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Examiners' Report
June 2016

GCSE Astronomy 5AS01 01

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Introduction

The Unit 1 examination paper required candidates to demonstrate knowledge and understanding of a wide range of astronomical phenomena, as well as applying their understanding to some unfamiliar situations.

As in previous years, it was clear from the responses of candidates to this paper that many centres work very hard to ensure that their candidates are not only aware of the key astronomical principles within the Specification but also have a thorough understanding of them. This was clear in questions where students were asked to consider a new or unfamiliar situation, where candidates generally showed considerable flexibility and understanding. It is also clear that a number of centres ensure that their candidates are extremely well-informed on astronomical developments and discoveries.

This paper identified a few areas where candidates' recall of astronomical information from the Specification was not complete. These included:

- The benefits of heliocentric theories of the Solar System (Q.3b)
- The discovery of Neptune (Q.8a)
- Neptune's satellite system (Q.8b)
- Reasons for large telescopes being reflectors (Q.10a)
- The location of the Oort Cloud (Q.13ai)
- The astronomical significance of the Tropic of Capricorn (Q.14c)
- The astronomical name for the Sun's visible disc (Q.15aii)

In addition, candidates had some difficulty applying their astronomical knowledge and understanding to the following unfamiliar situations:

- Applying their understanding of transits to identify the difficulties of observation (Q.9c) and the reasons for the rarity (Q.9d) of transits of Venus
- Applying their understanding of solar eclipses to the unfamiliar situation of an annular eclipse (Q.15)
- Applying their understanding of the transit method to an example of the detection of an exoplanet (Q.18a&b)
- Applying their understanding of the CMBR and Quasars to explain how they support the Big Bang theory (Q.19b&c).

Question 3 (a)

Almost all candidates were able to recall the specific astronomical term 'heliocentric'.

'Sun-centred' was not sufficient for the award of the mark, as it was essentially provided in the stem of the question.

Question 3 (b)

A significant number of candidates simply gave further detail regarding Copernicus' theory without necessarily answering the question.

For the award of the mark, candidates needed to describe the greater ease of calculating planetary positions or the simpler explanation for retrograde motion provided by the theory.

(b) In what other way did Copernicus' theory improve on earlier theories of the Solar System?

(1)

The planets orbitet the sun.

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Examiner Comments

Many candidates stated a feature of heliocentric theories, rather than giving one of the ways in which Copernicus' theory was more effective, such as being able to explain retrograde motion or allowing quicker calculation of planetary positions. This response therefore scored zero.

Question 3 (c)

Most candidates were able to recall two of Galileo's famous astronomical discoveries with an early telescope; such as the largest moons of Jupiter or the changing phase and size of the planet Venus.

Question 4 (a)

Although a spectacular event, providing a specific description of an auroral display proved to be quite a demanding task. Answers which failed to score the mark were too general, referring to 'patches' or 'flashes' of light in the sky rather than describing 'bands' or 'curtains' of coloured light.

Question 4 (b)

A number of candidates thought that artificial satellites (when visible) produce a flashing light in the sky – an appearance more characteristic of aircraft. Others failed to mention that they would appear to move across the sky for an observer on the Earth's surface.

Question 4 (c)

Many candidates appreciated that a fireball appears as a very bright meteor in the sky, with some even giving the magnitude limit (-4). Less successful candidates attempted to construct an answer from the name of the object, writing about 'balls of fire' in the sky.

Question 4 (d)

Most candidates showed a good understanding of the magnitude scale, appreciating that a magnitude of +5 would place a star at the very lowest levels of naked-eye visibility.

Question 6 (b)

Most candidates were able to recall two of the major differences between the near and far sides of the Moon, i.e. more craters, more terrae and fewer (almost no) maria.

Question 7 (a) (i)

Based on a recollection of the temperature of the Sun's photosphere, most candidates were able to provide an estimate for a typical sunspot temperature, within the wide latitude allowed for in the mark scheme.

