Examiners' Report

Principal Examiner Feedback

November 2020

Pearson Edexcel GCSE In Astronomy (1AS0)

Paper 2: Telescopic astronomy

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Introduction

Despite the unusually small cohort of candidates, a strong sense of their commitment to and enjoyment of the subject was still in evidence in their responses. Despite the fact that for most centres this course necessitates teaching and study outside the timetable, a genuine interest in the subject, often extending beyond the Specification, was frequently displayed.

Although this depth of understanding has been a hallmark of candidates' work in GCSE Astronomy for many years, it was very impressive to see it continuing in this extraordinarily difficult academic year.

In particular, the Examiners were pleased to see…

- An increasing proportion of candidates setting out the working for their calculations in a similar format to that recommended in the Mark Scheme. In other words, each of the following stages was made clear:
  - ✓ the **Equation** being used
  - ✓ the **Numbers** being substituted into the equation
  - ✓ the final **Answer**…
  - ✓ …along with the correct **Units**.

  This helps to ensure that any partial credit in an incorrect calculation is clearly visible.
- Many candidates were following the recommendations in some questions to include a clearly labelled diagram in their answers. This is particularly important in 'Explain…' questions since most ideas in astronomy are much more effectively explained using a diagram.
- A number of candidates whose study of the subject had obviously extended beyond the requirements of the Specification, enabling them to give additional detail in their answers. This evidenced their interest in the subject and enjoyment of the course and is a credit to both them and the teachers who have supported and inspired their learning.
- Familiarity with some of the key observations required by the Specification, clearly based on thorough revision. Examples included Eratosthenes' determination of the diameter of the Moon and Galileo's observations of the phases of Venus.

To improve performance in the future, candidates are advised the following:

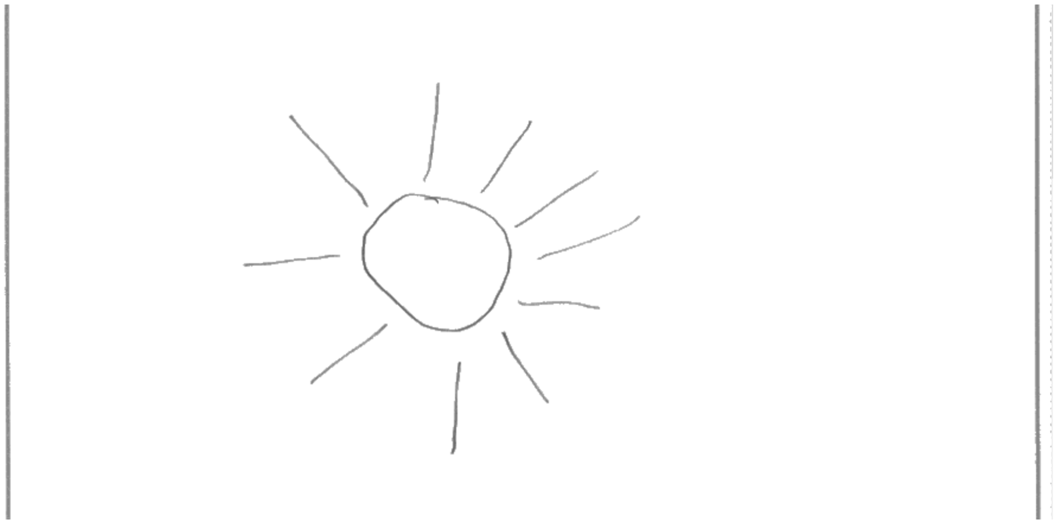
- use specific astronomical terms in their answers rather than vague adjectives. For example, when describing the quality of an image, candidates should refer to specific properties such as resolution, brightness, magnification, angle of view and other specific properties.
- ensure, where possible, that they have some observational experience with basic optical equipment such as binoculars and a small telescope, as required by the Observational Tasks. It was evident from a number of questions that many candidates were not able to justify their Specification knowledge with an understanding of how the features of optical instruments affect the images produced.

