



Pearson  
Edexcel

# GCSE (9-1) Astronomy

Exemplar work with  
commentary



## Introduction

This guide has been put together using student responses to our Summer 2025 paper in GCSE (9-1) Astronomy.

The question examples in this guide will give you a range of answers to show you the varied answers candidates may give. There are also detailed examiner comments for each answer to explain how the marks have been allocated, and the merits or development points for each answer.

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# 1AS0/01

## Example 1 – Question 1c

(c) In 1577, a very bright comet was visible from Earth.

The Danish astronomer Tycho Brahe described the comet.

He wrote that the comet's tail covered almost a quarter of the sky and that the comet was much brighter than a full Moon.

Draw on Figure 2 a sketch of a bright comet, like the comet seen in 1577.

(3)

### Mark Scheme

Question number	Answer	Mark
1(c)	<ul style="list-style-type: none"> <li>Extended shape consistent with a comet</li> <li>Cometary detail such as separate head/tail, coma, multiple tails</li> <li>Cometary shape that spans almost all the space between any two adjacent compass points.</li> </ul>	<p><b>(1)</b></p> <p><b>(1)</b></p> <p><b>(1)</b></p>

## Student answers

Draw on Figure 2 a sketch of a bright comet, like the comet seen in 1577.

(3) 3 Q01

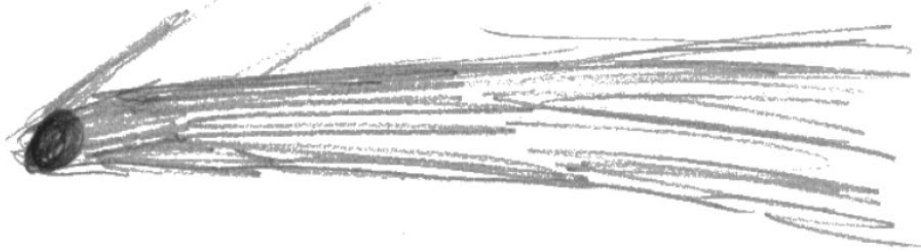
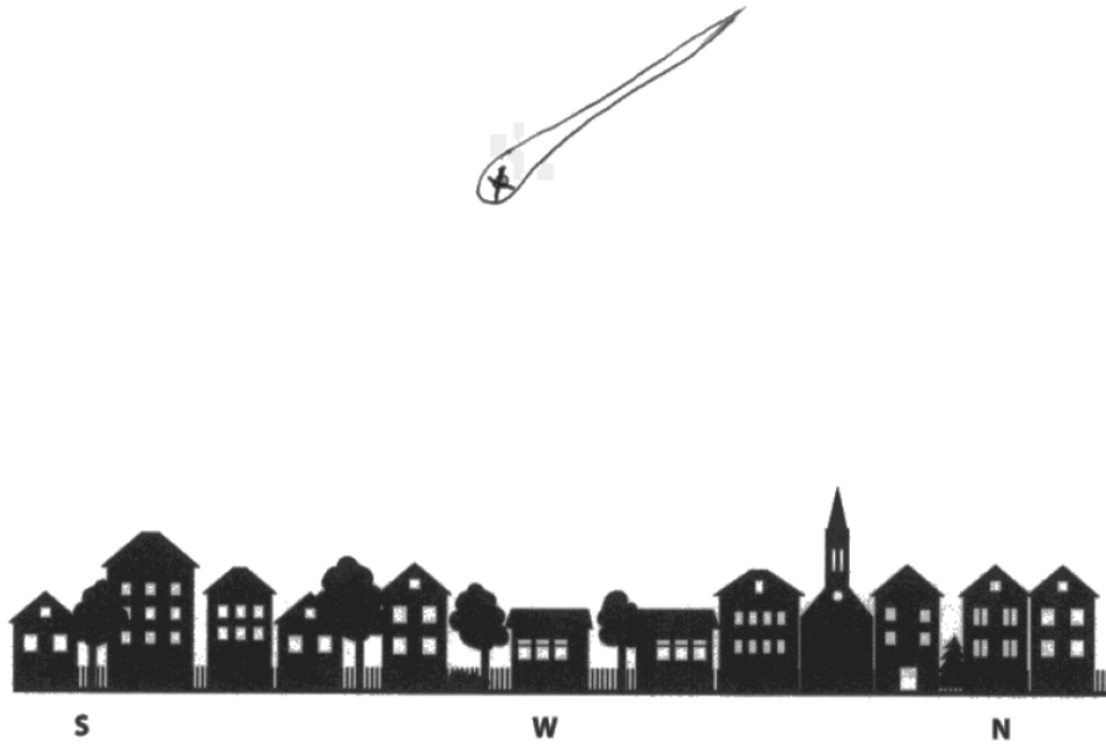


Figure 2

**Examiner comments:** this student's drawing clearly meets all three of the marking points and thus scores a comfortable three marks. As well as covering well over a quarter of the sky, it has clear indication of some key cometary features such as the nucleus and possibly part of a second tail. Some candidates increased the clarity of their drawings by including labels, although this was not necessary for the award of full marks.

**Mark awarded = 3**



**Examiner comments:** this student's drawing shows clearly the shape and structure of a typical comet, with indication of a nucleus/coma and a tail. However, it does not address the third of the marking points, based on Tycho Brahe's comment that the comet covered 'almost a quarter of the sky'. The length of this student's drawing is significantly less than the distance between adjacent compass points, marked on the horizon at the bottom of Figure 2.

**Mark awarded = 2**

## Example 2 – Question 3a


3 (a) (i) Draw a sketch of the asterism known as 'The Plough'.

(2)

(ii) Draw an arrow on your sketch to show the direction of the bright star Polaris.

(1)

### Mark scheme

Question number	Answer	Mark
3(a) (i)	<p>Recognisable 'plough' shape Approximately correct proportions of 'handle' to 'blade'.</p> 	<p>(1) (1)</p>
Question number	Answer	Mark
3(a) (ii)	<p>Arrow pointing from Merak-Dubhe (direction required).</p>	<p>(1)</p>

## Student answers

3 (a) (i) Draw a sketch of the asterism known as 'The Plough'.

(2) 2 Q03:



### Examiner comments:

(i) This student's response has all seven of the bright stars in The Plough arranged in the correct pattern and with approximately correct proportions to the distances between them. It therefore gains both the marking points for this question.

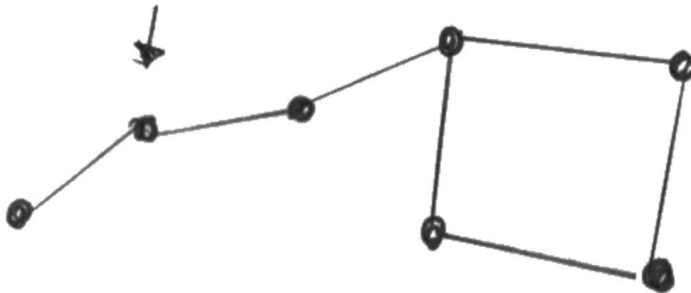
**Mark awarded = 2**

(ii) The arrow provided is clearly aligned with the direction of the two 'pointer' stars in The Plough asterism, as required for the single marking point.

**Mark awarded = 1**

3 (a) (i) Draw a sketch of the asterism known as 'The Plough'.

(2) 1 Q03



**Examiner comments:**

(i) This drawing clearly shows the characteristic 'blade and handle' shape of The Plough asterism and thus comfortably gains the first marking point. However, the three stars of the 'handle' are in a definite downward direction relative to the blade. In addition, these three stars do not form a consistent curve with Alioth slightly misplaced.

**Mark awarded = 1**

(ii) The arrow in this drawing is pointing at one of the stars, rather than indicating the direction of the Pole Star, as requested by the question.

**Mark awarded = 0**

3 (a) (i) Draw a sketch of the asterism known as 'The Plough'.

(2) 0 Q03ε



**Examiner comments:**

(i) This student's response contains a possible suggestion of four stars in a rectangle to provide the 'blade' of The Plough asterism but none of the other stars would be in the correct position to form any of the stars in the 'handle'. There is therefore nothing creditworthy in this drawing.

**Mark awarded = 0**

(ii) No arrow is provided in this drawing and so no credit can be given.

**Mark awarded = 0**

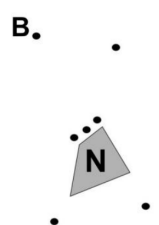
## Example 3 – Question 3bi-iii

(b) (i) Draw a sketch of the seven brightest stars in the constellation of Orion. (2)

(ii) Label the position of the bright star Betelgeuse on your sketch.  
Use the label **B**. (1)

(iii) Label the position of the Orion Nebula on your sketch.  
Use the label **N**. (1)

### Mark scheme

Question number	Answer	Mark
3(b)	(i) Stars arranged with correct topology Proportions of pattern (approximately) correct	(1) (1)
		
	(ii) Position of Betelgeuse correctly labelled ( <b>B</b> )	(1)
	(iii) Position of Orion Nebula correctly labelled ( <b>N</b> )	(1)

## Student answers

(b) (i) Draw a sketch of the seven brightest stars in the constellation of Orion.

2 Q03bi

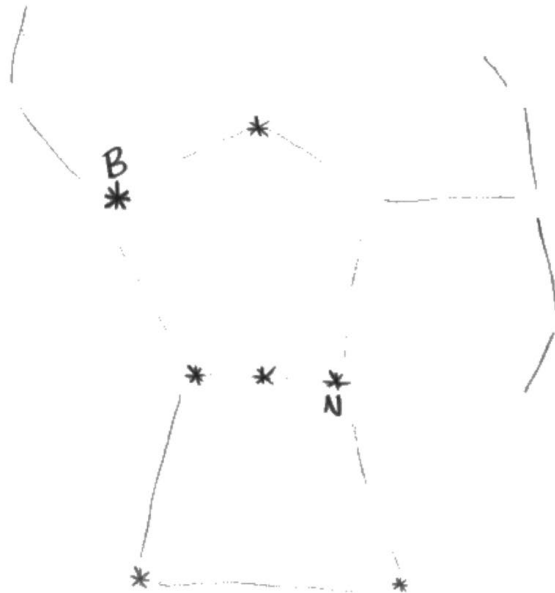


### Examiner comments:

- (i) This drawing clearly shows a 'belt' of three stars near the middle of a quadrilateral of stars. It is thus clearly recognisable as the constellation of Orion and achieves both marking points.  
**Mark awarded = 2**
- (ii) Betelgeuse is correctly marked as the top left-hand star in the quadrilateral of Orion.  
**Mark awarded = 1**
- (iii) The Orion Nebula needs is correctly shown in the area just below the 'belt' of Orion.  
**Mark awarded = 1**

(b) (i) Draw a sketch of the seven brightest stars in the constellation of Orion.

(2) Q03bi



**Examiner comments:**

- (i) At first glance, this drawing shows a definite 'belt' of three stars near the middle of a quadrilateral of four stars. The additional (unnecessary) drawing of Orion's arms and bow helps to support this. However, the top right-hand star of the quadrilateral (Bellatrix) is drawn in the wrong position – much too close to the central axis of the constellation. It could be argued that the candidate has correctly drawn the star Meissa, which is part of Orion. However, the question specifically asks for the seven 'brightest' stars in Orion, of which Meissa is not one.

**Mark awarded = 1**

- (ii) Betelgeuse is correctly marked as the top left-hand star in the quadrilateral of Orion.

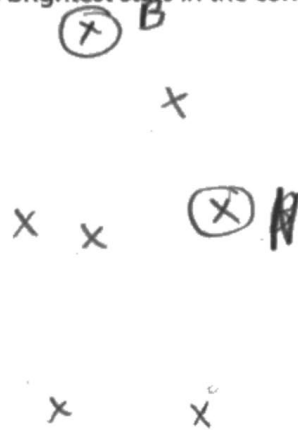
**Mark awarded = 1**

- (iii) Although a considerable distance from its actual position, the label for the Orion Nebula is placed within the constellation's quadrilateral and just below its 'belt' and is thus just creditworthy.

**Mark awarded = 1**

(b) (i) Draw a sketch of the seven brightest stars in the constellation of Orion.

(20) Q03bi



**Examiner comments:**

- (i) Orion's characteristic 'belt' within a quadrilateral of four stars is not immediately visible in this drawing. The quadrilateral is not correctly drawn, and the belt extends beyond it. However, a belt of three stars is clearly visible, allowing this response to gain one mark.

**Mark awarded = 1**

- (ii) Although the quadrilateral is not correctly drawn, the labelled star is (arguably) its top left-hand star and can thus be credited.

**Mark awarded = 1**

- (iii) The candidate appears to have identified one of the stars as being the Orion Nebula which is incorrect. Even the letter 'N' itself, is outside the creditable area shown in the Mark Scheme.

**Mark awarded = 0**

## Example 4 – Question 3biv

- (iv) The stars in the constellation of Orion have been observed by people living at a wide range of latitudes.

The Inuit people observed the stars of Orion from a latitude of over 70°N.

People in South America observed the stars of Orion from a latitude of 55°S.

Explain why the stars in Orion are visible over such a wide range of latitudes.

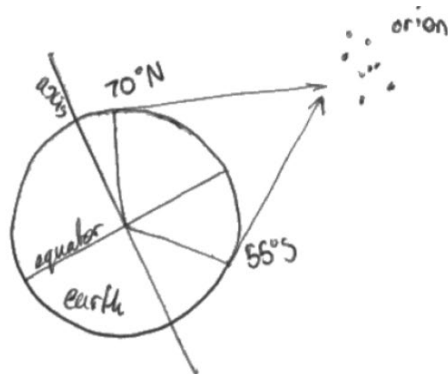
You may include a clearly labelled diagram in your answer.

(2)

### Mark scheme

Question number	Answer	Additional Guidance	Mark
3(b) (iv)	Stars of Orion are close to the Celestial Equator.	Ignore: Stars of Orion cover a large area.	(1)
	Any <b>one</b> from: <ul style="list-style-type: none"> <li>• Calculation of altitude of Orion/Cel Eq from either of given latitudes (20° or 35°)</li> <li>• Stars of Orion rise above the horizon from both locations (can be (horizon) lines drawn on diagram)</li> <li>• Orion visible from both hemispheres.</li> </ul>	Points may be established using text or diagram.	(1)

## Student answers



Orion would be very low in the sky for both, but for some of the year, each latitude would see it due to the tilt of the earth's axis and its rotation. Its a big constellation.

(Total for Question 3 = 9 marks) **9**

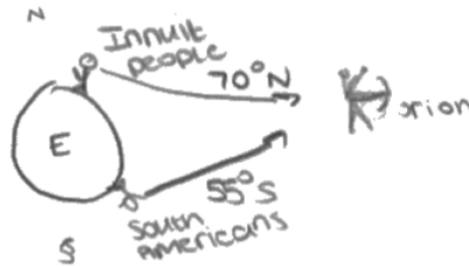
the top is visible at 70°N and bottom visible in south

**Examiner comments:** this response shows how almost all the marks on a question can be gained by the use of a clearly labelled diagram.

The student's carefully drawn, and fully labelled diagram shows that Orion is directly above the Earth's equator, i.e. on the celestial equator, thus gaining the first marking point.

The two sets of observers have been placed in approximately correct positions on the labelled Earth and lines representing the horizon drawn at both points, which is sufficient for the second marking point.

**Mark awarded = 2**



- Because each group are at different latitudes

**Examiner comments:** Although much of this response simply repeats what is stated in the question, it also partially addresses both of the required marking points. The constellation of Orion is drawn hovering above the middle of the Earth.

The diagram suggests the first marking point without fully achieving it. The constellation of Orion is shown hovering above the middle of the Earth but neither the earth's equator nor the celestial equator is labelled or mentioned.

The comment about latitude and the labelled latitudes on the diagram are re-statements of information given in the question. The lines sprouting from each of the observers are suggestive of indicating horizons but, once again, there is no clear labelling to confirm this.

The student also seems to have made an attempt to show the relative positions of the two groups of observers, with the Inuit shown closer to the pole than those in South America. However, the lack of a labelled equator or precisely positioned poles makes this hard to credit.

**Mark awarded = 1**

Orion is a big constellation,  
covers a large area of the sky  
and has bright stars. (Total for Question 3 = 9 marks)

**Examiner comments:** this response links Orion's extensive visibility to observers on the Earth to the brightness of its stars and the area of sky that it covers. Since neither of these points is correct, it contains nothing creditworthy.

**Mark awarded = 0**

### Example 5 – Question 4b

(b) Explain why there is **not** a solar and a lunar eclipse every month.

You may include a clearly labelled diagram in your answer.

(3)

### Mark scheme

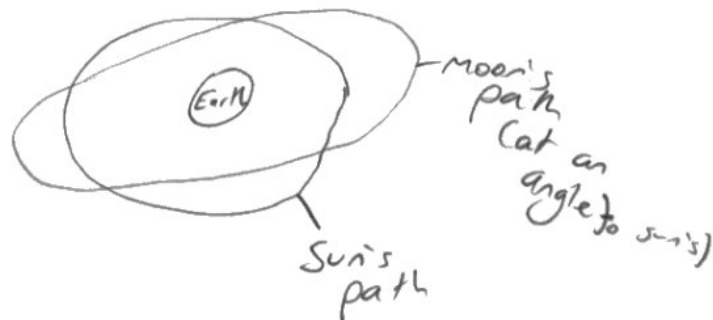
Question number	Answer	Mark
4(b)	Moon completes one orbit (of Earth) each month	(1)
	Moon's orbit takes it through two possible eclipse positions	(1)
	Moon's 'tilted' orbit (usually) places it above or below plane of Earth's orbit (ecliptic).	(1)

## Student answers

(b) Explain why there is **not** a solar and a lunar eclipse every month.

You may include a clearly labelled diagram in your answer.

(3) Q04b

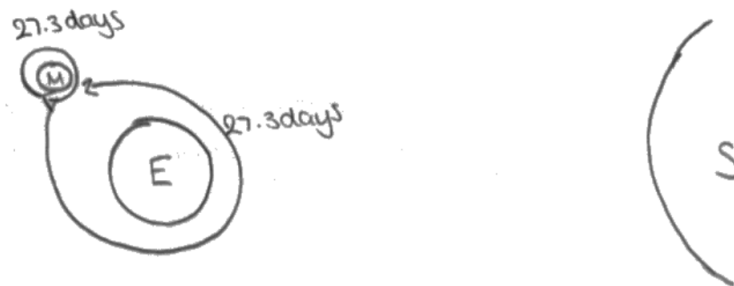


The moon does not orbit the earth on the ecliptic, it orbits at an angle to the ecliptic. This means the two cross paths (from our perspectives) rarely, not every month.

**Examiner comments:** This response mentions the central point of this explanation – that the plane of the Moon’s orbit is tilted with respect to the Sun’s orbital plane or the ecliptic.

However, this point is not developed, and the answer also seems to suggest that the Moon crosses the Sun’s orbital path, which is incorrect.

**Mark awarded = 1**



- because the moons orbit = its rotation whilst the Earth orbits the sun
- this means it doesn't always align

**Examiner comments:** Although this response presents a broadly correct diagram of the motions of the Sun, Moon and Earth it does not address the specific issue raised by the question. The last line of the answer is related to the question but is insufficiently developed for the award of a mark.

**Mark awarded = 0**

## Example 6 – Question 4ci

(c) Eid al-Fitr is a festival in the Islamic calendar.

The passage below explains how the date of Eid al-Fitr is found each year.

*“The festival of Eid al-Fitr falls on the first day of the month of Shawwal. On the last day of the previous month, astronomers look carefully in the sky for the first sight of the start of the crescent Moon phase. Once this very thin crescent Moon has been seen, the New Moon phase is over and the month of Shawwal begins, with the festival of Eid al-Fitr.”*

(i) An astronomy student suggests:

*“Why not start each month with a full Moon – it is much easier to see in the sky.”*

Explain **one** astronomical advantage of starting each month with the first sight of the crescent Moon instead of the full Moon.

(3)

### Mark scheme

Question number	Answer	Mark
4(c) (i)	(To naked eye) Moon appears (close to) full for several days	(1)
	‘Appearance’ of first crescent lasts a much shorter time	(1)
	Greater precision in date obtained (accept ‘more accurate’). [“Easier to see” (crescent Moon) scores 1.]	(1)

## Student answers

- (i) An astronomy student suggests:

*"Why not start each month with a full Moon – it is much easier to see in the sky."*

Explain **one** astronomical advantage of starting each month with the first sight of the crescent Moon instead of the full Moon.

(3) 2, Q04

Its difficult to tell exactly which day is full moon, as it often appears full for 3-4 days, whereas with a crescent, the moon goes from completely dark in its new phase, to a sliver of light, which is easier to see due to the contrast.

**Examiner comments:** This is a high-quality response which is close to achieving all three marking points. The lengthy period over which the moon can appear full to the naked eye and the much shorter period associated with the appearance of the crescent Moon are both very clearly explained.

To achieve full marks the student simply needed to say that use of the crescent Moon would give a more precise measurement of the time of the end of the month. However, "easier to see" is not quite sufficient for the award of this marking point.

**Mark awarded = 2**

It is hard to see when the Moon becomes exactly full, whereas for a Crescent Moon, the Moon ~~will be seen in the night~~ is at the stage where it becomes visible in the night sky again rather than being entirely in the daytime.

**Examiner comments:** This response begins very promisingly, clearly pointing out the first marking point - the extended period over which the Moon can be judged to be 'full' by the naked eye. However, it does not continue by stating the second marking point by contrasting this with the crescent Moon.

**Mark awarded = 1**

(i) An astronomy student suggests:

*"Why not start each month with a full Moon - it is much easier to see in the sky."*

Explain **one** astronomical advantage of starting each month with the first sight of the crescent Moon instead of the full Moon.

(3) 0 Q04c

One astronomical advantage of starting each month with a crescent moon is that we see the moon for a longer period of time

**Examiner comments:** The first half of this response is effectively repeating the question, and the second half is unclear, leaving nothing creditworthy in the answer.

**Mark awarded = 0**

## Example 7 – Question 4cii

(ii) Table 2 shows the dates of Eid al-Fitr in recent years.

Year	Date of Eid al-Fitr
2021	12th May
2022	1st May
2023	20th April
2024	9th April

**Table 2**

Explain why Eid al-Fitr is on a different date each year.

(2)

.....

.....

.....

.....

### Mark scheme

Question number	Answer	Mark
4(c) (ii)	Date linked to (motion/position/phase of) Moon / lunar month	(1)
	Lunar month/(phase) cycle: not the same length as calendar months <i>OR:</i> not a whole number in a calendar year.	(1)

## Student answers

Explain why Eid al-Fitr is on a different date each year.

<sup>(2)</sup> Q04cii

The moon's orbital period is not a factor of the length of a year, the moon orbits at a different rate to Earth so full moons will occur at different times over of year, independent of the sun and earth.

**Examiner comments:** This response efficiently provides both the marking points within its first sentence – the link to the motion of the Moon and the fact that there are not a whole number of lunar months in a year.

**Mark awarded = 2**

Explain why Eid al-Fitr is on a different date each year.