Question 7 (a) (ii)

This question required candidates to apply their understanding of the Sun's rotation to the static image presented in Figure 2. The lateral direction of the sunspots' motion would depend on the absolute orientation of the image and hence movement to the left or the right was equally credited. Sunspots were expected to move a short distance across the solar disc, with both A and B moving in the same direction and some slight motion towards the Sun's equator was acceptable.

Question 7 (b)

Although most candidates were aware of either the projection or filtering method for observing the Sun safely, many failed to score full marks on this question due to the poor quality of their diagrams. To achieve full credit, diagrams should be drawn with a ruler where appropriate and have all items clearly labelled.

Question 8 (a)

Although listed in the specification, many candidates were unable to supply sufficient specific detail on this important astronomical discovery. A number of answers described very general discoveries, which could easily apply to a large number of astronomical objects.

(a) Describe the discovery of the planet Neptune.

(2)

Neptune was discovered by accident as someone was said to be 'observing the heavens' when he discovered a strange light which turned out to be Neptune

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Examiner Comments

This response is too general to score any marks.

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Examiner Tip

When describing a discovery such as this, include as much **specific** detail as possible. This answer is very general and could therefore apply to a large number of astronomical bodies.

Question 8 (b)

Many candidates' answers contained general descriptions only, which could apply to almost any of the gas giant planets, e.g. 'lots of moons', 'captured by its strong gravity', 'mostly made of rock and ice'.

As this topic is specifically listed in the specification, details which could only apply to Neptune were necessary for credit on the mark scheme.

Question 9 (b)

Almost all candidates appreciated that Venus needs to be between the Earth and the Sun for it to appear to transit the Sun's disc.

Question 9 (c)

A popular answer to this question was that there was inadequate 'technology' to observe the solar disc safely before 1639, which is not the case. A number of students registered the reference in the question to 'detailed observations', for which a telescope is necessary.

Question 9 (d)

Candidates presented a wide range of answers to this question. Some responses centred around the different orbital periods of the two planets, whereas others identified that the answer was more closely linked to the tilt of the orbital planes. Mid-scoring candidates tended to state that one of the planets had a tilted orbit, whereas the highest scoring candidates realised that against the backdrop of empty space, there is only the relative tilt between the two orbits.

A particularly succinct and high-scoring answer was that 'the orbit of Venus is tilted relative to the ecliptic'.

A few candidates referred to the tilt of Venus itself, which is of course, different to the tilt of its orbital plane.

(d) Although Venus orbits the Sun once every 225 days, transits of Venus are extremely rare. Explain why they are so rare.

(2)

because the earth orbits the sun every 365 days and they can ~~and~~ only occur when Venus' and earth's orbits are alligned by the sun

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Examiner Comments

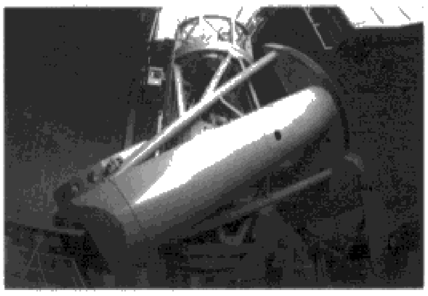
This answer focuses on the different orbital periods of the Earth and Venus, whereas it is the relative tilt of their orbital planes which makes transits so rare. It therefore scored zero.

Question 10 (a)

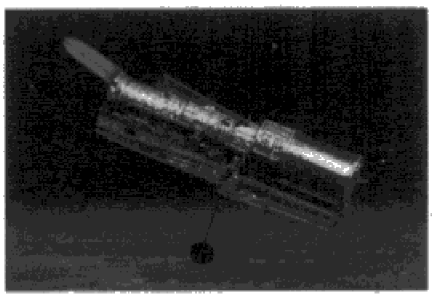
This question was misinterpreted by a number of candidates who described the advantages of large aperture telescope over small aperture instrument, which was not required by the question. Some candidates correctly wrote about the higher quality images from reflecting telescopes (compared to a refractor with a similar aperture) but used very general terms such as 'clearer', 'sharper' or 'better', whereas they should have referred to the improved resolution.

