



Pearson
Edexcel

Examiners' Report

Principal Examiner Feedback

Summer 2023

Pearson Edexcel

GCSE Astronomy (1AS0)

Paper 2: Telescopic Astronomy

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Introduction

The GCSE Astronomy examination continues to be centred around non-tiered examination papers with the 3½ hours of examination time split between two papers:

- Paper 1 – Naked-eye Astronomy
- Paper 2 – Telescopic Astronomy

The subject content of each paper mirroring a similar division of material within the Specification.

The central focus on observational astronomy is very evident in these examination papers where many questions are designed around presenting candidates with the results of an astronomical observation and asking them to process the information and arrive at scientific conclusions. Others ask them to comment on the conclusions which others, such as archaeoastronomers, have placed on astronomical data.

Guidance for centres

It is clear from this year's examination that centres and their candidates have worked extremely hard on their astronomical studies, despite the inevitable disruption from the unprecedented events of recent years.

The enthusiasm and commitment which have always characterised those involved with the teaching and learning of GCSE Astronomy continue to be evident. Centres and their candidates are to be commended for the conspicuous hard work and dedication (often as part of an extra-curricular provision) which clearly went into the preparation of this year's cohort.

Across both examination papers, this year's candidates demonstrated a number of impressive qualities, reflecting high quality teaching and learning throughout their courses:

- Candidates continue to show good flexibility when dealing with the wide range of data that the subject generates.
- Many candidates were able to apply their knowledge and understanding to the new or unfamiliar situations presented in many examination questions.
- Many candidates coped very well with the often very demanding mathematical skills required by the questions in this year's papers, including skills such as squaring, cubing and logarithmic scales.
- Strong graphical skills were demonstrated in both the creation and use of graphs.
- Many candidates showed excellent background knowledge in the subject, allowing them to enhance the depth and detail of their answers.

In addition, the following points have been identified as areas where future candidates could strengthen their performance in this qualification:

Question requirements

Although it may seem an obvious point, it is clear that a significant number of candidates are losing marks because they have not fully understood the requirements of the question, In particular candidates must pay close attention to the Command word used at the start of each question as these invariably determine the structure of the mark scheme

- Questions which ask candidates to Explain will not award any marks for a description. When answering these questions candidates must be clear that they are explaining **why** something happens and not simply describing **what** happens. Candidates should ensure that their answer gives material additional to that in the question and that they are not just repeating the question.
- Questions which ask candidates to 'Evaluate...' will require them to come to some kind of judgement or conclusion after having looked at both sides of the information presented.

- Questions that ask candidates to 'Show...' will award marks for each step of astronomical reasoning in the working. Marks will not be awarded for unexplained numbers or calculations.

A full list of the Command words used in the GCSE Astronomy examination and guidance on their requirements can be found in the Specification.

Diagrams

By the nature of the subject, almost every GCSE Astronomy examination question involves the use of a diagram either in the question, the answer or in the mind of the candidate answering it.

- Most concepts in astronomy are more clearly expressed using a diagram and so candidates are advised to use a fully labelled diagram whenever it will make their answer clearer. Obviously, a diagram is required by the mark scheme in questions which state 'Use a diagram...'. Although it is optional in questions stating 'You may use a diagram...' it is still strongly recommended. The use of diagrams to clarify answers was definitely a hallmark of the higher-scoring candidates in this year's examination.
- It is essential that all the key parts of a diagram are clearly labelled. A number of 'diagrams' seen by this year's Examiners contained lines and curves representing important items, but which had no label, often rendering the diagram insufficient for the award of marks.
- Candidates are advised to use a ruler whenever possible in their diagrams. Diagrams drawn without the use of a ruler can easily descend into becoming rough sketches.
- Diagrams in GCSE Astronomy often involve drawing an area of the night sky. Given its apparently 'domed' appearance this is something which candidates should practise beforehand as it can present something of a drawing challenge. Nevertheless, regarding each small section of the sky as a piece of flat graph paper, with lines drawn with a ruler and clearly labelled can make this a more straightforward task.

Calculations

In both examination papers, calculations often represent a significant number of marks, and it is important that each candidate shows the full extent of their ability in these questions.