  For the 2020 series, this could be done indirectly via online resources or remote observation and this provision will continue in the next series. In addition, Pearson is working on providing further resources which will help candidates to gain further insight into observational astronomy.
- look closely at the command word for each question and ensure that their answer focuses entirely upon it.
- pay close attention to the units required by a question as this may not always be the same as that delivered by an equation.

- ensure all parts of a diagram are correctly labelled and that a ruler has been used wherever necessary. Many diagrams in astronomy involve straight lines and the Examiners were a little concerned to see a high proportion drawn ‘freehand’.

Q1c

This question was designed to be a very simple test of awareness of the most basic lunar features. Almost all candidates were able to achieve this mark, with many adding additional features such as rays or central peaks and often accompanied by low-angle shading to emphasise relief.



Q3ci+ii

This question was designed to test whether candidates understood which features of an image were affected by aperture (light grasp and resolution) and which were primarily determined by focal length (magnification and angle of view).

A large number of candidates found it challenging to achieve this distinction and wrote about a range of image qualities in both parts of this question. Quite a few candidates did not seem to appreciate the brightness of the planet Jupiter, which is easily within the light grasp of the naked-eye.

Hence the best answers linked the telescope's aperture to the need for high resolution to make out surface features on Jupiter and its focal length to the need for a sufficient magnification and angle of view, as shown below.

·The higher the aperture, the better resolution
·And the clearer Jupiter is in the image.
This gives the image a clear view of Jupiter

(ii) a telescope with a focal length of 200 cm

(2)

The bigger the focal length is, the better
magnification you get
This gives the image of all Jupiters 'lines'.

Q3ciiii

This is an example of a question where candidates who had actual observational experience of telescopic observations of this kind scored much more confidently than other candidates. As well as providing a focal length within the suitable range, they were able to give a reasoned justification for their choice.

(iii) Owen has a range of eyepieces available for the telescope in Figure 1.

Suggest a suitable focal length for the eyepiece in order to obtain the view in Figure 2 and give a reason for your answer.

(2)

Focal length = 50 mm

This would achieve a magnification of 40x as $\frac{200}{5} = 40$ which would give a good image of Jupiter

(Total for Question 3 = 9 marks)

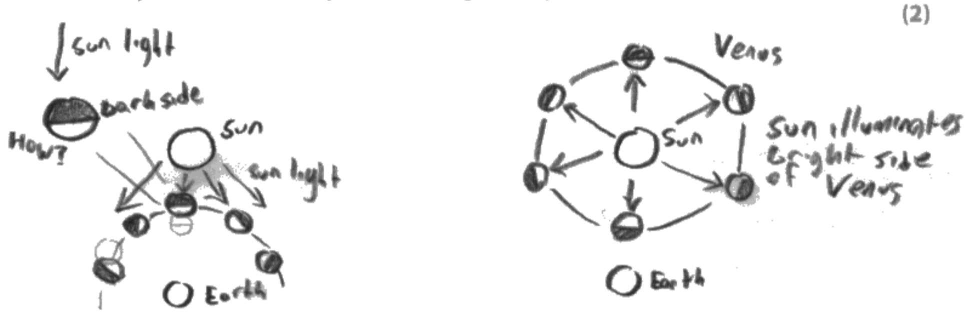
Q4a

A surprisingly high proportion of candidates did not seem to be very familiar with these famous drawings, part of Galileo's observational evidence for a heliocentric solar system. Consequently, many were distracted by the changing phase of Venus which can be achieved in both a Sun and Earth-centred solar system.

Even those who correctly commented on Venus' changing angular size, often felt it necessary to comment on its changing phase too.

You may include a carefully labelled diagram in your answer.

(2)



If Venus orbited the Earth, its angular width would NOT change, and it would not be able to make those phases. These are only possible if it orbits the Sun.

As always, the higher-scoring candidates were generally those who followed the advice to include a clearly-labelled diagram in their answer.