10 Figure 5 shows two large reflecting telescopes currently used by professional astronomers.

The Hale Telescope



The Hubble Space Telescope



(Source: © NASA)

Figure 5

The table below gives some information about each telescope.

	The Hale Telescope	The Hubble Space Telescope
Diameter of main mirror	5m	2.5m
Location	California, USA	Orbiting Earth

(a) Give **two** reasons why the world's largest telescopes are reflectors rather than refractors.

(2)

1 refractors are much heavier than reflectors

2 it is much harder to make large enough lenses for refractors

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Examiner Comments

A number of candidates gave two points, which were very closely linked to the same reason. Iin this case the problem of large lenses being very heavy and unwieldy. This answer thus gained only one of the two marks available.

Question 10 (b)

This question tested candidates' ability to select and organise astronomical information into a coherent conclusion, selecting evidence for both sides of the argument. To achieve the higher marks, candidates needed to provide more detailed and/or more quantitative points such as the fact that the Hale telescope's mirror would collect four times as much light as that of the Hubble Space Telescope or that the Hubble would have access to non-visible parts of the electromagnetic spectrum.

Question 11 (a)

Almost all candidates realised that early unmanned probes provided information on which to base decisions about future manned missions.

Question 11 (b) (i)

The correct answer which described the significantly lower gravity on the Moon, compared to the Earth, was very popular. A small but significant number of candidates stated that there was no gravity on the Moon, which was insufficient for the award of the mark.

Question 11 (b) (ii)

Most candidates realised that the lack of a significant atmosphere on the Moon would result in descending spacecraft arriving more quickly than on the Earth.

Question 11 (c) (i)

Almost every candidate was able to recall the name of the most famous lunar mission and many were also able to supply the correct mission number for the first manned moon landing.

Question 11 (c) (ii)

Candidates showed a good level of recall of the various measurements taken as part of the ALSEP programme, with analysis of Moon rocks and measurements of gravity, magnetic field and solar wind being the most popular correct answers.

Question 11 (d)

There was widespread understanding that the constantly dark sky was caused by the lack of atmosphere on the Moon and the majority of candidates were able to identify the process of scattering as the cause of the Earth's blue sky.

(d) Explain why the sky appears black, rather than blue, during daytime on the Moon.

(2)

The moon does not have an atmosphere, so no specific colour of light is scattered

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Examiner Comments

This answer explains clearly the reason why the daytime sky does not appear blue on the Moon.

Question 12 (a) (i)

Most candidates were able to identify the time shown by the sundial as the Apparent Solar Time, from the two times shown in Figure 7.

Question 12 (a) (ii)-(iii)

12 a (ii)

Although this question simply required candidates to substitute values into the equation provided, care was needed requiring the negative sign of the Equation of Time, whilst changing the subject of the equation.

12 a (iii)

A significant number of candidates did not appreciate fully the implications of this question's requirement to show that the longitude was 2°W, rather than simply calculate it. Many candidates were able to obtain an answer of 2W from the data in the question but fewer candidates explained the steps that they took along the way, which enabled them to gain full marks.

For full marks, candidates needed to show that the time difference between this location and Greenwich was 8 minutes, i.e. the difference between Local and Greenwich Mean Time and then to explain that every four minutes of time difference represents a longitude difference of 1°, with local times behind that of Greenwich indicating a westerly longitude.

Answers in which 8 minutes appeared out of nowhere and were then divided by 4 for no apparent reason were not uncommon and did not score well in this question.

(a) (i) State the Apparent Solar Time when this photograph was taken.

(1)

9am

(ii) If the Equation of Time on the day when this photograph was taken was –2 minutes, calculate the Mean Solar Time at this location.

Use the equation:

Equation of Time = Apparent Solar Time – Mean Solar Time

(2)

MST = AST - EoT

MST = 9:00 - -2

MST = 9:02

(iii) Hence show that the longitude of the location where the photograph was taken is 2°W.