- It is important that candidates bring an adequate calculator to both examination papers so that they can meet all its mathematical demands. As well as basic arithmetical functions, astronomical calculations can often involve more complex operations such as squaring, cubing, taking logarithms etc.
- Candidates should ensure that they are familiar with the operation of their chosen calculator.
- Given that some calculations are now worth three or even four marks, the provision of clear structured working is now more important than ever.
- The provision of clear working is essential in questions which require candidates to 'Show...' rather than 'Calculate...'. In these questions there are obviously no marks for the final answer (given on the paper) and all marks are for the steps in the working and their astronomical justification.
- It is recommended that candidates give their final answers to a sensible number of significant figures, taking their cue from the data given in the question, in addition to the precise answer resulting from their calculation.
- Questions asking candidates to 'Analyse...' will require them to use the numerical data provided within the question as part of their answer. These data can be provided in a table, graph or other form but must be used in the candidates' calculations if full marks are to be obtained.

2 d

This worked well as an early differentiated question. Some candidates often made reference to the image suffering from poor resolution/light grasp and the need for a larger aperture.

larger
~~bigger~~ appature would allow for more
light which would increase the resolution

(0 marks)

Many responses **stated** that a shorter exposure time was required but did not go on to **explain** why, thus only gaining 1 mark.

3 a i

This question proved difficult, and not many candidates gave the correct response. An example of a correct answer is shown below.

It is dense, so a parachute or airbag
can be used to slow the descent of the probe for a
soft landing.

(1 mark)

Although the Martian atmosphere is not dense, the key point that a parachute can be used has been clearly stated.

It was surprising to note that many candidates thought that heat shielding is not required and that this was therefore an advantage.

The martian atmosphere is thin, so it does not the
probe does not need a heat shield to cope with air resistance

(0 marks)

This response would have been awarded the mark for the disadvantage for the planned mission (Q3aii).

3 a ii

An example of a model answer:

Friction will cause heating and
potential damage of the probe

3 b i

This question was well answered by the majority of candidates. The most common problem encountered was the requirement to convert units and centres are encouraged to practise this skill.

3 b ii

There are effectively two possible answers to this question. Either the distance is greater than the value stated, or the speed is less. It was common for candidates to appreciate that the distance between Earth and Mars could increase due to the orbital movement of the planets, as demonstrated in the example below (which gained the mark).

(1)

*The Mars will move in its orbit when the space probe is traveling
so there is an extra distance to go.*

However, there were a few occasions where the orbital motion of the planets was referred to, but the candidate did not then go on to clearly link this with an increase in planetary distance. This example scored no marks:

*Earth and Mars are constantly moving in their
orbits meaning this short distance is brief.*

4 a iv

This question worked well at differentiating ability. Candidates sometimes repeated their answer in different ways. The example below only gained 1 mark because the candidate has effectively repeated the same answer three times.

- 1 Black hole absorbs all light not making it visible
- 2 requires a specific wave length to be seen.
- 3 can only be seen using x rays.

To gain 3 marks, the candidate would be expected to correctly state three distinct marking points.

5 a ii

The majority of candidates were able to *state* that we are located within the Milky Way galaxy (for one mark), but few were then able to clearly go on and *explain* why this makes classification difficult. The command word "explain" requires a justification/exemplification of a point. The answer must contain some element of reasoning/justification.

Because Earth is inside Milky Way, which means that there is no way to see it from the side

This is a common response for 1 mark. The candidate has not fully explained that it is knowledge of the shape/structure of a galaxy that is required to determine its Hubble classification.

5 b i

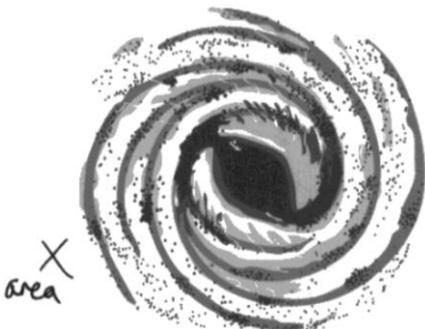
Provided that the location of the Sun was shown in the plane of the galaxy, a wide range of acceptable positions were allowed. This included in the centre of the galaxy due to the possibility of perspective effects. Also, because no scale was given, there was some leniency for positions indicated beyond $2/3$ from the galaxy's centre.