Q4b

Despite the body of numerical data provided, this question simply required candidates to notice the similarity between the smallest angles theoretically resolvable by the human eye and the maximum angular size of Venus (at its crescent phase).

Given the potentially spectacular seeing conditions in ancient times, this gives the hypothesis to be evaluated in the question. A number of candidates mentioned additional relevant issues such as the low altitude of Venus and the generally lighter sky behind it, both of which suggest that the figures in Figure 4 represent idealised conditions.

In addition, a number of candidates did not take notice of the instruction to make use of numerical data from Figure 4, without which full marks could not be obtained.

Evaluate the suggestion that ancient astronomers were able to observe the changing shape of Venus.

Use the data in Figure 4.

(3)

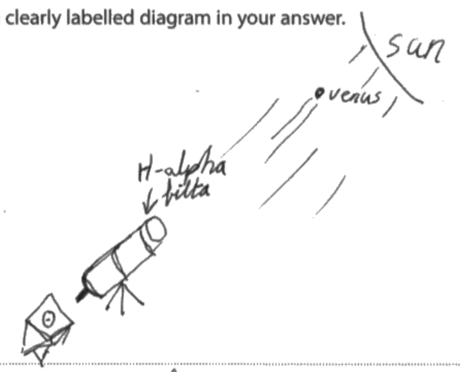
No, ancient astronomers were not able to see the changing shape of Venus. The angular resolution of the human eye is in the range of the angular diameter of a crescent phase Venus, which is what might have been described as horns. However, the full phase has an angular diameter to small to be seen by the human eye. Only after the invention of the early Galilean telescope were humans able to see a small enough resolution through it to view the full Venus.

Q4c

Most candidates spotted the cues in the photograph that telescopic projection had been used and thus included both these elements in their answers. As always, it was very difficult for candidates to achieve full marks in this question without the use of a clearly-labelled diagram.

You may include a clearly labelled diagram in your answer.

(2)



The observer could fit an H-alpha filter onto the camera or telescope - like above - and then take a photo through the camera or project the image onto a screen with a telescope and take a photo of the screen.

Q4di

Almost all candidates were able to multiply the figure given on the Formulae and Data Sheet for the diameter of the Earth by 12 000 to give the correct answer in this question, with many sensibly using standard form for their answer.

By comparing their measurements of the transit, they find that the distance between the Earth and the Sun is 12000 times the diameter of the Earth.

(i) Calculate the distance between the Earth and the Sun.

Use the results of Alice and Bob's observations.

Use data from the Formulae and Data Sheet.

Give your answer in kilometres.

(2)

$12000 \times 13000 = 1.56 \times 10^8$

Distance = 1.56×10^8 km

Q4dii

Although many candidates correctly wrote about the greater difference in latitude between Alice and Bob's positions, far fewer went on to point out that this would give a bigger **difference** between the observations of the transit that they made.

Alice and Bob's observations give a more accurate value for the distance between the Earth and the Sun than the observations made in 1761.

Explain why Alice and Bob's observations give a more accurate result.

(2)

Alice and Bob are at latitudes with a larger distance between them than the 1761 observations. This means a larger angle is observed between the latitudes at which Venus appears on the Sun's disk. These larger angles are easier to measure and therefore give a more accurate result in the conclusion.

(Total for Question 4 = 11 marks)

Many candidates simply said that their positions would ensure a more accurate result (which is largely repeating the question) or referred to their access to twenty-first century technology.

This is a little surprising as a thorough understanding of this method for determining the absolute distance between the Earth and the Sun is specifically required by the Specification.

Q5b

As in previous questions, candidates should always refer to specific features of telescopes (aperture, focal length etc) and specific qualities of their images (sharpness, brightness etc.) rather than responses along the lines of 'telescopes aren't big enough so the images won't be good enough' which inevitably score no marks. Candidates should remember to refer to any specific astronomical parameters or the fact that redshift is only observed in galaxies outside the Local Group.

Explain why astronomers using earlier telescopes were not able to discover the red-shift of light from other galaxies.