<sup>(2)</sup> Q04cii

because they need a very thin crescent moon to see to know the new moon phase is over and the month of Shawwal begins

**Examiner comments:** Although much of this response repeats material that is given in the question, by mentioning the use of the Moon, it is just sufficient for the award of the first marking point. It establishes a clear link between the date of Eid al-Fitr and the appearance of the Moon.

**Mark awarded = 1**

## Example 8 – Question 5a

5 (a) Explain what is meant by the 'Equation of Time'.

(2)

.....

.....

.....

### Mark scheme

Question number	Answer	Mark
5(a)	Difference between Mean and Apparent solar time (accept correct EoT equation)	(1)
	Any <b>one</b> from: Caused by eccentricity of Earth's orbit Caused by inclination of Earth's orbit Annual variation of...	(1)

### Student answers

5 (a) Explain what is meant by the 'Equation of Time'.

(2) 1 Q05

The EQUATION OF TIME is the difference between the apparent solar time and mean solar time ( $AST - MST = EOT$ ). It can be positive or negative.

**Examiner comments:** This response makes the first marking point twice. The additional comment about the Equation of Time being positive or negative is insufficient for a second mark.

**Mark awarded = 1**

5 (a) Explain what is meant by the 'Equation of Time'.

(2) 1 Q05c

apparent solar time (Ast) - mean solar time (MST)

**Examiner comments:** This response simply states that the Equation of Time is the difference between apparent and mean solar time, thus achieving the first marking point only.

**Mark awarded = 1**

## Example 9 – Question 5biii

(iii) Explain why the Sun does **not** rise at an earlier time on the days after 21st December, even though the winter solstice has passed.

You may include a clearly labelled diagram in your answer.

(3)

### Mark scheme

Question number	Answer	Mark
5(b) (iii)	Day length increases/Sun sets later (after solstice)	(1)
	Equation of Time decreasing...	(1)
	...more quickly than daylight length increasing.	(1)

## Student answers

The day is still getting longer but mostly because the sun sets later because the Equation of Time is getting smaller.

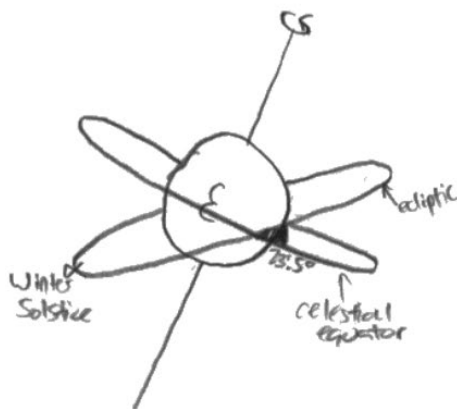
**Examiner comments:** this response achieves the first two marking points of this demanding question by pointing out that most of the increasing daylight length is seen at sunset, due to the decreasing Equation of Time.

To achieve the final marking point, the student needed to say that the Equation of Time was decreasing at a faster rate than the daylight length was increasing.

**Mark awarded = 2**

You may include a clearly labelled diagram in your answer.

0 Q5biii



The Sun does not rise earlier due to the limits of Earth's tilt. Earth reaches the point when the angle between the ecliptic and celestial equator is at its largest. From then on, the ~~noon everyday~~ altitude of the Sun at noon everyday rises again.

**Examiner comments:** Despite an initially promising diagram, this response appears to be suggesting that the angle between the celestial equator and the ecliptic varies during the year, which is not correct. Pointing out that the Sun's midday altitude increase after the solstice is not addressing the explanation required by the question.

**Mark awarded = 0**

## Example 10 – Question 6a

- 6 Box Hill Tunnel is a railway tunnel in the south-west of England.

Figure 4 shows a map of the tunnel and a picture of one of its entrances.

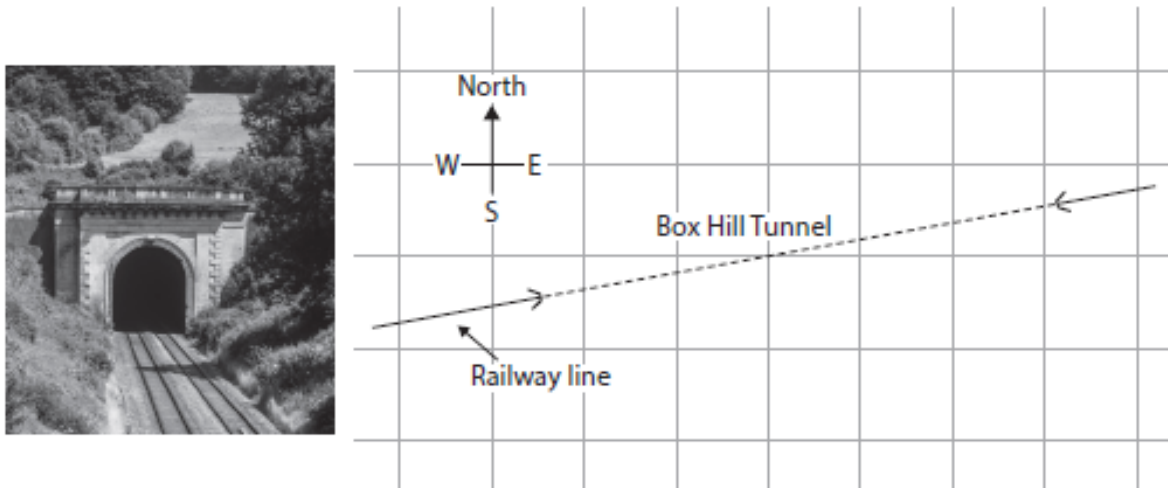


Figure 4

It has been suggested that the Sun shines directly through the tunnel on only one occasion each year – at sunrise on 9th April.

Table 4 shows the azimuth of the Sun at sunrise on some dates during April.

Date	Azimuth of Sun at sunrise
2nd April	81°30'
4th April	80°00'
6th April	78°45'
8th April	77°30'
10th April	76°00'
12th April	75°00'
14th April	74°00'

Table 4

- (a) (i) Plot on Figure 5 a graph of the Sun's azimuth at sunrise from 2nd April to 14th April.

Use the data in Table 4.

(3)

## Mark scheme

Question number	Answer	Mark
6(a) (i)	<i>Suitable size</i> – covers more than half the graph sheet both vertically and horizontally.	(1)
	<i>Both axes correctly labelled</i> – ‘Date’ on horizontal axis <b>and</b> ‘Azimuth (°)’ (Accept: ‘Azimuth (°)’) on vertical axis.	(1)
	<i>Correctly plotted points with smooth curve/line of best fit</i>	(1)

Student answers

3 Q06a

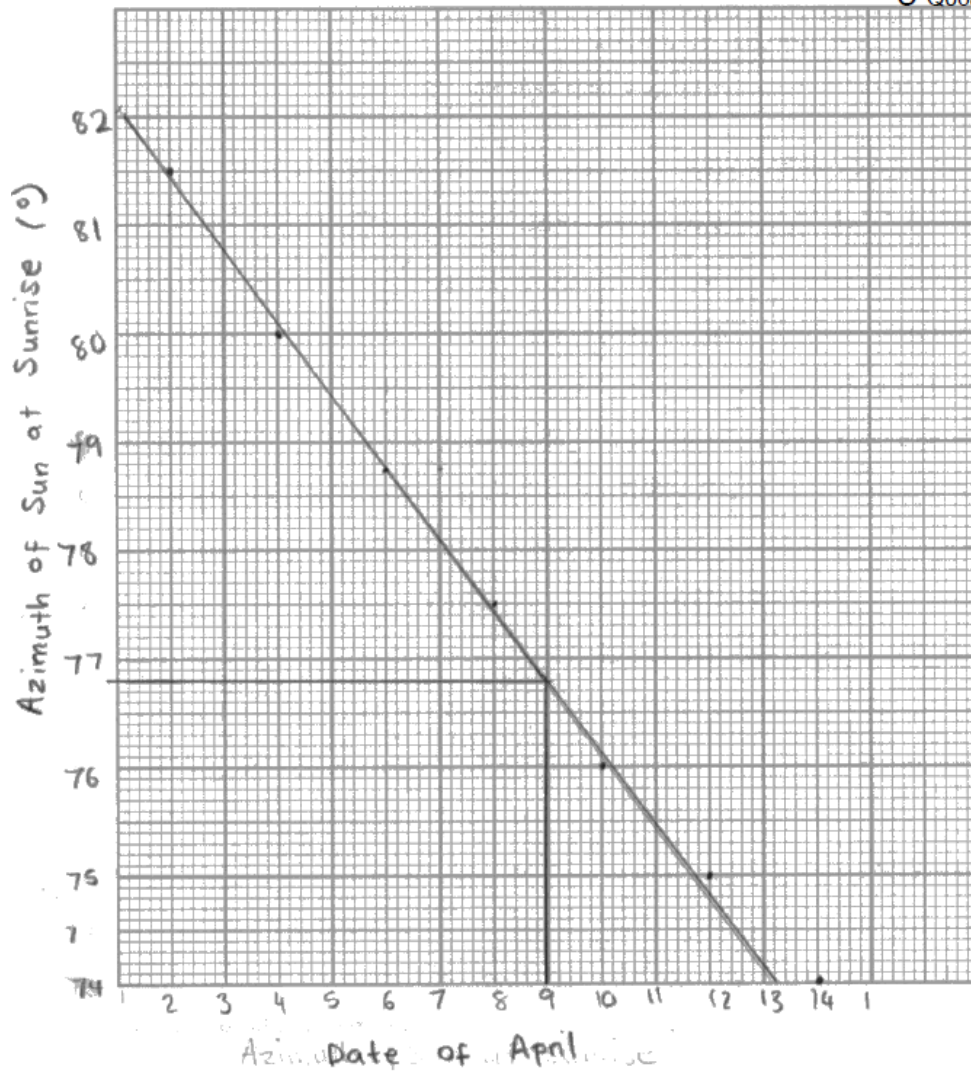


Figure 5

**Examiner comments:** this student's graph meets all three of the required marking points with good use of the space available, correctly labelled axes, correctly plotted points and a line of best fit.

**Mark awarded = 3**

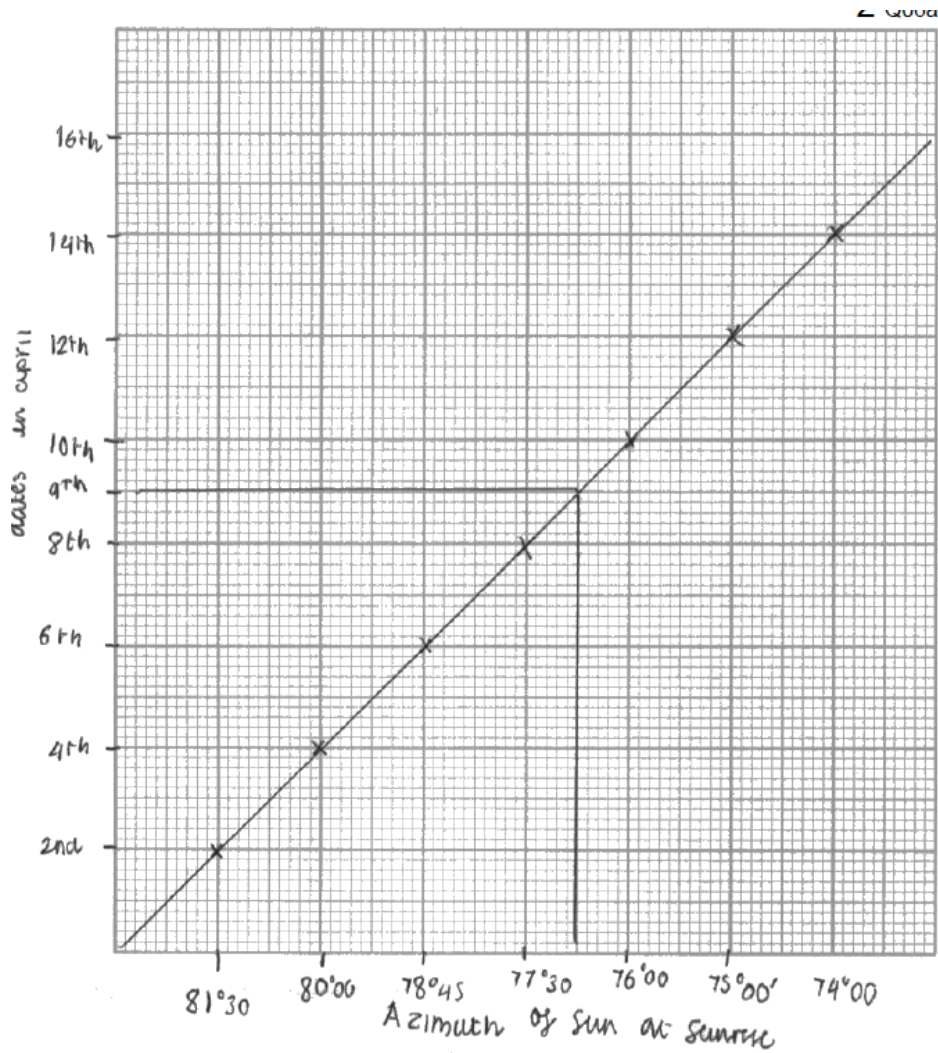


Figure 5

**Examiner comments:** Although there are a number of issues with this student's graph, they (perhaps fortunately) only result in the loss of one mark. Firstly, the student has chosen to plot the independent variable (date) on the vertical axis of the graph. Secondly, they have plotted the azimuth scale in reverse, resulting in an incorrect line of best fit.

**Mark awarded = 2**

## Example 11 – Question 6b

- (b) Evaluate the suggestion that the Sun shines through Box Hill Tunnel on only one occasion each year – at sunrise on 9th April.

Use information from Figure 4, Table 4 and Figure 5.

(6)

### Mark scheme

Question number	Answer	Mark
6(b)	<p><b>Marking instructions</b></p> <p>Markers must apply the descriptors in line with the general marking guidance and the qualities outlined in the levels-based mark scheme below.</p> <p><b>Indicative content guidance</b></p> <p>The indicative content below is not prescriptive and candidates are not required to include all of it. Other relevant material not suggested below must also be credited. Relevant points may include:</p> <ul style="list-style-type: none"> <li>• Tunnel is straight so possible for Sun to shine through it</li> <li>• Azimuth of Sun on 9<sup>th</sup> April is similar to angle of tunnel</li> <li>• Tunnel points roughly E NE/WSW – close to direction of spring sunrise/set</li> <li>• During year, Sun rises at all angles between NE and SE</li> <li>• Sun must shine through at sunset on another (autumn) day</li> <li>• Sun must shine through tunnel either twice or no times each year.</li> <li>• Small changes in azimuth each day/tunnel is quite wide so Sun should shine through on several days (around 9<sup>th</sup> April).</li> </ul>	(6)

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1-2	<ul style="list-style-type: none"> <li>• Basic interpretation and evaluation of the data/information may be attempted but will be limited and narrow in scope. (AO3)</li> <li>• The response will contain basic information with little linkage between points made. Lines of reasoning may be attempted but are incomplete or lack clarity. A conclusion may be attempted but lacks support. (AO3)</li> </ul>
Level 2	3-4	<ul style="list-style-type: none"> <li>• Interpretation and evaluation of the data/information that Attempts to synthesise and integrate relevant knowledge. (AO3)</li> <li>• The response shows some linkages and lines of reasoning with some structure, leading to a conclusion that is partially supported. (AO3)</li> </ul>
Level 3	5-6	<ul style="list-style-type: none"> <li>• Comprehensive interpretation and evaluation of the data/information that demonstrates the skills of synthesising and integrating relevant knowledge throughout the response. (AO3)</li> <li>• The response shows a well-developed, sustained line of scientific reasoning which is clear, coherent and logically structured, leading to a supported conclusion. (AO3)</li> </ul>

## Student answers

(b) Evaluate the suggestion that the Sun shines through Box Hill Tunnel on only one occasion each year – at sunrise on 9th April.

Use information from Figure 4, Table 4 and Figure 5.

=> near perfectly parallel

=> sunset

=> sunset

=> direction of sun direction 2012

NE  
ESE

Q06

The suggestion that the Sun does shine through Box Tunnel at sunrise on 9th April is ~~correct~~ ~~disregarding~~ probably correct ~~for~~ since the angle between its eastern entrance and ~~the~~ due north looks to be roughly  $77^\circ$ . However this would require that the weather was clear and that trees do not block the Sun's light. However, this is not the only occasion each year. Firstly, the direction of sunrise is east on the vernal equinox before moving to northeast for the summer solstice. ~~Then~~ Between these times is the first occasion on the 9th April, but as the direction comes back to east for the vernal equinox, it will cross  $77^\circ$  azimuth again, some time in August. Furthermore, the Sun ~~will~~ will shine through the tunnel west to east at sunset on two occasions – the 9th April and the ~~the~~ aforementioned date in August.

**Examiner comments:** This student's response shows the skills of synthesis and integration required for Level 2. Evidence supporting their conclusion is clearly presented and additional qualifications related to other occasions when the Sun shines through Box Tunnel are well integrated. The student has mentioned a number of points from the Indicative Content lost and thus scores the higher of the marks in the level 2 band.

**Mark awarded = 4**

(b) Evaluate the suggestion that the Sun shines through Box Hill Tunnel on only one occasion each year – at sunrise on 9th April.

Use information from Figure 4, Table 4 and Figure 5.

(6) Q06t

• when shining directly through azimuth should be east =  $90^\circ$

• sun rises in east

• as dates go on azimuth gets further away from  $90^\circ$  -

April 9th  $\approx 76^\circ$

April 2nd =  $81^\circ 30'$

↙ closer to east, ~~shining~~ closer to shining directly through than April 9th

claim is wrong

will likely shine directly through in May

**Examiner comments:** This student's response is presented as a list of short phrases which makes it more difficult for linkages and smooth synthesis to be demonstrated. The response also seems to link shining through the tunnel with shining east, which is not correct.

As a result, this response does not meet the requirements of a Level 2 answer.

**Mark awarded = 2**

## Example 12 – Question 7a

7 Owen is planning to make some naked-eye observations of the Milky Way.

(a) Describe how the Milky Way appears in the night sky to a naked-eye observer.

(2)

### Mark scheme

Question number	Answer	Mark
7(a)	Any <b>two</b> from: <ul style="list-style-type: none"> <li>• faint hazy band(s) of light</li> <li>• contains a large number of stars</li> <li>• crossed by dark patches</li> <li>• stretches across (large area of) sky.</li> </ul>	(2)

### Student answers

7 Owen is planning to make some naked-eye observations of the Milky Way.

(a) Describe how the Milky Way appears in the night sky to a naked-eye observer.

(2) 2 Q07:

A band of <sup>smudges</sup> faint light across  
the sky.

**Examiner comments:** Although only one sentence, this response covers two of the points in the mark Scheme. It establishes that the Milky Way is a faint band of light and that it stretches across the sky and thus scores full marks.

**Mark awarded = 2**

7 Owen is planning to make some naked-eye observations of the Milky Way.

(a) Describe how the Milky Way appears in the night sky to a naked-eye observer.

(2) 1 Q07a

a hazy line through the night sky. seen surrounded by many  
stars

**Examiner comments:** this response contains little specific information but does indicate that the Milky Way stretches across the sky, allowing it to meet one of the points on the Mark Scheme.

**Mark awarded = 1**

7 Owen is planning to make some naked-eye observations of the Milky Way.

(a) Describe how the Milky Way appears in the night sky to a naked-eye observer.

(2) 0 Q07a

as a random shape of stars and gas

**Examiner comments:** this response uses very general terms which could apply to a wide range of astronomical objects which is never advisable when describing a specific object like the Milky Way.

Although the Milky Way contains stars and gas, the question asks for a naked-eye description, making it not possible to credit this point.

**Mark awarded = 0**

## Example 13 – Question 7bii

- (ii) State **two** advantages of using a planisphere, rather than a star map, when planning observations.

(2)

1 .....

.....

2 .....

.....

### Mark scheme

Question number	Answer	Additional Guidance	Mark
7(b) (ii)	Indicates position of objects relative to horizon/meridian.	Accept: 'shows which objects are above horizon' / 'shows objects' altitude/azimuth'	(1)
	Takes account of observer's location/date/time.		(1)

## Student answers

(ii) State **two** advantages of using a planisphere, rather than a star map, when planning observations.

(2) 2 Q07b

1 You can see your horizon

2 You can move the sky to see a specific date's precise night sky.

**Examiner comments:** This response makes both points in the Mark Scheme, although its first point would have benefitted from being expressed a little more clearly. "You can see your horizon" is not entirely clear but just about indicates that a planisphere includes the observer's horizon – unlike a star chart.

The second point is much more completely expressed and comfortably achieves the second marking point.

**Mark awarded = 2**

(ii) State **two** advantages of using a planisphere, rather than a star map, when planning observations.

(2) 1 Q07bii

1 specific to the date of observation

2 specific to the location of the observer

**Examiner comments:** This response makes two correct points about a planisphere but they both relate to the same (second) point in the Mark Scheme, giving the student only one mark for this response.

**Mark awarded = 1**

(ii) State **two** advantages of using a planisphere, rather than a star map, when planning observations.

(2) Q07bii

1 a planisphere gives exact dates and times whereas a  
star map doesn't

2

**Examiner comments:** Although this response refers to a planisphere's use of dates and times, the phrase "gives exact dates and times" is not correct. A planisphere can be adjusted to allow for the date and time of the observation but this is not 'giving' dates and times. The response does not therefore meet the requirements of the second marking point.

**Mark awarded = 0**



## Mark scheme

Question number	Answer	Mark
7(c)	<p><b>Marking instructions</b> Markers must apply the descriptors in line with the general marking guidance and the qualities outlined in the levels-based mark scheme below.</p> <p><b>Indicative content guidance</b> The indicative content below is not prescriptive and candidates are not required to include all of it. Other relevant material not suggested below must also be credited. Relevant points may include:</p> <ul style="list-style-type: none"> <li>• Red safelight to preserve dark adaptation</li> <li>• Observing site away from street/house lights</li> <li>• Faint object being observed</li> <li>• Need to avoid view being blocked by large hills shown</li> <li>• Star charts available for accurate positioning of sketches</li> <li>• Repeat observations</li> </ul>	(6)

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1-2	<ul style="list-style-type: none"> <li>• Basic interpretation and evaluation of the data/information may be attempted but will be limited and narrow in scope. (AO3)</li> <li>• The response will contain basic information with little linkage between points made. Lines of reasoning may be attempted but are incomplete or lack clarity. A conclusion may be attempted but lacks support. (AO3)</li> </ul>
Level 2	3-4	<ul style="list-style-type: none"> <li>• Interpretation and evaluation of the data/information that Attempts to synthesise and integrate relevant knowledge. (AO3)</li> <li>• The response shows some linkages and lines of reasoning with some structure, leading to a conclusion that is partially supported. (AO3)</li> </ul>
Level 3	5-6	<ul style="list-style-type: none"> <li>• Comprehensive interpretation and evaluation of the data/information that demonstrates the skills of synthesising and integrating relevant knowledge throughout the response. (AO3)</li> <li>• The response shows a well -developed, sustained line of scientific reasoning which is clear, coherent and logically structured, leading to a supported conclusion. (AO3)</li> </ul>

## Student answers

Design a suitable observing programme that will allow Owen to make accurate sketches of the Milky Way.

