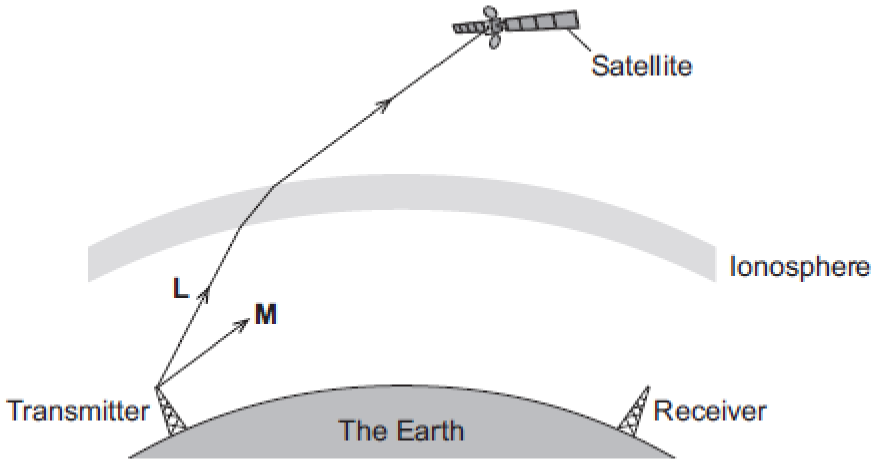
Q1.

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)

Q2.

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)

Q3.

Galaxies emit all types of electromagnetic wave.

(a) (i) Which type of electromagnetic wave has the shortest wavelength?

(1)

(ii) State **one** difference between an ultraviolet wave and a visible light wave.

(1)

(b) Electromagnetic waves travel through space at a speed of 3.0×10^8 m/s.

The radio waves emitted from a distant galaxy have a wavelength of 25 metres.

Calculate the frequency of the radio waves emitted from the galaxy and give the unit.

Frequency = ____________________

(3)

(c) Scientists use a radio telescope to measure the wavelength of the radio waves emitted from the galaxy in part (b) as the waves reach the Earth. The scientists measure the wavelength as 25.2 metres. The effect causing this observed increase in wavelength is called red-shift.

(i) The waves emitted from most galaxies show red-shift.

What does red-shift tell scientists about the direction most galaxies are moving?

(1)

(ii) The size of the red-shift is **not** the same for all galaxies.

What information can scientists find out about a galaxy when they measure the size of the red-shift the galaxy produces?

(2)

(iii) What does the observation of red-shift suggest is happening to the Universe?

(1)

(Total 9 marks)

Q4.

(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.

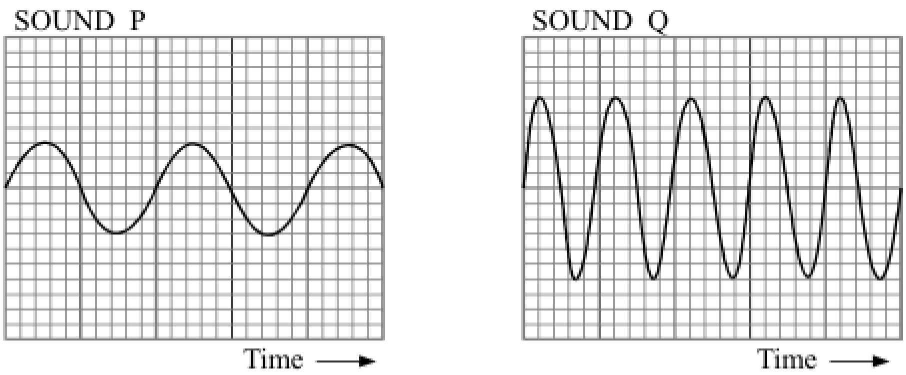
Why would an X-ray telescope based on Earth **not** be able to detect X-rays emitted from distant stars?

(1)

(Total 6 marks)

Q5.

The diagram shows the oscilloscope traces of two different sounds P and Q. The oscilloscope setting is exactly the same in both cases.



P and Q **sound** different.
Write down **two** differences in the way they sound.
Explain your answers as fully as you can.

1.

2.