5 b ii

The majority of responses incorrectly indicated the position of dark matter.

Historically, it was thought that dark matter was primarily located in a ring surrounding spiral galaxies. This observational evidence comes from measurements on galaxy rotation curves and has been around for over 40 years. However, recent research now suggests that dark matter density is highest at the centre of a galaxy and decreases with distance from the centre. This work forms the basis for much of our current understanding of the structure of dark matter halos.

Candidates are encouraged to note words in **bold**. This is to stress the importance of the word. The following example is a point rather than an area and was not awarded the mark.



5 b iii

Many candidates stated that it is easier to see the globular clusters when drawn in Figure 10 (side view) of the galaxy. However, they were not awarded the mark because there was no/incorrect reference to the actual location of globular clusters. Note that when a question states "you may include a labelled diagram", then it would be prudent to do so and often the mark scheme reflects this.

This example scored 2 marks:

This is because figure 11 shows the 'top' of the galaxy in a 'birds eye' view. This means we wouldn't be able to determine if the cluster was in the galaxy or not. Figure 11 would show where the 'high' or 'low' the cluster's would be

5 c

This "analyse" question required candidates to study and make comment on the graph - in this case stating the difference between the predicted model and actual observations. Unfortunately, some candidates just "explained" the nature of dark energy. The following example demonstrates this and was only awarded the second marking point.

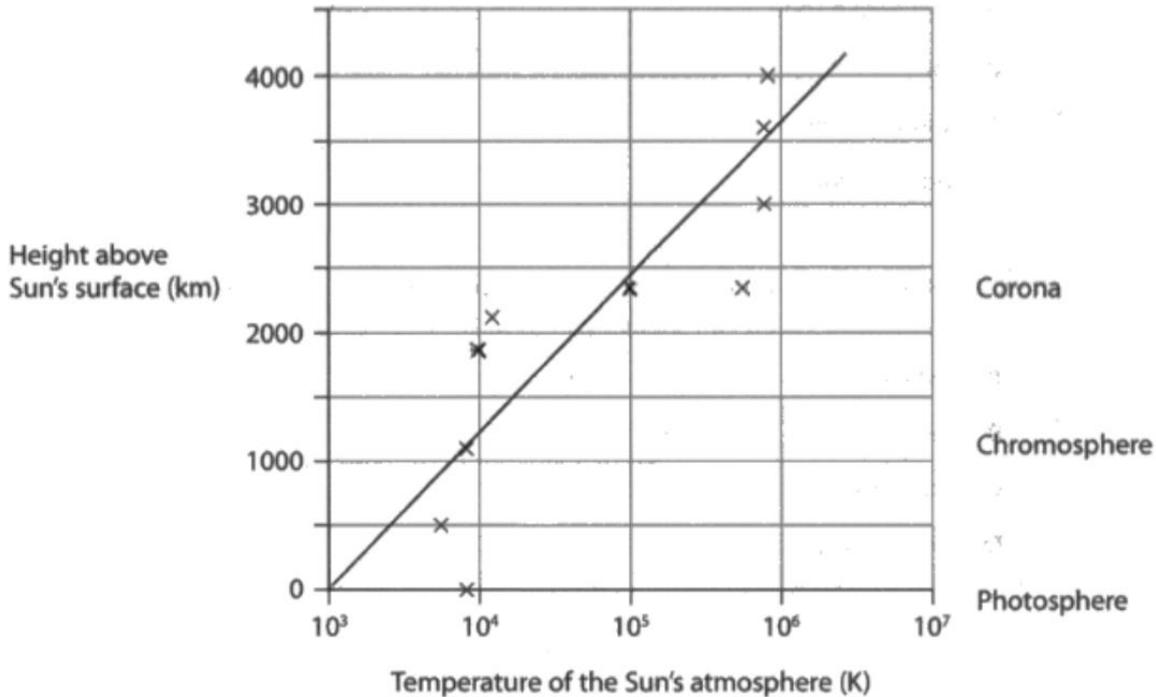
The expansion of the universe is speeding up.
This has to be caused by some sort of energy we cannot see; dark energy

This example scores full marks:

Observations show that the mean distance between galaxies increases further than gravity. This means another energy is increasing the rate of acceleration of galaxies.

