagnetic radiation.

Calculate the frequency of microwaves of wavelength 3 cm.
(The velocity of electromagnetic waves is $3 \times 10^8 \text{ m/s}$.)

.....

.....

.....

.....

(4)

(Total 8 marks)

19

(a) The wavelengths of four different types of electromagnetic wave, including visible light waves, are given in the table.

Type of wave	Wavelength
Visible light	0.0005 mm
A	1.1 km
B	100 mm
C	0.18 mm

Which of the waves, A, B, or C, is an infra red wave?

.....

(1)

- (b) A TV station broadcasts at 500 000 kHz. The waves travel through the air at 300 000 000 m/s.

Use the equation in the box to calculate the wavelength of the waves broadcast by this station.

wave speed = frequency x wavelength

Show clearly how you work out your answer.

.....
.....

Wavelength = m

(2)

- (c) What happens when a metal aerial absorbs radio waves?

.....
.....
.....
.....

(2)

- (d) Stars emit all types of electromagnetic waves. Telescopes that monitor X-rays are mounted on satellites in space.

Why would an X-ray telescope based on Earth **not** be able to detect X-rays emitted from distant stars?

.....
.....

(1)

(Total 6 marks)

20

Waves may be longitudinal or transverse.

(a) Describe the differences between longitudinal waves and transverse waves.

.....

.....

.....

.....

.....

.....

.....

.....

.....

(3)

(b) Radio waves are electromagnetic waves.

Describe how radio waves are different from sound waves.

.....

.....

.....

.....

.....

.....

.....

.....

(4)

(Total 7 marks)

Mark schemes

1	(a)	(i)	(visible) light <i>accept visible</i>	1
		(ii)	microwaves	1
	(b)	J		1
	(c)	(i)	B	1
		(ii)	shorter than	1
	(d)	(i)	To find out if using a mobile phone is harmful to health	1
		(ii)	any two from:	
			<ul style="list-style-type: none">(X has a) low(er) SAR value <i>"it" refers to mobile phone</i> <i>accept has a low(er) rate</i>(maximum) energy absorbed (by the head) is less <i>accept energy emitted (by phone) is less</i> <i>accept radiation for energy</i>(if mobiles are harmful) less likely to cause harm <i>accept will not cause harm</i> <i>accept it is safer</i>	2
				[8]
	2	(a)	(i)	L
		(ii)	N	1
(c)			the answer should be in the form: <i>not inside the eye</i> either for both marks an arrangement which could demonstrate visibly light travels in straight lines <i>full credit should be given for answer presented as a diagram</i> and an explanation of how it shows the straightness	

or for one mark

named device which uses principle of light travelling in straight lines to work

examples

light (from a street lamp) strikes an object producing a shadow

laser light travelling through (fine) dust shows a straight beam

three pieces of card with central holes need to be lined up to be able to see through the third hole from the first

ray box type experiment using mirrors/prisms, etc

beams on paper or in smoke

torch beams through smoke

example devices:-

-pinhole camera (qualification may get second mark)

-periscope

-optical fibre

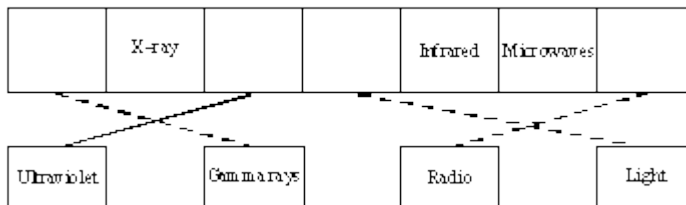
*-reflection 'in a **mirror***

2

[4]

3

(a) all **three** correct



one only correct, **1** mark only

allow names in boxes

*there should be only **one** line from **or** to each box*

2

(b) the same as

1

(d) any **two** from:

- bones absorb X-rays
- so film not exposed
- X-rays pass through flesh or skin or
- body or tissue (to expose film)

