Mr Baker's Science-Stuff

EM Waves

Name: _____

Class: _____

Date: _____

Time: **218 minutes**

Marks: **218 marks**

Comments:

Q1.

The diagram below shows the position of three types of wave in the electromagnetic spectrum.

Radio waves	**A**	**B**	**C**	Ultraviolet	X-rays	**D**

(a) Which position shows where visible light is in the spectrum?

Tick **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(b) Which **one** of the statements about electromagnetic waves is correct?

Tick **one** box.

Radio waves have a higher frequency than X-rays. ☐

Radio waves have a longer wavelength than ultraviolet. ☐

X-rays have a longer wavelength than radio waves. ☐

X-rays travel faster through the air than ultraviolet. ☐

(1)

(c) Give **one** possible danger of exposing your skin to ultraviolet radiation.

_____

_____

(1)

(d) Having an X-ray taken exposes a person to ionising radiation.

The table below gives the average radiation dose for an X-ray of the chest and an X-ray of the upper digestive system.

Part of the body	**Radiation dose in millisieverts (mSv)**
Upper digestive system	5.0
Chest	0.1

The risk of an X-ray causing cancer is about 1 in 20 000 for each mSv of radiation received.

Compare the risk of developing cancer from having an X-ray of the upper digestive system with the risk from having an X-ray of the chest.

Use the data in the table.

_____

_____

_____

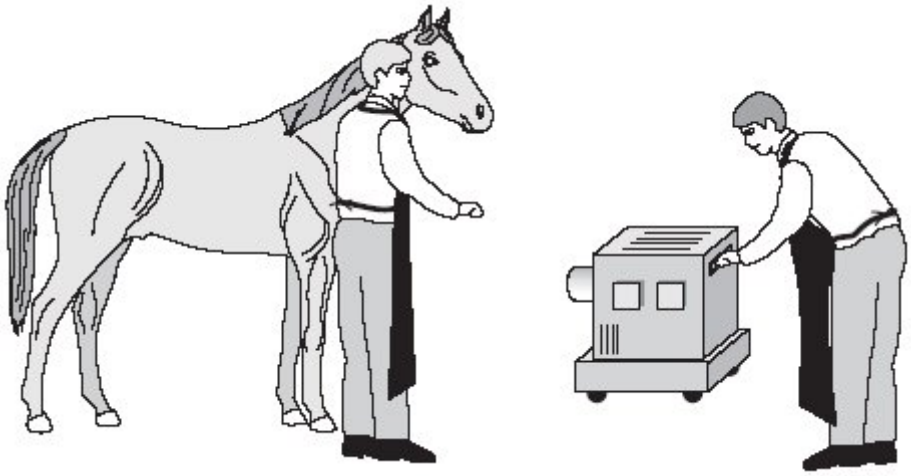
_____

(2)

(Total 5 marks)

Q2.

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.

_____

_____

_____

_____

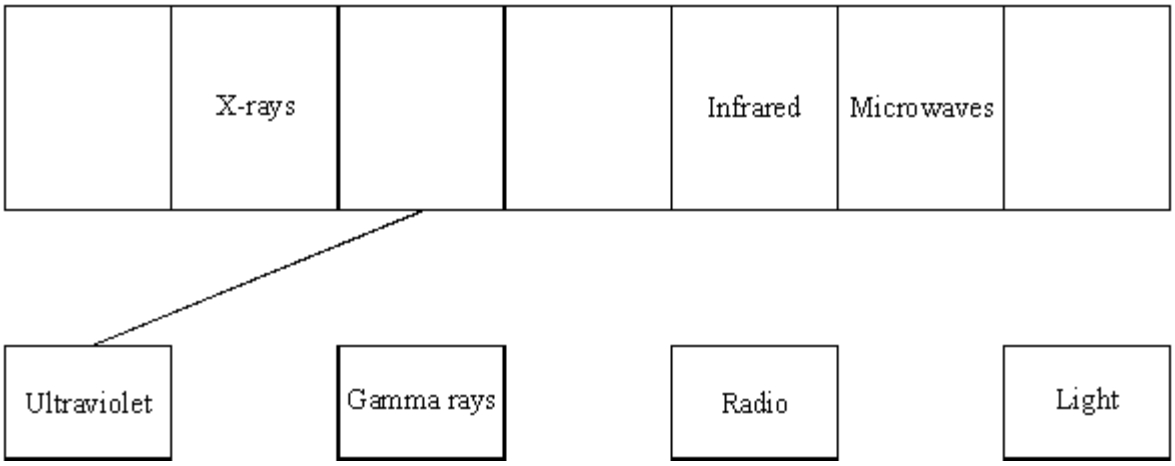
_____

_____

(Total 3 marks)

Q3.

(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.

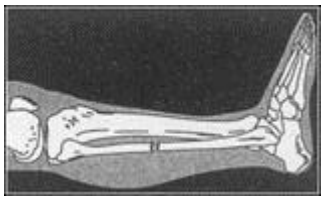
The speed of radio waves through a vacuum is

faster than
the same as
slower than

the speed of light through a vacuum.

(1)

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



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

_____

_____

_____

(2)

(Total 5 marks)

Q4.

(a) Mobile phones send *digital* signals using electromagnetic waves.

(i) Which **one** of the following types of electromagnetic wave is used to carry information between masts in a mobile phone network?

Draw a ring around your answer.

light	**microwave**	**radio**

(1)

(b) Some people worry that using a mobile phone may be bad for their health.

Look at this information taken from a recent newspaper article.

- Scientists in Sweden found that the regular use of a mobile phone increases the risk of a cancerous growth between the ear and the brain.
- Some people who use mobile phones for a long time complain of headaches and tiredness. The same effect has not been noticed in laboratory tests.
- There is no reliable evidence to link using mobile phones with ill health.
- The waves from a mobile phone are not strong enough to cause long-term heat damage to cells in the body.

(i) Complete the following sentence by drawing a ring around the word in the box that is correct.

The evidence from different scientists doing the same investigation is reliable if

all the scientists get

different
identical
random

results.

(1)

(ii) What information in the article supports the idea that mobile phones are bad for your health?

_____

_____

_____

_____

(2)

(iii) Some scientists say that using a mobile phone is totally safe.

What information in the article supports this view?

_____

_____

_____

_____

(2)

(Total 6 marks)

Q5.

(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.

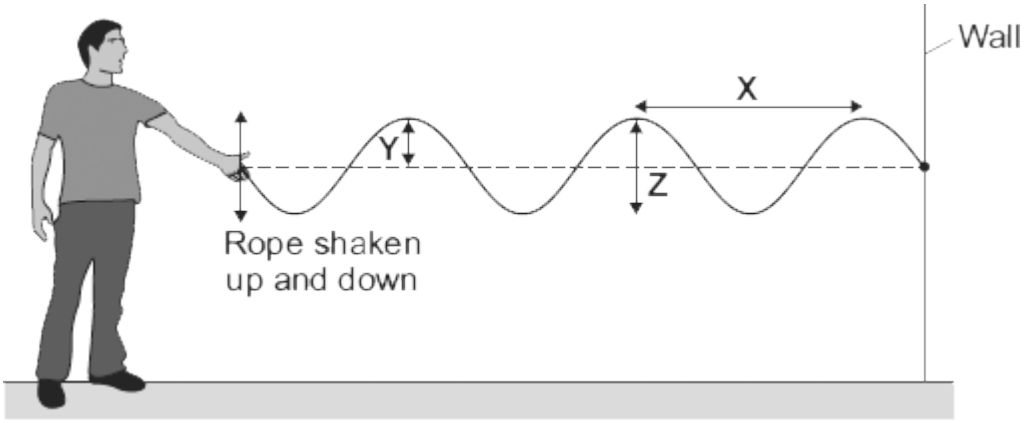
Microwaves travel through a vacuum at

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.

Show clearly how you work out your answer.

_____

_____

Wave speed = _____ m/s

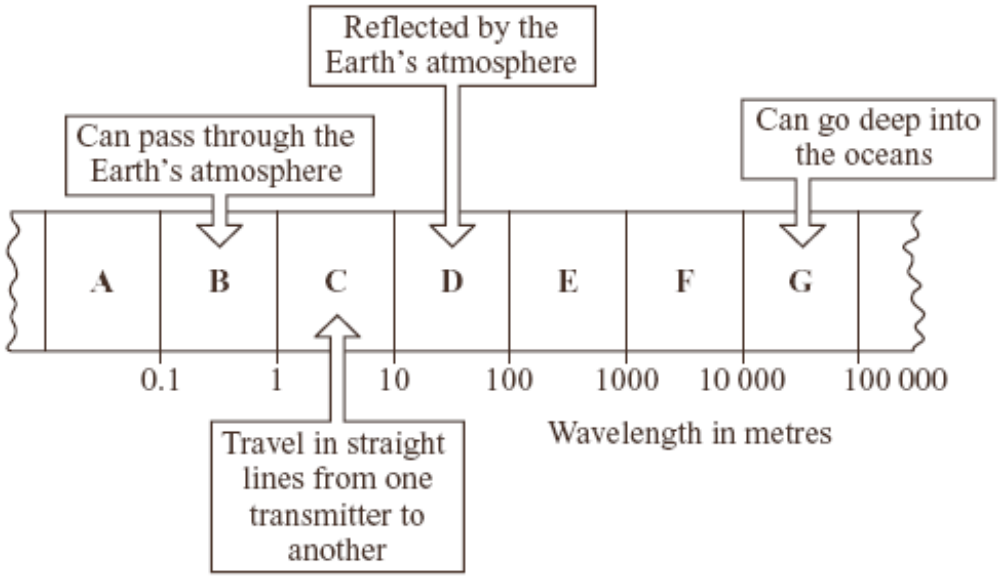
(2)

(Total 10 marks)

Q6.

The diagram shows a small part of the electromagnetic spectrum divided into seven sections.

The different properties of the waves in each section make them useful in different ways.



The waves in which section, **A**, **B**, **C**, **D**, **E**, **F** or **G**, are:

(a) used to send a signal to a satellite in space

_____

(1)

(b) used to communicate with a submarine under the water

_____

(1)

(c) used by a radio station to broadcast programmes around the world

_____

(1)

(d) the waves with the shortest wavelength?

_____

(1)

(Total 4 marks)

Q7.

(a) Which one of the following is not an electromagnetic wave?

Tick **one** box.

Gamma rays ☐

Sound ☐

Ultraviolet ☐

X-rays ☐

(1)

(b) What type of electromagnetic wave do our eyes detect?

_____

(1)

(c) What is a practical use for infrared waves?

Tick **one** box.

Cooking food ☐

Energy efficient lamps ☐

Medical imaging ☐

Satellite communications ☐

(1)

Scientists have detected radio waves emitted from a distant galaxy.

Some of the radio waves from the distant galaxy have a frequency of 1 200 000 000 hertz.

(d) Which is the same as 1 200 000 000 hertz?

Tick **one** box.

1.2 gigahertz ☐

1.2 kilohertz ☐

1.2 megahertz ☐

1.2 millihertz ☐

(1)

(e) Radio waves travel through space at 300 000 kilometres per second (km/s).

How is 300 000 km/s converted to metres per second (m/s)?

Tick **one** box.

300 000 ÷ 1000 = 300 m/s ☐

300 000 × 1000 = 300 000 000 m/s ☐

300 000 + 1000 = 301 000 m/s ☐

300 000 – 1000 = 299 000 m/s ☐

(1)

(f) Write the equation which links frequency, wavelength and wave speed.

_____

(1)

(g) Calculate the wavelength of the radio waves emitted from the distant galaxy.

Give your answer in metres.