6 b i

Centres should remind their students that a "line of best fit" does not have to be a straight line. There were many examples as shown below, where the data points were plotted correctly for two marks. However, a straight line of best fit was then forced through the data, often through the perceived origin.



6 b iii

Candidates were allowed to answer in many different numerical ways. The most common incorrect answer was 10⁸ (K).

6 b iv

This example correctly stated that it would be difficult to extrapolate (1 mark), but did not reference as to why (i.e., the unpredictable changes in the graph).

~~As it is not~~ As there are no points on axis on Figure 13 extending to 6,000 km, it is simply an estimate based on the trend and line of best fit, so the true value could be very different, due to other factors, as we do not fully understand how temperature changes at different altitudes above the sun. (Total for Question 6 = 9 marks)

This is a model answer and was awarded 2 marks:

The graph may temporarily plateau again like with the values from roughly 2100 - 2400 km, therefore may not follow the pattern of the rest of the points plotted for the corona. Therefore, my estimate may be inaccurate as I assumed the gradient of the line of best fit would remain relatively consistent (Total for Question 6 = 9 marks)

7 a i

There were many acceptable answers to this question, and it was surprising to note how many candidates correctly referred to refracting telescopes suffering from chromatic aberration, even though it is not on the syllabus.

This example scored 2 marks:

1. refracting telescopes use lens to capture and focus light whereas reflecting telescopes use mirrors.
2. With refracting telescopes you may get chromatic aberration whereas with reflecting telescopes you ~~to~~ they will have no chromatic aberration.

Candidates must try and avoid giving the 'reverse argument' as a second point – it needs to be a separate/distinct fact. In this example, which scored 1 mark, both points are referring to the same key principle that refractor objectives use a lens OR reflector objectives use a mirror.

1. refractors use lenses ~~and re~~
2. reflectors use mirrors

7 a ii

This can be answered in very few words, as shown in this example (1 mark):

galilean uses a concave lens.

And this example gives a little more detail and was awarded 1 mark.

Galilean uses a concave lense where a Keplerian uses a convex lense.

Sentences that start with "One of them..." or "It uses a..." score no marks, and candidates should be reminded that the difference must be referenced to a specific telescope.

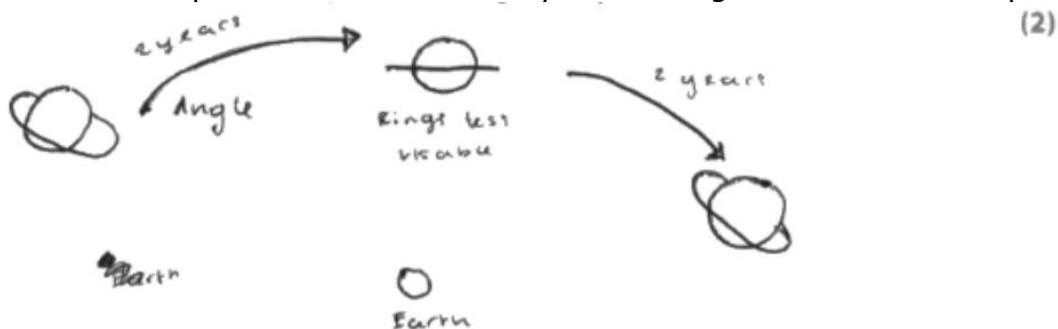
one uses converging lenses while the other uses diverging lenses

7 b i

This question proved to differentiate ability well. Some candidates did not appreciate that it was the rings (and not the moons) that Galileo was observing. They went on to explain occultations of the moons behind Saturn.

Candidates that realised it was the orientation of Saturn's rings that were changing with time scored 1 mark, but surprisingly few then gained the second marking point - that the rings would "disappear" when viewed edge on.

This 2 mark example demonstrates clearly how a diagram can aid the explanation.