Use the data in Figure 8.

(3)

Redshift, to be noticable, has to be extreme, meaning that the galaxies will be very far away from us. Smaller telescopes wouldn't have been large enough to see these galaxies as they are so dim - requiring a large apetore for enough light grasp - and so distant - requiring very strong magnification, which couldn't be done on telescopes before this.

Q5c

Although most candidates were aware that blueshift indicates motion towards the observer, not all went on to give the full two-mark explanation that this was due to the gravitational attraction between the Andromeda and Milky Way galaxies/their joint membership of the Local Group.

(c) Later observations found some galaxies whose light is blue-shifted.

These included the Andromeda and Triangulum galaxies.

Explain why the light from these galaxies is blue-shifted.

(2)

The light is blue-shifted because they are moving ~~an away from~~ towards us.

Q5d

Majority of candidates found it challenging to effectively provide a response to this question. The question asked for specific effects on the images due to light pollution. A large proportion of candidates used very general adjectives such as 'worse', 'lower quality' or 'harder to see' which were too vague to gain any credit.

Some candidates seemed to have mis-read the question and listed possible sources of light pollution such as streetlightts.

State **two** ways in which light pollution from Los Angeles could affect the images from the optical telescopes at the Mount Wilson Observatory.

(2)

1 poorer contrast for photos so detailed analysis [illegible] harder (brighter sky)

2 very dim objects canot be seen and the number of stars/galaxies in sky will decrease

Q6a

Most candidates showed an awareness of the need for metal to reflect (and thus focus) radio waves.

(a) State the reason why the dish in a radio telescope must be made from metal.

(1)

~~[illegible]~~ To capture and ~~[illegible]~~ relfrect the radio waves

Q6b

Once again, to be answered effectively this question required mention of specific image qualities such as resolution and specific features of radio waves such as wavelength, as set out in the Mark Scheme. Lower-attaining candidates argued along the lines of needing to collect lots of radio waves because they are very big.

(b) Explain why the dish in this radio telescope needs to have a much larger diameter than the mirrors in the largest optical telescopes.

(3)

Because radio waves have very long wavelengths this reduces resolution.
So they need a larger ~~up~~ diameter to get a larger aperture, so ~~there resolution is~~ to make up for that ~~tes~~ loss of resolution.

Q6ci

This question required candidates to explain the difference between a single-dish radio telescope and an array of smaller dishes which synthesise a very large 'virtual' aperture. Once again, the higher-scoring responses included specific technical terms.

This telescope has three dishes, spread out over 1600 m.

Each dish has a diameter of 18 m.

(i) Explain why this radio telescope is made up of several smaller dishes, rather than a single large dish.

(3)

It is cheaper and more effective for several smaller dishes to be connected to gain a higher resolution. This is called Radio Aperture Synthesis. The telescopes are connected electronically to gain a higher resolution image.

Q6cii

The best answers to this question were precise about the changes which they would recommend. For example, suggesting an increased 'diameter' or 'aperture' for each dish rather than simply suggesting that each dish could be made 'bigger'.

(ii) State **two** ways that the resolution of this telescope could be increased.

(2)

1 Add more telescopes to the array.

2 Increase the diameter of each telescope.

Q7b

A promising proportion of candidates were able to identify Star E as the one most likely to be a white dwarf. However, candidates are reminded that the major determinant of the mark awarded for this question was candidates' ability to provide a 'comprehensive…interpretation' and a 'well-developed, sustained line of scientific reasoning' to support their final answer.

Star E. A white dwarf should have a mass similar to the sun so star A B unacceptable as it would become a supernova. White dwarf stars are usually of a low magnitude. Their apparent magnitude does not really matter as it is per the observer on Earth. However the absolute magnitude measures at a value of 10 parsecs so it can be used. Stars with a low absolute magnitude are D, B and E. However white dwarfs are of a high spectral class on a hertzsprung russell diagram usually O or B. The only stars of this class are A and E. However the absolute magnitude of A B too high it is likely to be a supergiant. E, is the only star to fit all criteria making it the white dwarf star.