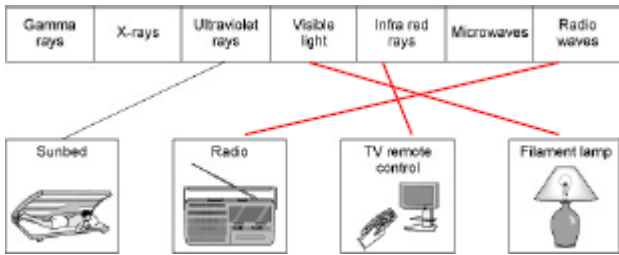
allow X-rays cannot pass through bones

2

[5]

4

(a) all three lines correct



allow 1 mark for each correct line

if more than one line goes from a device then all lines from that device are wrong

3

(b) (i) skin cancer

do **not** accept cancer
do **not** accept sunburn
correct answer only

1

(ii) other factors may be involved

accept may have been in the Sun too long
accept (over)-use of sunbeds and (over)- exposure to the Sun
(both) give the same symptoms
accept any other sensible factor that could lead to doubt
do **not** accept irrelevant answers eg may be run over by a car
do **not** accept killed by exposure to the Sun

1

(iii) can assess risk

answers should be in terms of assessing our own health risk

or

make your own decision

accept so you limit its use / don't use one
do **not** accept so you don't get skin cancer
do **not** accept so you don't get sunburn

1

[6]

5

Quality of written communication

award for a sensible sequence of **two** points

1

X-rays do not go through lead

accept lead protects them from the X-rays

accept not exposed to X-rays

1

lead stops / reduces risk of X-rays harming / damaging / killing (persons) cells

accept X-rays (may) cause cancer

accept organs for cell

do **not** accept references to electric shock

do **not** accept stops bones of people showing on X-ray

answers involving the horse wearing an apron are incorrect

references to gamma rays are incorrect

1

[3]

6

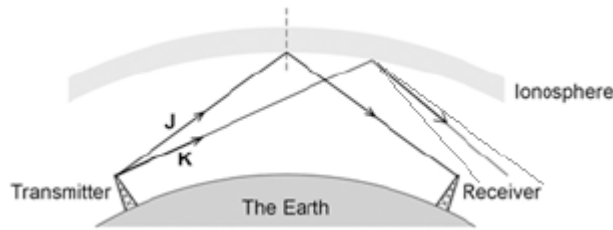
(a) (i) reflection of wave **K** at or within the ionosphere

allow dashed lines

1

angle i = angle r

'judge by eye'



tolerance for the reflected ray is between the first e and last r

ignore arrows

a reflected ray to the receiver doesn't score 2nd mark

additional rays shown don't score 2nd mark

1

(ii) normal

1

(b) (i) microwave

1

(ii) refraction

1

(c) All electromagnetic waves are transverse.

1

All electromagnetic waves have the same speed in a vacuum.

1

[7]

7

- (a) (i) X-ray(s) 1
- (ii) gamma rays 1
- (iii) infrared 1
- (b) the same speed as 1
- (c) (i) horizontal arrow drawn pointing to the right
judge by eye
accept drawn anywhere on diagram 1
- (ii) Y 1
- (iii) any **one** from:
- any type of electromagnetic wave
accept electromagnetic wave(s)
 - water (wave)
do not accept seismic waves
 - (earthquake / seismic) S waves
do not accept P waves
do not accept earthquakes 1
- (d) (i) 3 1
- (ii) 3.6
- or**
- their (d)(i) $\times 1.2$ correctly calculated
 $v = f \times \lambda$
allow 1 mark for correct substitution
ie 3 or their (d)(i) $\times 1.2$ provided that no subsequent step is shown 2

[10]

8

- (a) higher frequency
general properties / uses are neutral
or
shorter wavelength
*do **not** accept different frequency / wavelength / energy*
or
greater energy
1
- (b) the same (speed)
accept they travel at the speed of light
1
- (c) pass through / transmitted by the plastic / casing
1
reflected by the metal / plates
*do **not** accept bounce / deflected etc for reflected*
if neither marking point scores an answer reflected (back to boat / from the device) scores 1 mark
1
- (d) (i) waves are not reflected from the walls
accept microwaves / radar for waves
*do **not** accept bounce / deflected etc for reflected*
or
only waves (reflected) from the device are detected
accept to stop reflected waves affecting results
1
- (ii) different types (of device) can be compared
fair test is insufficient
accept idea that only one variable is then changed
1
- (iii) so (measurements / results / scientists) are not biased towards one type / manufacturer of device/s
accept to avoid bias
accept so they are not biased
1