Use information from Figure 7 to help you include suggestions for an appropriate observing site.

(6) 4 Q07

Owen should observe the milky way at 10pm every ~~5 days~~ ~~week~~ for 2 days for a month drawing it at 10pm then two hours later at 12pm. He should plan his observations around the weather selecting clear cloudless nights for an unobstructed view. He should also not look at any screen or light for at least an hour before to ensure his eyes are dark adapted ~~to~~ so he can view the milky way in more detail. He should make his observation from on top of the hill in Figure 7 where there are a lack of trees and structures to obscure his view.

He should observe from the edge of the hill on the left side so he can see the horizon clearly and so if the Milky Way is lower in the sky it is still visible. Also, being further away from the urban area and above it means there will be less light pollution when observing so he can create more accurate drawings as the stars appear more prominent in the sky, not ~~be~~ effectively dimmed against a lighter background of light pollution. On every drawing he should record the viewing conditions of the evening with the Antoniadi scale ranging from 1 to 5 with 5 the best, clearest conditions and ~~one~~ 1 the worst with lots of atmospheric turbulence and light pollution. He should order his sketches chronologically so he can determine the best most accurate one and ignore anomalies.

**Examiner comments:** This student's response synthesises the information in the question and integrates this with considerable additional knowledge and understanding, thus comfortably meeting the standards required for Level 2.

The response offers a number of the practical suggestions for observing the Milky Way listed in the Indicative Content, putting it in the upper half of the Level 2-mark band.

**Mark awarded = 4**

Design a suitable observing programme that will allow Owen to make accurate sketches of the Milky Way.

Use information from Figure 7 to help you include suggestions for an appropriate observing site.

(6) 3 Q07

• date: when there are clear Milky Way Galaxy is closest to zenith / appears to culminate

• environment: unobstructed view of sky e.g. no tall buildings, little light pollution, clear skies / not cloudy, calm atmosphere to prevent twinkling

• before: go outside about 30 mins before

scheduled observation time to give eyes time for dark adaptation

during: use red light to ~~prev~~ when drawing as this won't cause light pollution

before: predraw a circle to make sketching quicker

**Examiner comments:** The 'bullet point list' style of writing is well suited to questions asking for the design of an observational programme. It allows the sequence of preparations, observations and precautions to be clearly established. As in this example, this can then result in a response worthy of Level 2.

This student has also written almost complete sentences for each bullet point, further strengthening their responses' position in Level 2. They have also mentioned some of the points from the Indicative Content list in the Mark Scheme.

**Mark awarded = 3**

## Example 15 – Question 8a

- 8 (a)** In the third century BCE, the Greek astronomer Aristarchus made observations of a last quarter Moon.

He used these observations to calculate how many times further away from the Earth the Sun was than the Moon.

Explain how he was able to do this.

You may include a clearly labelled diagram in your answer.

(4)

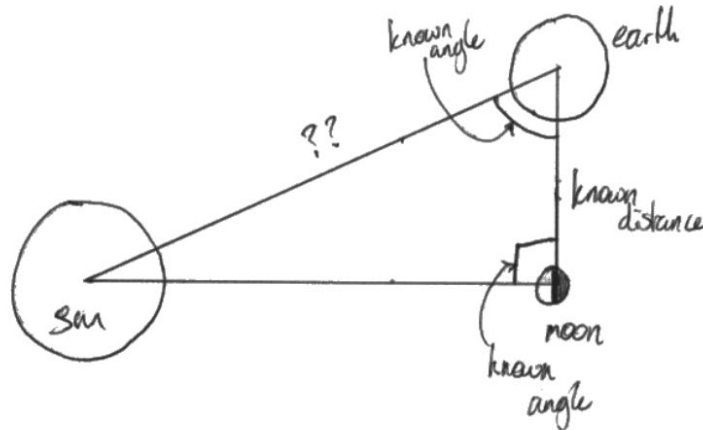
### Mark scheme

Question number	Answer	Mark
<b>8(a)</b>	Right-angled triangle between E, M and S (at quarter Moon phase)...	(1)
	...with Moon at right angle	(1)
	Measurement of angle between Moon and Sun (from Earth)	(1)
	Trigonometry/scale drawing to find ratio of E-S/E-M sides.	(1)
	<i>(Marks can be established by text or labelled diagram)</i>	

## Student answers

You may include a clearly labelled diagram in your answer.

14 Q08a



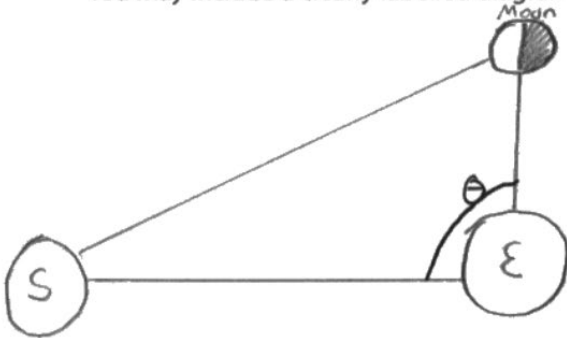
Aristarchus measured the angle between the moon and sun ( $\sim 90^\circ$  as it is last quarter phase), he knew the distance from earth to moon, and he knew the angle between the moon and the earth  $\therefore$  using distance to sun =  $\cos(\text{earth-moon angle}) \cdot (\text{distance from earth-moon})$ .

**Examiner comments:** This student has made very effective use of both text and a carefully labelled diagram to address all four of the points in the Mark Scheme, thus scoring full marks.

**Mark awarded = 4**

You may include a clearly labelled diagram in your answer.

(4) 3 Q08a



$$\frac{1}{\cos\theta} = \frac{d_s}{d_m}$$

At last quarter, Aristarchus knew that the Sun-Earth-Moon angle was nearly  $90^\circ$ . By measuring the angle between the Sun and Moon indicated by  $\theta$ , he could apply basic geometry ( $\frac{1}{\cos\theta}$ ) to work out the factor you must multiply the distance to the Moon by to get the distance to the Sun.

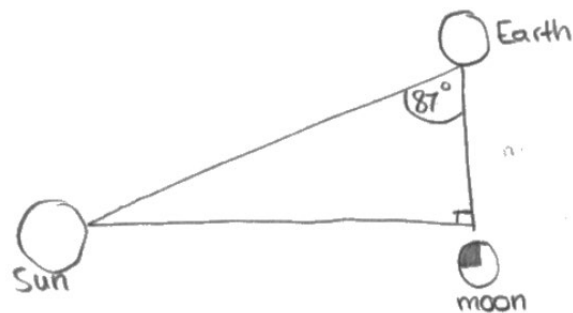
**Examiner comments:** This high-quality response to this demanding question achieves almost all the points listed in the Mark Scheme, using both text and a labelled diagram.

The student's only mistake has been to place the Earth, instead of the Moon at the right angle in their triangle.

**Mark awarded = 3**

You may include a clearly labelled diagram in your answer.

(4) 3 Q08a



- moon at half phase
- $90^\circ$  to earth and sun
- found angle between moon and sun to be  $\approx 87^\circ$
- distance between earth and moon known
- pythagorus to work out distance between earth and sun

**Examiner comments:** This student has used a bullet-point list for the text in their answer, which is an effective way of describing an observational procedure. Their description of Aristarchus' method is almost correct but the wrong lunar phase is indicated in both their text and diagram, which has lost them a mark.

**Mark awarded = 3**

## Example 16 – Question 8bi

- (b) Aristarchus combined his measurement with other measurements to estimate the distance from the Earth to the Sun.

A summary of these measurements is shown in Table 5.

Measurement	Value
Radius of Earth	6 300 km
Ratio of distance to Moon and diameter of Earth	10
Ratio of distance to Sun and distance to Moon	19

**Table 5**

- (i) Calculate a value for the distance from the Earth to the Sun.

Use the information in Table 5.

Show each stage in your working clearly.

(3)

Distance from the Earth to the Sun = ..... km

## Mark scheme

Question number	Answer	Mark
8(b) (i)	<u>2 394 000</u> (km) (accept 2 400 000 (km))	(3)
	Any <b>two</b> from: Doubling of Earth's radius (12 600km) Multiplication by 10 or 19 / use of 190	(2)

## Student answers

- (i) Calculate a value for the distance from the Earth to the Sun.

Use the information in Table 5.

Show each stage in your working clearly.

(3) 3 Q08

$$6300 \times 2 = 12600$$

$$\text{distance to moon} = 10 \times 12600 = 126000$$

$$\text{distance of sun} = 19 \times 126000 = 2394000$$

Distance from the Earth to the Sun = 2394000 km

**Examiner comments:** This student has correctly completed the calculation for this question, including noticing that the radius of the Earth, given in Table 5, needs to be doubled before combining with the other numbers in the table.

They have also sensibly included evidence of the stages in their working. This would have ensured that they would have still gained some marks even if their final answer had been incorrect.

**Mark awarded = 3**

(i) Calculate a value for the distance from the Earth to the Sun.

Use the information in Table 5.

Show each stage in your working clearly.

(3) 1 Q08

$$6300 \div 10 \times 19 = 11970$$

Distance from the Earth to the Sun = 11970 km

**Examiner comments:** This student's calculation has resulted in an incorrect answer due to division by one of the ratios given in Table 5 instead of multiplication. However, due to the provision of working, some credit can be given for a correct multiplication by the solar/lunar distance ratio, which is part of the correct solution.

**Mark awarded = 1**

## Example 17 – Question 8bii

- (ii) Calculate the percentage error in your value for the distance from the Earth to the Sun.

Use information from the Formulae and Data Sheet.

Use the equation:

$$\text{Percentage error} = \frac{(\text{Calculated distance} - \text{true distance})}{\text{True distance}} \times 100\% \quad (2)$$

Percentage error = .....%

### Mark scheme

Question number	Answer	Mark
8(b) (ii)	<p><b>98</b>(.4) (%) (or figure consistent with their (i))</p> <p>Any <b>one</b> from:            Calculation of error:            (150 000 000 – 2 394 000) = 147 606 000 (km)            Division by 150 000 000(km)</p>	<p><b>(2)</b></p> <p>(1)</p>

## Student answers

$$\text{Percentage error} = \frac{(\text{Calculated distance} - \text{true distance})}{\text{True distance}} \times 100\% \quad (2)$$

$$\frac{7,394,000 - (1.5 \times 10^8)}{1.5 \times 10^8} \times 100$$

$$= -98.4$$

$$\text{Percentage error} = \underline{\quad 98.4 \quad} \%$$

**Examiner comments:** Following on from the equation given in the question, this student has shown clearly which numbers are being substituted for which variables and how the final answer is calculated.

On this occasion, the correct answer is produced, gaining the student full marks. In addition, if the final answer had been incorrect, this student could still have achieved one mark, for their clear working.

**Mark awarded = 2**

$$\text{Percentage error} = \frac{(\text{Calculated distance} - \text{true distance})}{\text{True distance}} \times 100\% \quad (2)$$

$$1.0 \times 1.5 \times 10^8 = 1.5 \times 10^8$$

$$\frac{(182700 - 1.5 \times 10^8)}{1.5 \times 10^8} \times 100\% = -0.998782$$

$$\text{Percentage error} = -0.998782\%$$

**Examiner comments:** This student calculated the Earth-Sun distance as 182 700km in the previous question (8bi). However, they have correctly calculated the percentage error of this value in this question, showing their working clearly.

It is therefore possible for them to score full marks on this question as the only reason for their incorrect final answer would be their earlier error in Q8bi. However, despite including it in their working they have forgotten to convert their fractional error into a percentage error by multiplying by 100. They therefore lose a mark, as percentage error is specifically requested in the question.

**Mark awarded = 1**

## Example 18 – Question 8b(iii)

- (iii) Astronomers in ancient times were able to make very accurate observations of objects in the sky.

However, estimates of the distance from the Earth to the Sun in ancient times were very inaccurate.

Explain why these estimates were very inaccurate.

(2)

### Mark scheme

Question number	Answer	Additional Guidance	Mark
8(b) (iii)	Sequence of (different) measurements/observations needed (to find E-S distance)  (Small) errors in each measurement combined/compounded in final E-S distance.	Reject: in ancient times measurements were inaccurate / no modern technology/ no telescopes were available.	(1)  (1)

### Student answers

Explain why these estimates were very inaccurate.

This is because you need to take a lot of measurements to work out the E-S distance + each one has its own errors. (2)

**Examiner comments:** This response clearly indicates the need for multiple observations and measurements when calculating the Earth-Sun distance and the fact that each contributes to the inaccuracy of the final value. The response has therefore met both the points required by the Mark Scheme.

**Mark awarded = 2**

Explain why these estimates were very inaccurate.

(2) 1 Q8biii

Calculations of this heavily reliant on previous calculate inaccurate calculations like Earth to moon distance. Therefore, Astronomers Earth to Sun value is also inaccurate.

(Total for Question 8 = 11 marks) **10**

**Examiner comments:** This response strongly implies that the Earth-Sun distance relies on (at least one) earlier observation and thus inevitably inherits observational errors from it. It has thus gained the second marking point in the Mark Scheme.

**Mark awarded = 1**

Explain why these estimates were very inaccurate.

(2) 0 Q8bii

- technological differences  
 - our satellites make it easier to get more accurate  
~~more~~ estimates.

**Examiner comments:** This response presents the popular idea that ancient estimates for the astronomical unit were inaccurate due to a lack of modern technology such as telescopes and satellites. However, there are numerous examples of the high precision of ancient astronomical observations. Calculation of the astronomical unit was achieved by combining several observations, resulting in substantial compound error, which is not mentioned in this response.

**Mark awarded = 0**

## Example 19 – Question 9a

- 9 Figure 8 shows the weather vane at Sydney Observatory in Australia. The photograph was taken shortly after local noon on 21st March.



Figure 8

Sydney has a latitude of  $34^{\circ}\text{S}$ .

- (a) Calculate the altitude and azimuth of the Sun at local noon in Sydney on 21st March.

(4)

Altitude = .....

Azimuth = .....

### Mark scheme

Question number	Answer	Mark
9(a)	<b>Altitude = <math>56^{\circ}</math></b>	<b>(3)</b>
	Any <b>two</b> from: <i>Calculation of co-latitude (<math>90^{\circ} - 34^{\circ}</math>)</i> <i>Sun on Celestial Equator</i> <i>Declination of Sun = <math>0^{\circ}</math></i>	(2)
	<b>Azimuth = <math>0^{\circ}</math></b> (accept '(due) North')	<b>(1)</b>

### Student answers

Sydney has a latitude of  $34^{\circ}\text{S}$ .

☺

- (a) Calculate the altitude and azimuth of the Sun at local noon in Sydney on 21st March.

(4) 4 Q09:

$$90 + 34 = \cancel{124} \quad 90 - 34^{\circ}!$$

$$90 - 34^{\circ} = 56^{\circ} \quad \text{why 4 marks}$$



Altitude = ~~124~~  $56^{\circ}$

Azimuth = ~~0~~  $0^{\circ}$

**Examiner comments:** This student has correctly calculated both parts of this question and thus receives full marks. They have also shown their calculations so that they would still receive some credit if their final answers were incorrect. A further improvement to their working would be to include the astronomical ideas that they have used such as the Sun being on the celestial equator and having a declination of  $0^{\circ}$ . In this way they would be certain of scoring almost all the marks, even if their final answer was not correct.

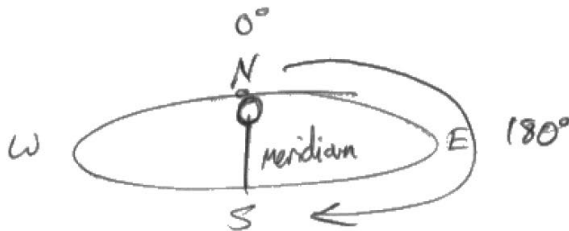
**Mark awarded = 4**

(a) Calculate the altitude and azimuth of the Sun at local noon in Sydney on 21st March.

↻ vernal equinox

$$90 - 34 = 56^\circ$$

(4) 3 Q09e



Altitude = ~~34~~ 56<sup>n</sup> °

Azimuth = 180 °

**Examiner comments:** This student has correctly calculated the Sun's altitude but not its azimuth and thus scores three marks. Their working shows their altitude calculation clearly but would have provided even stronger support in the event of an incorrect final answer if the astronomical reasons behind subtracting 34° from 90° were stated, as shown in the Mark Scheme.

Sketches of the Earth relative to the celestial sphere and of the observer's horizon are excellent aids in question like this and this candidate has made use of both. Sadly, they have not prevented the candidate from the common assumption of the Sun being due south, rather than due north, at noon.

**Mark awarded = 3**

(a) Calculate the altitude and azimuth of the Sun at local noon in Sydney  
on 21st March.

altitude  
SCP = 34° ~~W~~ S

(4) Q09a

Spring equinox = Dec = 0

$$\begin{aligned} PD &= 90 - \text{Dec} \\ &= 90 - 0 \\ &= 90 \end{aligned}$$

Altitude = 90°

Azimuth = 180°

**Examiner comments:** This response does not arrive at the correct answer for either part of the question. However, the student has made an effort to set out not only their calculations but also the astronomical ideas that they have used. As a result, they have gained one mark for pointing out that the Sun has a declination of zero at the spring equinox.

As with many candidates who live in the northern hemisphere of the Earth, the candidate has also assumed that the Sun will be due south at noon (180° azimuth) whereas, as the photograph shows, the Sun is due north (0° azimuth) at noon in Sydney.

This response would also have benefitted from more thorough checking of the answers. Further thought about the altitude of 90° for the Sun would reveal that it cannot be correct as Sydney is comfortably outside the Earth's tropical zone (23½°N to 23½°S latitude).

**Mark awarded = 1**

## Example 20 – Question 9b

(b) On 21st June, the Sun reaches its highest point in the sky in Sydney at 01:53 GMT.

The Equation of Time on 21st June is +2 minutes.

Calculate the longitude of Sydney.

Give your answer to the nearest degree.

(4)

Longitude of Sydney = .....°

### Mark Scheme

Question number	Answer	Mark
9(b)	<b>151°</b> (151¼°)	<b>(3)</b>
	Any <b>one</b> from: Correct calculation of local <i>mean</i> time in Sydney (using Equation of Time): <b>11:58</b> Correct calculation of apparent solar time in Greenwich (using Equation of Time): <b>01:55</b>	(1)
	Any <b>one</b> from: Dividing their time difference (mins) by 4 Correct calculation of time difference between Sydney and Greenwich (12:00-01:55 or 11:58-01:53): <b>10h 5min</b> or <b>605mins</b>	(1)
	East (E)	<b>(1)</b>

## Student answers

(b) On 21st June, the Sun reaches its highest point in the sky in Sydney at 01:53 GMT.

The Equation of Time on 21st June is +2 minutes.

Calculate the longitude of Sydney.

Give your answer to the nearest degree.

(4) 3 Q09b

$$\begin{aligned}
 \text{EOT} &= \text{AST} - \text{MST} \\
 2 &= \text{AST} - 01:53 \\
 \text{AST} &= 01:55 \\
 12:00 - 01:55 &= 605 \text{ mins} \\
 150 &\div 1 \text{ hr} \\
 15 \times \frac{605}{60} &= 151.25 \\
 &\approx 151
 \end{aligned}$$

Longitude of Sydney =  $151^\circ$   
 ~~$151^\circ \text{W}$~~

**Examiner comments:** This response shows a correct calculation of the angular distance between Sydney and the Prime Meridian, accompanied by calculations with some astronomical justification. The working shown could be enhanced further by stating the astronomical significance of each calculated number.

Unfortunately, this response does not indicate that the calculated longitude is East of the Prime Meridian and thus a mark is lost.

**Mark awarded = 3**

Calculate the longitude of Sydney.

Give your answer to the nearest degree.

(4) 2 Q09b

$$\begin{array}{l}
 \text{AST} \xrightarrow{\text{EOT}} \text{MST} \xrightarrow{\text{Long}} \text{GMT} \\
 12:00 \rightarrow \cancel{11:58} \rightarrow 1:53 \\
 \\
 \text{MST} = \text{AST} - \text{EOT} \\
 \text{MST} = 12:00 - 2 \\
 \\
 \downarrow \\
 01:55 \\
 \\
 4 \text{ min} = 1^\circ
 \end{array}$$

Longitude of Sydney = 29°

**Examiner comments:** The key to this question is calculating the time difference between Sydney and Greenwich, either by comparing their apparent solar times or by comparing their mean times. This student's response appears to complete only the first stage of both methods. The AST in Greenwich (01:55) is calculated (although not labelled) and the calculation for the mean time in Sydney (12:00 - 2) is also shown. This response therefore effectively gains the same working mark twice.

The response also gains a second mark as there is evidence that the student understands the need to divide the number of minutes by four to find the number of degrees of longitude. Although not explicitly shown in their working, they have divided the AST in Greenwich by four to arrive at their final answer.

**Mark awarded = 2**

(b) On 21st June, the Sun reaches its highest point in the sky in Sydney at 01:53 GMT.

The Equation of Time on 21st June is +2 minutes.

Calculate the longitude of Sydney.

Give your answer to the nearest degree.

$$01:53 + 00:02 = 01:55$$

(4) 1 Q09t

Longitude of Sydney = .....

**Examiner comments:** This response does not progress very far through the many stages towards the final answer. However, the student has correctly calculated the apparent solar time in Greenwich, which gains one mark.

The next stage would have been to compare this value of the AST in Greenwich with the AST in Sydney, given in the question.

**Mark awarded = 1**

## Example 21 – Question 9c

(c) The star Canopus culminates at an altitude of  $71^{\circ}18'$  when observed from Sydney.

Calculate the declination of the star Canopus.

(3)

Declination = .....<sup>o</sup>.....'