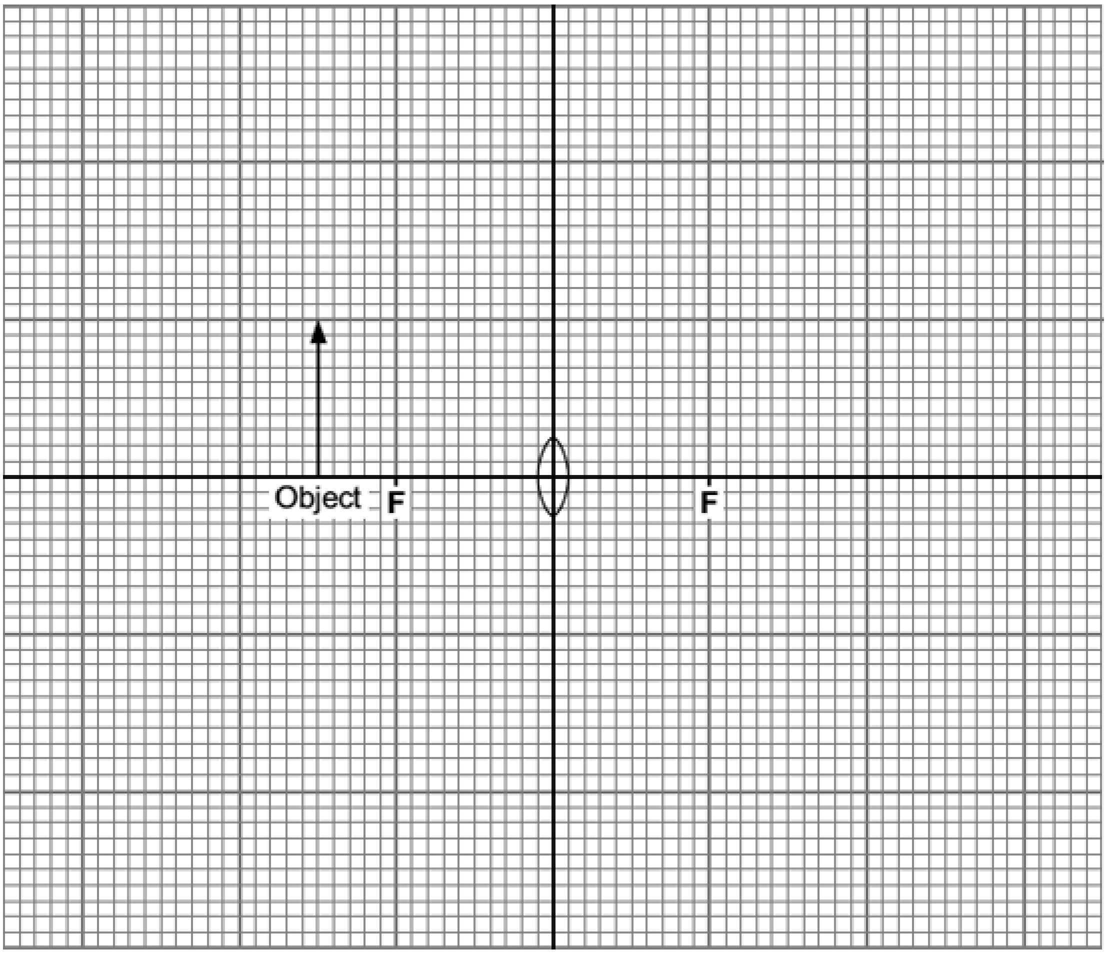
(Total 5 marks)

Q6.

A student investigated how the nature of the image depends on the position of the object in front of a large converging lens.

The diagram shows one position for the object.

(a) Use a ruler to complete a ray diagram to show how the image of the object is formed.



Key: F = principal focus

(4)

(b) Describe the nature of this image relative to the object.