The position of saturn relative to Earth caused an apparent change in the angle between saturn and Earth. When saturn is tilted, the rings are more visible, however when saturn is parallel to Earth, the rings are more difficult to resolve.

7 b iii

This question requires candidates to define "field of view" and then appreciate that Saturn has a small angular size. **Angle** is the key word here and is required in both marking points. The majority of candidates did not refer to an angle in their response and thus this question was poorly answered.

In this common example, the candidate appreciates that Saturn appears small in the sky, but this scored no marks due to omission of angular measurements.

Saturn's rings are quite close to the planet, so would still be in the field of view even if it was small.

The next example scored 1 mark, where the field of view has been linked to an angular measurement, but the small angular size of Saturn's rings has not been mentioned.

Field of view is how much of the sky you can see. Seeing a small angle of the sky shouldn't affect how well you can see Saturn's rings as this will be affected by the light grasp.

7 d

Few candidates scored full marks on this question. There were many responses that referred to Image 2 having higher resolution/a brighter image/lower magnification. However, this had to be linked to the **differences between the telescopes** as stated in the question to gain any marks. The following example which scored no marks lists the differences between the images only.

- Telescope 1, lower resolution = lower detail
- = Telescope 2, higher resolution = higher detail
- = Telescope 1, lower magnification = lower detail
- Telescope 2, higher magnification = higher detail
- Telescope 1, ~~higher~~^{longer} field of view, lower resolution
= lower detail
- Telescope 2, higher field of view, higher resolution
= higher detail

In this example, the candidate correctly made reference to two telescope differences (objective size and focal length) and two effects this would have on the image. Light grasp was not mentioned. 2 marks.

Telescope 1 has a smaller aperture as the image resolution is worse.
Telescope 1 has a larger magnification so has either a larger focal length of the objective lens, or a smaller focal length of the eyepiece.
Telescope 2 has a larger aperture as the resolution is higher but it has a smaller objective lens focal length as there is less magnification.

This is an example of a 3 mark response.

The second image has a higher resolution and a higher contrast. This may be because the second telescope had a ~~larger~~ larger aperture so more light was let in to the telescope. Telescope 1 has a higher magnification, implying it has a larger ~~on~~ objective focal length or ~~lower~~ eyepiece focal length.

8 a

This question differentiated candidates' knowledge. Each marking point became less accessible – especially the limitations to the HR diagram, where few marks were scored.

The following example score the full 3 marks:

cannot find the distance to star which are extremely far away as parallax angle too small to be measured accurately

The period of Cepheid variables

^{The star} ~~these~~ must be a Cepheid variable star to find its distance through this method.

Use of the Hertzsprung–Russell diagram

Must know ~~whether~~ ^{whether} star is a main sequence, red giant or white dwarf. As having the spectral type will give you 2 results for its absolute magnitude.

8 b

A reasonably well answered question, given the level of maths required. However, it was a shame that so many candidates managed to calculate a distance of 1000 pc but then forgot to convert this distance to light years, thus failing to achieve the final mark.

8 c

Most candidates found this question accessible and were able to score some marks, although the Level 3 responses were quite rare.

Weak candidates would spend a long time describing general observing techniques such as dark adaptation, avoiding light pollution, and wearing warm clothes. However, this was not answering the question.

Most candidates suggested that the reference stars were located too far away, but few then also appreciated that the reference stars also needed a greater range of apparent magnitudes.

Candidates often made the mistake of suggesting that the observations could be performed over a longer time period, when in fact more frequent observations were required.

Graphical analysis of the data was rarely mentioned.

9 b

This question was answered well, with many candidates achieving full marks. Candidates should refrain from starting a sentence with "it is..." because clarification needs to be made as to whether the statement refers to the brown dwarf or the planet.

Common incorrect responses referred to gravity – usually being too weak (for either the brown dwarf or the planet). The planet not lying in the habitable zone also scored no marks – this answer was too vague.

The planet not supporting an atmosphere scored no marks. Planets could have liquid water below the surface (without the need of an atmosphere) as is highlighted in question 9(c)(i).

9 c i

A model answer scoring 2 marks:

Internal tidal heating may have increased temperature beneath surface of Enceladus to a level that can maintain liquid water and sustain life.