(2)

GMT longitude is 0° 1 min every degree of longitude.

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Examiner Comments

In common with many answers, this response correctly identifies the Apparent Solar Time and then uses the equation provided to calculate the Mean Solar Time. However, it then confuses the two minute difference between these two times with the two degrees of longitude.

Question 12 (b)

The majority of candidates appreciated that shadow lengths would be longer in March although following the same U-shaped pattern.

Question 13 (a) (iii)

This question simply required candidates to identify one of the suggested means by which an object in the Oort Cloud can be disturbed into assuming the orbital path of a long-period comet, as set out in the mark scheme.

Question 13 (a) (i)-(ii)

13 a (i)

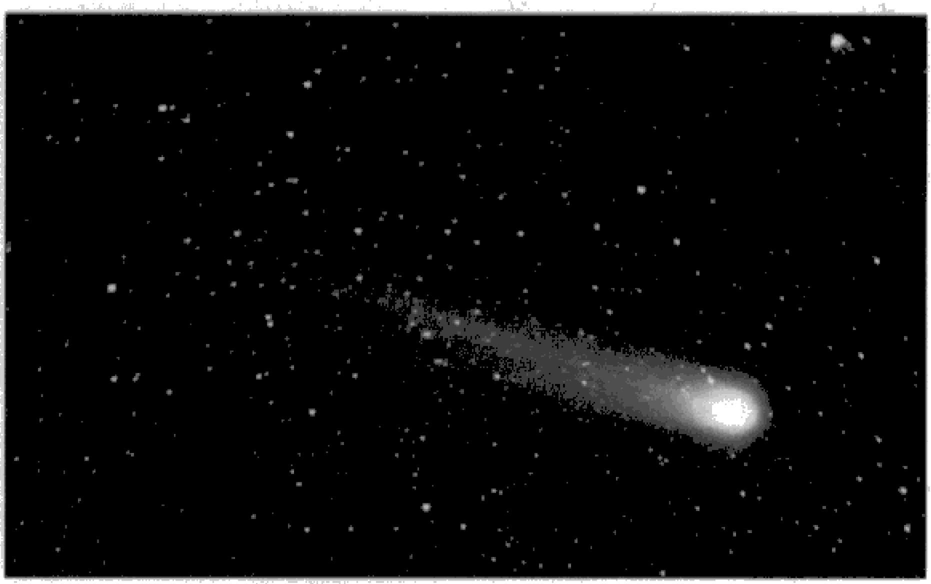
The majority of candidates were able to draw the significantly elliptical orbit characteristic of a long-period comet, although a number forgot that the Sun will be at one of the orbit's foci, rather than at its approximate centre.

Fewer candidates were able to give an acceptable representation of the Oort Cloud, such as by a large circle, centred on the Sun. Many drew it as a relatively small object, orbiting the Sun rather like a very distant planet.

13 a (ii)

Almost all candidates who drew a suitable elliptical path for the long-period comet were able to indicate the perihelion point as its closest approach to the Sun.

13 Long-period comets, like Comet Hyakutake shown in Figure 9, can take many thousands of years to complete one orbit of the Sun. They are thought to originate in the Oort Cloud.