- (e) (i) any **two** from:
- if temperature is mentioned rather than angle a maximum of 1 mark can be scored*
 - (for any angle) **A** values < **B** values
*or converse eg **B** values are higher / better / stronger*
 - **A** values increase with (increasing) angle
*accept weakest at 0° strongest at 15°
values go up is insufficient*
 - **B** values decrease with (increasing) angle
*accept strongest at 0° weakest at 15°
values go down is insufficient*
 - **A** values do not vary as much (as **B** values)

2

- (ii) **D**
- mark is for the reason
reason cannot score if **D** is not chosen*

values are always over 2(.0)

1

[10]

9

- (a) (i) microwaves
- (ii) can pass through the ionosphere
*accept travels in a straight line
accept atmosphere for ionosphere
do **not** accept air for ionosphere*

1

1

- (b) any **two** from:
- analogue is continuously varying
*do **not** accept analogue has many values*
 - digital has only discrete values
*accept digital is on or off
accept digital is 1 or 0
accept digital is binary*
 - digital is less prone to interference (than analogue)
accept digital is easier to restore
 - digital can be processed more easily (than analogue) by a computer

2

- (c) higher the frequency, further the wave travels
(into the atmosphere before reflection) 1
- (d) 15 000
- allow 1 mark for correct transformation and substitution*
- ie $\frac{300\,000\,000}{20}$*
- an answer of 15 000 000 only gains 1 mark*
- allow both marks for an answer of 15 MHz (unit must be changed)*
- an answer of 15 gains no credit* 2

[7]

10

- (a) X-rays are ionising
or
X-rays kill / damage cells
accept cause cancer 1
- any stray X-rays are absorbed by screen 1
- which reduces the radiation dose to the radiographer 1
- (b) medical records / X-ray records 1
- of people with cancer 1
- (c) a CT scan gives a 3D image 1
- therefore the image can be observed from different directions 1

[7]

11

- (a) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the [Marking guidance](#), and apply a 'best-fit' approach to the marking.

0 marks

No relevant / correct content.

Level 1 (1-2 marks)

There is a basic description of either wave

OR

What happens to either wave when they enter the body. However there is little other detail.

Level 2 (3-4 marks)

There is either:

A clear description of BOTH waves

OR

A clear description as to what happens to BOTH waves inside the body

OR

A clear description of ONE of the waves with clear detail as to what happens to either wave inside the body.

Level 3 (5-6 marks)

There is a detailed description of BOTH of the waves

AND

A detailed description as to what happens to EITHER wave inside the body.

Examples of the points made in the response:

Description of an X-ray

- X-rays are electromagnetic waves / part of the electromagnetic spectrum
*do **not** allow a description of a property – eg X-rays travel*
- X-rays are (very) high frequency (waves)
through a vacuum / at the speed of light
- X-rays are (very) high energy (waves)
- X-rays have a (very) short wavelength
- Wavelength (of X-rays) is of a similar size to (the diameter of) an atom
- X-rays are a transverse wave
correct description acceptable – oscillations / vibrations are perpendicular (at 90°) to direction of energy transfer
- X-rays are ionising radiation

Description of ultrasound

- ultrasound has a frequency above 20 000 (hertz)
- or**
- ultra sound is above 20 000 hertz
- ultrasound is above / beyond the human (upper) limit (of hearing)
accept ultrasound cannot be heard by humans
 - ultrasound is a longitudinal wave
correct description acceptable – oscillations / vibrations (of particles) are parallel (in same direction) to direction of energy transfer

Statement(s) as to what happens to X-rays inside the human body:

- X-rays are absorbed by bone
- X-rays travel through / are transmitted by tissue / skin

Statement as to what happens to ultrasound inside body:

- ultrasound is (partially) reflected at / when it meets a boundary between two different media
- travel at different speeds through different media