____

____

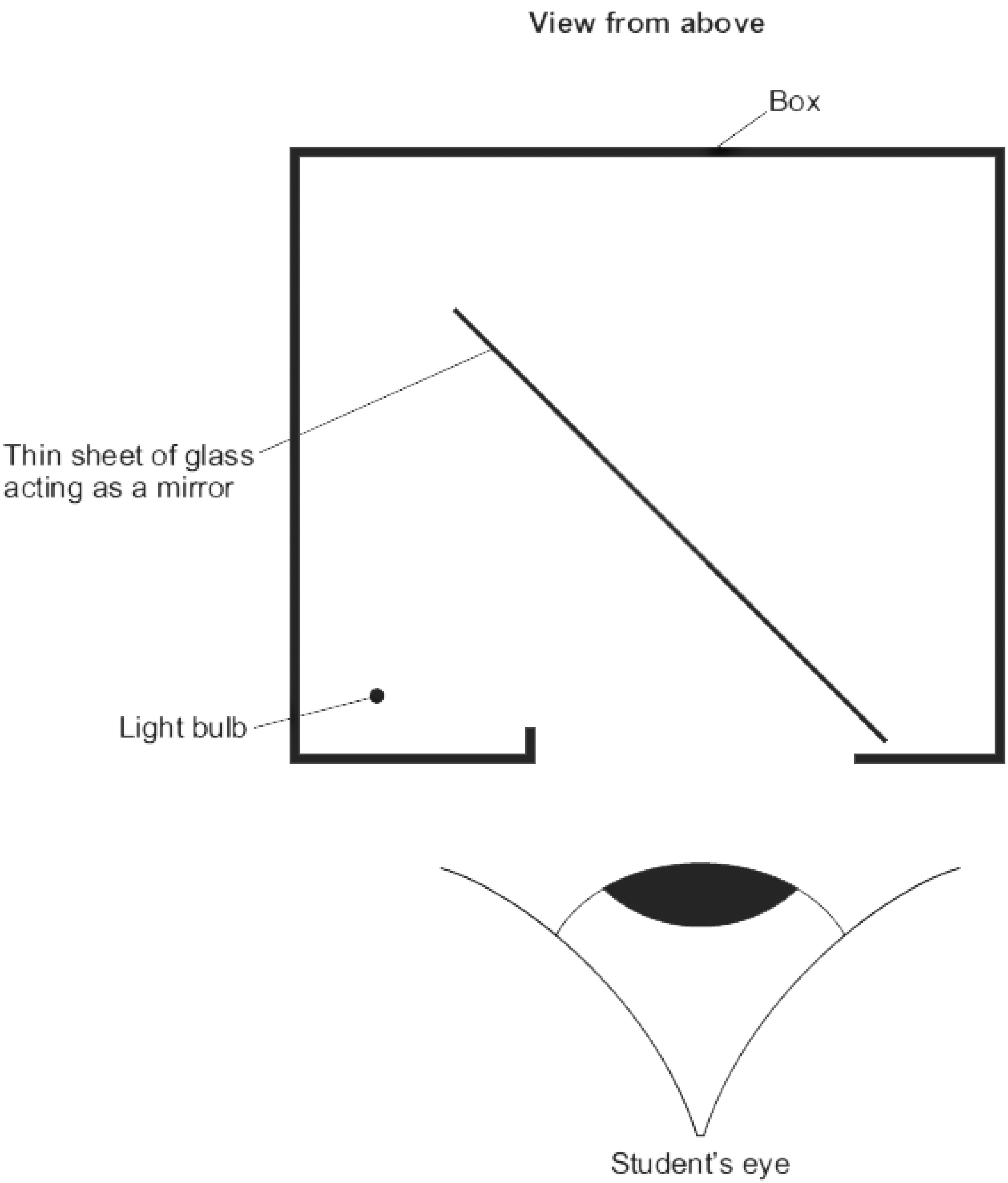
____

(2)
(Total 6 marks)

Q7.

The diagram shows a model used to demonstrate an illusion known as 'Pepper's Ghost'.

A small light bulb and thin sheet of glass are put inside a box. The thin sheet of glass acts as a mirror. Although the light bulb is switched on, a student looking into the box cannot see the bulb. What the student does see is a virtual image of the bulb.



(a) Use a ruler to complete a ray diagram to show how the image of the light bulb is formed. Mark and label the position of the image.

(4)

(b) The image seen by the student is virtual.

Why?

____

____

(1)

(Total 5 marks)

Mark schemes

Q1.

(a) (i) microwave

1

(ii) refraction

1

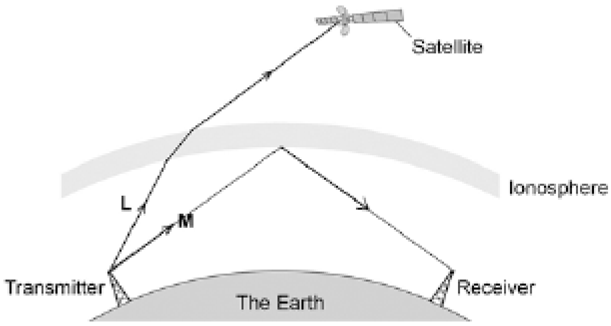
(b) (i) wave M continues as a straight line to the ionosphere and shown reflected

accept reflection at or within the ionosphere

1

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

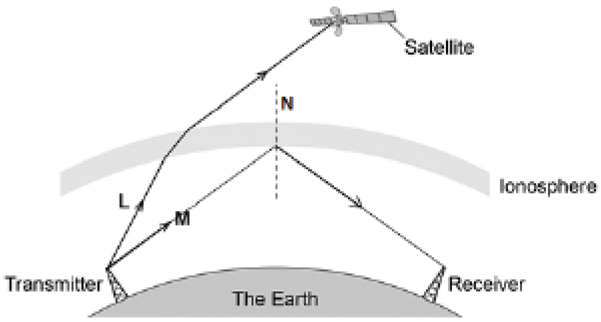
if more than 2 rays shown 1 mark maximum



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]

Q2.