### Mark scheme

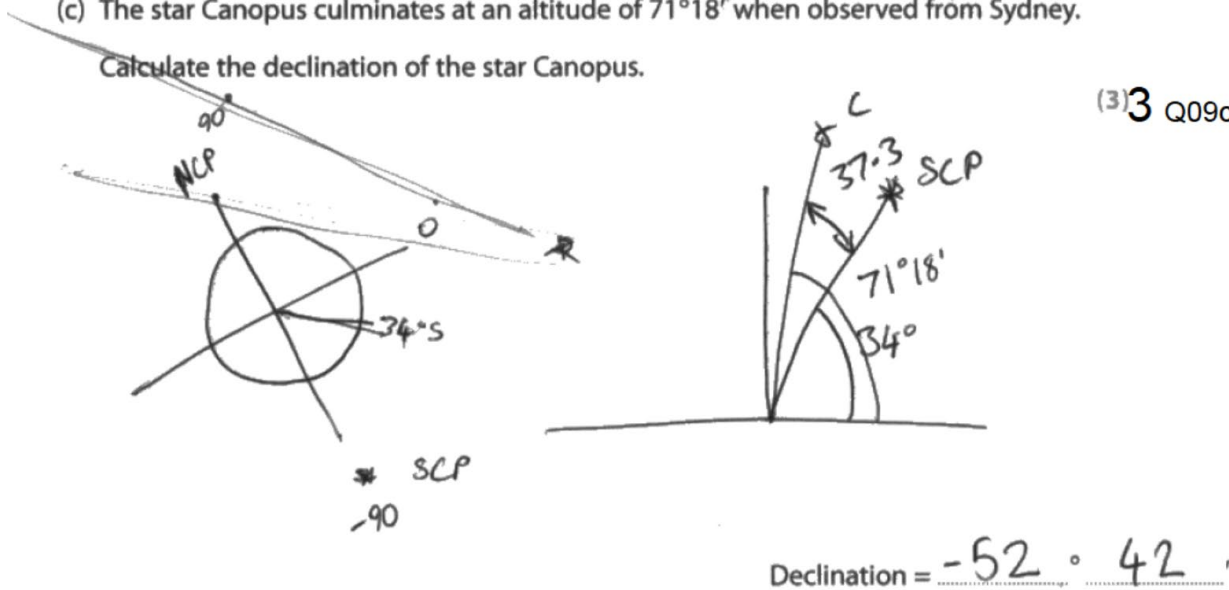
Question number	Answer	Mark
9(c)	<b>-52° 42'</b> ( $52^{\circ} 42'$ or $52^{\circ} 42'S$ score 2) <i>37° 18' scores (2)</i>	<b>(3)</b> (2)
	Or Calculation of altitude of SCP from Sydney ( $34^{\circ}$ ) Subtraction of altitude of SCP ( $34^{\circ}$ ) from altitude of Canopus ( $71^{\circ}18'$ )	(1) (1)
9(c)	Allow: <b>-15° 18'</b> ( $15^{\circ} 18'$ or $15^{\circ} 18'S$ score 2)	<b>(3)</b>
	Or: Calculation of altitude of Celestial Equator from Sydney ( $56^{\circ}$ ) Subtraction of (northern) altitude of Canopus ( $71^{\circ}18'$ ) from altitude of Celestial Equator ( $56^{\circ}$ )	(1) (1)

## Student answers

(c) The star Canopus culminates at an altitude of  $71^{\circ}18'$  when observed from Sydney.

Calculate the declination of the star Canopus.

(3) 3 Q09c



**Examiner comments:** This student has correctly calculated the declination of the star Canopus, remembering that it is in the southern half of the celestial sphere and therefore has a negative declination.

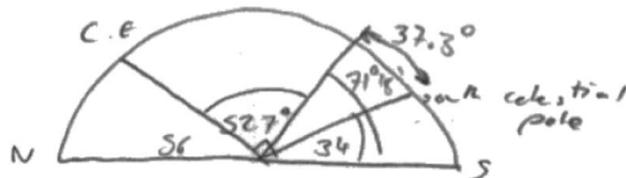
Although the arithmetical operations to arrive at the correct answer are quite simple, this question requires the candidate to visualise the relationship between the observer's horizon, the celestial equator or poles and the star Canopus. This successful student has clearly made use of both horizon and celestial sphere sketches to help them in this demanding question.

**Mark awarded = 3**

(c) The star Canopus culminates at an altitude of  $71^{\circ}18'$  when observed from Sydney.

Calculate the declination of the star Canopus.

(3) 2 Q09c



Declination = 52 ° 42 ,

**Examiner comments:** This student's response again shows the importance of using a diagram to visualise the situation presented in this demanding question. The key to this question lies in visualising the relative positions of the observer's horizon, the celestial equator and Canopus. This student's 'cross section' along the observer's meridian has shows this very clearly and has allowed them to find the correct angle for the declination of Canopus.

Sadly, the fact that Canopus is south of the celestial equator and thus has a negative declination has been missed and has cost the student a mark.

**Mark awarded = 2**

(c) The star Canopus culminates at an altitude of  $71^{\circ}18'$  when observed from Sydney.

Calculate the declination of the star Canopus.

(3) 0 Q09c

Declination =  $45^{\circ} 45'$

**Examiner comments:** This student's response illustrates the importance of including clear working with all parts of a calculation. Although the final answer given is incorrect, up to two of the three marks for this question were available for any correct calculation or astronomical points, as shown in the Mark Scheme.

Including the calculation or astronomical thinking that led to the answer of  $45^{\circ} 45'$  could have gained the candidate one or two marks on this demanding question.

**Mark awarded = 0**

## Example 22 – Question 10b

(b) Observations of planets show that they appear to perform ‘retrograde motion’.

Explain what is meant by the ‘retrograde motion’ of a planet.

You may include a clearly labelled diagram in your answer.

(2)

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### Mark scheme

Question number	Answer	Mark
10(b)	Backwards motion/loops (of planets)	(1)
	<p>Any <b>one</b> from:</p> <ul style="list-style-type: none"> <li>• apparent motion for observers on Earth</li> <li>• relative to stars</li> <li>• over a few weeks/months</li> <li>• caused by different orbital speeds of planets. (allow ‘over-/under-taking’).</li> </ul>	(1)

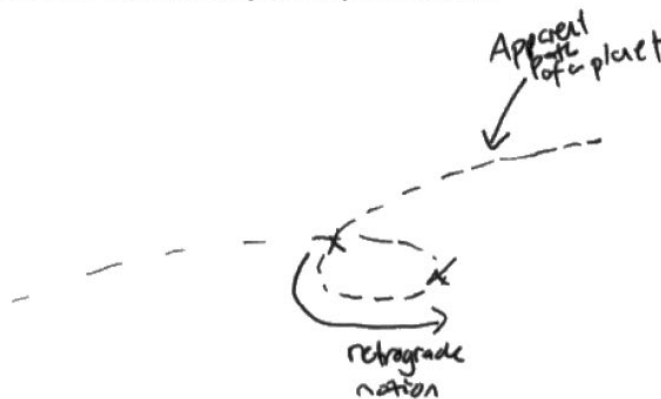
## Student answers

(b) Observations of planets show that they appear to perform 'retrograde motion'.

Explain what is meant by the 'retrograde motion' of a planet.

You may include a clearly labelled diagram in your answer.

(2) 2 Q10k



~~The~~ RETROGRADE MOTION is the apparent backwards motion of ~~stars~~ planets against background stars. It occurs ~~when~~ due to the difference in orbital periods of the Earth and other planets.

**Examiner comments:** This student has clearly demonstrated both of the marking points required by this question. Their response illustrates the effectiveness of a clearly labelled diagram. It would almost be possible to award both marks in this question for their diagram alone – a clear and labelled background of stars would be necessary for this. In this response the stellar background is fully clarified in the accompanying text, allowing full marks to be awarded.

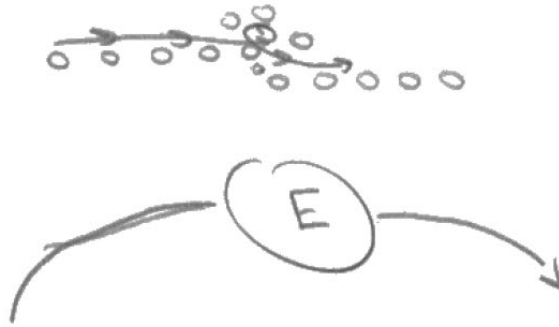
**Mark awarded = 2**

(b) Observations of planets show that they appear to perform 'retrograde motion'.

Explain what is meant by the 'retrograde motion' of a planet.

You may include a clearly labelled diagram in your answer.

(2) 1 Q10t



- When a planets orbit is slower at points, to observers  
it appears to move backwards

**Examiner comments:** It is clear that this student has a good understanding of the idea of retrograde motion. However, their response illustrates the importance of including clear labelling with all diagrams.

The text of their answer firmly establishes the idea of a backward motion and thus the first marking point is secured. The diagram looks very promising in terms of establishing the second marking point by establishing a stellar background. However, since the upper part of their diagram offers no labels for the small circles, this point cannot be awarded.

With a few words of additional labelling on the diagram, this answer would have comfortably achieved two marks.

**Mark awarded = 1**

## Example 23 – Question 10ci

- (c) (i) A student comments: “The planet Mars orbits the Sun at a distance of 1.5 AU but takes a lot more than 1.5 years to complete one orbit.”

Explain why Mars takes much more than 1.5 years to orbit the Sun.

(2)

.....

.....

.....

.....

### Mark scheme

Question number	Answer	Mark
10(c) (i)	<p>Any two from:</p> <ul style="list-style-type: none"> <li>• Because T and r are not proportional/Kepler’s Third Law</li> <li>• Calculation of actual sidereal period of Mars (1.9 years)</li> <li>• Mars moves more slowly <u>in/along its orbit</u> than Earth</li> <li>• Due to weaker gravity (at its greater distance from the Sun).</li> </ul>	(2)

## Student answers

- (c) (i) A student comments: "The planet Mars orbits the Sun at a distance of 1.5 AU but takes a lot more than 1.5 years to complete one orbit."

Explain why Mars takes much more than 1.5 years to orbit the Sun.

(2) Q10ci

This is because  $T^2$  is proportional to  $r^3$ . Therefore,  $\sqrt{1.5^3} = 1.837$ . Therefore  $T$  would equal around 1.84 years ~~at~~ and therefore more than 1.5.

**Examiner comments:** This student has correctly identified Kepler's Third law as the reason for lack of proportionality between  $T$  and  $r$  and has then gone on to illustrate this by correctly calculating the sidereal period of Mars. They therefore gain full marks for this question.

**Mark awarded = 2**

- (c) (i) A student comments: "The planet Mars orbits the Sun at a distance of 1.5 AU but takes a lot more than 1.5 years to complete one orbit."

Explain why Mars takes much more than 1.5 years to orbit the Sun.

The relationship isn't directly proportional:  $\frac{T^2}{r^3} =$  <sup>(2)</sup>1 Q10c  
 constant (~~same~~ constant same for all planets around sun).  
 This means that the constant has to equal the ~~orbit~~ time period <sup>2</sup> divided by orbital period <sup>3</sup>

**Examiner comments:** This response makes the first marking point several times and thus only scores one mark. Since the command word in the question is 'Explain...' it was necessary to move on from a statement of Kepler's Third Law to gain the second marking point.

**Mark awarded = 1**

## Example 24 – Question 10cii

(ii) The asteroid 2530 Shipka orbits the Sun at a mean distance of 3.0 AU.

Calculate the orbital period of this asteroid.

Give your answer in years.

(3)

Orbital period = ..... years

### Mark scheme

Question number	Answer	Mark
10(c) (ii)	<u>5.2</u> (years) (5.196)	(3)
	Any <b>two</b> from: Use of $T^2/r^3$ $3^3$ or 27	(2)

## Student answers

(ii) The asteroid 2530 Shipka orbits the Sun at a mean distance of 3.0 AU.

Calculate the orbital period of this asteroid.

Give your answer in years.

(3) Q10c

$$R = 3$$

$$T^2 = r^3$$

$$T^2 = (3)^3$$

$$T^2 = 27$$

$$T = 5.196$$

$$T = 5.2$$

Orbital period = 5.2 years

**Examiner comments:** This student has calculated the correct answer to this question and has also provided full and clear working, arranged in logical sequence. As well as obviously scoring full marks, they would also have scored two marks even if their final answer had been incorrect.

(In algebraic terms, the change from capital 'R' to lower case 'r' during the working is less than ideal.)

**Mark awarded = 3**

(ii) The asteroid 2530 Shipka orbits the Sun at a mean distance of 3.0 AU.

Calculate the orbital period of this asteroid.

Give your answer in years.

(3) **3** Q10ci

$$\text{earth: } \frac{1^2}{1^3} = 1$$

$$\frac{T^2}{3^3} = 1$$

$$1 \times 3^3 = T^2 = 27$$

~~END~~

$$T = 3\sqrt{3} = 5.196152423$$

Orbital period = 5.2 years

**Examiner comments:** This student has also calculated the correct answer to this question as well as providing clear working. When working in astronomical units (AU) and years, Kepler's Third Law can simply be stated as  $T^2 = r^3$ , without the need to include the constant of 1 in the early lines of the working.

Nevertheless, this student has correctly navigated their working to gain full marks. They have also noted that the nine decimal places offered by their calculator are unnecessary in this question!

**Mark awarded = 1**

(ii) The asteroid 2530 Shipka orbits the Sun at a mean distance of 3.0 AU.

Calculate the orbital period of this asteroid.

Give your answer in years.

(3) 1 Q10c

$$\begin{array}{r}
 1 \text{ AU} = 1.5 \times 10^8 \text{ km} \\
 \times 3 \qquad \qquad \times 3 \\
 \hline
 3 \text{ AU} = 450000000 \text{ km}
 \end{array}$$

orbital period = 3 years

$$\begin{array}{l}
 \frac{T^2}{r^3} = 1 \\
 \frac{(T^2)}{4500000000^3} = 1 \\
 T^2 = 1 \times (4500000000)^3 \\
 = 9.1125 \times 10^{25} \\
 \sqrt{\quad} \\
 9.5459 \dots \times 10^{12}
 \end{array}$$

$$\frac{T^2}{r^3} = 1$$

$$\frac{T^2}{3^3} = 1$$

$$\frac{T^2}{9} = 1$$

$$T^2 = 9$$

$$\sqrt{\quad} \quad \sqrt{\quad}$$

$$T = 3$$

Orbital period = 3 years

**Examiner comments:** This student's working starts off in the correct place, with a statement of Kepler's Third Law. However, in the second line 'r<sup>3</sup>' accidentally becomes 'r<sup>2</sup>', resulting in an incorrect final value.

Despite getting the wrong answer, the fact that this student has included full working means that they can still gain a mark for this question.

This response also serves as a reminder of the importance of checking final answers thoroughly before moving on to the next question. The student's algebraic slip here has resulted in a value for the sidereal period which is the same as that given for the orbital radius – something only possible under Kepler's third Law for the Earth.

**Mark awarded = 1**

## Example 25 – Question 10ciii

- (iii) An astronomer has discovered three exoplanets. These three exoplanets all orbit the same star.

Some information about the orbits of these exoplanets is shown in Table 6.

Exoplanet	Mean orbital radius (AU)	Orbital period (years)
<b>A</b>	1.5	0.64
<b>B</b>	3.0	1.81
<b>C</b>	4.5	3.33

**Table 6**

Calculate the mass of the star that these three exoplanets orbit.

Use information from Table 6.

Give your answer in solar masses.

(3)

### Mark scheme

Question number	Answer	Mark
10(c) (iii)	<b>8.2</b> (solar masses) ( <i>Accept 8.3</i> )	<b>(3)</b>
	0.12 scores 2 or any <b>two</b> from: Use of $T^2/r^3$ for one of the planets Calculation of 0.12 Calculation of average of values of $T^2/r^3$ for all three planets. Calculation of reciprocal of (their value for) $T^2/r^3$ .	(2)

## Student answers

Calculate the mass of the star that these three exoplanets orbit.

Use information from Table 6.

Give your answer in solar masses.

(3) 3 10cii

$$\frac{T^2}{r^3} = \text{constant}$$

$$\frac{(0.64)^2}{(1.5)^3} = 0.1213629\dots$$

$$\begin{array}{l} \text{constant} \\ \text{Sun} \end{array} : \begin{array}{l} \text{constant} \\ \text{star} \end{array}$$

$$= 1 : 0.12136\dots$$

$$= \frac{1}{0.12136\dots}$$

$$= 8.239746\dots$$

Mass of star = 8.2 solar masses

**Examiner comments:** This student has correctly calculated the value of  $T^2/r^3$  (for Exoplanet A) and then divided it into one to gain the correct answer for this question. Their answer is accompanied by clear calculations and this is thus a strong example of a response gaining full marks.

**Mark awarded = 3**

Calculate the mass of the star that these three exoplanets orbit.

Use information from Table 6.

Give your answer in solar masses.

(3) 2 10cii

$$\frac{T^2}{r^3} = k$$

$$\begin{array}{l} \text{A) } \frac{0.64^2}{1.5^3} = 0.121362963 \\ \text{B) } \frac{1.81^2}{3.0^3} = 0.121337037 \\ \text{C) } \frac{3.33^2}{4.5^3} = 0.12169\dots \end{array} \left. \vphantom{\begin{array}{l} \text{A) } \\ \text{B) } \\ \text{C) } \end{array}} \right\} 0.12$$

Mass of star = 0.12 solar masses

**Examiner comments:** This student is clear the answer to this question lies in calculating the value of  $T^2/r^3$ . They have also realised that calculating this value for all three exoplanets and taking an average will increase accuracy. They have shown their working clearly and arrived at a mean value of 0.12 solar masses.

However, in common with many students, they have forgotten that the mass of the central star is **inversely** proportional to this constant. The correct answer is thus  $1/0.12$  or 8.33 solar masses.

This response underlines the importance of checking the size of any numerical answer before moving on to the next question. There are a number of clues in the table that the central star in this exoplanetary system is much more massive than the Sun. Exoplanet A, for example, orbits at a similar distance to that of Mars around the Sun. However, instead of having an orbital period of 1.88 years, it completes an orbit in just 0.64. This indicates that it is in a much stronger gravitational field than Mars and must therefore be orbiting a star with a **greater** mass than the Sun. An answer like 0.12 therefore needs further checking.

**Mark awarded = 2**

# 1AS0/02

## Example 1 – Question 2dii

(ii) Figure 7 shows two images of the Moon.

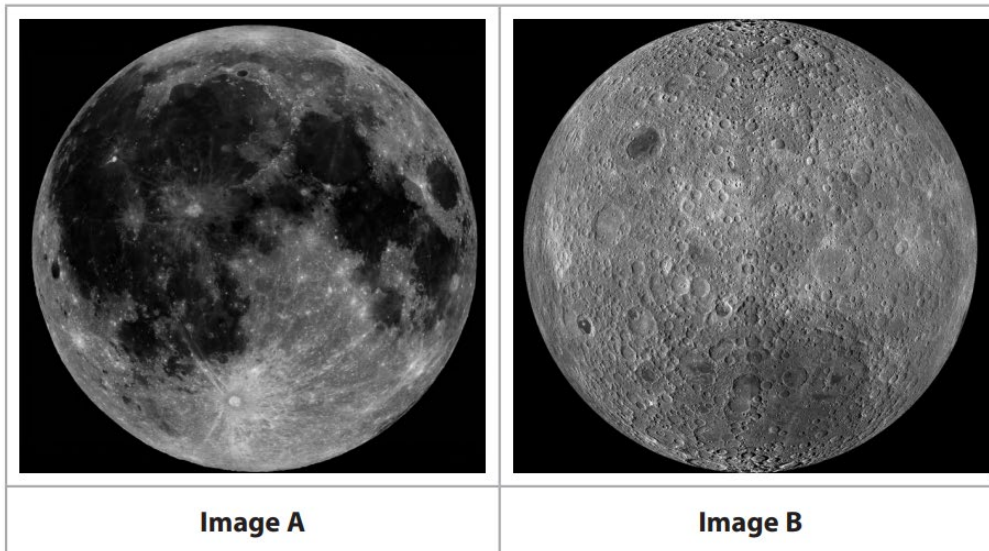


Figure 7

Explain why **Image B** in Figure 7 must have been taken from a spacecraft.

(2)

.....

.....

.....

.....

### Mark Scheme

Question number	Answer	Mark
2 (d)(ii)	Image B is an image of the far side of the Moon (1)  which <u>only</u> be viewed by spacecraft / which cannot be viewed from Earth (1)	2

## Student answers

Explain why **Image B** in Figure 7 must have been taken from a spacecraft.

(2) Q02

Image B is of the far side of the moon, it always faces away from earth due to tidal locking, to take a picture, you must therefore be in a spacecraft/use a spacecraft.

**Examiner comments:** This student's response clearly addresses both points in the Mark Scheme (along with mention of the Moon's tidal locking) and thus comfortably scores full marks.

**Mark awarded = 2**

Explain why **Image B** in Figure 7 must have been taken from a spacecraft.

(2) Q02di

It is much more detailed and shows the moons craters unlike image A.

**Examiner comments:** This student has clearly looked closely at the two images in Figure 7 and has correctly identified the greater number of craters in Image B – a characteristic of the far side of the Moon.

Unfortunately, the question focuses on the practicalities of obtaining images of the Moon's far side and thus this response does not gain any marks.

**Mark awarded = 0**

## Example 2 – Question 3b

(b) Astronomers observing galaxies have concluded that the Universe is expanding.

Describe these observations.

You may include a clearly labelled diagram in your answer.

(2)

.....

.....

.....

.....

### Mark scheme

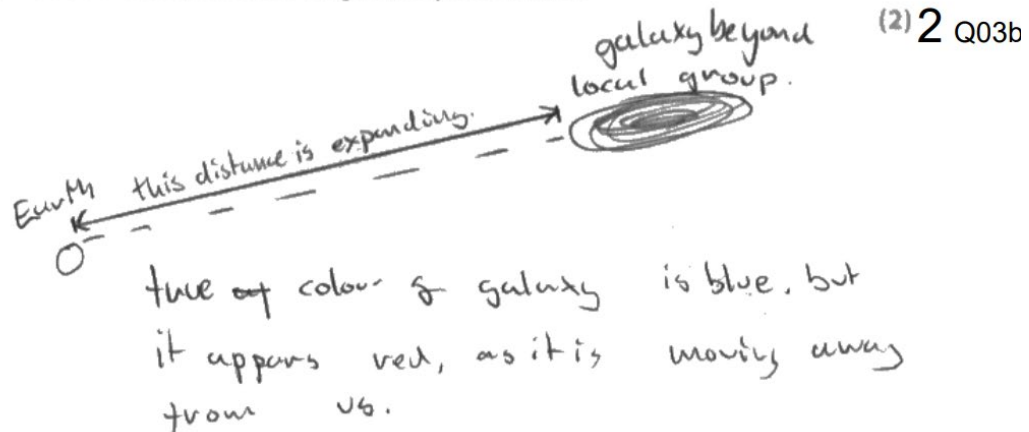
Question number	Answer	Mark
3 (b)	Galaxies are moving away from us / receding (1) and any <b>one</b> point from: <ul style="list-style-type: none"> <li>• galaxies appear redshifted / light from galaxies appears to shift to longer wavelengths</li> <li>• Hubble's Law</li> <li>• velocity increases with distance</li> <li>• galactic distances obtained from supernova light curves</li> </ul>	2

## Student answers

(b) Astronomers observing galaxies have concluded that the Universe is expanding.

Describe these observations.

You may include a clearly labelled diagram in your answer.



All far away galaxies have redshift, this means their light has been skewed red, and means they are moving away from us.

**Examiner comments:** This student's response firmly establishes the idea that distant galaxies are moving away from us, correctly giving the observation of redshift as the major observational evidence. Both points are conveyed by the text provided but the labelled diagram reinforces these points.

The response could be improved by being more specific about the idea of 'far away' galaxies and using the correct spelling of 'galaxies' but neither of these details is required by this question.

**Mark awarded = 2**

dark energy and dark matter prove the universe is  
expanding also things are moving further away  
from earth.

**Examiner comments:** This student's response begins by discussing concepts much more advanced than those required by the question. The need for a relatively simple answer should have been clear from the fact that this question is near the start of the examination paper.