Q7ci

Almost all candidates were able to complete the diagram correctly and thus label a suitable parallax angle. A pleasing proportion also used a ruler for both their lines.

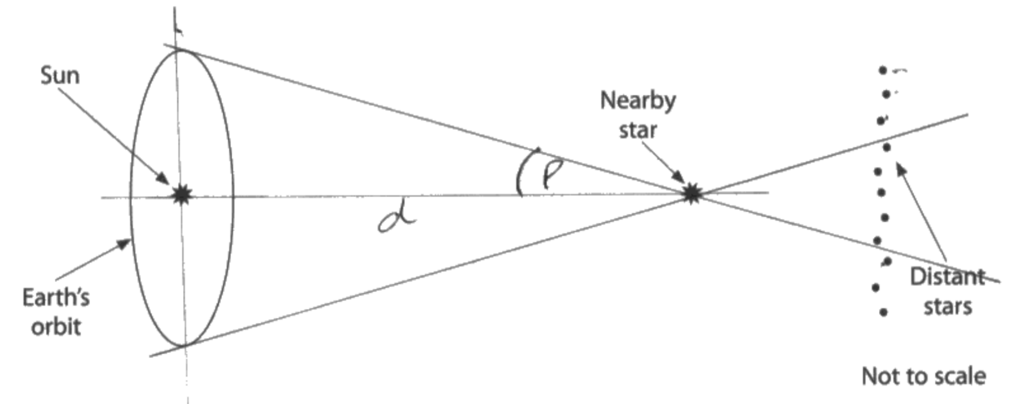


Figure 13

(i) Complete Figure 13 to show the parallax angle of the nearby star, for an observer on the Earth.

Label the angle '**P**'.

(2)

Q7cii

A few candidates forgot that a smaller parallax angle results from objects being further away not closer and thus gave the answer 0.25pc.

Many candidates correctly realised that a parallax angle of 0.25” indicates a distance of 4 parsecs, from the definition of the parsec. However, a number did not notice that the question required the answer to be converted into light years.

> (ii) The astronomer measures the parallax angle of the star Procyon B to be 0.25″.
>
> Calculate the distance of Procyon B in light years.
>
> (3)
>
> $d = \frac{1}{p}$ p in arc seconds
>
> d in pc
>
> 4pc = 13,04
>
> Distance = 13 l.y.

Q8a

The principle that objects orbiting solely under the influence of the force of gravity will move more slowly at greater distances (where the force is weaker) was generally well known.

> (a) Explain this suggestion, using the idea of gravity.
>
> (2)
>
> The ~~putt~~ further away an object is from another object, the weaker the force of gravity is.

Q8bi

Despite the vital role of radio waves in determining the structure of the Milky Way galaxy, very few candidates were able to show any detailed knowledge of its ability to pass through areas where visible light would be heavily scattered.

> (b) A second group of astronomers measures the speed of some stars at different distances from the core of the galaxy.
>
> They use 21 cm radio waves for these observations.
>
> (i) Explain why they used 21 cm radio waves for these observations.
>
> (2)
>
> These radio waves can go through the 20cm zone of dust which stops other waves

Q8bii

Almost all candidates were able to interpret the shape of the 'Observation' curve as showing that the speed of stars was increasing but at a declining rate.

Their results are shown by the curve labelled '**Observation**' in Figure 15.

(ii) Describe the connection between **Speed of star** and **Distance from core** shown by the '**Observation**' curve in Figure 15.

(2)

As the distance from the core increases, the speed of stars increase, however not proportionally, but at an angle a not steep angle

Q8c

Almost all candidates identified that the Theory and Observation data show very different results and many described this difference in terms of the increasing or decreasing speed of stars as distance from the galactic core increased.

A surprisingly small number of candidates were aware that this difference is currently explained in terms of the presence of dark matter and were thus able to score full marks on this question.