(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]

Q3.

(a) (i) gamma

accept correct symbol

1

(ii) any **one** from:

- (ultraviolet has a) higher frequency

  ultraviolet cannot be seen is insufficient
- (ultraviolet has a) greater energy
- (ultraviolet has a) shorter wavelength

  ignore ultraviolet causes cancer etc

1

(b) 1.2×10^7 / 12 000 000

*allow **1** mark for correct substitution, ie $3 \times 10^8 = f \times 25$*

2

hertz / Hz / kHz / MHz

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

*answers 12 000 kHz **or** 12 MHz gain **3** marks*

for full credit the numerical answer and unit must be consistent

1

(c) (i) away (from each other)

accept away (from the Earth)

accept receding

1

(ii) distance (from the Earth)

accept how far away (it is)

1

speed galaxy is moving

1

(iii) (Universe is) expanding

1

[9]

Q4.

(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

<u>ignore</u> explanations

1

[6]

Q5.

- Q is louder
- Q is higher (pitch/note but <u>not</u> frequency)

  [if loudness and pitch both mentioned but direction wrong / absent credit 1 mark]
- louder because bigger amplitude/height
- higher pitch because higher frequency/shorter wavelength/waves closer together
- factor of 2 mentioned w.r.t either

  (NB converse answer for P)

  each • for 1 mark

[5]

Q6.

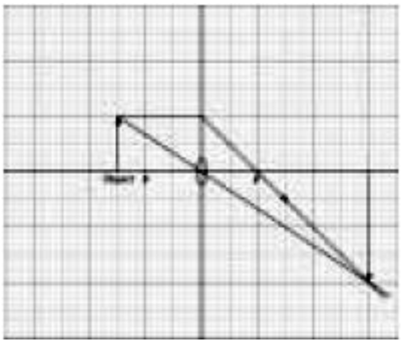
(a) any **two** for **1** mark each

deduct (1) from the first two marks if a ruler has not been used but the intention is clear

ray from the object's arrowhead

- through centre of lens
- parallel to the axis then, when it reaches the lens, through F on the right
- through F on the left then, when it reaches the lens parallel to the axis

*example of a **4** mark response*



*if more than two construction lines have been drawn all must be correct to gain **2** marks*

construction lines drawn as dashed lines do not score credit

2

image shown as vertical line from axis to where their <u>rays</u> intersect

image need not be marked with an arrowhead but, if it is, it must be correct

1

ray direction shown

only one correct direction

arrow needed but there must not be any contradiction

1

(b) any **two** from:

- inverted

  accept ‘upside down’

- magnified

  accept ‘bigger’

- real

  accept ‘not virtual / not imaginary’

  *one correct feature gains **1** mark*

  ignore any reference to position

  an incorrect feature negates a correct response

2

[6]

Q7.

(a) two rays drawn from the bulb and reflected by the glass *angle **I** = angle **R** judged by eye*

*allow **1** mark for one incident and reflected ray even if angle **I** doesn't equal angle **R***