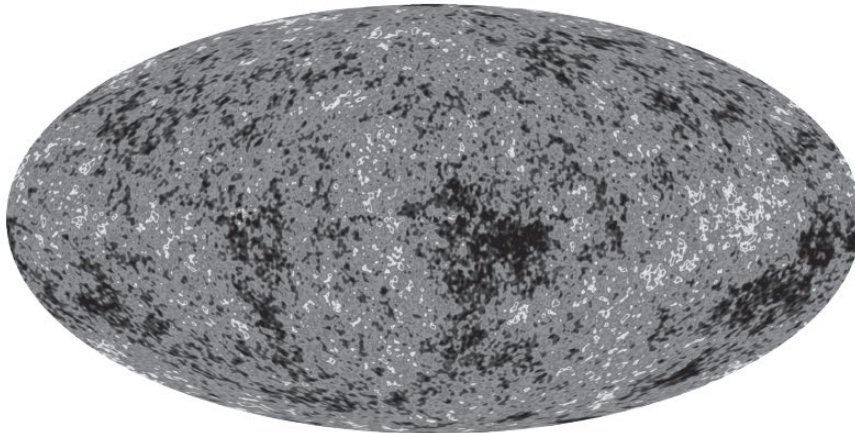
The response does mention things moving away from Earth but this cannot be accepted for the first marking point without specific mention of galaxies.

**Mark awarded = 0**

## Example 3– Question 3d

(d) Figure 8 shows an image taken by the Wilkinson Microwave Anisotropy Probe (WMAP).

The image shows the differences in temperature within the cosmic microwave background (CMB) radiation.



**Figure 8**

Explain how the data in Figure 8 have helped to explain the current structure of the Universe.

(2)

.....

.....

.....

### Mark scheme

Question number	Answer	Mark
3 (d)	<p>Any <b>two</b> points from:</p> <ul style="list-style-type: none"> <li>• image shows (information about) the early Universe</li> <li>• image shows temperature is not uniform</li> <li>• non-uniformity linked to distribution of galaxies, e.g.               <ul style="list-style-type: none"> <li>○ hotter regions formed (clusters of) galaxies</li> <li>○ galaxies (today) are not uniformly distributed throughout the Universe</li> <li>○ fluctuations have helped determine Universe's (changing) composition, including existence of dark matter / dark energy (which effects its evolution)</li> </ul> </li> </ul>	2

## Student answers

Explain how the data in Figure 8 have helped to explain the current structure of the Universe.

(2) Q03d

The temperature hotspots shown in the image show the ~~path~~ of areas where remaining heat from the Big Bang is still, showing w the chemical composition of the early universe and area of singularity that the universe has expanded from. Shows areas of ~~early~~ objects are very far away. (Total for Question 3 = 6 marks) **5**

**Examiner comments:** This student's response contains a range of relevant information but specifically identifies temperature variations within the image ('hot spots') and the early universe ('Big Bang').

It therefore achieves two marks.

**Mark awarded = 2**

Explain how the data in Figure 8 have helped to explain the current structure of the Universe.

(2) Q03d

~~It shows areas with less density and higher dens. It shows that the~~  
It shows that the Universe has cooled down since then ~~is~~ decreasing the density of the current Universe. (Total for Question 3 = 6 marks) **2**

**Examiner comments:** This response contains the correct idea that the universe has cooled down and reduced its density. However, the central theme of this question relates to the non-uniformities in both the temperature and density profiles of the universe, neither of which is mentioned here.

This response therefore does not meet any of the points listed in the Mark Scheme.

**Mark awarded = 0**

## Example 4 – Question 5bii

(b) Table 2 shows the mass, absolute magnitude and lifetime of four stars.

Star	Mass (compared to the Sun)	Absolute magnitude, M	Lifetime (years)
A	0.1	10	$10^{11}$
B	1	5	$10^{10}$
C	10	0	$10^9$
D	100	-5	$10^8$

**Table 2**

(i) Identify the star in Table 2 (A, B, C or D) that is most like the Sun.

(1)

Star: .....

(ii) Stars with a greater mass have a shorter lifetime.

Explain this relationship.

You may use information from Table 2.

(3)

### Mark scheme

Question number	Answer	Additional Guidance	Mark
5 (b)(ii)	<p>Any <b>three</b> from:</p> <p>(higher mass stars have...)</p> <ul style="list-style-type: none"> <li>• greater inward gravitational pressure</li> <li>• higher temperature / pressure (in their core)</li> <li>• {brighter/lower} absolute magnitude / more powerful</li> <li>• burn their fuel more quickly / run out of fuel faster / have a higher rate of fusion</li> </ul>	Allow reverse argument throughout	<b>3</b>

## Student answers

(ii) Stars with a greater mass have a shorter lifetime.

Explain this relationship.

You may use information from Table 2.

(3) 3 Q05

Both C and D have shorter lifespan. For example C is ten times larger so has ten times shorter lifespan, while D is 100 times larger and has a 100 times shorter lifespan. This is because of their size, their luminosity is very bright with magnitudes exceeding the sun. This means that these giant stars are very hot, burning through their "fuel", using up their hydrogen very rapidly due to higher pressure and higher temperatures. When all fusion ceases, stars with bigger masses will reach main sequence.

**Examiner comments:** Illustrated by some examples from the data about star given in Table 2, this response does not mention the increased gravitational forces compressing a larger mass star but nevertheless covers the other three remaining marking points. It is therefore sufficient for the award of full marks.

**Mark awarded = 3**

(ii) Stars with a greater mass have a shorter lifetime.

Explain this relationship.

You may use information from Table 2.

(3) 1 Q05I

Stars with a greater mass have a shorter lifetime because they burn up much more energy and produce more energy compared to stars with fewer mass and a longer lifetime. Stars die when they burn up all their energy and form black holes typically.

**Examiner comments:** This student's response strongly implies that higher mass stars burn through their supplies of fuel and energy more quickly than low mass stars and thus gains one mark. This idea is not supported by the clear statements about gravitational pull, temperature and magnitude required for a full mark answer.

**Mark awarded = 1**

(ii) Stars with a greater mass have a shorter lifetime.

Explain this relationship. <sup>weight</sup>

You may use information from Table 2.

(3) 0 Q05t

Stars with a greater mass have a shorter lifetime is shown in Star D. This is because the gas particles are bouncing around losing energy for the star to only live a short period of time.

**Examiner comments:** Despite containing some promising comments about the motion of gas particles within the star, this response does not progress beyond a restatement of the question and thus does not achieve any of the points on the Mark Scheme.

**Mark awarded = 0**

## Example 5 – Question 5biii

(iii) Star C is located 1000 pc from Earth.

Calculate the apparent magnitude of star C.

Use the equation:

$$M = m + 5 - 5 \log d$$

(2)

Apparent magnitude of star C = .....

### Mark scheme

Question number	Answer	Mark
5 (b)(iii)	<p>10 (2)</p> <p>calculation:</p> $M = m + 5 - 5 \log d$ $0 = m + 5 - 5 \log 1000$ $m = 10$ <p>Award <b>one</b> mark for:</p> <ul style="list-style-type: none"> <li>• <math>0 = m + 5 - 5 \log 1000</math></li> <li>• <math>m = M - 5 + 5 \log d</math></li> </ul>	2

## Student answers

(iii) Star C is located 1000 pc from Earth.

Calculate the apparent magnitude of star C.

Use the equation:

$$M = m + 5 - 5 \log d$$

<sup>(2)</sup> Q5biii

$$0 + 5 + 5 \log(1000)$$

Apparent magnitude of star C = 10

**Examiner comments:** This student has correctly calculated a value of 10 for the apparent magnitude of Star C and thus gains full marks. They have included some working, which would have gained credit in the event of their final answer being incorrect. With a complex equation such as the distance-modulus equation, it is often advisable to include more than one stage in the calculation. In this example a second line showing correct valuation on  $\log(1000)$  such as “ $m = 0 - 5 + 15$ ” would constitute full working.

**Mark awarded = 2**

(iii) Star C is located 1000 pc from Earth.

Calculate the apparent magnitude of star C.

Use the equation:

$$M = m + 5 - 5 \log d$$

$$M = 10 + 5 - 5 \log(1000) \quad (2) \text{ Q5biii}$$

Apparent magnitude of star C = 0

**Examiner comments:** This student's calculation shows the importance of attention to detail when using the distance-modulus equation. The substitution of numbers into the equation is far from straightforward, with two quantities having the letter 'm'. This was further complicated in this question by a column giving the mass of the stars in Table 2.

In this calculation the mass of Star C has been substituted as its absolute magnitude, leading to an incorrect answer which cannot be credited.

The student's answer of zero also illustrates the importance of checking numerical answers. An answer of zero for Star C would mean that its apparent and absolute magnitudes were the same – clearly impossible for a star at a distance of 1000pc.

**Mark awarded = 0**

## Example 6 – Question 5c

- (c) The observed brightness of a star decreases in proportion to the square of its distance from Earth.

The Sun has an apparent magnitude of -27 when viewed from a distance equal to the radius of the Earth's orbit.

Calculate the apparent magnitude of the Sun when viewed from a distance of 10 AU.

(2)

Apparent magnitude of the Sun = .....

### Mark scheme

Question number	Answer	Mark
5 (c)	<p>-22 (2)</p> <p>calculation:</p> <p>intensity of Sun decreases by <math>10^2 = 100</math></p> <p>This corresponds to a change in magnitude of 5 <b>(1)</b></p> <p style="padding-left: 40px;">apparent magnitude of Sun = <math>-27 + 5</math>  <span style="padding-left: 80px;">= -22 <b>(1)</b></span></p> <p>notes:            -32 scores 1 mark  <math>M = 4.57\dots</math> scores 1 mark</p>	<b>2</b>

## Student answers

- (c) The observed brightness of a star decreases in proportion to the square of its distance from Earth.

The Sun has an apparent magnitude of -27 when viewed from a distance equal to the radius of the Earth's orbit.

Calculate the apparent magnitude of the Sun when viewed from a distance of 10 AU.

change in  $m = \text{distance change}^2$  (2) Q05c

$10 \text{ AU} \div 1 \text{ AU} = 10 \quad 10^2 = 100 \times \text{dimmer.}$

$\log_{2.5}(100) = 5 \text{ (app)} \quad -27 + 5 = -22$

Apparent magnitude of the Sun = -22

**Examiner comments:** This student has correctly pointed out that increasing distance by a factor of ten will reduce brightness by a factor of 100, which is equivalent to a magnitude change of five. They have thus arrived at the correct answer of -22, supported by clear working.

**Mark awarded = 2**

- (c) The observed brightness of a star decreases in proportion to the square of its distance from Earth.

The Sun has an apparent magnitude of -27 when viewed from a distance equal to the radius of the Earth's orbit.

Calculate the apparent magnitude of the Sun when viewed from a distance of 10 AU.

$$M = m + 5 - 5 \log(d)$$

$$M = -27 + 5 - 5 \log(10)$$

$$= -27$$

(2) Q05c

Apparent magnitude of the Sun = -27

**Examiner comments:** Although this question can be solved using the link between brightness and distance stated in the question, many students attempted to use the distance-modulus equation. This student has substituted a value for the distance of the Sun in astronomical units (AU), instead of parsecs.

This results in a value of -27 for the Sun's apparent magnitude which acts as a reminder of the importance of checking numerical answers, as this is the same as the Sun's usual apparent magnitude for observers on Earth.

**Mark awarded = 0**

## Example 7 – Question 6a

6 (a) Pinhole projection is one safe method for observing the Sun.

Describe **one other** safe method for observing the Sun.

You may include a clearly labelled diagram in your answer.

(2)

.....

.....

.....

.....

### Mark scheme

Question number	Answer	Mark
6 (a)	telescope/binoculars (with shadow caster) (1) projecting image onto a card/screen (1)  <b>OR</b>  telescope with H-alpha/solar filter (1) with filter correctly attached to telescope (1)  <b>OR</b>  glasses with solar filter (1) covering both eyes (1)	2

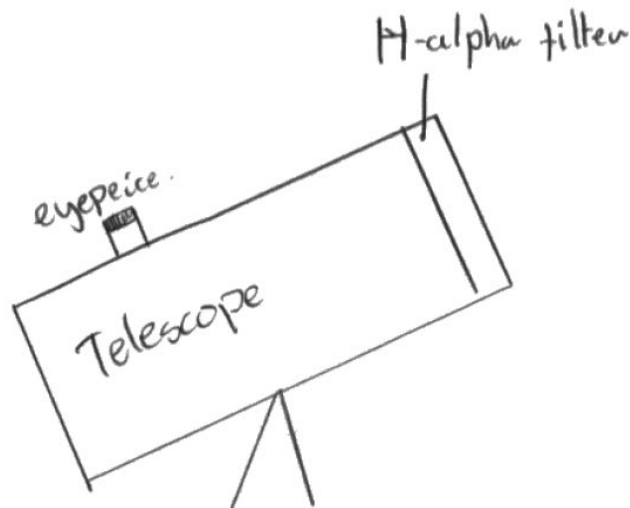
## Student answers

- 6 (a) Pinhole projection is one safe method for observing the Sun.

Describe **one other** safe method for observing the Sun.

You may include a clearly labelled diagram in your answer.

(2) Q06a



Attaching an H-alpha filter to the telescope securely will allow you to observe the sun safely. Ensure it is not cracked, as this will make it ineffective.

**Examiner comments:** This student's response describes the method of solar observation using a telescope and H-alpha filter. Both of these items are clearly explained and illustrated by the clear and labelled diagram. This response therefore comfortably achieves both points on the Mark Scheme.

**Mark awarded = 2**

5 (a) Pinhole projection is one safe method for observing the Sun.

Describe **one other** safe method for observing the Sun.

You may include a clearly labelled diagram in your answer.

(2) Q06a

H - Alpha filter. Place onto telescope. Selects red band width of light, allowing observers to safely observe sun with telescope. Shows detail of sun as well as magnification.

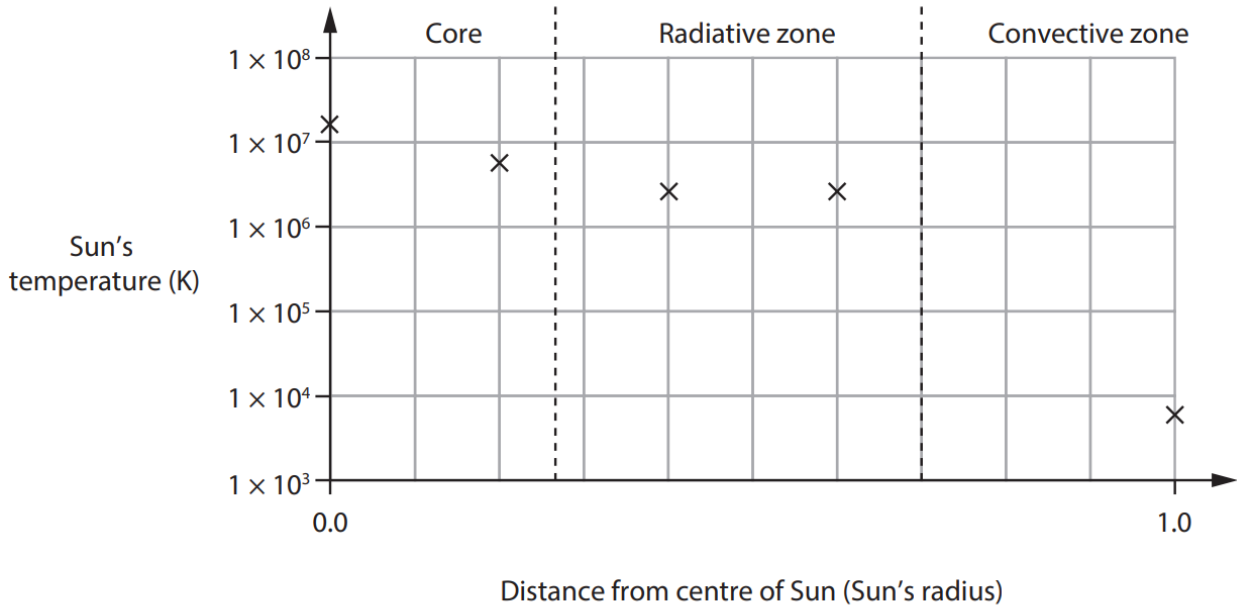
**Examiner comments:** This student's description is clearly based on a correct method – the use of an H-alpha filter. However, although the filter is mentioned, there is no guidance as to how it is to be used apart from the phrase “place onto telescope”.

There is additional description of the role of the H-alpha filter but nothing further about its actual use in the observational method. A clearly labelled diagram would have covered this point by showing the filter in its correct position.

As both marks in this question are for describing the observational method, this response can only be awarded one mark. It also underlines the importance of always including a clearly labelled diagram when describing observational methods.

**Mark awarded = 1**

## Example 8 – Question 6ci



**Figure 10**

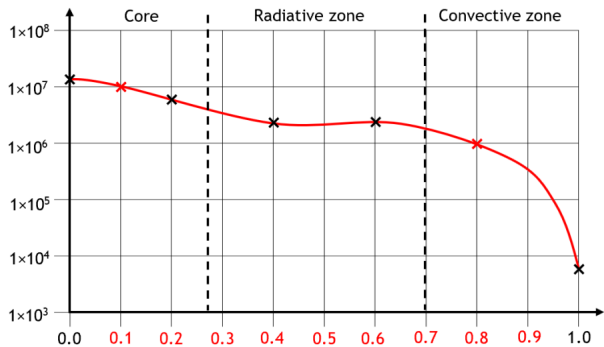
(i) Complete the graph in Figure 10 to show all the data in Table 3.

You should:

- complete the scale on the horizontal (distance) axis
- plot the remaining points
- draw a line of best fit.

(3)

## Mark scheme

Question number	Answer	Mark
6 (c)(i)	<p>Correct scale added to horizontal axis (1)</p> <p>Both points plotted correctly (1)</p> <p>Suitable smooth, continuous best fit line drawn through the data points (1)</p>	3
		

Student answers

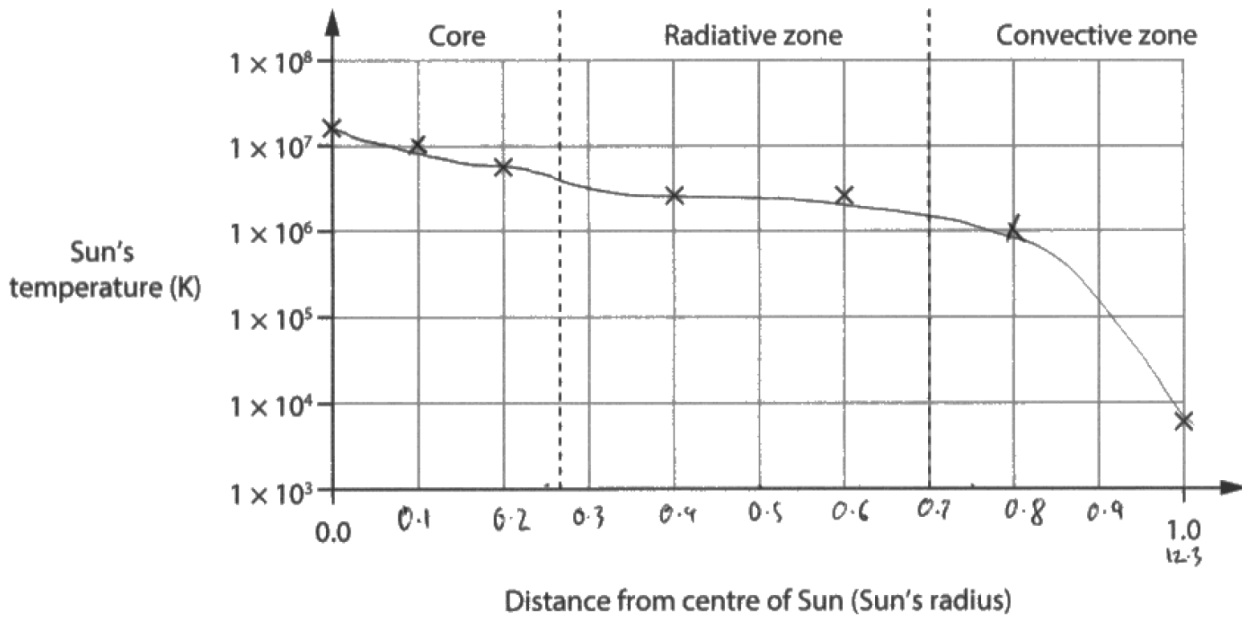


Figure 10

**Examiner comments:** This response securely covers all three of the points required by the Mark Scheme – a correct scale, points and line of best fit. It therefore comfortably scores full marks.

**Mark awarded = 3**

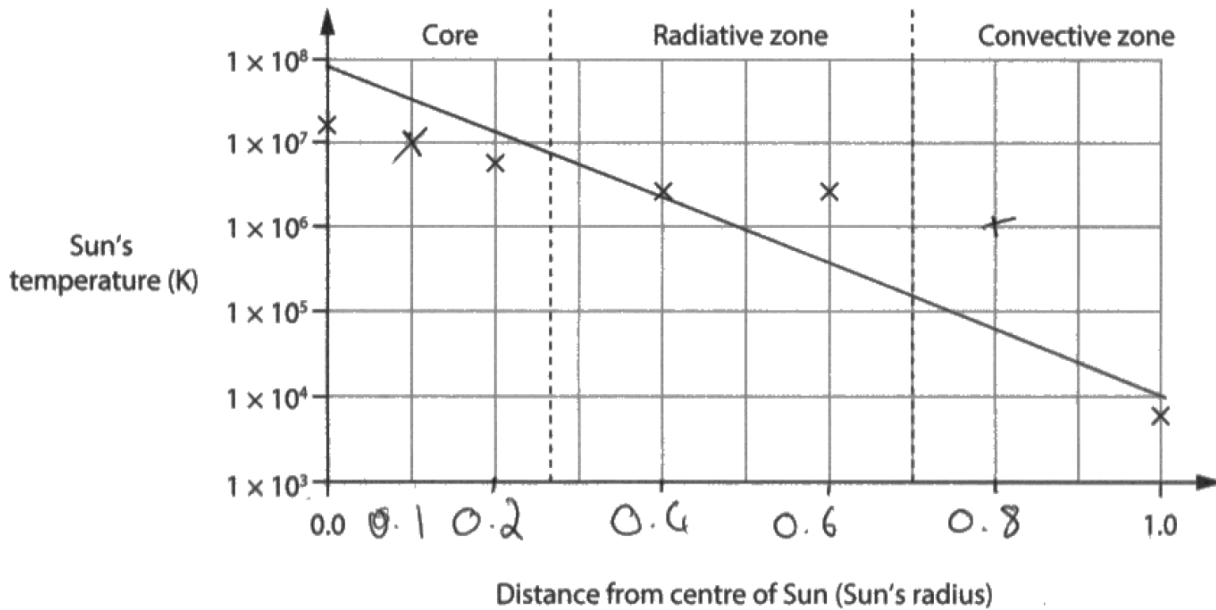


Figure 10

**Examiner comments:** This student has correctly labelled the horizontal axis of Figure 10 and has plotted the remaining points correctly. However, although the points clearly form a curve, a straight line has been drawn through the central point. Since there is no reason why the central point should be more accurate than the others, this technique for finding the line of best fit is rarely successful, despite its popularity. As a result, this response gains only the first two points on the Mark Scheme.