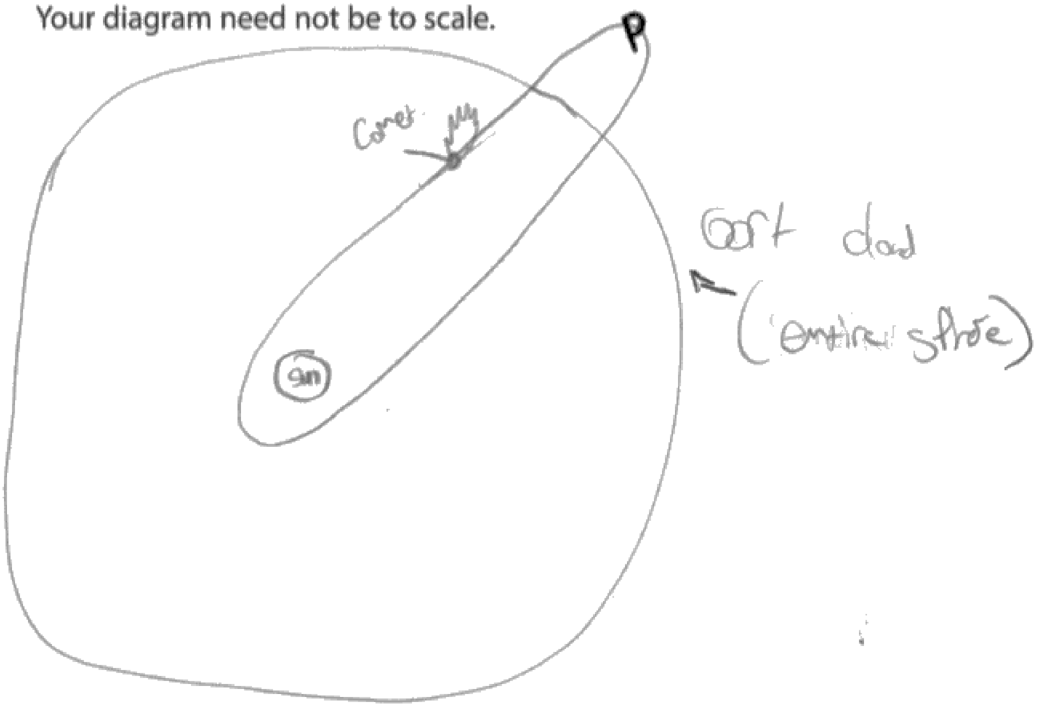
(Source: © NASA)

Figure 9

(a) (i) Draw a labelled diagram to show the position of the **Sun** and the **Oort Cloud**. Include the **orbit** of a long-period comet.

Your diagram need not be to scale.

(2)



(ii) Mark the position of the comet when it is at perihelion on your diagram. Use the letter **P**.

(1)

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Examiner Comments

Although it was difficult to give any real sense of scale in this diagram, this candidate has correctly shown the comet in a very eccentric orbit around the Sun, with the Sun at one focus and the Oort Cloud as centred around the Sun. Despite the rather squashed shape of the Oort Cloud, this was sufficient for the award of this mark.

Unfortunately, they have confused perihelion with aphelion and placed their letter P at the point furthest, rather than closest to the Sun.

Question 13 (b)

Almost all candidates appreciated that 50AU is ten times further from the Sun than 5AU, and a sizeable proportion realised that the inverse square nature of gravity meant that the gravitational force would reduce by 100 times.

Question 13 (c)

Very few candidates had any difficulty substituting the values of T and r for this comet into the equation provided and obtaining the correct value of 27 (years).

Question 14 (a)

There was widespread recollection that a circumpolar star never sets, although some candidates thought that this meant that it would be visible all the time.

Question 14 (b)

This question provided an accessible but demanding test of candidates' ability to use their understanding of the Celestial Sphere to predict the visibility of various objects from differing locations on the Earth.

Most candidates were able to get at least two of the six cells correct and thus gain one mark. Fewer candidates were able to give the correct answers to all six cells and thus score full marks.

Question 14 (c)

Even though many candidates knew that the Tropic of Capricorn is located at a latitude of 23.5^{o}S, only a minority were able to explain its astronomical significance as the most southerly latitude from which the Sun is still overhead at noon on the Winter Solstice (December 21st).

(c) Explain the astronomical significance of the Tropic of Capricorn.

(2)

It is one of the extreme latitudes, at 23.5°S from the equator, and is where the Sun will be directly over ~~on the Summer Solstice~~ the equator during an equinox.

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Examiner Comments

In common with many candidates, this answer shows an awareness of the geographical location of the Tropic of Capricorn but is confused about its astronomical significance. It establishes that the Tropic is related to the limit of places where the Sun can be seen directly overhead (1) but does not go on to establish that this will happen on 21st December. It was therefore awarded one mark out of two.