_____

_____

_____

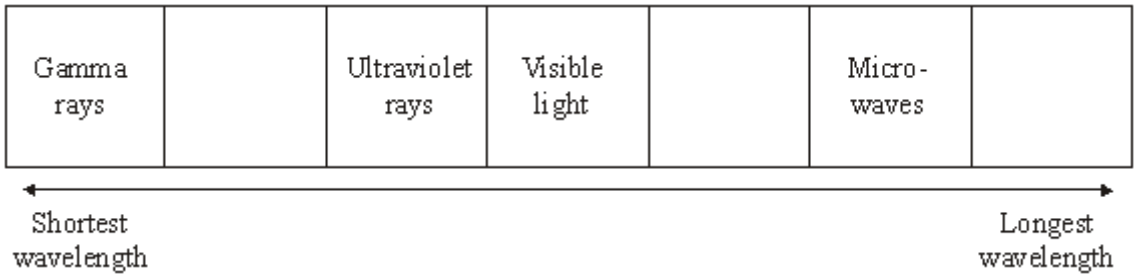
wavelength = _____ m

(3)

(Total 9 marks)

Q8.

The table shows the electromagnetic spectrum.
Three types of wave have been missed out.



(i) Use words from the box to complete the table.

infra red rays	**radio waves**	**X-rays**

(2)

(ii) Which **one** of the following gives a use of gamma rays?

Put a tick (✓) in the box next to your choice.

to communicate with satellites ☐

to see objects ☐

to kill cancer cells ☐

(1)

(iii) Complete the following sentence by drawing a ring around the correct word in the box.

All electromagnetic waves move

energy
gases
particles

from one place to another.

(1)

(Total 4 marks)

Q9.

The diagram shows the seven types of wave that make up the electromagnetic spectrum.

Gamma rays	X-rays	Ultraviolet rays	Visible light	Infra red rays	Micro-waves	Radio waves

(a) (i) Microwaves and visible light can be used for communications.

Name **one** more type of electromagnetic wave that can be used for communications.

_____

(1)

(ii) Name **one** type of electromagnetic wave that has a longer wavelength than microwaves.

_____

(1)

(b) Wi-Fi is a system that joins a laptop computer to the internet without using wires. A 2400 megahertz microwave signal is used to link a computer to a device called a router.

What quantity is measured in hertz?

Draw a ring around your answer.

frequency **wavelength** **wave speed**

(1)

(c) A politician commented on the increasing use of Wi-Fi. He said: 'I believe that these systems may be harmful to children.'

(i) Suggest **one** reason why more scientific research into the safety of Wi-Fi systems is needed.

_____

_____

(1)

(ii) Complete the following sentence by drawing a ring around the correct line in the box.

What the politician said was

a fact.
an opinion.
a prediction.

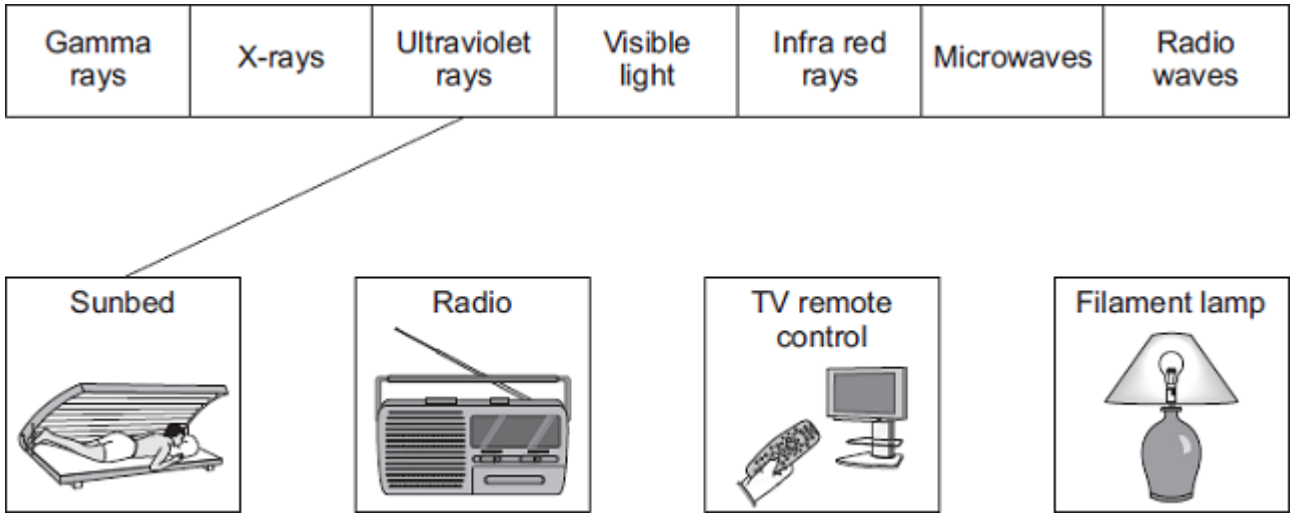
(1)

(Total 5 marks)

Q10.

(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.



(3)

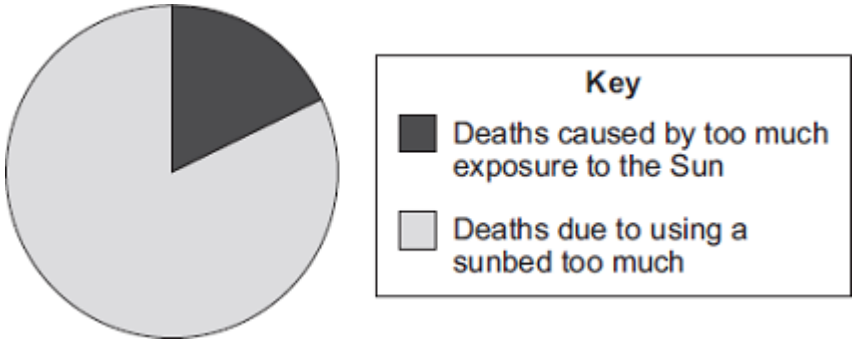
(b) A headline from a recent newspaper article is shown below.

(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?

_____

_____

(1)

(Total 6 marks)

Q11.

Figure 1 shows an X-ray of an arm with a broken bone.

Figure 1

© emmy-images/iStock

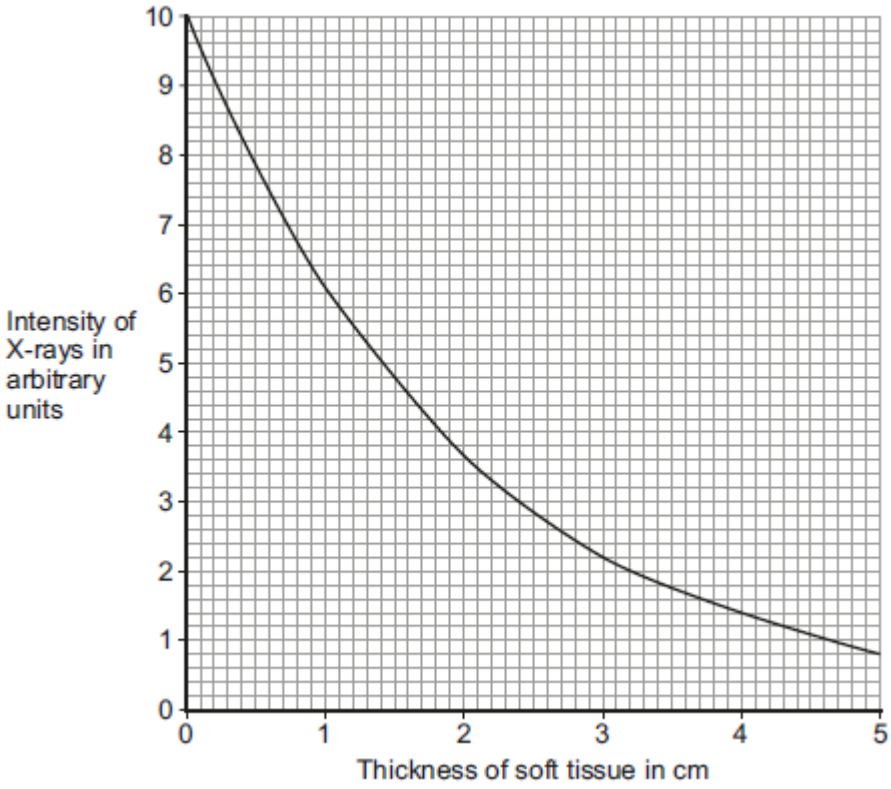
(a) Complete the following sentence.

X-rays are part of the _____ spectrum.

(1)

(b) **Figure 2** shows how the intensity of the X-rays changes as they pass through soft tissue and reach a detector.

Figure 2



(i) Use **Figure 2** to determine the intensity of X-rays reaching the detector for a 3 cm thickness of soft tissue.

Intensity of X-rays = _____ arbitrary units

(1)

(ii) Describe how the thickness of soft tissue affects the intensity of the X-rays.

_____

_____

_____

_____

(2)

(iii) The data in **Figure 2** are shown as a line graph and not as a bar chart.

Choose the reason why.

Tick (✓) **one** box.

Both variables are categoric ☐

Both variables are continuous ☐

One variable is continuous and one is categoric ☐

(1)

(c) What happens to X-rays when they enter a bone?

_____

_____

(1)

(d) How are images formed electronically in a modern X-ray machine?

Tick (✓) **one** box.

With a charge-coupled device (CCD) ☐

With an oscilloscope ☐

With photographic film ☐

(1)

(e) Radiographers who take X-ray photographs may be exposed to X-rays.

(i) X-rays can increase the risk of the radiographer getting cancer.

Why can X-rays increase the risk of getting cancer?

Tick (✓) **one** box.

X-rays travel at the speed of light	☐
X-rays can travel through a vacuum	☐
X-rays are ionising	☐

(1)

(ii) What should the radiographer do to reduce the risk from X-rays?

_____

_____

(1)

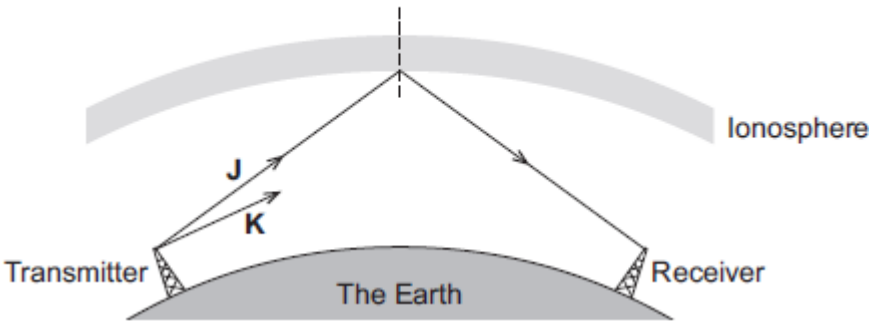
(Total 9 marks)

Q12.

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**.

Figure 1



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)

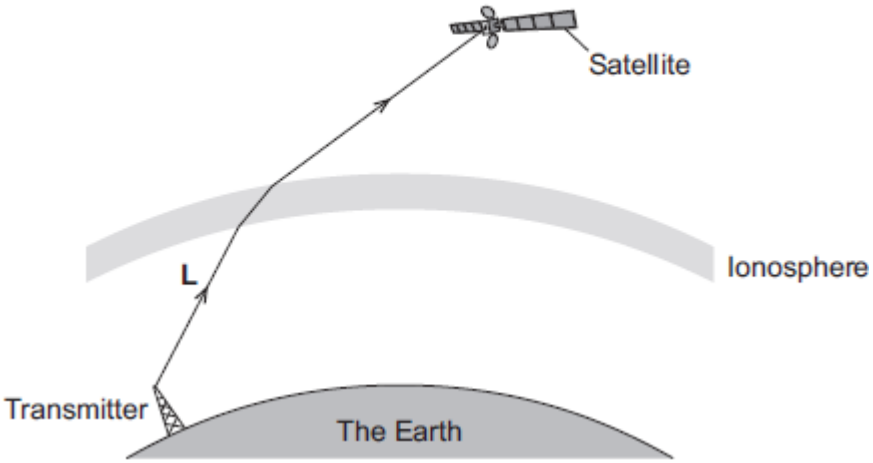
(ii) What is the name given to the dashed line in **Figure 1**?