This response emphasises the fact that many graphs in astronomy do not result in a straight line, particularly this one which covers several distinct areas within the Sun.

**Mark awarded = 2**

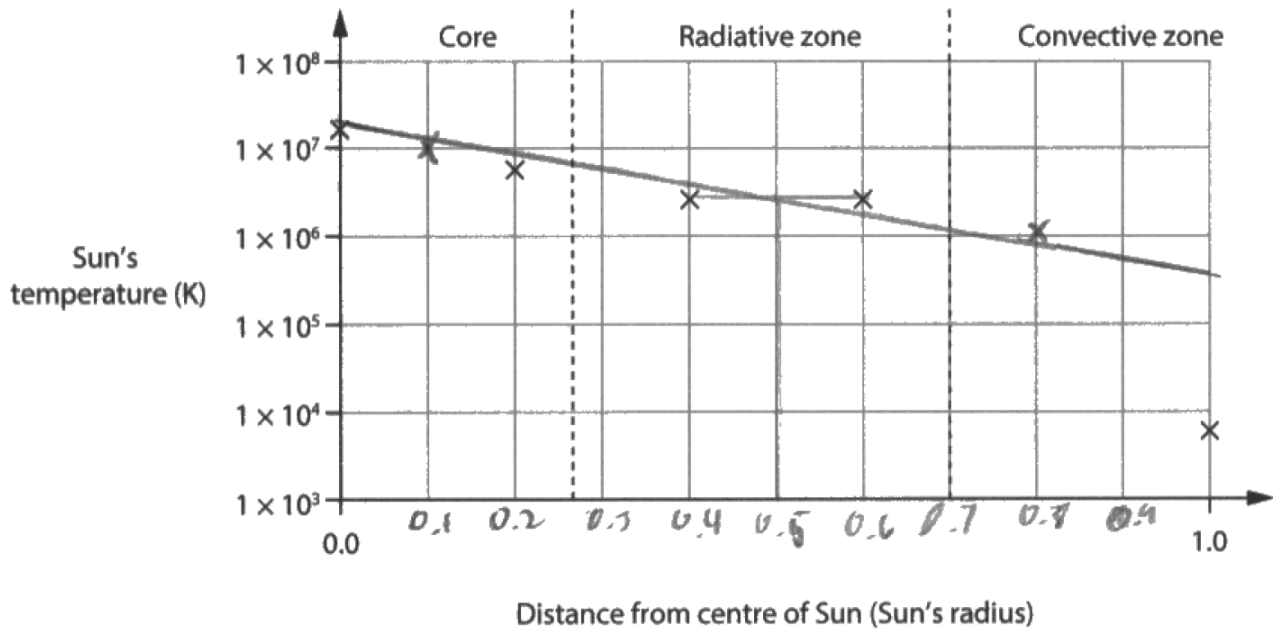


Figure 10

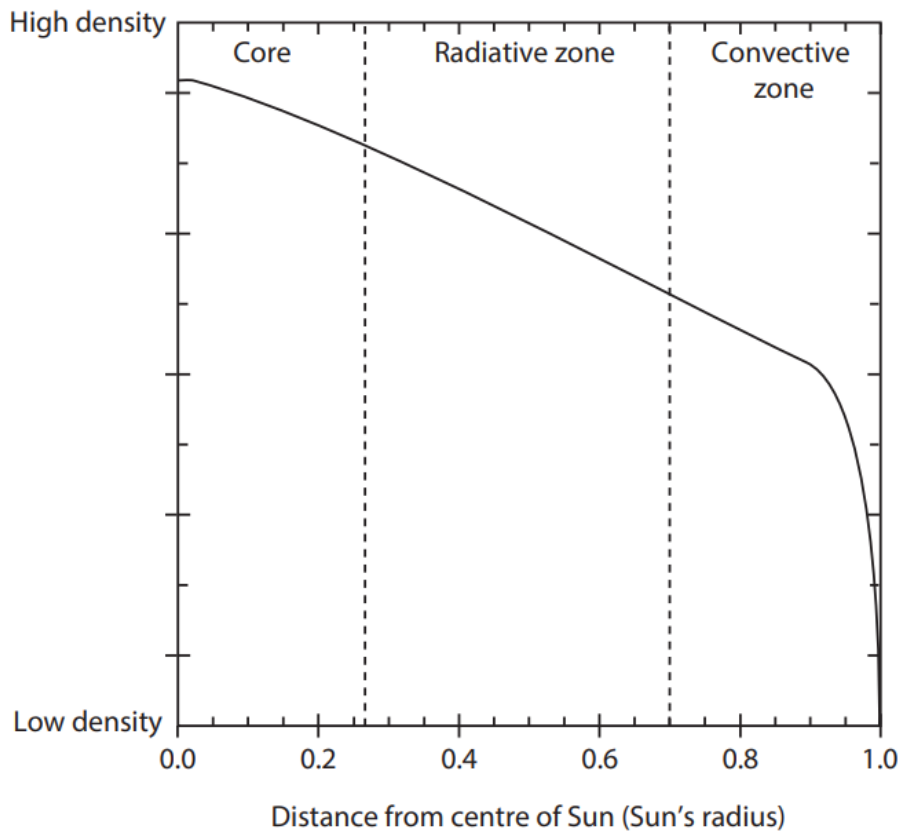
**Examiner comments:** This response clearly achieves the first two marking points by providing a suitable horizontal scale and correctly plotted points. However, it illustrates the popular belief that all graphs must be a straight line, achieving this by ignoring the last point entirely – effectively treating it as an anomaly.

There is no evidence in the question to suggest that this point is any less accurate than the others and the graph is clearly labelled to show that it shows temperature across three distinct zones of the Sun, with widely differing temperatures.

**Mark awarded = 2**

## Example 9 – Question 6civ

- (iv) Figure 11 shows a graph of the relative density of the Sun at different distances from its centre.



**Figure 11**

Analyse Figure 10 and Figure 11 in order to determine if there is a relationship between the Sun's temperature and its relative density.

(3)

.....

.....

.....

.....

.....

## Mark scheme

Question number	Answer	Mark
6 (c)(iv)	Any <b>three</b> from: <ul style="list-style-type: none"> <li>• yes / there is a relationship (between the Sun's temperature profile and the Sun's density profile) (1)</li> <li>• as temperature decreases, density decreases (as distance increases) (1)</li> <li>• the temperature and density are a maximum/highest at the centre of the Sun / core (1)</li> </ul> <b>OR</b> <ul style="list-style-type: none"> <li>• the temperature and density are a minimum/lowest at the surface of the Sun / convective zone (1)</li> </ul> <ul style="list-style-type: none"> <li>• the lines have a similar shape, e.g. the temperature and density decrease rapidly (with distance) in the convective zone / near the Sun's surface (1)</li> </ul>	<b>3</b>

## Student answers

Analyse Figure 10 and Figure 11 in order to determine if there is a relationship between the Sun's temperature and its relative density.

(3) 3 Q06

- Both have gradual decrease from core to convective zone
- Both have sharp dropoff near the Sun's surface
- They correlate very well, so there is likely a relationship, where a lower density correlates to lower temperature.

**Examiner comments:** This response clearly covers three of the points credited in the Mark Scheme. In addition, it is presented as a series of bullet points, making its contents much clearer.

The student has also made sure that there are three bullet points – acknowledging the three marks available for this question.

Although the vast majority of students answer questions like these as a piece of uninterrupted prose, the above form of presentation is clearly much more effective.

**Mark awarded = 3**

Analyse Figure 10 and Figure 11 in order to determine if there is a relationship between the Sun's temperature and its relative density.

(3) 3 Q06

Yes, as ~~the~~ both Figure 10 and Figure 11 show similar trends. As distance increases from core of sun from sun from Figure 10, temperature gradually decreases from core to radiative zone, until sharply decreasing in the convection zone. Figure 11 shows similar trends, also ~~decreases gradually then~~ sharply declining in density in its convection zone. This suggests that temperature and relative density are ~~positively~~ correlated, as density decreases, ~~then~~ so does temperature decrease.

(Total for Question 6 = 11 marks) **10**

**Examiner comments:** This response indicates a clear understanding that the correct answer to this question lies in a comparison of Figures 10 and 11, as indicated in the question. The two figures show that both temperature and density decrease with distance from the Sun, as this response points out.

It thus contains three of the points in the Mark Scheme and thus scores full marks.

**Mark awarded = 3**

Analyse Figure 10 and Figure 11 in order to determine if there is a relationship between the Sun's temperature and its relative density.

(3) 1 Q06c

The higher the density the higher the temperature in the core. However, the lower the density throughout the radiative zone and convective zone, the lower the Sun's temperature.

**Examiner comments:** This response begins with a clear statement that as density increases so does temperature, gaining the second marking point. It does not actually make a statement as to whether there is a relationship or not.

Consequently, it only scores one mark for its initial statement.

**Mark awarded = 1**

## Example 10 – Question 7aii

(ii) Mira is a red giant star in the late stages of stellar evolution.

Mira has a mass of 1.2 solar masses.

Describe how Mira will evolve in the future.

(2)

.....

.....

.....

### Mark scheme

Question number	Answer	Mark
7 (a)(ii)	Any <b>two</b> points from: <ul style="list-style-type: none"> <li>• planetary nebula</li> <li>• white dwarf</li> <li>• black dwarf</li> </ul>	<b>2</b>

### Student answers

(ii) Mira is a red giant star in the late stages of stellar evolution.

Mira has a mass of 1.2 solar masses.

Describe how Mira will evolve in the future.

(2) 2 Q07:

Its outer layers will migrate away to form a nebula, leaving a white dwarf, which will slowly cool into a black dwarf

**Examiner comments:** This high-quality response concisely covers all three of the possible future stages in the life of Mira and is thus awarded full marks.

**Marks awarded = 2**

(ii) Mira is a red giant star in the late stages of stellar evolution.

Mira has a mass of 1.2 solar masses.

Describe how Mira will evolve in the future.

(2) 2 Q07

It will leave a planetary nebula and become a white dwarf into a black dwarf. This is because it won't surpass the electron degeneracy pressure

(iii) The brightness of Mira changes because of a change in its surface temperature.

At lower temperatures, some of Mira's visible light becomes infrared.

according to the Chandrasekhar limit of  $1.44 M_{\odot}$  solar masses.

**Examiner comments:** This student has clearly provided all three possible future stages in the life of the star Mira and their response has therefore been awarded full marks.

However, this response illustrates the importance of tailoring answers to the command word of the question – 'Describe' in this case. This student has fully achieved this in the first sentence of their answer. The remainder of their answer is an attempt to 'Explain' which obviously gains no further credit in the Mark Scheme for a 'Describe' question.

**Marks awarded = 2**

(ii) Mira is a red giant star in the late stages of stellar evolution.

Mira has a mass of 1.2 solar masses.

Describe how Mira will evolve in the future.

(2) 1 Q07:

Will condense, forming a white dwarf star

**Examiner comments:** This student's response is clearly describing the correct evolutionary path for Mira but it has only described the next stage and thus only scores one of the two marks available.

This response illustrates the importance of ensuring that answers contain sufficient points to gain full marks. The provision of two (rather than one) marks for the question indicates clearly that more than one stage in the future life of Mira are required.

**Marks awarded = 1**

## Example 11 – Question 7aiii

- (iii) The brightness of Mira changes because of a change in its surface temperature.

At lower temperatures, some of Mira's visible light becomes infrared.

Explain how a drop in Mira's surface temperature affects its brightness.

(2)

### Mark scheme

Question number	Answer	Mark
7 (a)(iii)	(drop in temperature results in a) reduction in brightness / is dimmer (1)  because infrared light is not visible (to unaided eye) (1)	2

### Student answers

Explain how a drop in Mira's surface temperature affects its brightness.

Spectrum shifts towards longer wavelengths at lower temperatures, which means less of the light it emits is visible light, so brightness appears to drop. (2) 2 Q7ai

**Examiner comments:** This response comfortably achieves the full two marks as it clearly mentions the reduction in brightness and the fact that infrared radiation is not visible.

**Mark awarded = 2**

(iii) The brightness of Mira changes because of a change in its surface temperature.

At lower temperatures, some of Mira's visible light becomes infrared.

Explain how a drop in Mira's surface temperature affects its brightness.

(2) 1 Q7a(ii)

The reduction in ~~brightness~~ surface temperature reduces its brightness.

**Examiner comments:** This response correctly states that the brightness of Mira will decrease and thus achieves the first point on the Mark Scheme.

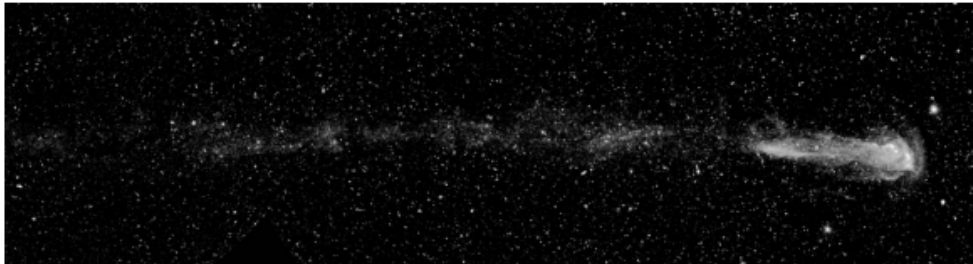
However, there are a number of clues in the question that more is required for the award of the second mark. Firstly, the common word in this question is 'Explain' not simply 'Describe'. Questions using the 'Explain' command word always require some form of explanation, i.e. an additional sentence beginning with 'Because...'.  
Secondly, two marks are available for this question, further suggesting that a simple statement of how the brightness of Mira will change cannot score full marks.

**Mark awarded = 1**

## Example 12 – Question 7aiv

(iv) Figure 12 shows an ultraviolet image of Mira. A tail can be seen.

The tail is caused by the star moving through space.



**Figure 12**

Mira has a velocity of 130 km/s and has been creating this tail for 30 000 years.

Calculate the length of the tail.

Use information from the Formulae and Data Sheet and the equation:

$$\text{Length of tail} = \text{speed} \times \text{time}$$

Give your answer in parsecs.

(3)

### Mark scheme

Question number	Answer	Mark
7 (a)(iv)	<p>4.0 pc (3.97 pc) (3)</p> <p>calculation:</p> <p>convert 30 000 years into seconds (1)  <math>\text{time} = 30\,000 \times 365 \times 24 \times 60 \times 60 = 9.46 \times 10^{11}</math></p> <p>calculation of tail length (1)  <math>\text{length of tail} = 130 \times 9.46 \times 10^{11}</math>  <math>= 1.23 \times 10^{14}</math></p> <p>convert length from km to pc (1)  <math>\text{length of tail} = 1.23 \times 10^{14} \div 3.1 \times 10^{13} = 4.0 \text{ (pc)}</math></p> <p>accept <math>1.3 \times 10^{-7}</math> (pc) for 2 marks</p>	3

## Student answers

Give your answer in parsecs.

(3) Q07aiv

$$\begin{aligned}
 \text{length} &= \text{speed} \times \text{time} \\
 &= 130 \text{ km/s} \times \left( 30000 \overset{\text{years}}{\times} \overset{\text{days}}{365} \overset{\text{hours}}{\times} 24 \overset{\text{minutes}}{\times} 60 \right) \\
 &= 1.22 \dots \times 10^{14} \\
 1.22 \dots \times 10^{14} &\div 3.1 \times 10^{13} \text{ parsecs} \\
 &= 4.0 \text{ parsecs (2sf)}
 \end{aligned}$$

**Examiner comments:** This student's response clearly shows how the correct answer of 40 parsecs is obtained using the information in the question and the equation provided. It therefore scores full marks.

**Mark awarded = 3**

Give your answer in parsecs.

(3) Q07ai

$$\frac{9.4608 \times 10^{11}}{3.1 \times 10^{13}} = 3.0515 \approx 3 \text{ or } 3.97$$

Length of tail = 3.97 parsecs

**Examiner comments:** Although this student has arrived at the correct numerical answer and has thus been awarded full marks, their answer is not supported by sufficiently clear or detailed working. In the event of their final answer being incorrect, it would have been difficult to award either of the two marks available for the calculation.

Clearly a large part of the calculation has been completed on the candidate's calculator or in their head, with only a final result being written down. The only part of the calculation written down appears to be a final unit conversion into parsecs.

In addition, there is no indication of what their calculation represents, once again making it difficult for the examiner to credit their working.

**Mark awarded = 3**

Give your answer in parsecs.

(3) Q07ai

$$\begin{aligned}
 \text{velocity} &= 130 \text{ km/s} \\
 \text{tail for} &= 30,000 \text{ years} \\
 130 \times 30,000 &= 3900000 \\
 3900000 \div 3.26 & \\
 &= 1196319.018
 \end{aligned}$$

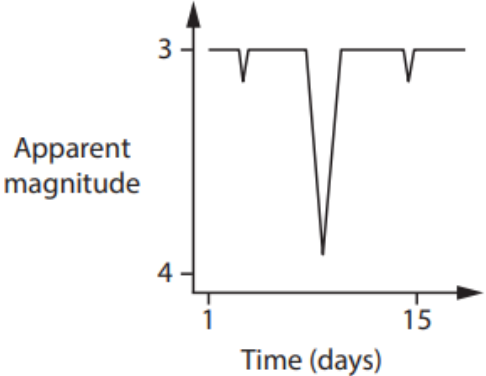
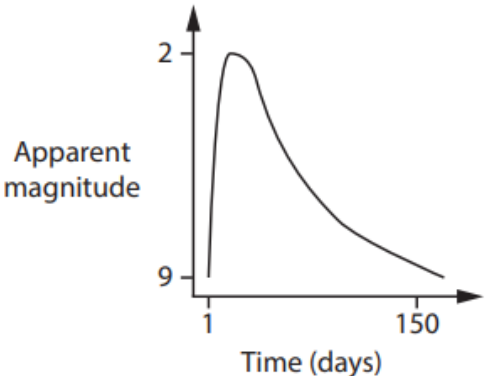
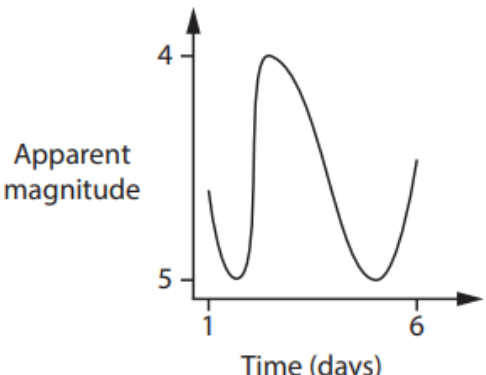
$$\text{Length of tail} = \underline{1196319.018} \text{ parsecs}$$

**Examiner comments:** This student's response shows a correct multiplication of the speed of the star by the time for which the tail has existed and thus gains one mark. However, it has not taken into account the incompatible units of the velocity (km/s) and the time (years). Hence the final answer is not in parsecs.

**Mark awarded = 1**

## Example 13 – Question 7b

(b) Table 4 shows light curves for three variable stars.

Variable star	Light curve
<p style="text-align: center;"><b>A</b></p>	 <p style="text-align: center;">Time (days)</p>
<p style="text-align: center;"><b>B</b></p>	 <p style="text-align: center;">Time (days)</p>
<p style="text-align: center;"><b>C</b></p>	 <p style="text-align: center;">Time (days)</p>

**Table 4**



## Mark scheme

Question number	Answer	Mark																							
7 (b)	<p><b>Marking instructions</b></p> <p>Markers must apply the descriptors in line with the general marking guidance and the qualities outlined in the levels-based mark scheme below.</p> <table border="1"> <thead> <tr> <th>Level</th> <th>Mark</th> <th>Descriptor</th> </tr> </thead> <tbody> <tr> <td></td> <td>0</td> <td>No rewardable material.</td> </tr> <tr> <td>Level 1</td> <td>1-2</td> <td>Lacks clarity. Basic interpretation and evaluation of the data/information may be attempted but will be limited and narrow in scope. The response will contain basic information with little linkage between points made. Lines of reasoning may be attempted but are incomplete or lack clarity. A conclusion may be attempted but lacks support.</td> </tr> <tr> <td>Level 2</td> <td>3-4</td> <td>Some structure. Interpretation and evaluation of the data/information that attempts to synthesise and integrate relevant knowledge. The response shows some linkages and lines of reasoning with some structure, leading to a conclusion that is partially supported.</td> </tr> <tr> <td>Level 3</td> <td>5-6</td> <td>Comprehensive and well structured. Comprehensive interpretation and evaluation of the data/information that demonstrates the skills of synthesising and integrating relevant knowledge throughout the response. The response shows a well-developed, sustained line of scientific reasoning which is clear, coherent and logically structured, leading to a supported conclusion.</td> </tr> </tbody> </table> <p><b>Indicative content guidance</b></p> <p>The indicative content below is not prescriptive, and candidates are not required to include all of it. Other relevant material not suggested below must also be credited.</p> <p>Relevant points may include links between:</p> <ul style="list-style-type: none"> <li>• type of star and period length</li> <li>• type of star and shape of light curve</li> <li>• type of star and range of apparent magnitudes</li> </ul> <table border="1"> <thead> <tr> <th>Star</th> <th>Type of variable star</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>Eclipsing Binary</td> </tr> <tr> <td>B</td> <td>Supernova</td> </tr> <tr> <td>C</td> <td>Cepheid variable</td> </tr> </tbody> </table>	Level	Mark	Descriptor		0	No rewardable material.	Level 1	1-2	Lacks clarity. Basic interpretation and evaluation of the data/information may be attempted but will be limited and narrow in scope. The response will contain basic information with little linkage between points made. Lines of reasoning may be attempted but are incomplete or lack clarity. A conclusion may be attempted but lacks support.	Level 2	3-4	Some structure. Interpretation and evaluation of the data/information that attempts to synthesise and integrate relevant knowledge. The response shows some linkages and lines of reasoning with some structure, leading to a conclusion that is partially supported.	Level 3	5-6	Comprehensive and well structured. Comprehensive interpretation and evaluation of the data/information that demonstrates the skills of synthesising and integrating relevant knowledge throughout the response. The response shows a well-developed, sustained line of scientific reasoning which is clear, coherent and logically structured, leading to a supported conclusion.	Star	Type of variable star	A	Eclipsing Binary	B	Supernova	C	Cepheid variable	6
Level	Mark	Descriptor																							
	0	No rewardable material.																							
Level 1	1-2	Lacks clarity. Basic interpretation and evaluation of the data/information may be attempted but will be limited and narrow in scope. The response will contain basic information with little linkage between points made. Lines of reasoning may be attempted but are incomplete or lack clarity. A conclusion may be attempted but lacks support.																							
Level 2	3-4	Some structure. Interpretation and evaluation of the data/information that attempts to synthesise and integrate relevant knowledge. The response shows some linkages and lines of reasoning with some structure, leading to a conclusion that is partially supported.																							
Level 3	5-6	Comprehensive and well structured. Comprehensive interpretation and evaluation of the data/information that demonstrates the skills of synthesising and integrating relevant knowledge throughout the response. The response shows a well-developed, sustained line of scientific reasoning which is clear, coherent and logically structured, leading to a supported conclusion.																							
Star	Type of variable star																								
A	Eclipsing Binary																								
B	Supernova																								
C	Cepheid variable																								

## Student answers

Variable star A is an eclipsing binary. <sup>(6)</sup>4 Q07b  
 Light curve shows the bigger dip of when the dimmer star eclipses the brighter star, while the two smaller dips of apparent magnitude represent the eclipse of the dimmer star by the brighter star. The areas of the graph which are flat show brightness when both stars are not eclipsed and or occulted, <sup>thw</sup> at its brightest of the binary system, luminosity doesn't change too drastically.