Question 15 (a) (i)

Most candidates were able to recall that solar eclipses of any kind can only occur at a New Moon.

Question 15 (a) (ii)

Despite the clear explanation and photograph of an annular eclipse provided in the question, many candidates confused it with a total solar eclipse and thought that the bright area around the outside of the Moon's disc was the corona.

Question 15 (b) (i)

Poor spelling cost some candidates this mark as examiners needed to be sure that the written word was 'elliptical' and not 'eclipse' or 'ecliptic', which have very different astronomical meanings.

Question 15 (b) (ii)

For full marks, candidates simply needed to establish that the angular size of the Moon at this point is slightly less than the angular size of the Sun. Diagrams containing rays drawn as straight lines with a ruler and accompanied by arrows were preferred over casually drawn sketches, which were insufficient for the award of the mark for the diagram.

Some candidates essentially re-drew Figure 10 or drew diagrams to show that the Moon was further from the Earth than normal, neither of which fulfilled the requirements of the mark scheme.

Question 16 (a) (i)

This question provided quite a demanding test of candidates' understanding of the cycle of stellar evolution, particularly as this question required both nebulae to be correct for the award of the mark.

Question 16 (a) (ii)

This question provided quite a demanding test of candidates' understanding of the cycle of stellar evolution.

Question 16 (a) (iii)

This question provided quite a demanding test of candidates' understanding of the cycle of stellar evolution, particularly as this question required both nebulae to be correct for the award of the mark.

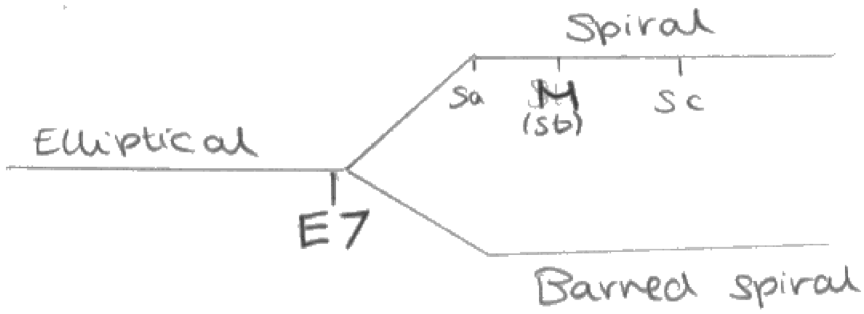
Question 16 (b)

Almost all candidates understood that the Hubble Tuning Fork diagram arranges galaxies into a tuning fork-shaped structure according to their shape. A number of candidates who clearly had a full recollection of the diagram lost a mark due to carelessness with the case-sensitive labelling.

Candidates were allowed to place the M label for the Milky Way towards the middle of either time of the fork, i.e. as a spiral or barred-spiral galaxy. Some candidates were unsure of which end of the fork's handle to place the E7 label and some thought that the scale of classification for elliptical galaxies ran from E0 to E9 (perhaps confusing it with the numbered division of the scale of stellar spectral classes).

(b) (i) In the space below, draw a Hubble Tuning Fork diagram, showing clearly the location of barred spiral, elliptical and spiral galaxies.

(3)



(ii) Indicate clearly the position of the Milky Way galaxy on your diagram. Use the letter **M**.

(1)

(iii) Indicate clearly the position of an E7 galaxy on your diagram. Use the label **E7**.

(1)

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Examiner Comments

The candidate has only shown how the shape of the galaxy changes for one arm, both were required for full marks.

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Examiner Tip

To gain full marks for this diagram it was necessary to show how the shape of the galaxy changes along each arm of the diagram, either by sketches or using the classification letters such as Sa, Sb, Sc etc. (as this candidate has done for only one of the arms).