_____

(1)

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

Figure 2



(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.	

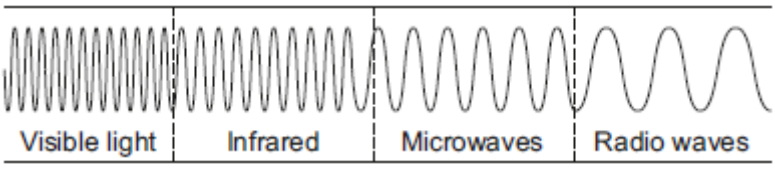
(2)

(Total 7 marks)

Q13.

Infrared and microwaves are two types of electromagnetic radiation.

The diagram below shows the positions of the two types of radiation within part of the electromagnetic spectrum.



(a) Name **one** type of electromagnetic radiation which has more energy than infrared.

_____

(1)

(b) Use the correct answer from the box to complete each sentence.

Each answer may be used once, more than once or not at all.

greater than	**less than**	**the same as**

The wavelength of infrared is _____ the wavelength of microwaves.

The frequency of microwaves is _____ the frequency of infrared.

The speed of microwaves in a vacuum is _____ the speed of infrared in a vacuum.

(3)

(Total 4 marks)

Q14.

The figure below shows an incomplete electromagnetic spectrum.

A	**microwaves**	**B**	**C**	**ultraviolet**	**D**	**gamma**

(a) What name is given to the group of waves at the position labelled **A** in the figure above?

Tick **one** box.

infrared ☐

radio ☐

visible light ☐

X-ray ☐

(1)

(b) Electromagnetic waves have many practical uses.

Draw **one** line from each type of electromagnetic wave to its use.

Electromagnetic wave	Use
Gamma rays	For fibre optic communications
Microwaves	For communicating with a satellite
Ultraviolet	To see security markings
	To sterilise surgical instruments

(3)

(c) Complete the sentence.

Use an answer from the box.

black body	**ionising**	**nuclear**

X-rays can be dangerous to people because X-rays are

_____ radiation.

(1)

(Total 5 marks)

Q15.

The figure below shows an X-ray image of a human skull.

Stockdevil/iStock/Thinkstock

(a) Use the correct answers from the box to complete the sentence.

absorbs	**ionises**	**reflects**	**transmits**

When X-rays enter the human body, soft tissue _____

X-rays and bone _____ X-rays.

(2)

(b) Complete the following sentence.

The X-rays affect photographic film in the same way that _____ does.

(1)

(c) The table below shows the total dose of X-rays received by the human body when different parts are X-rayed.

Part of body X-rayed	**Dose of X-rays received by human body in arbitrary units**
Head	3
Chest	4
Pelvis	60

Calculate the number of head X-rays that are equal in dose to one pelvis X-ray.

_____

_____

_____

Number of head X-rays = _____

(2)

(d) Which **one** of the following is another use of X-rays?

Tick (✓) **one** box.

Cleaning stained teeth ☐

Killing cancer cells ☐

Scanning of unborn babies ☐

(1)

(Total 6 marks)

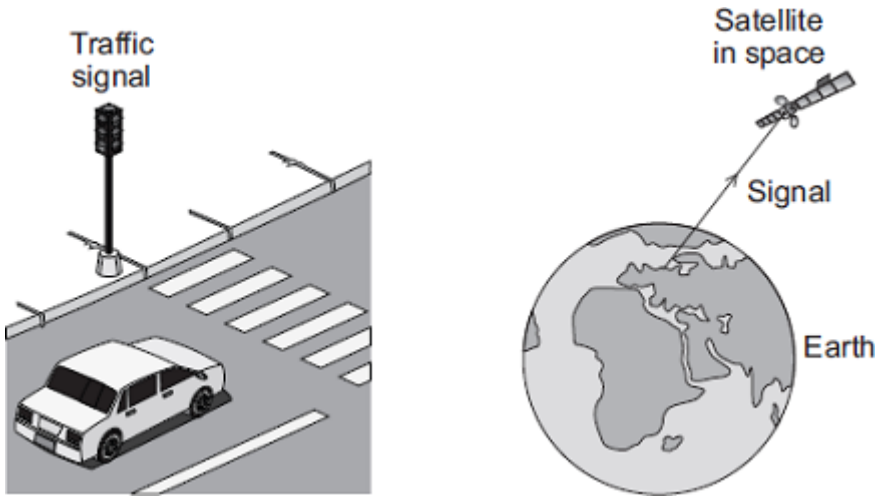
Q16.

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

(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?

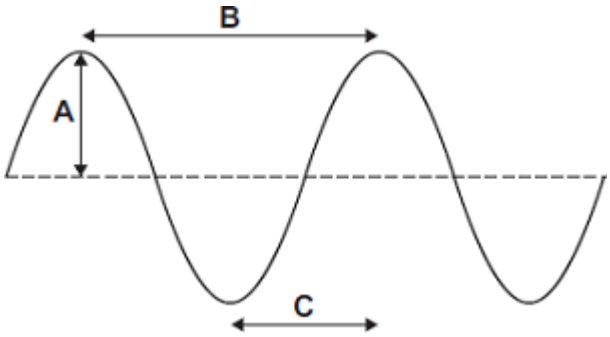
Draw a ring around the correct answer.

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.

_____

_____

_____

_____

(2)

(Total 8 marks)

Q17.

(a) Complete the following sentences.

Ultrasound waves have a minimum frequency

of _____ hertz.

The wavelength of an X-ray is about the same as

the diameter of _____ .

(2)

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

The images show one medical use of ultrasound and one medical use of X-rays.

©monkeybusinessimages/iStock/Thinkstock

© targovecom/iStock/Thinkstock

Compare the medical uses of ultrasound and X-rays.

Your answer should include the risks, if any, and precautions, if any, associated with the use of ultrasound and X-rays.

_____

_____

_____

_____

_____

_____

_____

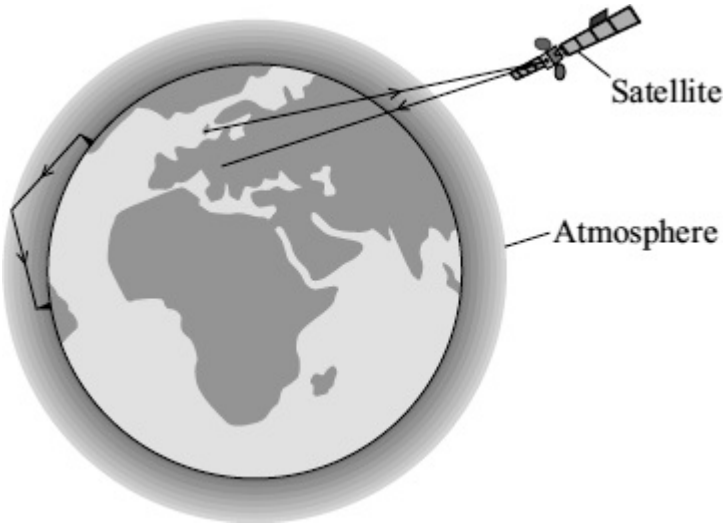
_____

(6)

(Total 8 marks)

Q18.

(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?

_____

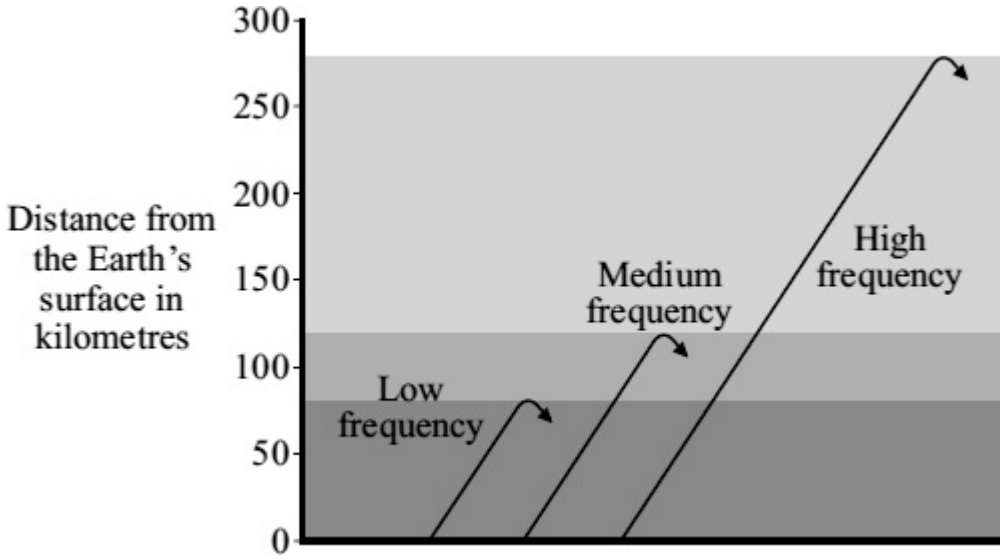
(1)

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

_____

(1)

(b) 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.

_____

_____

(1)

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

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

Calculate the frequency, in kilohertz (kHz), of these waves.

Show clearly how you work out your answer.

_____

_____

_____

_____

Frequency = _____ kHz

(2)

(Total 5 marks)

Q19.

After a person is injured a doctor will sometimes ask for a photograph to be taken of the patient's bone structure, e.g. in the case of a suspected broken arm.

(i) Which type of electromagnetic radiation would be used to take the photograph?

_____

(1)

(ii) Describe the properties of this radiation which enable it to be used to photograph bone structure.

_____

_____

_____

(2)

(Total 3 marks)

Q20.

(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?

_____

_____

(1)

(Total 6 marks)

Q21.

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?

_____

_____

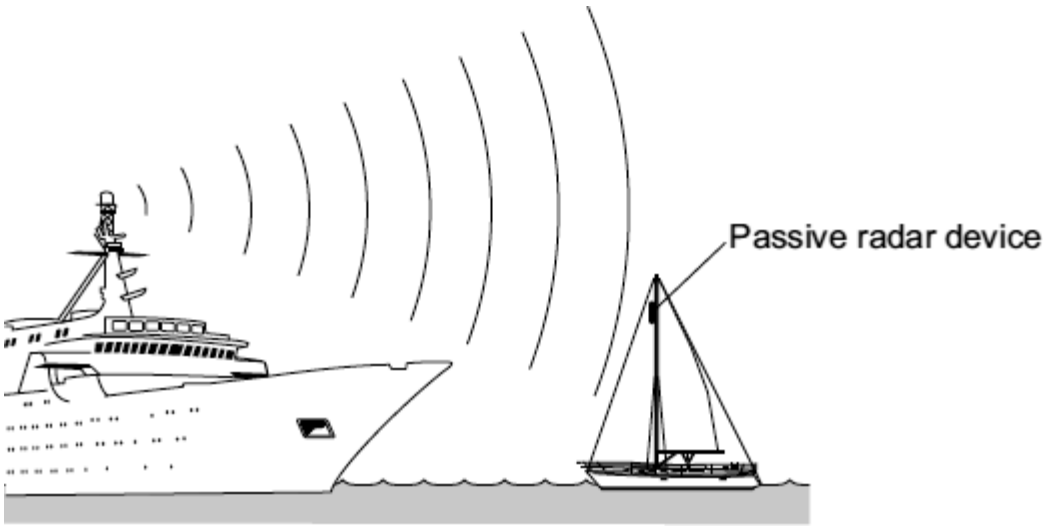
(1)

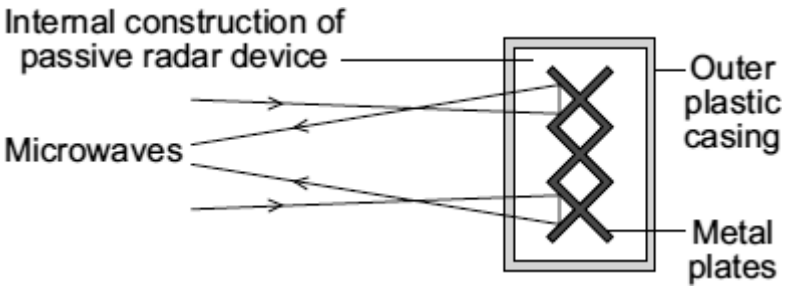
(b) How fast do microwaves travel through the air or a vacuum compared to radio waves?