- (b) (because the X-rays) are ionising
accept a description of what ionising is

1

(they will) damage cells
instead of cell, any of these words can be used:
DNA / genes / chromosomes / nucleus

or

mutate cells / cause mutations / increase chances of mutations

or

turn cells cancerous / produce abnormal growths / produce rapidly growing cells
*do **not** accept they can be dangerous (to human health)*
*do **not** accept damage to soft tissue*

or

kill cells

1

- (c) any **one** from:

- removal / destruction of kidney / gall stones
- repair of damaged tissue / muscle
accept examples of repair, eg alleviating bruising, repair scar damage, ligament / tendon damage, joint inflammation
accept physiotherapy
*accept curing prostate cancer **or** killing prostate cancer cells*
- removing plaque from teeth
cleaning teeth is insufficient

1

[9]

12

- (a) (i) compare (the health of) mobile phone users with non-mobile phone users
must be an implied comparison between users and non-users
any idea of doing an experiment negates the mark

1

- (ii) increase the sample size
accept use more people
accept have a large sample size
repeat the research / test is neutral

1

- (iii) ethical

1

(b) (i) so the phones can be compared (fairly)
a fair test is insufficient
accept different tests (may) give different results
*do **not** accept to make the results reliable, unless qualified*
eg all variables are controlled
*do **not** accept bias unless qualified*

1

(ii) yes all are below the legal limit / 2 (W/kg)

or no and any **one** from:

- even absorbing a small amount of energy may be harmful
accept microwaves for energy
accept emits energy absorbed by head / other parts of body
- no proof that small amounts of energy are not harmful
accept because the SAR value is not 0 (W/kg)

1

(c) any **one** from:

- to get an independent opinion
- company scientists may be biased
accept company scientists may manipulate results

1

[6]

13

(a) radiates
 absorbs / conducts
 reflects

for 1 mark each

3

(b) C make sure the lamp is the same distance from both tubes
 B switch on the lamp
 A switch off the lamp
 E wait for the temperature to stop rising
 D read the thermometers

for 1 mark each

5

[8]

14

(a) (i) microwave

1

(ii) refraction

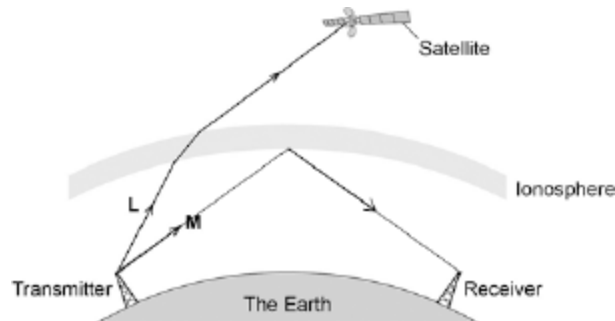
1

- (b) (i) wave M continues as a straight line to the ionosphere and shown reflected
accept reflection at or within the ionosphere

1

correctly reflected wave shown as a straight line reaching the top of the receiver

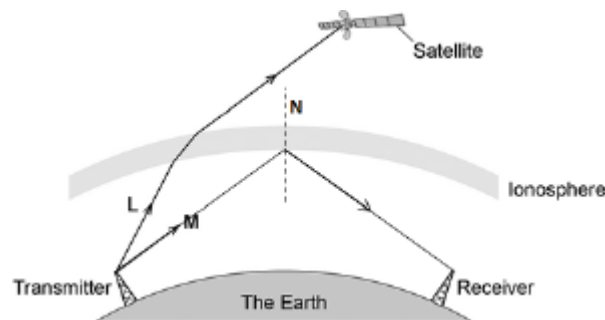
if more than 2 rays shown 1 mark maximum



ignore arrows

1

- (ii) normal drawn at point where their **M** meets the ionosphere



1

- (c) any **two** from:

- transverse
- same speed (through air)
accept speed of light or $3 \times 10^8 \text{ m / s}$
- can be reflected
- can be refracted
- can be diffracted
- can be absorbed
- transfer energy
- can travel through a vacuum

an answer travel at the same speed though a vacuum scores 2 marks

- can be polarised
- show interference.

travel in straight lines is insufficient

2

[7]

15

(a) any **two** from:

- travel (at same speed) through a vacuum / space
do not accept air for vacuum
- transverse
- transfer energy
- can be reflected
- can be refracted
- can be diffracted
- can be absorbed
- travel in straight lines