(c) Analyse the data in Figure 15 to explain the difference between the '**Theory**' and '**Observation**' curves.

(4)

The theory curve is like that as gravity follows the inverse square law, so as the distance from the core increases the speed decreases (seen by the negative gradient). However this is not true as the observation curve has a positive gradient. This is because of dark matter outside (or the halo) of the galaxy which provides a force to the stars further away from the centre so that they orbit around the nucleus quicker than the stars nearer the nucleus

Q8d

This proved to be a very demanding question, with only a relatively small proportion of candidates obtaining the correct answer. However, despite the fact that there were two marks available for elements of correct working, most of the remaining candidates scored zero.

This was due to the poor presentation of calculations. In many cases the final answer was accompanied by a selection of numbers scattered around the space provided for calculation. Many candidates made no attempt to explain each part of their calculation.

> Calculate the wavelength that this spectral line will appear to have in the spectrum of galaxy B, when observed by an astronomer in galaxy A.
>
> (3)
>
> 400.0nm
>
> 399.6 line 480.0
>
> B → P A
>
> 80nm
>
> 399.6+80nm: 0.4 80.4nm
>
> 479.6
>
> Wavelength = ~~480.4~~ 479.6 nm

Some candidates worked out the speed of each galaxy relative to the Earth and then combined them whilst others calculated the relative shift between the two galaxies and then applied this to the rest wavelength. Either method was capable of gaining credit for all stages of its working, as long as these were made clear and unambiguous in the candidate's response.

Q9a

As listed in the Mark Scheme, the data in Figure 18 contained a number of patterns related to their accuracy, upon which candidates could comment in their answers. Similarly, Wahida's observing location clearly showed a number of factors which would affect the accuracy of her observations such as the large Moon and streetlights.

> (a) Analyse the information in Figures 17 and 18 in order to comment on Wahida's observational method.
>
> (3)
>
> Wahida has observed near light pollution - a town or city and ~~near the moon~~ on full moon. Her results show that she has condenses the magnitude scale such to less than 2.5x between magnitudes. Her results for dimmer stars are ~~no~~ quite far from correct. In most cases, however, she has placed them in the correct order of magnitude.

Q9b

The Examiners were pleased to see almost all the observational issues related to this question identified across the cohort of candidates. However, as set out in the Mark Scheme each year, the highest marks can only be awarded to responses which set out a 'comprehensive…evaluation' via a 'well-developed, sustained line of scientific reasoning' rather than simply presenting a list of unconnected points.

(b) Evaluate ways to improve Wahida's observations in order to obtain more accurate estimates of the stars' magnitudes.

(6)

One way to improve is by going to an area that has no light pollution. An ideal place would be deep in the countryside ~~A~~ but not near any towns or villages. This will remove light pollution effecting data. It would also be good to go when there is a new moon as the bright full moon will also effect the data that she records. Another would be to go on multiple nights to ~~compare if~~ see is the magnitude changes - however all of these nights must be fairly simmiler in terms of condition of the moon, same obscuring place and also same viewing conditions. It would also be a very good idea to only observe on very clear nights.

Q9c

Although essentially a relatively straightforward recall question, the majority of candidates could offer little more than an emission nebula being a cloud of gas which emits light. Higher-attaining candidates were able to provide further specific details such as the role of ionisation or its links to stellar formation.

(c) Wahida discovers that the constellation of Orion contains an emission nebula.

Describe what is meant by an emission nebula.

(2)

A ~~small~~ cloud of dust and gas that gives out light

Q10ai

Most candidates clearly appreciated the difficulties of conducting a fair test of brightness between the Sun and Sirius – a major issue in Huygens' method as described in the question. In addition, many candidates noted the practical difficulties in estimating the brightness of an object as bright as the Sun.

10 (a) In the seventeenth century, the Dutch astronomer Christiaan Huygens made observations to compare the brightness of the star Sirius with the brightness of the Sun.

(i) State **two** practical difficulties in carrying out this comparison.