_____

(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.





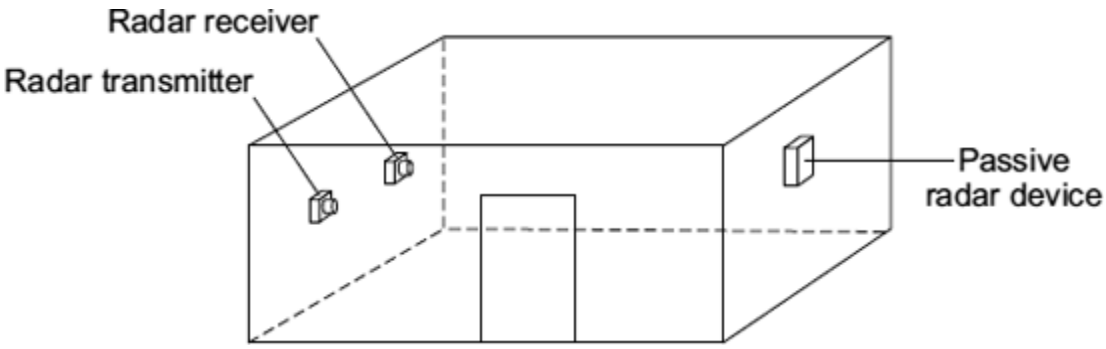
Microwaves can be absorbed, reflected or transmitted by different materials and types of surface.

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

(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?

(1)

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

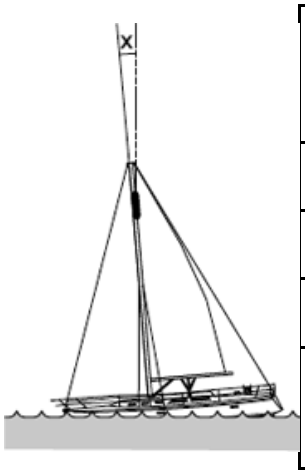
(1)

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

(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**.

_____

_____

_____

_____

(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?

_____

Give a reason for your answer.

_____

_____

(1)

(Total 10 marks)

Q22.

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)

Q23.

(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.

Calculate the wavelength of the waves broadcast by this station.

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)

Q24.

(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 ☐

10^{-4} metres to 10^{15} metres ☐

10^{-6} metres to 10^{6} metres ☐

(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.

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.

_____

_____

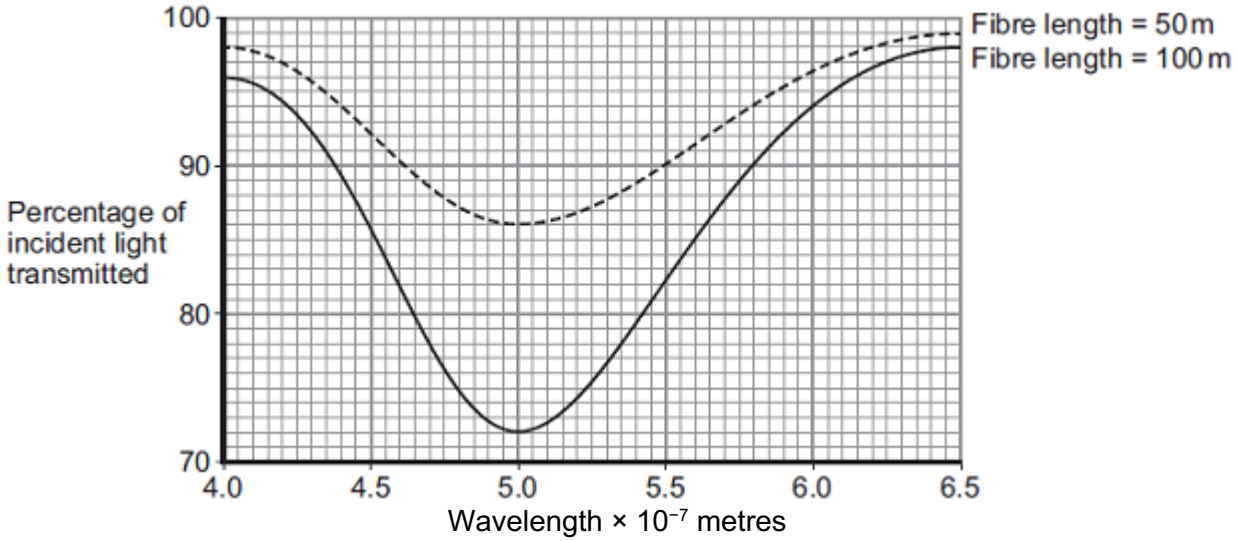
(1)

(Total 6 marks)

Q25.

Different wavelengths of light can be used to transmit information along optical fibres.

The graph below shows how the percentage of incident light transmitted through a fibre varies with the wavelength of light and the length of the fibre.



Compare the percentages of incident light transmitted through the two different fibres over the range of wavelengths shown.

(Total 3 marks)

Q26.

Different parts of the electromagnetic spectrum have different uses.

(a) The diagram shows the electromagnetic spectrum.

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

(i) Use the correct answers from the box to complete the sentence.

amplitude	**frequency**	**speed**	**wavelength**

The arrow in the diagram is in the direction of increasing _____

and decreasing _____ .

(2)

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

The range of wavelengths for waves in the electromagnetic spectrum is approximately

- 10^{-15} to 10^{4}
- 10^{-4} to 10^{4}
- 10^{4} to 10^{15}

metres.

(1)

(b) The wavelength of a radio wave is 1500 m.
The speed of radio waves is 3.0×10^{8} m / s.

Calculate the frequency of the radio wave.

Give the unit.

_____

_____

Frequency = _____

(3)

(c) (i) State **one** hazard of exposure to infrared radiation.

_____

(1)

(ii) State **one** hazard of exposure to ultraviolet radiation.

_____

(1)

(d) X-rays are used in hospitals for computed tomography (CT) scans.

(i) State **one** other medical use for X-rays.

_____

_____

(1)

(ii) State a property of X-rays that makes them suitable for your answer in part **(d)(i)**.

_____

_____

(1)

(iii) The scientific unit of measurement used to measure the dose received from radiations, such as X-rays or background radiation, is the millisievert (mSv).

The table shows the X-ray dose resulting from CT scans of various parts of the body.

The table also shows the time it would take to get the same dose from background radiation.

Part of the body	X-ray dose in mSv	Time it would take to get the same dose from background radiation
Abdomen	9.0	3 years
Sinuses	0.5	2 months
Spine	4.0	16 months

A student suggests that the X-ray dose and the time it would take to get the same dose from background radiation are directly proportional.

Use calculations to test this suggestion and state your conclusion.

_____

_____

_____

_____

_____

_____

_____

(3)

(Total 13 marks)

Q27.

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?

_____

_____

(1)

(c) 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.

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

_____

_____

_____

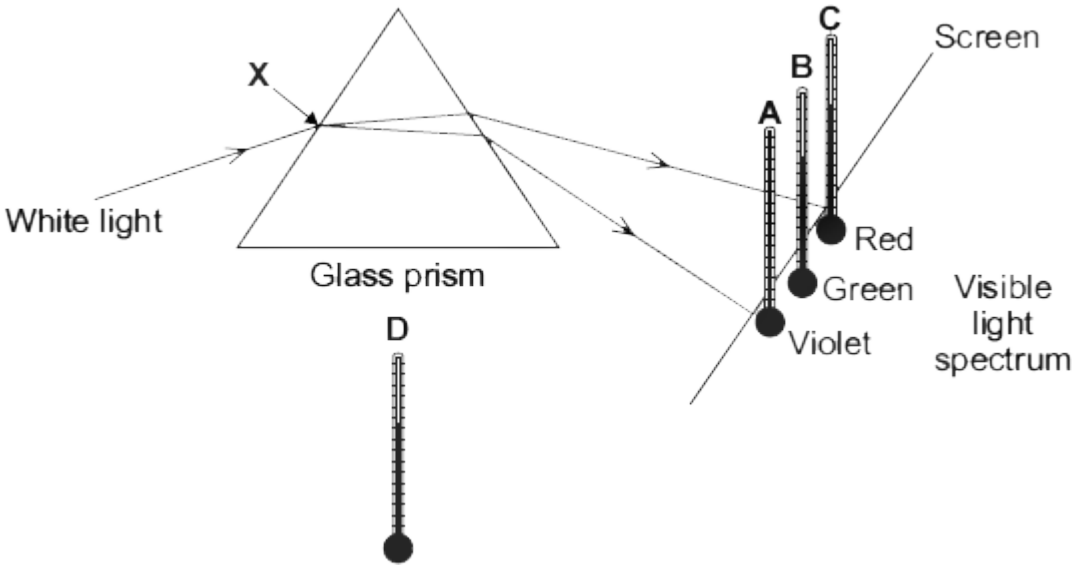
Frequency = _____

(3)

(Total 6 marks)

Q28.

The diagram shows the apparatus that a student used to investigate the heating effect of different wavelengths of light.



(a) (i) The student put thermometer **D** outside of the light spectrum.

Suggest why.

_____

_____

(1)

(ii) The table gives the position and reading of each thermometer 10 minutes after the investigation started.

Thermometer	Position of thermometer	Temperature in °C
A	in violet light	21
B	in green light	22
C	in red light	24
D	outside the spectrum	20

What should the student conclude from the data in the table?

_____

_____

_____

_____

(2)

(b) A similar investigation completed in 1800 by the scientist Sir William Herschel led to the discovery of infrared radiation.

Suggest how the student could show that the spectrum produced by the glass prism has an infrared region.

_____

_____

_____

_____

(2)

(c) A person emits infrared radiation at a frequency of 3.2×10^{13} Hz.

Calculate the wavelength of the infrared radiation that a person emits.

Take the speed of infrared radiation to be 3.0×10^{8} m/s.

Show clearly how you work out your answer.

_____

_____

_____

_____

Wavelength = _____ m

(2)

(d) A thermal imaging camera detects infrared radiation. Electronic circuits inside the camera produce a visible image of the object emitting the infrared radiation.

At night, police officers use thermal imaging cameras to track criminals running away from crime scenes.

Thermal imaging cameras work better at night than during the day.

Explain why.

_____

_____

_____

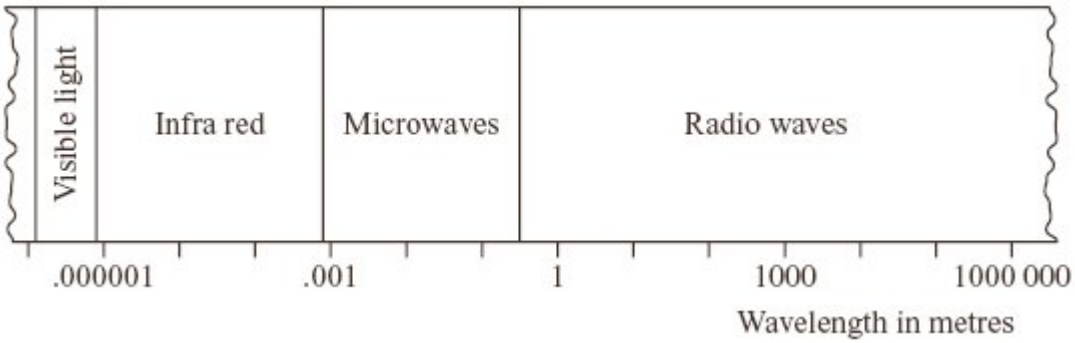
_____

(2)

(Total 9 marks)

Q29.