2

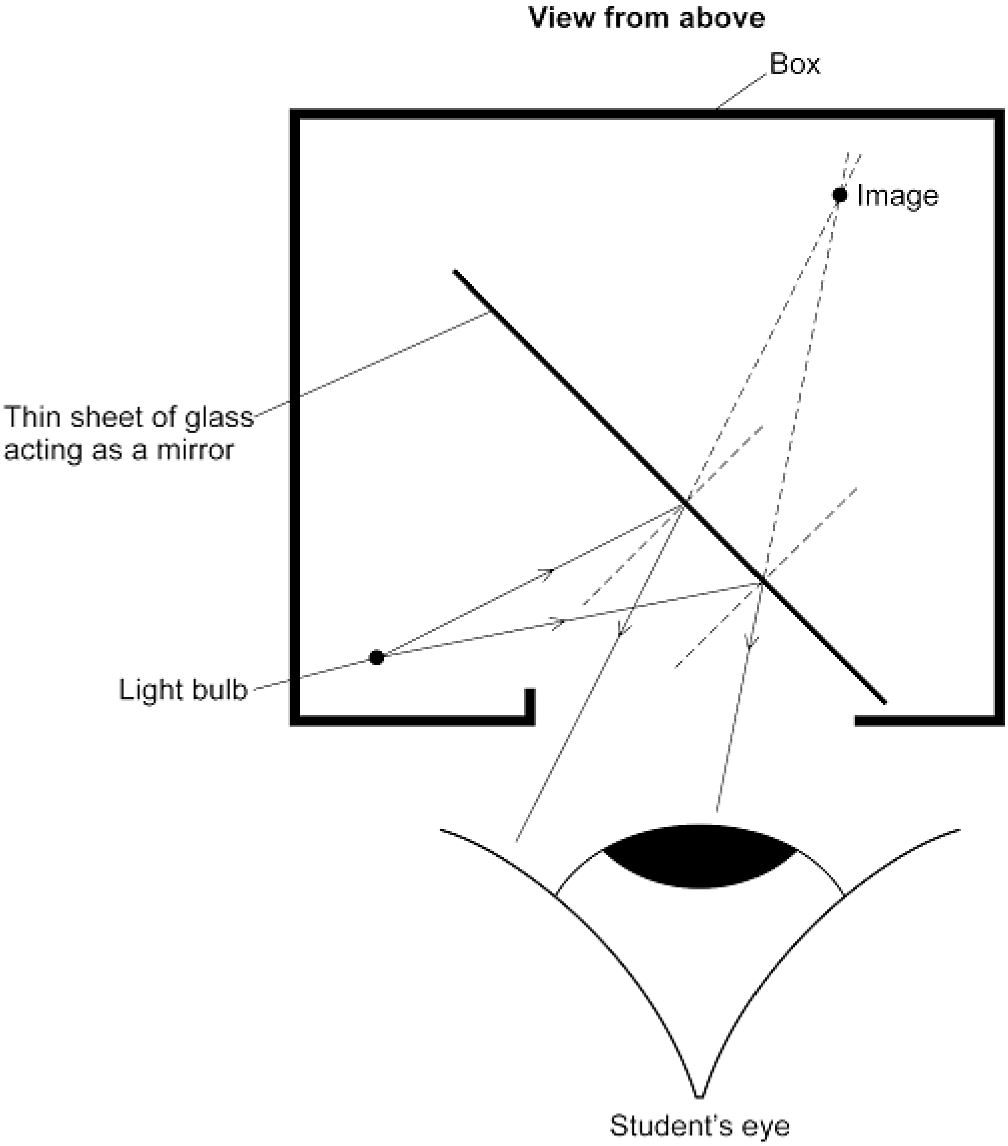
at least one arrow drawn in correct direction

any conflicting arrows negate this mark

ignore any arrows drawn on construction lines behind the glass

1

position of image correct



judged by eye

1

(b) image is formed by virtual / imaginary rays crossing

accept construction lines only show where the light seems to come from

accept the image is behind the glass / mirror

accept image is seen through the glass / mirror

accept (real) rays of light do not pass through the image

accept (real) rays do not cross
accept the image is a reflection (of the object)
accept the image is formed by reflection
*do **not** accept a virtual image can't be formed on a screen*
*do **not** accept the object / image is reflected*

1

[5]

Examiner reports

Q1.

(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.

Q3.

(a) (i) Over half of students correctly identified gamma. There was a range of other responses, some of which were not electromagnetic waves, indeed some were not waves of any kind.

(ii) Almost half of the students gave a correct answer. Common incorrect responses referred to uses of these waves.

(b) Many students were able to identify the correct equation, and substitute numbers into it. Common errors were wrongly transposing the equation and attempting to convert 25 metres into cm or km.

(c) (i) Over three-quarters of the responses were correct.

(ii) Nearly two-thirds of students were able to identify at least one correct piece of information which can be obtained from the size of the red-shift.

(iii) The vast majority of responses were correct. There are still a number of students who confuse the 'Universe' with 'Earth'.

Q4.

(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.

Q6.

(a) A significant number of candidates (approximately a quarter) failed to score any marks, with an equal number scoring all four. Many candidates, having completed the ray diagram, successfully omitted any arrows showing direction. It was perhaps fortunate that marks were not awarded for the accuracy of the diagram as this was often poor. Independent marks meant that candidates were able to score one or two marks for image placement or ray direction even when their rays were more suitable for a mirror instead of the lens shown.

(b) Surprisingly just under half of candidates scored both marks. Many candidates lost credit by producing a long list of features that were often contradictory.

Q7.

(a) Very few students were able to locate the correct position of the image. Many students were able to draw one ray from the object to the glass and show it reflecting towards the eye, but in most cases, the angle of incidence was significantly and obviously different to the angle of reflection. If arrows were drawn on the rays, they were mostly shown in the correct direction. A second ray from the object and construction rays behind the glass were rarely seen. Less than a tenth of students achieved three or four marks.

(b) Very few answers explained that the image is formed by virtual / imaginary rays crossing.