(2)

1 When the Sun is visible, Sirius is not

2 To look at the sun safely, you would need to use a filter, but Sirius would not be visible through the same filter.

Q10aii

Although a number of candidates had clearly spotted that 20 000 is the square root of 400 million, full marks could only be achieved by accompanying this with an astronomical justification such as mention of the inverse square law.

(ii) Huygens estimated that the Sun is approximately 400 million times brighter than the star Sirius.

He concluded that Sirius must therefore be 20 000 times further away from the Earth than the Sun.

Explain how he came to this conclusion.

(2)

20,000 is the square root of 400 million. Light, being radiation, follows the inverse-square law so a distance of 20,000 would make Sirius 1/400,000,000th the apparent magnitude of the Sun.

Q10aiii

Huygens' method attributes all of the difference in apparent brightness between the Sun and Sirius to their differing distances from the Earth. In other words, it assumes that they have the same intrinsic brightness or absolute magnitude.

(iii) State **one** assumption that Huygens made about the Sun and the star Sirius.

(1)

that they have the same absolute magnitude

Q10aiv

This question simply required candidates to multiply the value for the Earth to Sun distance from the Formulae and Data Sheet by Huygens' value of 20 000. Nevertheless, it was pleasing to see many candidates setting out their working in an organised fashion, such as in the example shown below.

(iv) Calculate the distance from the Earth to the star Sirius.

Use Huygen's estimate that Sirius is 20 000 times further from the Earth than the Sun.

Use information from the Formulae and Data Sheet.

Give your answer in kilometres (km).

(2)

Distance from Earth to Sirius = Distance from Earth to Sun × 20 000

$= 1.5 \times 10^8 \times 20\ 000$

$= 3 \times 10^{12}$ km = 3 000 000 000 000 km

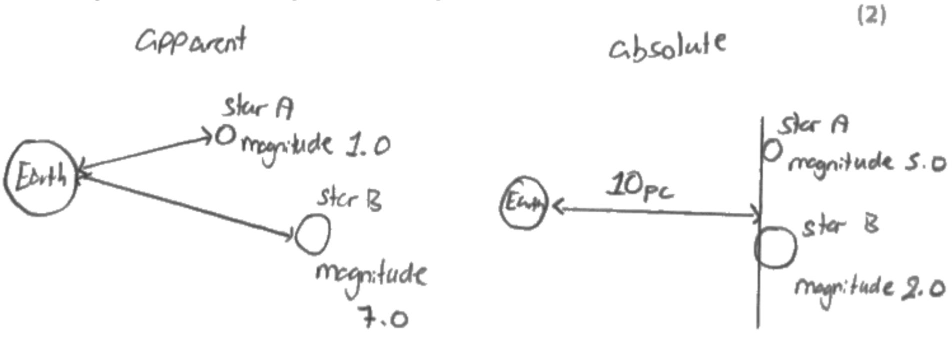
Distance = 3×10^{12} km

Q10bi

This question was well answered by this year's cohort of candidates as it referred to a familiar area of the Specification and a skill which relates to several other areas. Effective answers made good use of diagrams to make clear the distances involved and some candidates also made use of a ruler when labelling them.

You may include a carefully labelled diagram in your answer.

(2)



Apparent magnitude is how bright a star seems to be from Earth. However distance will change how bright a sun is which is what absolute magnitude factors in. Absolute magnitude is how bright a star is if they are all 10 parsecs away.

Q10bii

It was encouraging to see the increasing number of candidates who are setting out their calculations in a similar format to that modelled each year by the Mark Scheme. As well as making it much more straightforward for the marker to identify each correct stage.

Calculate its apparent magnitude.

Use the equation:

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

(3)

1.42 = m + 5 − 5 log(2.69)

1.42 = m + 5 − 2.108019639

3.528 = m + 5

8.53 = m

Apparent magnitude = −1.472

Candidates are also reminded that it is generally not advisable to give more significant figures in their answers than the number given in the question data.