The diagram represents part of the electromagnetic spectrum.



(i) Visible light travels through air at 300 000 000 m/s.

Why can we assume that radio waves travel through air at the same speed as light?

_____

(1)

(ii) A radio station broadcasts at a frequency of 200 kHz.

Calculate the wavelength of the waves broadcast by this radio station. Show clearly how you work out your answer.

_____

_____

Wavelength = _____ m

(2)

(iii) Draw a vertical line on the diagram above to show the position of this radio wave in the electromagnetic spectrum.

(1)

(Total 4 marks)

Q30.

Microwaves are used to transmit signals to the satellite. The microwaves have a wavelength of 0.6 metres (m) and travel through space at a speed of 300 000 000 metres per second (m/s).

(i) Write down the equation which links frequency, wavelength and wave speed.

_____

(1)

(ii) Calculate the frequency of the microwaves. Show clearly how you work out your answer and give the unit.

_____

_____

_____

Frequency = _____

(3)

(Total 4 marks)

Q31.

(a) The new Tetra communications system to be used by the police transmits signals using microwaves of wavelength 75 cm.

Calculate the frequency of the microwaves used by the Tetra system. Show clearly how you work out your answer.

_____

_____

Frequency = _____ hertz

(2)

(b) Read the following extract from a newspaper and then answer the questions that follow.

> Residents of Stag Hill Court, a luxury block of flats, are shocked at the plans to site a mobile phone mast on the roof of the flats. They oppose the mast on health grounds, quoting research in Germany that has found a possible increase in cases of cancer around mobile phone masts.
>
> A spokesperson for the telecoms company said, 'The residents should not worry. The research carried out by our own scientists has found no link between ill health and mobile phone masts'.
>
> This has not reassured the residents, who argue that new independent research is urgently needed.

(i) Explain why living near a mobile phone mast could cause ill health.

_____

_____

_____

_____

_____

(3)

(ii) Suggest **two** reasons why the residents have **not** been reassured by the research carried out by the telecoms company.

1. _____

_____

2. _____

_____

(2)

(Total 7 marks)

Q32.

All radio waves travel at 300 000 000 m/s in air.

(i) Give the equation that links the frequency, speed and wavelength of a wave.

_____

(1)

(ii) Calculate the wavelength, in metres, of a radio wave which is broadcast at a frequency of 909 kHz. Show clearly how you work out your answer.

_____

_____

_____

Wavelength = _____ metres

(2)

(Total 3 marks)

Q33.

(a) Microwaves and visible light are two types of electromagnetic wave. Both can be used for communications.

(i) Give **two** properties that are common to both visible light and microwaves.

1. _____

_____

2. _____

_____

(2)

(ii) Name **two** more types of electromagnetic wave that can be used for communications.

_____ and _____

(1)

(b) Wi-Fi is a system that joins computers to the internet without using wires. Microwaves, with a wavelength of 12.5 cm, are used to link a computer to a device called a router. Microwaves travel through the air at 300 000 000 m/s.

Calculate the frequency of the microwaves used to link the computer to the router.

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

_____

_____

_____

Frequency = _____

(3)

(c) Wi-Fi is used widely in schools. However, not everyone thinks that this is a good idea.

A politician commented on the increasing use of WiFi. He said: 'I believe that these systems may be harmful to children.'

However, one group of scientists said that there is no reason why Wi-Fi should not be used in schools. These scientists also suggested that there is a need for further research.

(i) Suggest what the politician could have done to persuade people that what he said was not just an opinion.

_____

_____

(1)

(ii) Why did the group of scientists suggest that there is a need for further research?

_____

_____

(1)

(Total 8 marks)

Q34.

(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.

Calculate the wavelength of the waves broadcast by this station.

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?

_____

_____

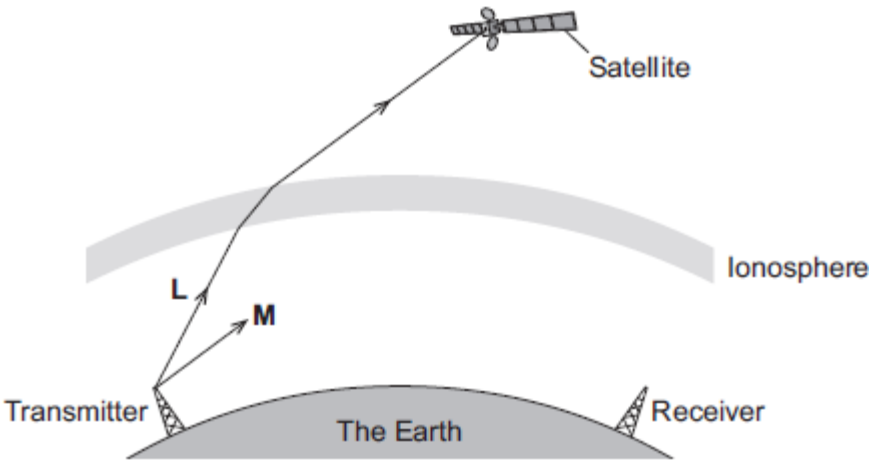
(1)

(Total 6 marks)

Q35.

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)

Q1.

(a) C

1

(b) radio waves have a longer wavelength than ultraviolet

1

(c) (risk of) skin cancer

cancer is insufficient

or

(prematurely) ageing skin

skin damage is insufficient
ignore kills skin cells

1

(d) risk is higher (for X-ray of uds than X-ray of chest)

1

by a factor of 50

or

risk calculated for each type of X-ray
chest X-ray = 1:200 000 (1)
uds = 1:4000 (1)

1

[5]

Q2.

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

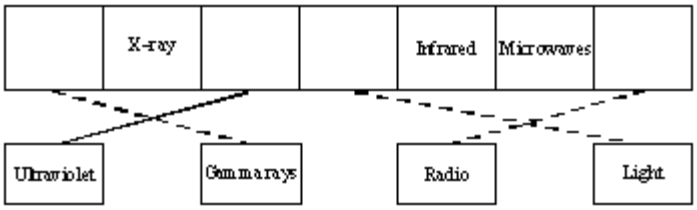
accept X-rays (may) cause cancer
accept organs for cell
*do **not** accept references to electric shock*
*do **not** accept stops bones of people showing on X-ray*
answers involving the horse wearing an apron are incorrect
references to gamma rays are incorrect

1

[3]

Q3.

(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

(c) 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]

Q4.

(a) (i) microwave

1

(b) (i) identical

1

(ii) • increased risk of cancerous growth (between ear and brain)

1

• complaints of headaches and tiredness

1

(iii) any **two** from:

- tests in a laboratory did not give effects of tiredness or headaches
- waves not strong enough to cause long term heat damage to cells
- evidence to link mobile phones and ill health is not reliable

2

[6]

Q5.

(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) × 1.2 correctly calculated

$v = f \times \lambda$

*allow **1** mark for correct substitution*

ie 3 or their (d)(i) × 1.2 provided that no subsequent step is shown

2

[10]

Q6.

(a) B

1

(b) G

1

(c) D

1

(d) A

1

[4]

Q7.

(a) sound

1

(b) (visible) light

1

(c) cooking food

1

(d) 1.2 gigahertz

1

(e) 300 000 × 1000 = 300 000 000 m/s

1

(f) wave speed = frequency × wavelength

allow v = f λ

1

(g) 300 000 000 = 1200 000 000 × λ

*an answer of 0.25 scores **3** marks*

1

$$\lambda = \frac{300\,000\,000}{1\,200\,000\,000}$$

*allow ecf from **(e)***

1

λ = 0.25 (m)

1

[10]

Q8.

(i) X-rays

infra red (rays)

radio (waves)

all three in correct order

*allow **1** mark for **1** correct*

2

(ii) to kill cancer cells

1

(iii) energy

1

[4]

Q9.

(a) (i) infra red (rays)

accept IR

or

radio (waves)

*do **not** accept heat waves*
*do **not** accept TV waves*

1

(ii) radio (waves)

this answer only

1

(b) frequency

1

(c) (i) *answer should be in terms of establishing if harmful or not harmful ie trying to clear up any uncertainty*

*do **not** accept answers that assume it is harmful*
eg Wi-Fi systems will make you ill

need to know if it is harmful / makes you ill

accept idea that safety issue may worry people
accept idea that (more) research may reassure people
accept idea of finding out (the truth)

1

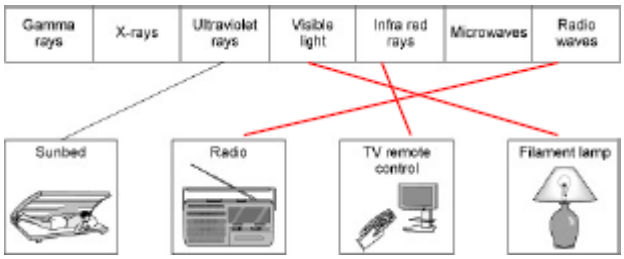
(ii) an opinion

1

[5]

Q10.

(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]

Q11.

(a) electromagnetic

accept e.m.

1

(b) (i) 2.2 (arbitrary units)

allow an answer between 2.1 and 2.3

1

(ii) the thicker the tissue the lower the intensity

accept more intensity is needed to pass through thicker tissue

1

the relationship is not linear

accept the line is not straight

*allow for **1** mark*

it still goes through with thicker tissue

or

intensity does not reach zero

or

at 5 cm X rays still pass through

1

(iii) Both variables are continuous

1

(c) (they are) absorbed

accept (they are) stopped

1

(d) With a charge-coupled device (CCD).

1

(e) (i) X-rays are ionising

1

(ii) stand behind a (protective) screen

accept leave the room

accept wear a lead apron

1

[9]

Q12.

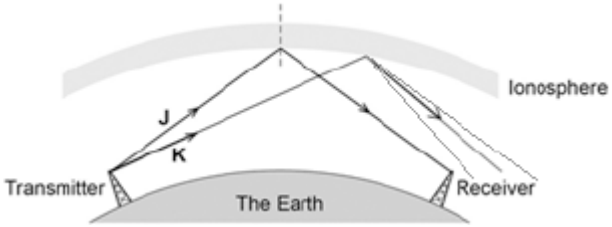
(a) (i) reflection of wave **K** at or within the ionosphere

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]

Q13.

(a) any **one** from:

- (visible) light
- UV / ultra violet
- X-ray
- gamma / γ-ray

1

(b) less than

1

less than

1

the same as

1

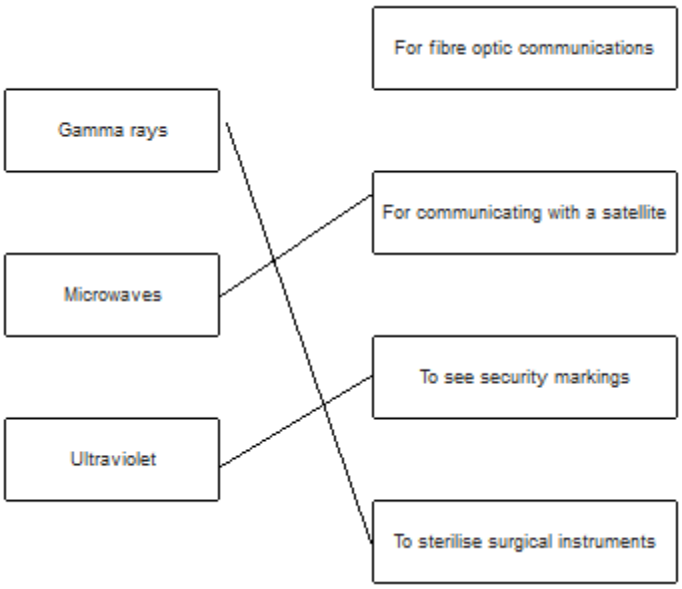
[4]

Q14.