2

(b) can pass through the ionosphere

accept atmosphere for ionosphere

do not accept air for ionosphere

accept travel in straight lines

accept not refracted / reflected / absorbed by the ionosphere

1

(c) diffraction (of waves around hills)

1

wavelength needs to be similar size to the obstacle / gap

1

radio has a long enough wavelength **or** TV doesn't have a long enough wavelength

an answer TV (waves / signals) have short wavelengths so do not diffract (around the hill) scores 2 marks

1

(d) $v = f \times \lambda$

$1.2 \times 10^6 / 1200\ 000$

allow 1 mark for correct substitution

ie $3.0 \times 10^8 = f \times 2.5 \times 10^2$

2

hertz / Hz

*do not accept hz **or** HZ*

*accept kHz **or** MHz*

*answers 1.2 MHz **or** 1200 kHz gain all 3 marks*

for full credit the unit and numerical value must be consistent

1

[9]

16	(a) (i) radio(waves)	1
	(ii) energy <i>correct answer only</i>	1
	(b) (i) 0.0125 (m) <i>allow 1 mark for correct transformation <u>and</u> substitution</i>	2
	(ii) make it hot(ter) <i>do not accept cook it</i> <i>accept (air) particles inside ball will move faster</i> <i>accept water in the ball gets hotter</i>	1
	(iii) wavelength decreases <i>ignore reference to speed</i>	1
	frequency increases	1
		[7]

17	(a) 10^{-15} metres to 10^4 metres	1
	(b) (i) any one from:	
	• (TV / video / DVD) remote controls <i>mobile phones is insufficient</i>	
	• (short range) data transmission <i>accept specific example, eg linking computer peripherals</i>	
	• optical fibre (signals) <i>do not accept Bluetooth</i>	1
	(ii) 0.17 <i>an answer 17 cm gains 3 marks</i> <i>an answer given to more than 2 significant figures that rounds to 0.17 gains 2 marks</i> <i>allow 1 mark for correct substitution, ie $3 \times 10^8 = 1.8 \times 10^9 \times \lambda$</i>	3

(c) (maybe) other factors involved

*accept a named 'sensible' factor, eg higher stress / sedentary lifestyle / overweight / smoking more / diet / hot office / age
not testing enough people is insufficient
unreliable data is insufficient*

1

[6]

18

(a) radio – 1500

ultra violet 3×10^{-8}

visible – 5×10^{-7}

X-rays – 1×10^{-11}

4

(b) 1×10^{10} Hz 10^{10} HzOK

for 4 marks

else 1×10^{10}

for 3 marks

else $3 \times 10^8/0.03$

for 2 marks

else $v = \text{frequency} \times \text{wavelength}$ or $3 \times 10^8 = 0.03f$
any answer with unit Hz scores 1, 2 or 3

for 1 mark

4

[8]

19

(a) C or 0.18 mm

1

(b) 0.6 (m)

*allow 1 mark for correct substitution and/or transformation or 1
mark for changing frequency to Hz
answer 600 gains 1 mark*

2

(c) creates an alternating current

*accept 'ac' for alternating current
accept alternating voltage*

1

with the same frequency as the radio wave

accept signal for radio wave

accept it gets hotter for 1 mark provided no other marks scored

1

- (d) X-rays cannot penetrate the atmosphere
accept atmosphere stops X-rays
*do **not** accept atmosphere in the way*

or

X-rays are absorbed (by the atmosphere) before reaching Earth
ignore explanations

1

[6]

20

- (a) the oscillation / vibration (causing the wave)
a movement causes the wave is insufficient

1

for a transverse wave is perpendicular to the direction of energy transfer
accept direction of wave travel

1

and for a longitudinal wave is parallel to the direction of energy transfer
accept direction of wave travel
if no marks awarded allow 1 mark for correctly linking perpendicular with transverse and parallel with longitudinal
the marks may be scored by the drawing of two correctly labelled diagrams

1

- (b) for radio waves:
accept converse for each mark

are transverse

1

travel at speed of light / higher speed

1

have greater frequencies

1

can travel through vacuum

accept sound waves are not electromagnetic for 1 mark

1

[7]