The following is a 1 mark response – unfortunately this candidate did not specify that the water was **beneath** the surface.

- due to Enceladus orbiting a large planet to Saturn, there are large tidal forces that are acted upon Enceladus.
- This caused liquid water to be present so astronomers ~~were~~ ^{would} want to investigate if it can support life.
liquid water is essential for life.

"liquid water" on its own scored no marks, for example:

Because it contains liquid water which makes it habitable to some creatures.

9 c ii

A two mark response:

The Goldilocks zone around a brown dwarf would be much closer to the star ~~to~~ as it does not produce a lot of heat. This is because it is too small to cause nuclear fusion to occur.

In the following examples, the candidates did not refer to the **location** of the Goldilocks Zone, both scoring no marks.

In this example they referred to the temperature of the zone.

Goldilocks Zone around a brown dwarf would have a lower temperature because of failed nuclear fusion & low mass ⁽²⁾

And in this example, "smaller" does not describe a location and was rejected.

. It would be smaller in a brown dwarf as the actual size of the body is small itself. The sun's goldilocks zone would be bigger

9 d

Candidates were able to access this question and the majority gave Level 2 responses. Level 3 was harder to access.

Most candidates were able to make correct reference to a star's spectral type and thus its surface temperature. They then linked this to distance and made a judgement on the suitability of the Goldilocks Zone location. However, fewer candidates went on to incorporate absolute magnitude.

Some candidates correctly identified star B as a blue giant and star D as a white dwarf. Although this was not required to gain full marks, it was usually an indicator for high level understanding and application.

10 a

This question proved very difficult for the majority of candidates. The question required the candidate to explain how the observed expansion of the Universe supported both the Big Bang and Steady State theories. Unfortunately, most candidates just gave a list/description of these two theories with no link to the expanding Universe.

The majority of candidates were able to state that the Big Bang Universe was created in a single event/point, and many could also make reference to the constant density of a Steady State Universe. However, this was rarely linked with the observed expansion.

In the following example (which scored 3 marks), both marking points are achieved for the Big Bang, but only the final marking point (constant density) is awarded for Steady State theory.

- If the expansion is reversed to when time = 0, then everything would have come from a singularity, which is what the big bang theory states that the universe started as

Support for the Steady State theory

- The steady state theory suggests that the density of the universe is remaining constant
- As the universe expands, more matter is created to keep the density constant

10 b

Most candidates stated that there are no close quasars. Some then went on to explain that this is related to time. However, it was a shame that many candidates did not then achieve full marks by not clearly linking these observations to a conclusion that the Universe has changed/evolved over time.

This example scored 3 marks.

(3)

If density ^{of the universe} λ was constant and new matter was being formed all the time then there would be quasars located near us. The fact there are no quasars near us and their redshift for those far away is very large suggests that matter is being diluted as the universe expands: it demonstrates they ~~are~~ are objects formed early during the history of the universe and have now ~~of~~ moved very far away hence the greater redshift.

The fact that there are no quasars close to us, and that they are "old objects formed in the early Universe" is awarded two marks. There is just sufficient evidence to also award the mark for stating that the Universe has evolved over time – by stating how a Steady State Universe differs to current observations.

10 c

A common mistake in this question occurred when candidates mixed up λ and λ_0 .

The following is a model answer scoring 4 marks: ...

For quasar A,

$$\left(\frac{532.5 - 520.5}{520.5} \right) \times 3 \times 10^5 = \text{6916 km/s}$$

For quasar B,

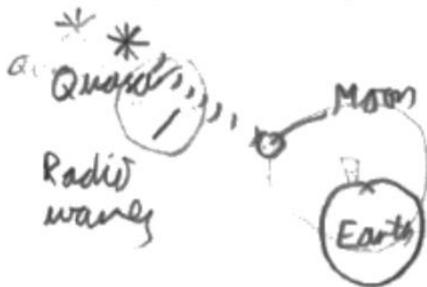
$$\left(\frac{543.8 - 520.5}{520.5} \right) \times 3 \times 10^5 = 13429 \text{ km/s}$$

$$13429 - 6916 = 6513$$

Difference in radial velocity = 6513 km/s

10 d

Many candidates appreciated that the Moon blocking the quasar during the occultation led to a more accurate location for the quasar. However, this was often not explained in sufficient detail. The following example only scored the first marking point:

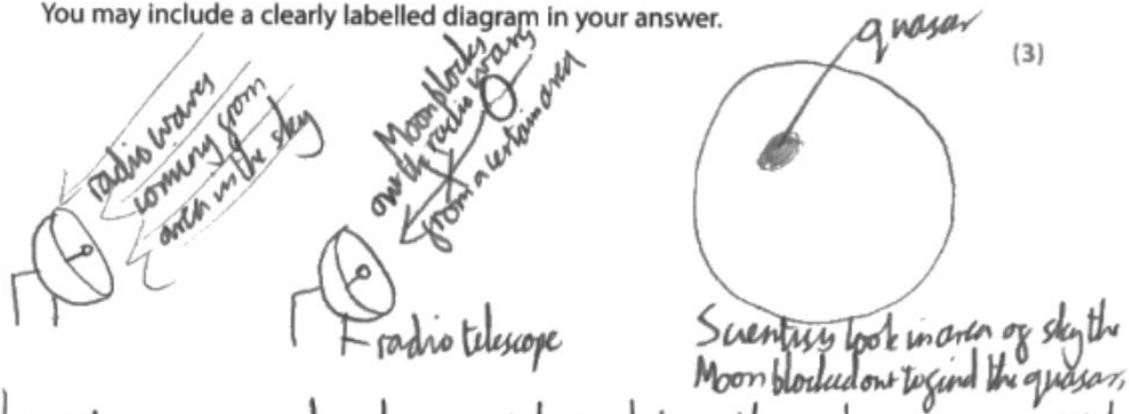


(3)

The radio telescopes being blocked from the quasar by the moon allowed for a more precise location to be found, as the quasar is located where the moon is when the radio signal stops. Knowing a more accurate region allowed for the scientists to know where to point their optical telescopes, allowing them to find the quasar.

This is another good example where the explanation of how an occultation led to a precise location of the quasar has not been addressed.

You may include a clearly labelled diagram in your answer.

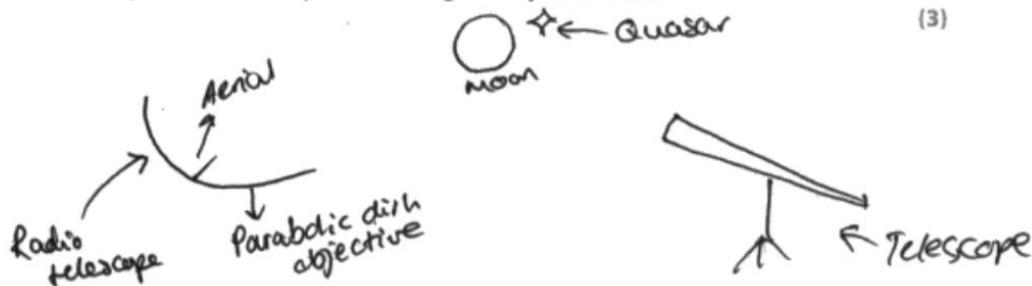


The astronomers used radio signals to detect the radio waves emitted by the quasar so they knew the rough location of the quasar in the sky. When the Moon occulted the radio source then the astronomers knew that the quasar must have been within the 0.5 arc degrees of the sky that the Moon was in at that time. This allowed the astronomers to use optical telescopes to look in the ~~part~~ area of sky the Moon occulted with a high magnification to find the precise location of the quasar.

Few candidates appreciated that the disappearance of the quasar had to be timed, thus allowing optical telescopes to identify the star-like object.

A 3 mark example:

You may include a clearly labelled diagram in your answer.



When the Moon occulted the quasar, the radio telescope did not detect the radio emissions from the source because it was blocked. Optical telescopes were then used to observe the Moon, and which star-like object became no longer blocked ~~at the~~ at the same time as the radio emissions were detected again. This ~~star~~ ^{by the radio telescope} object could then be identified as the source: the quasar.

This question differentiated abilities quite well, and only the most able candidates scored full marks.