(a) radio

1

(b)



*award **1** mark for each correct line*

if more than one line is drawn from any em wave then none of those lines gain credit

3

(c) ionising

1

[5]

Q15.

(a) transmits

correct order

1

absorbs

1

(b) light

*allow ultra violet **or** UV **or** infrared **or** IR **or** gamma*

1

(c) 20

*allow **1** mark for correct working, ie* $\frac{60}{3}$ *provided no subsequent step*

2

(d) Killing cancer cells

1

[6]

Q16.

(a) (i) (visible) light

accept visible

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:

- (X has a) low(er) SAR value

  "it" refers to mobile phone

  accept has a low(er) rate

- (maximum) energy absorbed (by the head) is less

  accept energy emitted (by phone) is less
  accept radiation for energy

- (if mobiles are harmful) less likely to cause harm

  accept will not cause harm
  accept it is safer

2

[8]

Q17.

(a) 20,000

accept 20 kilo

or

20 k

or *20 001*

1

an atom

1

(b) 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 in the Marking Guidance and apply a 'best-fit' approach to the marking.

0 marks
no relevant content

Level 1 (1−2 marks)
At least one relevant statement is given for either type of wave

Level 2 (3−4 marks)
either
a use, risk and precaution is given for one type of wave
or
A medical use is given for both types of wave
plus
a risk or precaution for one type of wave

Level 3 (5−6 marks)
At least one medical use is given for both types of wave linked to the risks and any precautions necessary

Examples of the points made in the response

Medical use of X-rays
Any one from:
- Detecting bone fractures
- Detecting dental problems
- Killing cancer cells
- CT scanning.

Ignore details about how X-rays / ultrasound work

accept any specific use of X-rays, eg

- *detecting heart / lung disorders (with chest X-rays)*
- *mammograms / breast cancer detection*
- *detecting stones / bowel disease (with abdominal X-rays)*

Risks with X-rays
X-rays pose a risk / danger / hazard

accept are harmful

X-rays cause ionisation / damage to cells
or
mutate cells / cause mutations / increase chances of mutations
or
turn cells cancerous / produce abnormal growths / produce rapidly growing cells
or
kill cells

accept a description of what ionising is

instead of cell, any of these words can be used: DNA / genes / chromosomes / nucleus

accept (may) cause cancer

Operator precautions with X-rays
The X-ray operator should go behind a (metal / glass) screen / leave the room when making an X-ray / wear a lead lined apron

accept appropriate precautions for the patient e.g. limit the

total exposure / dose (in one year)

wear a radiation badge is insufficient

Medical use of ultrasound

Any one from:

- Pre-natal scanning
- Imaging (a named body part).
- removal / destruction of kidney / gall stones
- removing plaque from teeth

  cleaning teeth is insufficient
- 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*

Risks with ultrasound

Ultrasound poses no risk / danger / hazard (to the user / patient)

accept ultrasound is safer than using X-rays

Ultrasound is not ionising

or

Ultrasound does not damage (human) cells

Precautions with ultrasound

The operator needs to take no precautions when making an ultrasound scan

this can be assumed if it is stated that ultrasound is harmless or it is safer than using x-rays or it is non-ionising

6

[8]

Q18.

(a) (i) microwaves

1

(ii) can pass through the ionosphere

accept travels in a straight line

accept atmosphere for ionosphere

*do **not** accept air for ionosphere*

1

(b) higher the frequency, further the wave travels (into the atmosphere before reflection)

1

(c) 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

[5]

Q19.

(i) X-rays or gamma rays

for 1 mark

1

(ii) passes through flesh;
stopped by bone/absorbed

for 1 mark each

2

[3]

Q20.

(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]

Q21.

(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]

Q22.

(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]

Q23.

(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]

Q24.

(a) 10^{-15} metres to 10^{4} metres

1

(b) (i) any **one** from:

- (TV / video / DVD) remote controls
  mobile phones is insufficient
- (short range) data transmission
  accept specific example, eg linking computer peripherals
- optical fibre (signals)
  *do **not** accept Bluetooth*

1

(ii) 0.17

*an answer 17 cm gains **3** marks*
an answer given to more than 2 significant figures that rounds to
*0.17 gains **2** marks*
*allow **1** mark for correct substitution, ie $3 \times 10^{8} = 1.8 \times 10^{9} \times \lambda$*

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]

Q25.

(for both fibres) increasing the wavelength of light decreases and then increases the percentage / amount of light transmitted

*accept for **1** mark:*
(for both fibres) increasing the wavelength (of light) to 5 (x 10^{-7} metres), decreases the (percentage) transmission

1

(for both fibres) the minimum transmission happens at 5 (x 10^{-7} metres)
or
maximum transmission occurs at 6.5 (x 10^{-7} metres)

*accept for a further **1** mark:*
(for both fibres) increasing the wavelength of the light from 5 (x 10^{-7} metres) increases the amount of light transmitted

increasing wavelength (of light), decreases the percentage transmitted is insufficient on its own

1

the shorter fibre transmits a greater percentage of light (at the same wavelength)

*accept for **1** mark:*
Any statement that correctly processes data to compare the fibres

1

[3]

Q26.

(a) (i) frequency

1

wavelength

1

(ii) 10^{-15} to 10^{4}

1

(b) 2.0×10^{5}

*correct substitution of 3.0×10^{8} / 1500 gains **1** mark*

2

Hz

1

(c) (i) (skin) burns

1

(ii) skin cancer / blindness

1

(d) (i) any **one** from:

- (detecting) bone fractures
- (detecting) dental problems
- treating cancer

1

(ii) any **one** from:

- affect photographic film
- absorbed by bone
- transmitted by soft tissue
- kill (cancer) cells

*answer must link to answer given in **(d)(i)***

1

(iii) 9 / 36 = 0.25
0.5 / 2 = 0.25
4 / 16 = 0.25

accept:

36 / 9 = 4

2 / 0.5 = 4

16 / 4 = 4

2

conclusion based on calculation

*two calculations correct with a valid conclusion scores **2** marks*

*one correct calculation of k scores **1** mark*

1

[13]

Q27.

(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) $v = f \lambda$

1.2×10^6 / 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

[6]

Q28.

(a) (i) to check rise in temperature (of other thermometers) was due to the (different wavelengths of) light

accept as a control / comparison

to measure room temperature is insufficient

1

(ii) any **two** from three:

- different colours produce different heating effects / (rises in) temperatures
- red light produces the greatest heating effect / (rise in) temperature

or

- violet produces the least heating effect / (rise in) temperature
- all colours produce a greater heating effect than outside the spectrum

an answer

the longer the <u>wavelength</u> the greater the (rise in) temperature

or

the lower the <u>frequency</u> the greater the (rise in) temperature

gains both marks

2

(b) move a thermometer into the infrared region / just beyond the red light

allow use an infrared camera / infrared sensor

1

the temperature increases beyond 24(°C)

accept temperature higher than for the red light

1

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

9.4×10^{-6}

accept 9.375×10^{-6} *or* 9.38×10^{-6}

or

0.0000094

accept 0.000009375

***or** 0.00000938*

*allow **1** mark for correct substitution*

ie $3 \times 10^{8} = 3.2 \times 10^{13 \times \lambda}$

2

(d) at night the surroundings are cooler

accept at night the air is colder

there is no heat from the Sun is insufficient

or

at night there is a greater temperature difference between people and surroundings

1

(so surroundings) emit less infrared (than in daytime)

accept camera detects a greater contrast

or

gives larger difference in infrared emitted (between people and surroundings)

1

[9]

Q29.

(i) all electromagnetic waves travel at the same speed through a vacuum, (so assume same speed in air)

accept 'all parts of spectrum' for electromagnetic waves

1

(ii) 1500 (m)

allow 1 mark for correct transformation and substitution

allow 1 mark for using 200 000 Hz

*answers 1 500 000 = **1** mark*

2

(iii) line drawn at correct position

anywhere between 1000 and next section (10 000)

accept their value for (a)(ii) drawn in

the correct position

1

[4]

Q30.

(i) wave speed = frequency × wavelength

accept correct transformation
accept $v = f \times \lambda$
accept s for speed
accept m/s = Hz x m

accept  *if subsequent use of*  *is correct*

1

(ii) 500 000 000

*credit for **1** mark correct transformation in words **or** numbers **or** correct substitution*

2

Hertz

***3** marks for 500 000k Hz **or** 500 MHz*
numerical answer **and** *unit must be consistent for full credit*

1

[4]

Q31.

(a) 400 000 000
or
correct equivalent

*allow **1** mark for correct transformation **and** substitution (of 75)*
*answer 4 000 000 gains **1** mark only*

2

(b) (i)

*any mention of alpha, beta, gamma waves scores **0** marks*

emit / uses / transmit / receive microwaves

accept radiation for microwaves throughout
ignore radio waves

1

some microwave / energy absorbed by / enters the body

ecf for their given electromagnetic wave
*do **not** accept goes through the body*

1

raises temperature of (body) cells / tissue / water

accept reference to water molecules vibrating faster
accept it could cause mutation / harm / kill cells
*do **not** accept answers in terms of ionisation*
ignore references to cancer

1

(ii) any **two** from:

- research (may be) biased
  or may have been misled in the past
  accept not independent
  ***or** may be lying*
- some research suggests a link
- long-term effect not proven / studied
  accept not studied for long enough
- residents may not have seen the research

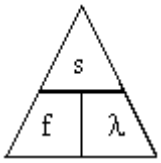
2

[7]

Q32.

(i) speed = frequency × wavelength

accept the equation rearranged
*accept v **or** s = f × λ*
do not allow w for wavelength
do not accept



unless subsequent calculation correct

1

(ii) 330 (m)

allow 1 mark for

$$\lambda = \frac{300\,000\,000}{909\,000}$$

***or** 300 000 000 = 909 000 × λ*
***or** answer of 330000(m) **or** 330033(m)*

2

[3]

Q33.

(a) (i) any **two** from:

- travel at the same speed (through a vacuum)
  accept travel at the speed of light
  accept air for vacuum
- can travel through a vacuum / space

*do **not** accept air for vacuum*

- transfer energy
- can be reflected
- can be refracted
- can be diffracted
- can be absorbed
- can be transmitted
- transverse

accept any other property common to electromagnetic waves

accept travel at the same speed through a vacuum for both marks

*do **not** accept both radiated from the Sun*

2

(ii) infra red

***both** required for the mark*

radio(waves)

accept IR for infra red

1

(b) 2 400 000 000

*correct transformation and substitution gains **1** mark*

ie $\frac{300000000}{0.125}$ ***or*** $\frac{300000000}{0.125}$

*an answer of 24 000 000 gains **1** mark*

***either** 2 400 000 kHz*

***or** 2 400 MHz scores **3** marks but the symbol only scores the 3rd mark if it is correct in every detail*

2

hertz

accept Hz

*do **not** accept hz*

1

(c) (i) presented (scientific) evidence / data

do an experiment / investigation is insufficient

1

(ii) to find out if there is a hazard (or not)

accept to find out if it is safe

accept not enough evidence to make a decision

not enough evidence is insufficient

1

[8]

Q34.