Variable B is a supernova. Graph shows an exponential increase in luminosity at the start and then a gradual decrease over a long period of time. Consistent with a supernova explosion, as huge amount of radiation <sup>including optical light</sup> are released as a supernova happens, <sup>before</sup> decreasing gradually as it cools down.

Variable C <sup>is</sup> a Cepheid variable. These stars pulsate predictably over consistent periods. The graph of C shows a decrease and increase <sup>of luminosity</sup>, which is most likely regular. C is a short range Cepheid as its period is less than a week.

(Total for Question 7 = 14 marks) **11**

**Examiner comments:** This response synthesises and integrates aspects of the material presented in the question. Several linkages and lines of reasoning are clearly expressed, placing the response at Level 2.

A number of astronomical points are made within the response, placing it in the upper half of the mark range for Level 2.

**Mark awarded = 4**

Evaluate the data in Table 4 in order to identify which of the stars is:

- a supernova
- a Cepheid variable
- an eclipsing binary.

Justify your answer in each case.

<sup>(6)</sup>3 Q07b

B is a supernova due to the large burst of apparent magnitude, followed by the dispersment of energy multiple days later. The supernova condenses itself so much that it explodes out, causing a large burst of energy before dying out, similar to B.

C is an eclipsing binary, because the apparent magnitude oscillates between 4 and 5, most likely revealing a smaller number as the stars get closer, and becomes larger when they are further away apart.

A is a Cepheid variable.

**Examiner comments:** This response shows many of the features required by a Level 2 response. However, it does not do this for all three of the objects listed in the question and therefore scores at the lower end of the Level 2 mark range.

**Mark awarded = 3**

162 Q07b

A is a Supernova because the mass drops dramatically showing they is now a black hole there as its peaking back up that's the force and other galaxies planets, milkyways, nebulars, stars gets getting gravitationally pulled through leading it to expand.

C is a eclipsing binary because as shown in the beginning the stars are separate. then they end up looking like they have merged together but in reality they are 100s hundreds of miles away and are only crossing over once another.

B is a Cepheid variable as the apparent mag-nitude is high as the days start. But then as days go by the apparent magnitude decreases

(Total for Question 7 = 14 marks) **3**

**Examiner comments:** Containing several statements that are ambiguous or, involving incorrect uses of the material provided in the question, this response represents only a basic explanation and interpretation of the question. It is therefore a Level 1 response.

**Mark awarded = 2**

## Example 14 – Question 8a(iii)

(iii) The JWST objective is made up from 18 smaller mirrors, instead of one large mirror.

Give **two** reasons for this.

(2)

1 .....

.....

2 .....

.....

### Mark scheme

Question number	Answer	Mark
8 (a)(iii)	Any <b>two</b> points from: <ul style="list-style-type: none"> <li>• easier to construct</li> <li>• cheaper to make</li> <li>• larger mirror would deform more</li> <li>• reduces space when launching / is able to fit into a rocket</li> </ul>	2

### Student answers

(iii) The JWST objective is made up from 18 smaller mirrors, instead of one large mirror.

Give **two** reasons for this.

(2) Q8a(iii)

1 *It is easier and cheaper to construct*

.....

2 *It isn't as heavy*

**Examiner comments:** This response concisely presents two advantages of a composite mirror and thus scores full marks.

**Mark awarded = 2**

(iii) The JWST objective is made up from 18 smaller mirrors, instead of one large mirror.

Give **two** reasons for this.

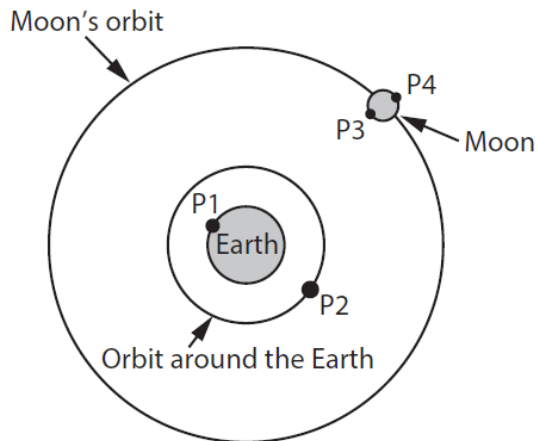
- 1 It decreases chromatic aberration significantly,
- 2 It is much easier to construct as they are much smaller allowing for larger apertures to be made with ease.

**Examiner comments:** This response provides only one correct reason – the ease of manufacture of the smaller mirrors. It therefore scores one mark.

**Mark awarded = 1**

## Example 15 – Question 8bi

(b) Figure 13 shows the Moon's orbit around the Earth.



Position	Description
P1	Earth's surface
P2	Orbit around the Earth
P3	Near side of the Moon
P4	Far side of the Moon

(Not to scale)

**Figure 13**

A new ultraviolet telescope has been developed to observe the Sun on each day of the year.

Astronomers have suggested four positions for this new ultraviolet telescope.

These positions are labelled P1, P2, P3 and P4.

- (i) State **one** observational reason why P1 is an **unsuitable** position for the proposed ultraviolet telescope.

(1)

### Mark scheme

Question number	Answer	Mark
8 (b)(i)	unable to observe ultra-violet radiation from the Earth's surface / (Earth's) atmosphere absorbs (most) ultra-violet radiation	1

## Student answers

- (i) State **one** observational reason why P1 is an **unsuitable** position for the proposed ultraviolet telescope.

(1) 1 Q08f

P1 is on the earth's surface. The earth's atmosphere blocks nearly all UV rays, so the telescope will not work.

**Examiner comments:** This student's response explains clearly the unsuitability of an observing position on the Earth's surface, due to absorption of ultraviolet radiation by the Earth's atmosphere.

**Mark awarded = 1**

- (i) State **one** observational reason why P1 is an **unsuitable** position for the proposed ultraviolet telescope.

(1) 0 Q08f

The earth's atmosphere absorbs infrared

**Examiner comments:** Although this student's response correctly identifies the Earth's atmosphere as a key part of the answer, it incorrectly focuses on its absorption of infrared, rather than ultraviolet, radiation.

**Mark awarded = 0**

## Example 16 – Question 8bii

(ii) The telescope needs to observe the Sun on each day of the year.

Analyse Figure 13 in order to explain whether P2, P3 or P4 would be a suitable position for the proposed ultraviolet telescope.

(3)

.....

.....

.....

.....

.....

.....

### Mark scheme

Question number	Answer	Mark
8 (b)(ii)	<p>P2 – <b>suitable</b> for telescope because above Earth’s atmosphere / in space / in orbit (1)</p> <p>P3 – <b>NOT suitable</b> for telescope – cannot observe the Sun each day (1)</p> <p>P4 – <b>NOT suitable</b> for telescope – cannot observe the Sun each day / cannot communicate with Earth (1)</p>	3

## Student answers

(ii) The telescope needs to observe the Sun on each day of the year.

Analyse Figure 13 in order to explain whether P2, P3 or P4 would be a suitable position for the proposed ultraviolet telescope.

(3) 3 Q08  
~~P3~~ P3 and P4 are not suitable, as the moon is tidally locked, so these positions will only face the sun for half the time. P2 is suitable, although it will only be able to see the sun half the time, it will orbit many times a day, so will be able to see the sun for enough time each day.  
 All days out of every 28 days so will go more than one day without facing the sun.

**Examiner comments:** This student's response has identified the observational problems with P3 and P4 and has thus correctly concluded that P2 is the best observing site of the four possibilities.

**Mark awarded = 3**

(ii) The telescope needs to observe the Sun on each day of the year.

Analyse Figure 13 in order to explain whether P2, P3 or P4 would be a suitable position for the proposed ultraviolet telescope.

(3) 2 Q08t

P2 and P3 may be unsuitable due to the reflection or emission of infrared from the Earth's atmosphere, but the Sun is very bright, so this may not matter. The Moon is tidally locked to Earth, and its synodic (the orbital) period is 29.5 days, so P3 and P4 are unsuitable. They will not be able to see the Sun for half the days each month. P2 is therefore suitable.

**Examiner comments:** Although this response arrives at the correct conclusion, it does not support it with a clear reason. Although it identifies the observational difficulties with observing sites on the Moon, it does not give a clear reason for rejecting each of P3 and P4. It therefore does not present a full analysis of the material presented in the question and can thus not be awarded full marks.

**Mark awarded = 2**

## Example 17 – Question 8cii

(ii) A student wishes to improve the telescope's images of Saturn.

The student replaced the telescope's eyepiece with an eyepiece that had a shorter focal length.

State **one** advantage of using an eyepiece with a shorter focal length.

(3)

State **two** disadvantages of using an eyepiece with a shorter focal length.

1 .....

2 .....

### Mark scheme

Question number	Answer	Additional Guidance	Mark
8 (c)(ii)	<p>Advantage, any one from:</p> <ul style="list-style-type: none"> <li>increased magnification / Saturn appears larger</li> <li>smaller field of view</li> </ul> <p>Disadvantages, any two from:</p> <ul style="list-style-type: none"> <li>dimmer image</li> <li>smaller field of view / harder to locate in sky</li> <li>{lower / worse / poorer} {image quality / resolution}</li> <li>requires more stable mounting / image moving around</li> <li>eye relief issues</li> </ul>	<p>Accept smaller field of view as one marking point only.</p>	3

## Student answers

(ii) A student wishes to improve the telescope's images of Saturn.

The student replaced the telescope's eyepiece with an eyepiece that had a shorter focal length.

State **one** advantage of using an eyepiece with a shorter focal length.

(3) Q08ci

~~telescope tube will be shorter~~ larger magnification

State **two** disadvantages of using an eyepiece with a shorter focal length.

1 smaller field of view.

2 less light grasp? resolution?

**Examiner comments:** This response provides three correct statements about the effect of reducing the focal length of the eyepiece and therefore gains all three marks.

Although it does not affect the mark, the addition of question marks after answers is unnecessary and does not improve the impact of students' answer.

**Mark awarded = 3**

(ii) A student wishes to improve the telescope's images of Saturn.

The student replaced the telescope's eyepiece with an eyepiece that had a shorter focal length.

State **one** advantage of using an eyepiece with a shorter focal length.

(3) **2** Q08ci

*greater magnification*

State **two** disadvantages of using an eyepiece with a shorter focal length.

1 *Reduced field of view, so harder to find objects*

2 *No increase in resolution*

**Examiner comments:** This student's response correctly identifies the increased magnification, but reduced field of view produced by a shorter focal length eyepiece lens.

Although the student has correctly identified the link between shorter eyepiece focal length and reduced image quality/resolution, their second disadvantage proposes 'no increase' in resolution, which is not the same thing. Only the first of their disadvantages can therefore be credited.

**Mark awarded = 2**

(ii) A student wishes to improve the telescope's images of Saturn.

The student replaced the telescope's eyepiece with an eyepiece that had a shorter focal length.

State **one** advantage of using an eyepiece with a shorter focal length.

(3) **2** Q08ci

*The shorter the focal length, the greater the magnification*

State **two** disadvantages of using an eyepiece with a shorter focal length.

1 ~~There is~~ *The telescope has a smaller field of view*

2 *The image will suffer from more chromatic aberration*

**Examiner comments:** This student's response correctly identifies the increased magnification, but reduced field of view produced by a shorter focal length eyepiece lens.

Since a shorter focal length eyepiece lens will not necessarily affect the level of chromatic aberration in the telescope, their second disadvantage does not gain any marks.

**Mark awarded = 2**

## Example 18 – Question 9ai

- 9 (a) (i) State **two** differences between the construction of optical telescopes and radio telescopes.

(2)

1 .....

.....

2 .....

.....

### Mark scheme

Question number	Answer	Additional Guidance	Mark
9 (a)(i)	<p>Any <b>two</b> points from:</p> <ul style="list-style-type: none"> <li>radio telescope has a larger {objective / aperture / reflector / diameter}</li> <li>radio telescope {objective / reflector} is made with lower precision</li> <li>radio telescopes can have a {reflector / dish} made of mesh</li> <li>radio telescopes do not need to be located at high altitude</li> <li>radio telescope {objective / reflector / dish} made from metal / is not silvered  <b>OR</b> optical telescope {objective / reflector} made from glass / lenses / is silvered.</li> </ul>	Accept reverse arguments	2

## Student answers

- 9 (a) (i) State **two** differences between the construction of optical telescopes and radio telescopes.

(2) 2 Q09:

1 Radio telescopes have much larger apertures.

2 Optical telescopes must have much smoother, more precise (glass) lenses, whereas this matters less for radio (can use metal).

- (ii) The sign below is displayed outside a radio telescope observatory.

**Examiner comments:** This student's response clearly presents the ideas of the need for larger physical apertures in radio telescope and the need for more precise manufacture in optical telescope. It therefore scores full marks.

**Mark awarded = 2**

- 9 (a) (i) State **two** differences between the construction of optical telescopes and radio telescopes.

(2)

1 A radio telescope has a bigger objective mirror

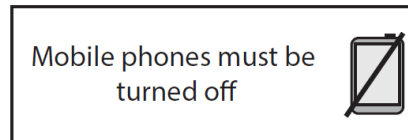
2 An optical telescope is made more carefully

**Examiner comments:** This student's reference to the larger objective mirror in a radio telescope clearly scores a mark. However, the statement that optical telescopes are made more 'carefully' is not sufficient to establish the idea that greater precision is needed in the machining of the reflecting surfaces in an optical telescope.

**Mark awarded = 1**

## Example 19 – Question 9aii

(ii) The sign below is displayed outside a radio telescope observatory.



Give **one** reason for this sign.

(1)

.....

.....

### Mark scheme

Question number	Answer	Mark
9 (a)(ii)	(mobile phone signal will) interfere / create noise / affect observations (1)	1

### Student answers

Give **one** reason for this sign.

(1) 1 Q09:

They emit radio frequencies for communication,  
which interfere with the signals being detected  
by the telescope

**Examiner comments:** This student has the correct idea of mobile phones emitting radio waves that could interfere with the operation of the radio telescope and thus achieves the mark for this question.

**Mark awarded = 1**

Give **one** reason for this sign.

(1) 0 Q09

To tell ~~pe~~ people to turn ~~of~~ their mobile phones

**Examiner comments:** This student has correctly stated that the sign instructs people to turn off their mobile phones, which is essentially repeating content given in the question. They have not gone on to give the astronomical reason behind the need for phones to be switched off – the essential element for the award of the mark in this question.

**Mark awarded = 0**

## Example 20 – Question 9bi

(b) Modern astronomical observations are often recorded using a digital sensor.

One example of a digital sensor is a CCD (charge-coupled device).

Figure 14 compares the proportion of light detected by a CCD with the proportion of light detected by the human eye.

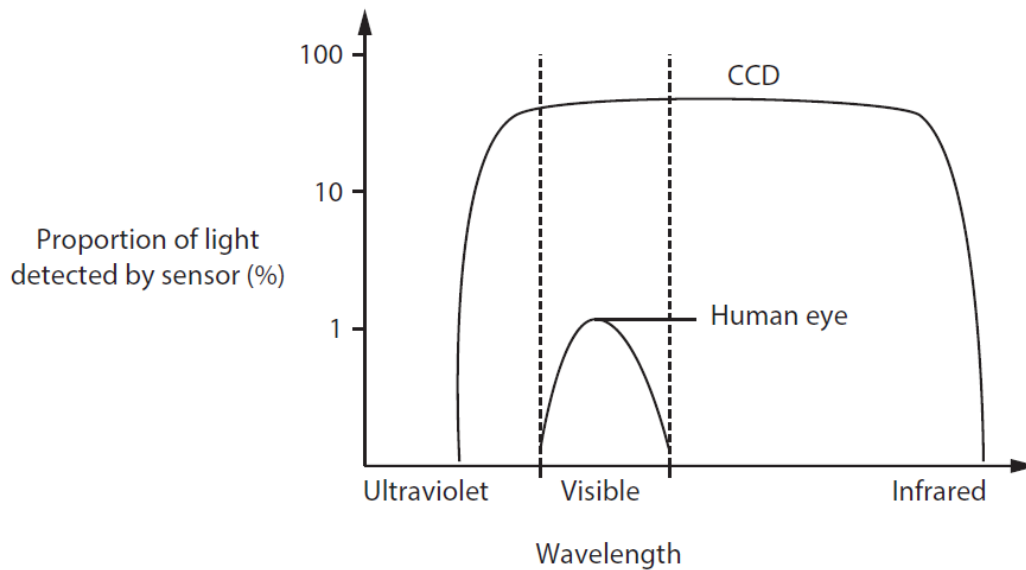


Figure 14

(i) Give **one** reason why CCDs are **not** used as sensors for radio astronomy.

(1)

### Mark scheme

Question number	Answer	Mark
9 (b)(i)	Any <b>one</b> from:  CCDs cannot detect radio waves (1) CCDs cannot detect waves longer than infrared (1) quantum efficiency of CCD's falls to zero beyond infrared (1)	<b>1</b>

## Student answers

(i) Give **one** reason why CCDs are **not** used as sensors for radio astronomy.

(1)1 Q09bi

*because they can't detect radio waves*

**Examiner comments:** This student has correctly pointed out that radio waves are not detected by CCDs and thus scores the mark available in this question.

**Mark awarded = 1**

(i) Give **one** reason why CCDs are **not** used as sensors for radio astronomy.

(1)1 Q09bi

*They cannot detect long wavelengths such as radio waves*

**Examiner comments:** This student has stated that CCDs cannot detect the long wavelengths that radio waves have and has thus scored the mark available in this question.

**Mark awarded = 1**

## Example 21 – Question 9bii

(b) Modern astronomical observations are often recorded using a digital sensor.

One example of a digital sensor is a CCD (charge-coupled device).

Figure 14 compares the proportion of light detected by a CCD with the proportion of light detected by the human eye.

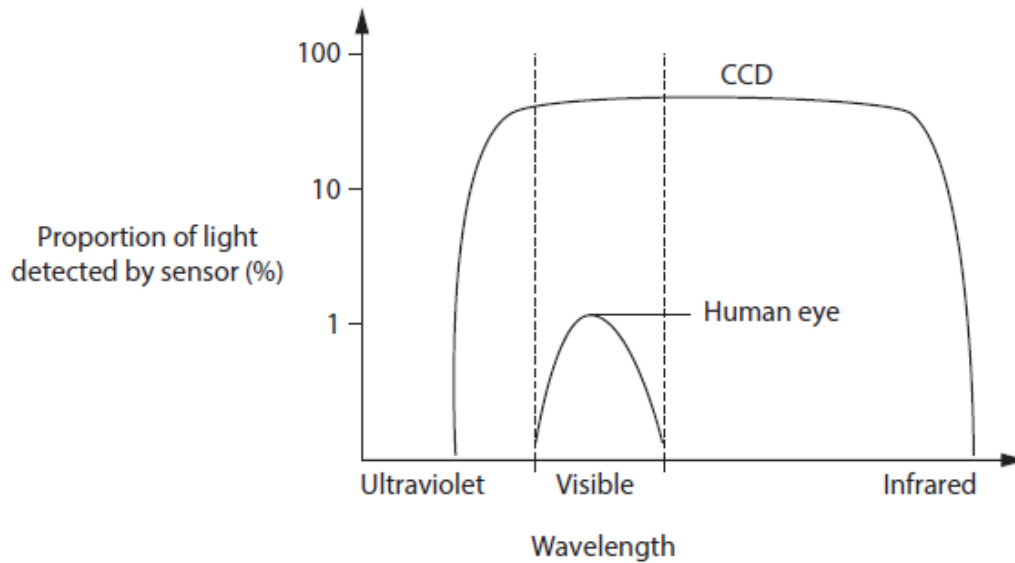


Figure 14

(i) Give **one** reason why CCDs are **not** used as sensors for radio astronomy.

(1)

(ii) Analyse Figure 14 in order to comment on the differences between a CCD sensor and the human eye.

(2)

## Mark scheme

Question number	Answer	Mark
9 (b)(ii)	<p>CCDs have a greater sensitivity / can see a greater proportion of light (than the human eye) (1)</p> <p>CCDs are able to observe a greater range of wavelengths / frequencies / able to observe into the ultraviolet and infrared (1)</p>	2

## Student answers

- (ii) Analyse Figure 14 in order to comment on the differences between a CCD sensor and the human eye.

(2) Q09bi

- A CCD detects much more light than a human eye, given the same brightness.

- A CCD can detect a much greater range of wavelengths, than a human eye.

**Examiner comments:** This response lists the greater sensitivity of the CCD and the broader range of wavelengths that it can detect – both of which are acceptable answers in this question.

**Mark awarded = 2**

- (ii) Analyse Figure 14 in order to comment on the differences between a CCD sensor and the human eye.

(2) Q09bi

The human eye can only see visible light, while a CCD's detect a larger range of light waves, and at a larger proportion detected.

**Examiner comments:** This response also covers both points shown in Figure 14 – the limited range of the human eye in terms of wavelengths detected and the much greater sensitivity of the CCD.

**Mark awarded = 2**

## Example 22 – Question 9c

- (c) A GCSE Astronomy student decides to use a photograph to determine the radiant point of a meteor shower more accurately.

Figure 15 shows the photograph taken by the student.



**Figure 15**

The student concludes that the photograph is not suitable for determining the radiant point.

Evaluate ways to improve the photograph in order to locate the radiant point more accurately.

(6)

.....

.....

.....

.....

.....

.....

.....

## Mark scheme

Question number	Answer			Mark
9(c)	<b>Level</b>	<b>Mark</b>	<b>Descriptor</b>	<b>6</b>
		0	No rewardable material.	
	Level 1	1-2	Lacks clarity. Basic interpretation and evaluation of the method but is limited and narrow in scope. Appraisal of potential improvements is unsupported.	
	Level 2	3-4	Some structure. Interpretation and evaluation of the method that attempts to synthesise and integrate knowledge. Potential improvements are partially supported by evidence of analysis of the method.	
	Level 3	5-6	Comprehensive and well structured. Interpretation and evaluation of the method demonstrates synthesising and integrating knowledge throughout the response. Potential improvements supported throughout showing well developed scientific reasoning that is clear, coherent and logically structured.	
	<b>Indicative content guidance</b>			
	The indicative content below is not prescriptive, and candidates are not required to include all of it. Other relevant material not suggested below must also be credited. Relevant points may include:			
	<b>Comment on photograph</b>		<b>Improvement</b>	
	Radiant not located in the photograph		Increase field of view / observe to the left of image	
	Not many meteors		Increase exposure time / take multiple photographs	
Only small part of the sky photographed / observed		Increase field of view / reduce magnification / use wide angle lens		
Photograph suffers from exposure light pollution		Change location / reduce time		
Constellations difficult to identify due to long star trails		Reduce exposure time (and take more images)		
Foreground takes up large fraction of photograph		Horizon at bottom of frame horizon in frame		

## Student answers

radiant point.