(a) C or 0.18 mm

1

(b) 0.6 m

*allow **1** mark for correct transformation and substitution*
*allow **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

or it gets hotter

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]

Q35.

(a) (i) microwave

1

(ii) refraction

1

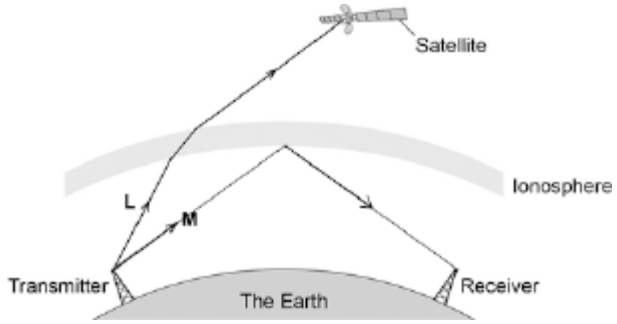
(b) (i) wave M continues as a straight line to the ionosphere and shown reflected

accept reflection at or within the ionosphere

1

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

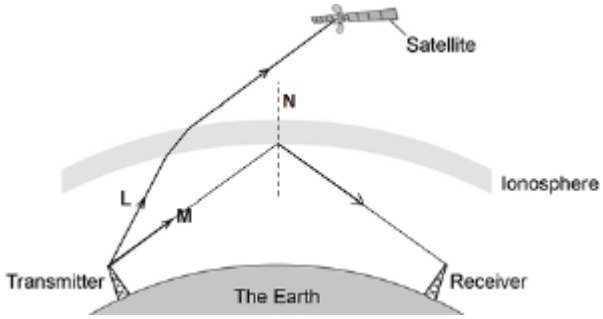
if more than 2 rays shown 1 mark maximum



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** 3×10^8 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]

Q1.

(a) Position ‘C’ was the most popular answer with 65% of the students scoring the mark.

(b) The direction in which the wavelength and the frequency change in the electromagnetic spectrum was less well known, with 45 % of the students choosing the correct answer.

(c) Of the students that scored this mark (44%) most responded with ‘skin cancer’, fewer referred to ‘premature aging of the skin’. The majority of the students gave responses that were too general and often not related to the skin. The most common was to state that the radiation causes cancer, rather than specifying skin cancer.

(d) 78% scored at least one mark for recognising that the risk of developing cancer increased with increased radiation dose. Fewer were able to quantify that it was fifty times more likely. Some of the students assumed that having an X-ray on a part of the body would mean that the cancer would be in the same part of the body.

Q2.

Providing of a copy of the Electromagnetic Spectrum enabled many candidates to correctly identify the types of waves utilised in various applications, but few candidates chose radio as the answer to part (a)(i). In part (b) few candidates realised the commonality of the speed of these waves.

Q3.

Although this question was generally answered well, in part (a) a significant number of candidates drew lines from the waves to boxes which already contained a named wave. In part (b) few candidates knew that radio waves and light have the same velocity through a vacuum. In part (d) a large number of candidates showed no understanding of X-rays exposing photographic film. Consequently they suggested other reasons for the bones showing white. These included variations on ‘bones are white’, ‘better for doctors to see’ and ‘bones reflect light’.

Q4.

In part (a)(i), the correct answer of microwaves was given by only about 50% of candidates.

In part (b)(i) most candidates were aware of the need for identical results to confirm the reliability of an investigation. Although parts (b)(ii) and (b)(iii) were both worth two marks the vast majority of candidates were satisfied, in each part, to supply only one piece of information from the newspaper article. For this reason most candidates scored only one mark for each part.

Q5.

(a) (i) Most students recognised that the waves missing from the diagram were X-rays.

(ii) Most students knew that gamma rays have the most energy.

(iii) About three-quarters of the students knew that a TV remote control uses infrared.

(b) Only about a quarter of the students realised that all electromagnetic waves travel at the same speed in a vacuum. The majority believed that microwaves would travel faster than radio waves.

(c) (i) Although the number of students drawing the arrow in the correct direction was just in the majority, a large proportion of students made no attempt at this question. Many had double headed arrows.

(ii) About half of the students correctly chose Y as the amplitude, while the majority of the other students chose Z.

(iii) Fewer than half of the students gave a correct answer. The majority of wrong answers were 'longitudinal' or 'sound'. A large number of students failed to attempt this question.

(d) (i) Very few students obtained the correct answer for the frequency of the wave, the most common answer being 3.6 instead of 3.

(ii) Most students obtained an acceptable answer for this calculation, albeit by multiplying their answer for part (d)(i) by 1.2. It is strange that most of the students who stated in part (d)(i) that the frequency was 3.6 put in a value of 3 in the calculation in this part.

Q6.

Many candidates made a good start with this question. The most common error being in part (c) where candidates were unable to understand that radio waves could be reflected by the Earth's atmosphere.

In part (d) it was disappointing to see that many candidates were unable to match the shortest wavelength with the waves next to the smallest number on the diagram.

Q8.

(i) Most candidates knew that radio waves have the longest wavelength, but many put X-rays and infra red rays the wrong way round.

(ii) Most candidates realised that a use of gamma rays is to kill cancer cells.

(iii) Only about 50% of the candidates knew that electromagnetic waves move energy from one place to another.

Q9.

(a) (i) Most candidates correctly chose radio waves or infra red.

(ii) Only just over half of the candidates correctly stated that radiowaves have a longer wavelength than microwaves.

(b) Just under half of the candidates knew that it is frequency that is measured in hertz.

(c) (i) Only the better candidates realised that the purpose of doing more scientific research is to obtain evidence and establish whether or not Wi-Fi is harmful. Many candidates started from the assumption that Wi-Fi is harmful, and that

the research was to find ways of reducing the harm. Some candidates misunderstood the question and talked about the dangers of allowing children to access the Internet.

(ii) Most candidates realised that the politician's statement was an opinion, although a significant number of candidates assumed that it was a fact.

Q10.

(a) Most students scored 2 or 3 marks in this question. The most common error was to suggest that TV remote controls employed microwaves.

(b) (i) Cancer was identified as the serious health problem by most students, but not all were able to give the correct response of 'skin cancer'.

(ii) There were many vague answers given here but the majority of correct responses stated that the symptoms of (over)-exposure to the Sun and (over)-use of sunbeds were very similar, thereby making the cause of death difficult to ascertain.

(iii) Many students simply repeated the stem of the question in their answer – 'so we know the possible dangers of using a sunbed'. Few answered in terms of assessing their own health risk when using these devices.

Q11.

(a) Nearly two thirds of students gained this mark. A common (incorrect) response was for students to call it the light spectrum rather than the electromagnetic spectrum.

(b) (i) The vast majority of students were able to read the correct value from the graph.

(ii) Over half of the students were able to describe the basic trend shown in the graph, but very few students could explain this to gain the second mark.

(iii) Just under two thirds of students identified the reason for using a line graph.

(c) Around a third of students gained this mark. There was a reasonably common misconception that X-rays are reflected by bone. A number of students linked the question to the properties of X-rays such as their ionising ability.

(d) Just under half the students gained this mark, most incorrect responses were 'with photographic film'.

(e) (i) The vast majority of students gained this mark.

(ii) Just over half of students gained this mark. Many students who did not score here wrote answers which were along the right lines, such as wear an apron, or wear a film badge.

Q12.

(a) (i) Just over a tenth of students did not attempt this question. Of those that did, few were able to secure both marks although more gained the mark for reflection at the ionosphere. Many extended rays from K which did not reach the ionosphere or went straight through it.

Common incorrect answers didn't reflect the incident ray at or in the ionosphere or reflected it at the normal of ray J. There were some freehand rays, most of which were a good attempt at drawing straight lines.

(ii) Very few students knew that the dotted line on the diagram was called the normal.

(b) (i) Just over half the students knew that signals were sent to the satellite using microwaves.

(ii) Almost two thirds of students knew that the process which occurs when the wave passes into the ionosphere is called refraction.

(c) Choosing the two correct answers, ie that electromagnetic waves are transverse and that all electromagnetic waves have the same speed in a vacuum, was the most popular combination. However, choosing that electromagnetic waves are longitudinal and that all electromagnetic waves have the same speed in a vacuum was also commonly seen. One fifth of students scored 2 marks, and slightly more than half scored 1 mark only. Some students did not read the rubric and ticked only one box or ticked more than two.

Q13.

(a) Over two thirds of students scored this mark. One of the most common correct responses was visible light; quite a few went to the very end of the EM spectrum and stated gamma rays, which was also creditworthy.

(b) Just under half of students scored 2 marks, few scored all 3 marks. Many students incorrectly thought that each response should only be used once, having not read the question carefully enough.

Q15.

(a) A very low proportion of students scored both marks, with a fifth of the students gaining 1 mark. Over two thirds of students scored zero.

(b) Just under a third of students gained the mark for identifying light.

(c) Most students gained 2 marks for completing this calculation successfully.

(d) Just under two thirds of students identified the correct answer of killing cancer cells.

Q16.

(a) (i) Most students realised that traffic lights communicate using visible light.

(ii) Most students thought that satellites used radio waves for communication rather than microwaves.

(b) About two thirds of the students correctly identified position **J** as being gamma rays.

(c) (i) Most students correctly identified **B** as showing the wavelength.

(ii) Most students knew that the wavelength of infrared waves is shorter than the wavelength of radio waves.

(d) (i) Most students realised that scientists were trying to find out if using a mobile

phone is harmful to health, although a significant proportion thought that it was to find out if mobile phones give out radiation.

(ii) Although many students were able to score both marks in this question, about half of them only scored one mark, either for explaining that mobile phone **X** would cause a smaller amount of energy to be absorbed by the head or that mobile phone **X** would be safer. Some students thought that the SAR value showed how much energy the phone itself absorbed.

Q17.

(a) Many of the students did not attempt to write down the minimum frequency of ultrasound, and a lot of the students were not aware that the wavelength of an X-ray is similar to the diameter of an atom, leading to some interesting responses. Only a small proportion of the students scored both marks with a further third of the students scoring one mark.

(b) This question was attempted by the vast majority of students, most of whom wrote a reasonably lengthy answer. Almost half of the students scored at least 4 marks. Some students chose to write down everything they knew about X rays or ultrasound, including lots of details about how they work which was not asked for in the question. There was a common misconception that X-ray photography uses gamma rays to produce images, and also that X-rays are radioactive. A lot of students limited themselves to level 2 by failing to write about the precautions necessary when using X-rays. Most students (perhaps prompted by the photographs in the question) were aware that ultrasound is used for fetal scanning, but a fair number of students stated that it was just used for scanning for babies, failing to mention that the babies in question were still in the womb. A lot of students stated that ultrasound was used to look for babies in the mother's stomach, which was allowed here but raises some questions about their knowledge of biology. A number of students got mixed up between CT scans and MRI scans.

Q18.

(a) (i) Answers were divided between microwaves and radio waves, with fewer than half of the candidates choosing the correct answer.

(ii) Not many answers were linked to the satellite communication idea; instead general properties of microwaves or radio waves were given.

(b) The majority of answers to this question were correct.

(c) Few candidates scored both marks. Many candidates were able to transform the equation correctly, and substitute values to give an answer of 15 000 000, however the majority of answers were left at this value and not converted into kHz.

Q19.

Generally well answered.

Q20.

Foundation Tier

(a) (i) Many candidates suggested carrying out a practical experiment such as putting a group of people in a room and forcing them to use a mobile phone constantly to see if they became ill. Answers along these lines were not

creditworthy.

It was expected that candidates would suggest a survey, in which health comparisons were made between a group of phone users and a group that did not use a phone. This was what most of the better candidates suggested. Some candidates however, chose the wrong groups to compare and they suggested comparing phone users who were ill with phone users who were not ill.

It was disturbing to see how many candidates believed that the main problem with mobile phones is that they are radioactive.

(ii) The best way to improve the reliability of a survey is to increase the sample size, and most of the better candidates stated this. Simply 'repeating' is not good enough.

(iii) Half of the candidates chose the correct answer of 'ethical'.

(b) (i) Many candidates were using the terms 'reliable', 'accurate', 'precise' and 'valid' (and sometimes all of these) without showing any understanding of their meaning, thus scoring no marks. As with ISAs, the term 'fair test' on its own, without any further explanation, does not qualify for a mark.

Only the better candidates realised that, unless the tests were the same, it is not possible to make any comparison between the phones.

(ii) The majority of candidates answered this question correctly, either by stating 'Yes, because all the values are below 2.0' or 'No, because even low levels of radiation may be harmful'.

(c) The majority of candidates realised that scientists employed by the company that made the devices could be accused of being biased.

Higher Tier

(a) (i) Only half the candidates answered this correctly. The most common correct answer was some reference to noise/interference with some candidates giving very detailed explanations of the removal of interference from the signal. Only a small number of candidates referred to the use of digital signals in computers and although a number had the idea of digital being better they often went on to talk about an improved picture or sound rather than discussing the quality of the signal.

(ii) The majority of candidates gained the mark for referring (sometimes in great detail) to the use of microwaves in cooking.

A small number gave the simple response 'in a microwave' and did not earn any credit. Only a few candidates mentioned the use in communications but most of these answers incorrectly referred to radio/television or even the TV remote control.

(b) (i) Only a minority of candidates gained the mark here. Most of the candidates knew that they needed to study the health of users/non-users but unfortunately the vast majority intended to do some sort of experiment which involved making volunteers use phones over a period of time and monitoring them. Candidates should be aware that medical experiments are not done on people to see if something is harmful. Those candidates who were going to research users health quite often neglected to mention that they would need to

compare with non-users. Some candidates who used the term test/experiment went on to explain that they would study health data demonstrating that the terminology in this question was a problem. The candidates' confusion and poor expression of ideas in a limited space was a concern.

(ii) Whilst many answers may have indicated the idea of increasing the sample size, the wording tended to be too brief or imprecise, for instance 'repeat the test' without specifying whether this was with other people or the same set of people.

(iii) Virtually all candidates identified the issue as being an ethical one.

(c) (i) Many candidates were using the terms 'reliable', 'accurate', 'precise' and 'valid' (and sometimes all of these) without showing any understanding of their meaning, thus scoring no marks. As with ISAs, the term 'fair test' on its own, without any further explanation, does not qualify for a mark. A significant minority of candidates realised that, unless the tests were the same, it is not possible to make any comparison between the phones.

(ii) A fairly straightforward question that was well answered. Most of those who did not score gave answers that had nothing to do with the information given or referred to microwaves being emitted rather than absorbed. Some candidates answered in terms of mobile phone masts and thus could not be given credit as they did not answer the question that was asked.

(d) Almost all candidates scored a mark here for demonstrating the need to avoid bias or the possibility of result manipulation. The candidates have perhaps too readily accepted the idea that people cannot be trusted to do a job properly or examine data impartially if given enough financial incentive to do otherwise.

Q21.

(a) This was a poorly answered question. Many candidates wrote about the uses of the two waves instead of the way in which the waves themselves were different or simply said that the wavelength / frequency was different without stating how.

(b) Again a poorly answered question, with many candidates believing that the waves would travel at different speeds. Just over one-fifth of candidates did not attempt this part question.

(c) Only a small percentage of candidates scored both marks for this question, as the majority of candidates failed to refer to what happened to the microwaves when they reached the plastic casing. Of those who did refer to this, many were confused between absorption and transmission.

Many candidates gained one mark for stating that the microwaves would be reflected, but some candidates lost this mark because they used the word 'bounce' or 'deflect' instead of 'reflect'.

(d) (i) Very few correct answers were seen to this question. Most candidates thought that the waves had to be absorbed in order to stop them escaping from the room and then possibly harming people.

(ii) A very poorly answered question, with the majority of candidates simply stating that this was in order to make it a fair test.

(iii) Only the better candidates realised that this was in order to eliminate any

possible bias, but many candidates simply repeated their 'fair test' answer.

(e) (i) Just over half of the candidates were able to score at least one mark here, although some of the weaker candidates thought that as the measurement was in degrees it must be referring to temperature.

(ii) This question was correctly answered by about half of the candidates.

Q22.

(a) In describing the difference between longitudinal and transverse waves less than one-fifth of students gave a clear description referring to the directions of oscillations and energy transfer. A vague statement correctly referring to 'parallel' and 'perpendicular' was awarded one mark, but statements such as 'in a transverse wave the wave moves perpendicular to the waves' were often seen.

(b) Hardly any students scored full marks for a description of how radio waves and sound waves differed. Many students thought that sound waves travelled faster and had greater frequencies. Most students knew that sound waves cannot travel through a vacuum.

Q23.

(a) Generally this was well done, with most students realising that 110 kWh should be multiplied by 15. Some students lost credit for use of inconsistent units with their numerical answers.

(b) A minority of students gained both marks for this question. Half of students were able to score one mark for working out an answer of 600 m, having failed to convert the frequency from kHz to Hz.

(c) Despite this answer being a direct fact as given in the specification, the majority of students failed to gain any credit.

(d) Less than a quarter of students scored this mark. A common answer was to say that the stars emitting X-rays were too far away.

Q24.

(a) Just over one-third of students answered correctly.

(b) (i) Just over one-third of students gave a correct example of infrared waves being used for communication, TV remote controls being the most common answer. A common answer which did not score a mark was 'mobile phones', although some candidates gained credit for expanding on this answer by referring to the transfer of data files in older mobiles.

(ii) Around 13% of students scored all three marks for this calculation. A similar number were able to perform the calculation correctly but either overlooked the instruction to give the answer to two significant figures, or did not understand what 'two significant figures' meant. A significant number of students substituted correctly into the equation and transposed it correctly, but were unable to carry out the calculation correctly, mainly because of the powers of ten. Answers of 1.66×10^{17} were common.

(c) Around half of the students were able to identify that there may be other factors affecting sperm count. Of the remaining responses, a variety of interesting answers

were seen.

Q25.

Many students failed to process the information supplied in the graph, and often just stated values. Less than one student in twenty gained all 3 marks.

Q27.

(a) Considering the large number of wave properties to choose from, students did not score well on this question. Only a tenth of students could give two correct properties.

(b) Few correct responses referring to microwaves being able to pass through the ionosphere were seen.

(c) Most students were able to identify the correct equation, and many were able to transpose and substitute correctly. Mathematical errors, often involving powers of ten, were then quite common. The unit of frequency was often omitted or written incorrectly as 'hz'.

Q28.

(a) (i) Many students scored this mark because they realised the need for a control in order for a comparison to be made. The most common non-creditworthy answer was to just measure room temperature without any reference as to why this was needed. There were a significant number of answers in terms of the possible effects of scattered / reflected / refracted / diffracted light.

(iii) Over three-quarters of students scored at least one mark, usually for red light being the hottest or outside the spectrum being cooler. Few students linked temperature rise to wavelength. Common errors included reference to there being infrared within the visible spectrum and red light having the shortest wavelength.

(b) This was a very poorly answered question with hardly any students scoring both marks. Most answers were very confused and lacked accurate scientific information. Many students clearly did not know where the infrared region was, whilst others thought that red light and infrared were the same thing or that infrared can be seen.

(c) Standard form is now part of the mathematical requirements for this specification. Whilst it was pleasing to see that some students were capable of using data given in this form, it was clear that the majority of students did not know what to do with the powers. There were also a significant number of students that were unable to transform the equation correctly. This usually resulted in zero marks, as no correct substitution was shown.

(d) This question was not answered well. Many students tried to link their answer to the absence of the Sun at night and / or more light during the day making it harder to see the criminal on the camera. A number of students gained one mark for reference to the temperature difference between the criminal and surroundings but, without reference to infrared. Some students thought the criminal would show up better as they were hot from running away!

Q29.

In part (i) few candidates realised that since both light and radio waves travel at the same

speed in a vacuum they are likely to travel at the same speed through air. In part (ii) many candidates calculated the correct answer. The most common error was not to convert kHz to Hz. Part (iii) was not attempt by a significant number of candidates.

Q30.

Part (i) was answered correctly by most candidates. In part (ii) there was a good degree of success, although some candidates clearly did not transfer figures correctly from their calculator, with answers out by a power of 10. Only the weaker candidates were unable to state the correct unit.

Q31.

In part (a)(i) a significant number of candidates divided by 75cm arriving at an answer of 4,000,000.

Part (b)(i) produced a wide range of answers; however few candidates scored all three marks. Many candidates scored two marks for the idea of 'microwaves damaging cells'. Most candidates scored at least one mark in part (b)(ii) with almost half scoring full credit. The idea that research could be biased and the need to present the evidence was well known.

Q32.

This question gave a full range of marks and it was quite well answered, although 909 kHz was often not converted to hertz.

Q33.

(a) (i) It appeared that the term .properties. was not understood by many candidates, and answers giving uses of the waves were more frequently seen. Candidates should be aware that they do not generally gain credit for repeating information which they have been given in the question, so saying that both waves were electromagnetic or that both could be used for communications did not score any credit.

(ii) This question was correctly answered by just under three quarters of candidates, although some candidates gave .visible light and microwaves. as an answer, failing to realise that the question had already referred to these waves.

(b) Although a large number of candidates were able to transform the equation and substitute values, the majority failed to convert the wavelength from centimetres. The majority of candidates either did not read that they also had to give the unit, or perhaps did not know what the unit was, but those who gave the unit usually did so correctly.

(c) (i) Many candidates seemed to have the correct idea but failed to express themselves correctly. A common incorrect answer was to suggest that the politician should carry out an experiment.

(ii) A surprisingly large number of answers indicated that candidates had read the question as asking why there was 'no need for further research'. Other answers included terms such as 'bias', 'valid' and 'accurate' that did not answer the question.

Q34.

(a) Although this was answered correctly by the majority of candidates, many did not use the given wavelength of visible light as a clue to obtaining the correct infra red wavelength.

(b) Most candidates correctly transformed and substituted into the equation, but many candidates did not score the second mark through not converting kHz to Hz.

(c) Very few candidates scored at all on this question; a small number gained one mark for the heating effect.

(d) Only a minority of candidates scored the mark for this question. Common misconceptions were that clouds or light pollution would affect the detection of Xrays, or that the X-rays were being sent from the telescope to the star, or that satellite telescopes were much nearer to the stars than terrestrial telescopes.

Q35.

(a) (i) One third of students scored the mark for this question. Many incorrect answers were seen, some being other waves in the electromagnetic spectrum, but many others were totally unconnected to electromagnetic waves.

(ii) The majority of students answered correctly identifying refraction as the process occurring as the wave passed through the ionosphere. Commonly seen incorrect answers were reflection and diffraction.

(b) (i) This question was well answered with about two thirds of students scoring 2 marks. Some students scored 1 mark only, usually for poor ray construction caused by drawing the ray freehand or the ray failing to reach the top of the receiver. Many students drew multiple rays which negated the 2nd mark. Some students drew the ray travelling to the satellite and back to the receiver, gaining no marks.

(ii) Over half of the students scored a mark. The mark was given for a dotted or a continuous line, labelled or not, as long as clearly the ‘normal’. Common mistakes involved drawing a line perpendicular to the incident ray M. If the ray was refracted into the ionosphere, this mark still scored if the normal was correct. A significant number of students seemed unfamiliar with the term ‘normal’ and a range of different points or lines at various places within the diagram were labelled.

(c) Around one quarter of students scored 2 marks, however many students gave more than 2 answers which included incorrect properties and negated their correct answers.