Evaluate ways to improve the photograph in order to locate the radiant point more accurately.

FOV of photograph is too small, so not enough ~~trails can~~ meteor trails can be seen, and the ~~radiant~~ radiant is not within the photograph.

Student should use lower magnification, to give a larger FOV, and estimate the radiant's position first to ensure it is within the FOV.

Student should move to a less light polluted area (more rural) to reduce the impact of skyglow, which makes the trails near the horizon harder to see, which reduces the number of meteor trails visible. The more meteor trails visible, the more accurate the radiant location. The student should move to an area with less trees and buildings, e.g. high upon a grassy hill, to make the horizon unobstructed, increasing the number of meteor trails visible, therefore improving the accuracy of the radiant location. The student could benefit from using a shorter exposure time, as the trails if enough the meteors have been seen, this will reduce the length of the star trails and allow for a more precise radiant location (only do this if there are plenty of meteor trails still visible with the shorter exposure). (Total for Question 9 = 12 marks) **12**

Student could use a machine to track the camera with the background stars, removing star trails, and giving the most precise radiant location.



**Examiner comments:** This response makes a number of effective suggestions, demonstrated a clear analysis and interpretation of the material provided in the question. It thus represents a synthesis of astronomical skills to solve the problem posed by the question. It is clearly at level 2 in the Mark Scheme.

**Mark awarded = 3**

The student concludes that the photograph is not suitable for determining the radiant point.

Evaluate ways to improve the photograph in order to locate the radiant point more accurately.

162 Q09c

To locate the radiant point accurately you first don't want to be surrounded by street lights, trees or in a town. To get a clear image go to an empty field and camp. You also want to make sure there's not any comets that might ruin your photo. So use Google and see when there is clear skies. Also will be difficult because you are unable to see the midpoints of where the stars are rotating around.

**Examiner comments:** This response offers a basic interpretation and very little evaluation of the methods to be used in this question. It is therefore characteristic of a Level 1 answer, offering a few helpful suggestions around the problem of locating the radiant point of a meteor shower.

**Mark awarded = 2**

## Example 23 – Question 10aii

10 (a) Figure 16 shows images of two galaxies.

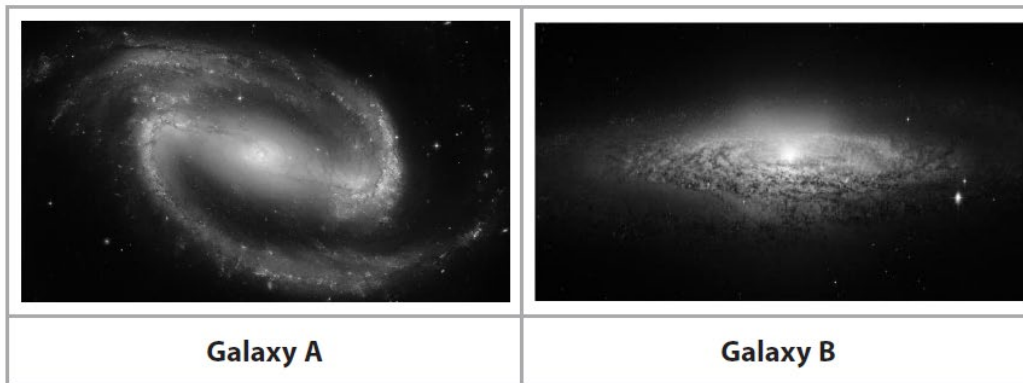


Figure 16

(i) State the Hubble classification of Galaxy A in Figure 16.

(1)

(ii) Explain why it is difficult to determine the Hubble classification for Galaxy B in Figure 16.

(2)

### Mark scheme

Question number	Answer	Mark
<b>10 (a)(ii)</b>	unable to determine shape / structure of spiral arms / central bulge / bar (1)  because galaxy is viewed (nearly) edge on (1)	<b>2</b>

## Student answers

- (ii) Explain why it is difficult to determine the Hubble classification for Galaxy B in Figure 16.

(2) 2 Q10a

We see galaxy B from an angle close to its flatter plane, making it hard for us to view its structure (presence of spiral arms, or a barred nucleus).

**Examiner comment:** This response clearly establishes that the classification difficulties are due to our angle of view and the consequent problems in viewing features such as spiral arms and the galactic nucleus. It therefore scores both marks available in the Mark Scheme.

**Mark awarded = 2**

- (ii) Explain why it is difficult to determine the Hubble classification for Galaxy B in Figure 16.

(2) Q10a

because its a photo taken on an angle not straight on top of

**Examiner comments:** This response is just sufficient for the award of the second marking point shown in the Mark Scheme. It points out that the photograph of Galaxy B has not been taken from 'straight on top of', i.e. it does not give a 'plan' view of the galaxy. This is broadly equivalent to stating that the photograph is 'edge on', as required by the Mark Scheme.

**Mark awarded = 1**

## Example 24 – Question 10bi

(b) The distance to a galaxy can be determined by measuring its apparent size.

Astronomers conclude that galaxies that appear smaller are further away.

(i) State **one** assumption that they have made.

(1)

### Mark scheme

Question number	Answer	Mark
10 (b)(i)	All galaxies are the same size (1)	1

### Student answers

(b) The distance to a galaxy can be determined by measuring its apparent size.

Astronomers conclude that galaxies that appear smaller are further away.

(i) State **one** assumption that they have made.

(1) 1 Q10b

*That all galaxies are the same size.*

**Examiner comments:** This response clearly expresses the idea required by the Mark Scheme – the assumption that all galaxies are broadly similar in size.

**Mark awarded = 1**

## Example 25 – Question 10bii

(ii) A galaxy has an apparent angular diameter of 40 arcminutes (40').

Calculate the distance to this galaxy.

Use the equation:

$$\text{distance to galaxy (pc)} = \frac{\text{average size of a galaxy (pc)}}{\text{angular diameter of galaxy (}^\circ\text{)}} \times 60$$

Take the average size of a galaxy to be 50 000 pc.

Give your answer in Mpc.

(3)

### Mark scheme

Question number	Answer	Mark
10 (b)(ii)	<p>4.5 Mpc (3)</p> <p>calculation:</p> <p>convert apparent angular diameter of galaxy into degrees (1)</p> $40 \div 60 = 0.67^\circ$ <p>calculate distance to galaxy (1)</p> $\frac{50\,000}{0.67} \times 60 = 4.5 \times 10^6 \text{ (pc)}$ <p>convert distance to Mpc (1)</p> $4.5 \times 10^6 \div 10^6 = 4.5 \text{ (pc)}$ <p>allow a range of answers if given to 3sf due to rounding errors</p> <p>an answer of 7.5 scores 2 marks  an answer of 7 500 000 scores 1 mark  an answer of 75 000 scores 1 mark  an answer of 0.075 scores 2 marks</p>	3

## Student answers

Take the average size of a galaxy to be 50 000 pc.

Give your answer in Mpc.

(3) Q10bi

$$\text{distance} = \frac{50000}{40:60} \times 60$$

$$= 75000 \times 60$$

$$= 4\ 500\ 000\ \text{pc}$$

$$= 4.5\ \text{Mpc}$$

Distance to galaxy = 4.5 Mpc

**Examiner comments:** This response arrives at the correct answer and also shows all the necessary stages in its working, ensuring that it would still score highly, even if the final answer had been incorrect.

The numbers being substituted into the equation given in the question are clearly shown, along with the stages in the conversion from pc to Mpc.

**Mark awarded = 3**

Take the average size of a galaxy to be 50 000 pc.

Give your answer in Mpc.

(3) **3** Q10b

$$\text{Mega pc} = 10^6 ?$$

$$4 \text{ arcmin} = \frac{2}{3} \text{ degree.}$$

$$\frac{50\,000}{\frac{2}{3}} \times 60 = 4\,500\,000$$

$$4\,500\,000 \div 10^6 = 4.5$$

Distance to galaxy = 4.5 Mpc

**Examiner comments:** Although this student's response arrives at the correct final answer, its supporting working is not set out very clearly. In the event that the final answer was incorrect, this response may not have gained all possible marks for working.

Labelling the stages in a calculation is strongly advised, so that it is clear what each line of numbers represents. In this example, some lines are part of the calculation of distance, some are unit conversions and others are reminders of key data. With no labelling, the examiner can often be unsure about how to follow the calculation 'thread' through the working.

**Mark awarded = 3**

(ii) A galaxy has an apparent angular diameter of 40 arcminutes (40').

Calculate the distance to this galaxy.

Use the equation:

$$\text{distance to galaxy (pc)} = \frac{\text{average size of a galaxy (pc)}}{\text{angular diameter of galaxy (}^\circ\text{)}} \times 60$$

Take the average size of a galaxy to be 50 000 pc.

Give your answer in Mpc.

(3) 2 Q10b

$$\frac{50000}{\frac{40}{60}} \times 60 = 4500000 \text{ pc}$$

$$= 4500 \text{ Mpc}$$

Distance to galaxy = 4500 Mpc

**Examiner comments:** This student's response shows a correct calculation of the distance to the galaxy described in the question – 4 500 000pc. However, the conversion from pc to Mpc has been made using a factor of 1000 instead of 1 000 000, resulting in an incorrect final answer.

However, the clear evidence of numbers correctly substituted into the equation and a correct calculation ensure that this mistake only costs the student one mark.

**Mark awarded = 2**

## Example 26 – Question 10ci

- (c) The redshift of a galaxy can be determined from observations of the spectral lines in the light from the galaxy.
- (i) Describe how astronomers obtain the patterns of spectral lines in the light from a galaxy.

You may include a clearly labelled diagram in your answer.

(2)

.....

.....

.....

### Mark scheme

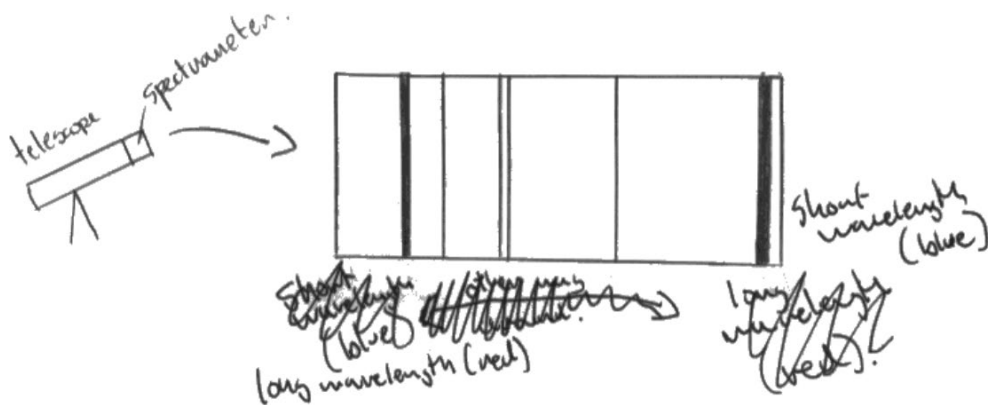
Question number	Answer	Mark
10 (c)(i)	<p>light is passed through a diffraction grating / spectrometer (1)</p> <p>Any <b>one</b> point from:</p> <ul style="list-style-type: none"> <li>• an image of spectrum is taken</li> <li>• positions / wavelengths of dark / light bands measured</li> </ul>	2

## Student answers

- (i) Describe how astronomers obtain the patterns of spectral lines in the light from a galaxy.

You may include a clearly labelled diagram in your answer.

(2) 2 Q10c



Astronomers use telescopes with very "large" apertures and ~~short~~ high magnifications, combined with spectrometers which split the light, to show absorption and emission lines from the galaxy.

**Examiner comments:** This response covers both marking points by mentioning the use of a spectrometer and showing a sketch of a typical spectrum with relative wavelength indicated alongside.

The diagram could have been improved by a clearer light path from telescope to spectrum, perhaps showing the light passing through the spectrometer in between.

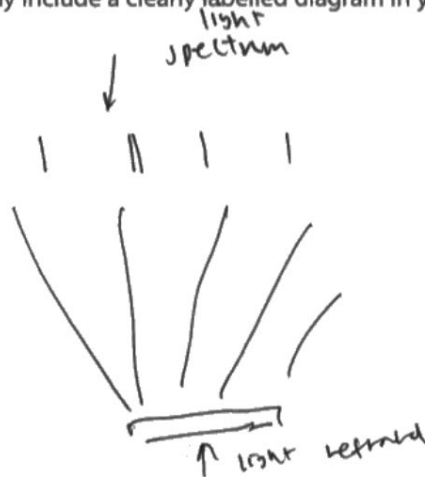
**Mark awarded = 2**

(c) The redshift of a galaxy can be determined from observations of the spectral lines in the light from the galaxy.

(i) Describe how astronomers obtain the patterns of spectral lines in the light from a galaxy.

You may include a clearly labelled diagram in your answer.

(2) 1 Q10ci



Attach spectrometer to telescope. It refracts light into a spectrum, showing absorption and emission lines at different wave lengths due to its composition.

**Examiner comments:** this student's response clearly mentions use of a spectrometer and thus scores the first marking point. However, it does not progress to covering the second marking point and it is not clear how much additional information is conveyed by the diagram. More specific labelling of the various freehand lines would improve matters.

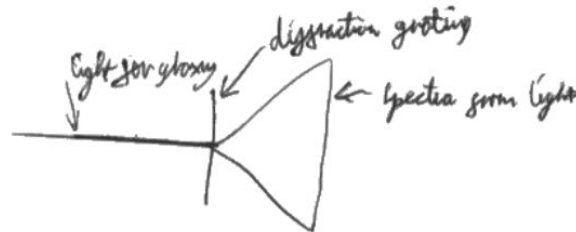
**Mark awarded = 1**

(c) The redshift of a galaxy can be determined from observations of the spectral lines in the light from the galaxy.

(i) Describe how astronomers obtain the patterns of spectral lines in the light from a galaxy.

You may include a clearly labelled diagram in your answer.

(2) 1 Q11



The send the light through a diffraction grating which produces the spectrum lines.

**Examiner comments:** This student's response contains a promising diagram showing the light path from the galaxy through to the spectrum. However, it only specifically mentions the use of a diffraction grating and thus only scores the first mark on the Mark Scheme.  
**Mark awarded = 1**

## Example 27 – Question 10cii

(ii) Describe how astronomers measure the redshift of a galaxy by studying the spectral lines in the light from the galaxy.

(2)

.....

.....

.....

.....

### Mark scheme

Question number	Answer	Additional Guidance	Mark
10 (c)(ii)	<p>Any <b>two</b> points from:</p> <ul style="list-style-type: none"> <li>• <u>wavelength</u> of spectral / absorption line from galaxy (spectra) (is measured) (1)</li> <li>• and compared to a standard / laboratory / 'stationary' spectra (1)</li> <li>• measure change / increase in wavelength (which can be used to determine redshift) (1)</li> <li>• equation <math>\frac{\lambda - \lambda_0}{\lambda_0} = \frac{v}{c}</math> correctly referenced (1)</li> </ul>	<p>Note: if equation is stated AND <math>\lambda</math> (wavelength of spectral / absorption line) or <math>\lambda_0</math> ('stationary' wavelength) defined – 2 marks</p>	2

## Student answers

galaxy  
(ii) Describe how astronomers measure the redshift of a galaxy by studying the spectral lines in the light from the galaxy.

(2) 2 Q10c

The absorption lines of the elements on the ~~sun~~ in the galaxy will correspond to emission lines of elements as measured in the lab. This change in wavelength shows the red/blue shift i.e. increase in wavelength observed or decreased in wavelength observed.

**Examiner comments:** This student's response clearly describes comparing the emission lines in the galactic spectrum to those in a laboratory spectrum and calculating the difference between the two, thus achieving a value for the red shift. It has therefore met both the points required by the Mark Scheme.

**Mark awarded = 2**

(ii) Describe how astronomers measure the redshift of a galaxy by studying the spectral lines in the light from the galaxy.

(2) 0 Q10c

- Match the pattern to known spectra  
- Calculate degree the shift observed by how much the lines have moved from the expected positions

**Examiner comments:** This response talks in quite general terms about comparing the galactic spectrum with a 'known' spectrum and identifying the 'shift'. However, it does not explicitly state the measurements to be taken and there is no mention of wavelength. It does not therefore meet the demanding standards required by the two marking points in the Mark Scheme.

**Mark awarded = 0**

## Example 28 – Question 10ciii

- (iii) Measurements of galactic distances and galactic redshifts can be used to determine a value for the Hubble Constant,  $H_0$ .

Complete the sketch graph in Figure 17 to show how astronomers have determined a value for the Hubble Constant using these measurements.

(3)

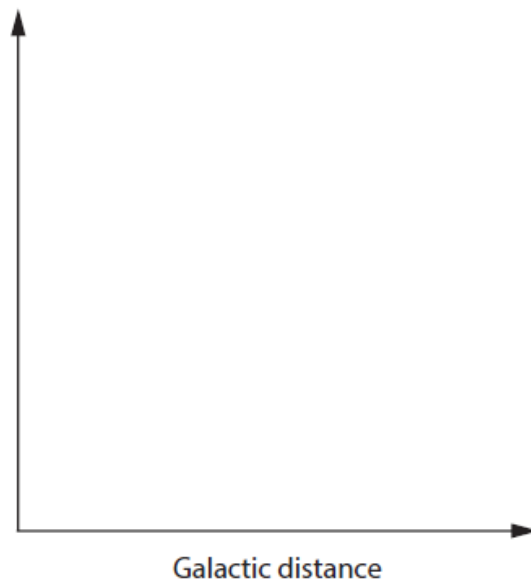


Figure 17

### Mark scheme

Question number	Answer	Mark
10 (c)(iii)	Graph of: galactic redshift / recession velocity on vertical axis (1) straight line through the origin (1) Hubble constant = gradient of straight line (1)	3

## Student answers

- (iii) Measurements of galactic distances and galactic redshifts can be used to determine a value for the Hubble Constant,  $H_0$ .

Complete the sketch graph in Figure 17 to show how astronomers have determined a value for the Hubble Constant using these measurements.

(3) 10ciii

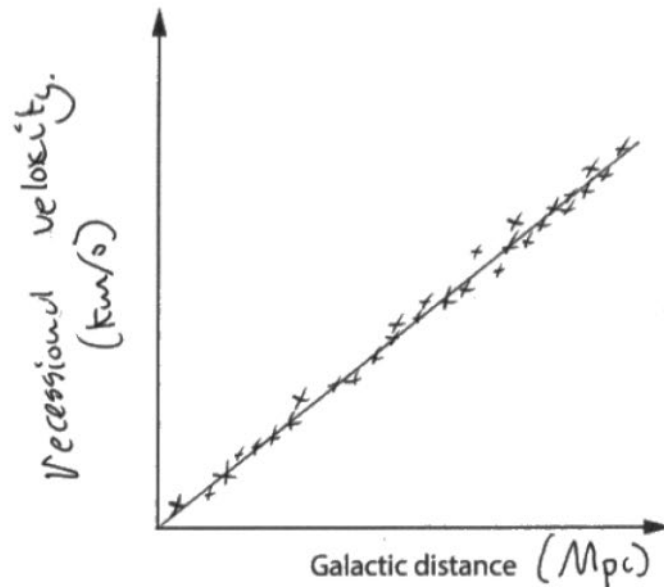


Figure 17

redshifts can be used to determine an object's recessional velocity. The gradient of this graph ( $\text{km/s/Mpc}$ ) is the Hubble constant. (Total for Question 10 = 14 marks) **14**

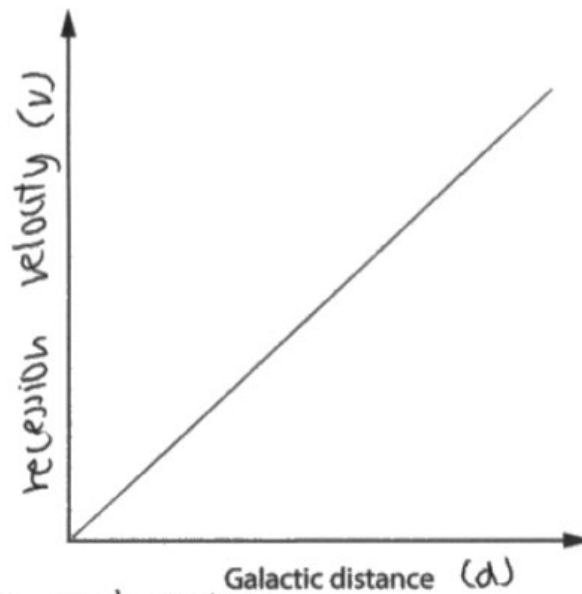
**Examiner comments:** This response clearly meets all the requirements of the Mark Scheme, with completed axes, a straight line through the origin and mention of the use of the gradient to find the Hubble Constant.

**Mark awarded = 3**

- (iii) Measurements of galactic distances and galactic redshifts can be used to determine a value for the Hubble Constant,  $H_0$ .

Complete the sketch graph in Figure 17 to show how astronomers have determined a value for the Hubble Constant using these measurements.

(3) 2 10ciii



line is Hubble's constant.

Figure 17

$V = H_0 d$ . Shows constant in the relationship between recession velocity and increasing distance.

**Examiner comments:** This response provides a complete set of axes and a straight line through the origin, along with a statement of Hubble's Law. This means that it has met the first two marking points on the Mark Scheme but has not mentioned the use of the gradient of the graph to find the Hubble Constant.

**Mark awarded = 2**

- (iii) Measurements of galactic distances and galactic redshifts can be used to determine a value for the Hubble Constant,  $H_0$ .

Complete the sketch graph in Figure 17 to show how astronomers have determined a value for the Hubble Constant using these measurements.

(3) 2 10ciii

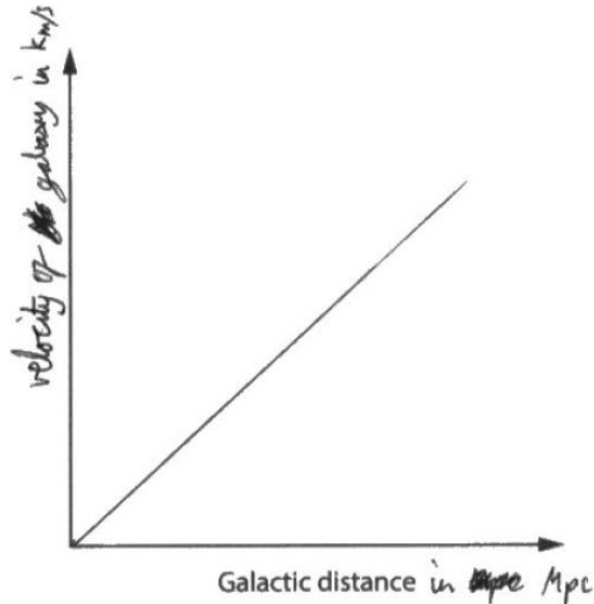


Figure 17

**Examiner comments:** This candidate has completed the axes on the graph, including suitable units and added a straight line through the origin. However, there are no details about how to use the graph to calculate a value for the Hubble Constant, i.e. using the gradient of the graph. This response therefore only scores the first two marking points.

**Mark awarded = 2**