Question 17 (a)

Although almost all candidates gained the first mark by explaining that a binary star system contains two stars relatively close together, fewer included the important astrophysical point that they are gravitationally bound to each other. 'Orbiting each other' was an acceptable alternative to specifically mentioning their mutual gravitational attraction.

Question 17 (b) (i)

A rather more scientific explanation than 'black holes suck in light' was required by this question, such as mentioning the very strong gravitational pull around a black hole or its extremely high escape velocity.

(b) (i) Explain why electromagnetic waves cannot escape from a black hole.

(2)

Because black holes don't give out any electromagnetic waves, they draw them in

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Examiner Comments

Since the question stated that electromagnetic waves cannot escape from a black hole, it was necessary to provide some further information to gain any credit in this question, such as by mentioning the very strong pull of gravity. This answer therefore scored zero.

Question 17 (b) (ii)

Many candidates appreciated the visual cue given by Figure 12 and explained how X-rays from the accretion disc of matter falling into the black hole can be detected by astronomers on Earth. Gravitational lensing was another popular suggestion.

Question 17 (c)

A few candidates confused the answer to this question with the danger to humans of X-rays but the majority correctly explained that X-rays are strongly absorbed by the Earth's atmosphere.

Question 17 (d)

This question effectively divided candidates into three distinct groups in terms of their understanding of the astronomical principles required by the calculation. Most candidates were able to calculate the difference in magnitude between the Sun and Cygnus X-1 as 11, although some candidates' mental arithmetic let them down with an answer of 10!

Candidates gaining full marks also appreciated that the magnitude difference represented the number of powers of 2.5 by which the brightnesses differed and thus correctly calculated 2.5^{11}.

(d) The Cygnus X–1 system has an absolute magnitude of –6.5 whereas the Sun has an absolute magnitude of only +4.5. How many times greater is the luminosity of Cygnus X–1 than that of the Sun?

(2)

$4.5 - -6.5 = 11$ $\quad 2.51^{11} = 25000$ times (2sf).

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Examiner Comments

This candidate has correctly determined the difference in magntiudes (11) and then used this correctly to calculate the difference in brightness. The answer has sensibly been given to two significant figures, in line with the data in the question.

Question 18 (a)

A surprisingly substantial number of candidates did not respond to this question's command word 'Explain' but gave a (sometimes very detailed) description of the variation in brightness graph, e.g. 100% until 2 hours, drops to 50% by 3 hours…'.

The question simply required candidates to explain that the dip in brightness was caused by a potential exoplanet passing between the star and Earth – the fundamental basis of the transit method.

Question 18 (b)

From the candidates' responses to Q18a, it appeared that a large number perhaps did not understand that an exoplanet transiting its parent star would produce a light curve of the form shown in Figure 13. Consequently, some candidates failed to appreciate that the hour taken by the light curve to drop from 100% represented the time taken for the exoplanet to travel across the limb of the star. The exoplanet's diameter is therefore simply
1 hour x 150 000 km/h = 150 000km.

(b) The planet is known to be travelling at about 150 000 km per hour as it orbits the star. Use this value and information from Figure 13 to estimate the size of the planet. Show the steps in your calculation clearly.

(2)

Planet takes around an hour to begin fully transiting. 150,000 km
1 h x 150000 km/h = km
150 ,000 km diameter

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Examiner Comments

This candidate has correctly identified the time taken for the light curve to drop (1 hour) as the time needed for the planet to cross the limb of its star, giving the exoplanet a diameter of 150 000km.

Question 18 (c)

Most candidates were able to recall another method for detecting the presence of exoplanets, although inevitably a few candidates simply provided another explanation of the transit method.

Question 19 (a)

This question required candidates to explain that the Big Bang theory proposes that the Universe started as a tiny particle that has increased in size since then, thus explaining the observed expansion of the Universe. The phrase 'hot dense state' appeared frequently.

Question 19 (b)

Many candidates were able to recall that the CMBR can be thought of as left over radiation from the Big Bang, with the phrase 'echo of the Big Bang' appearing regularly. A number of candidates wrote a (sometime lengthy) account of all their knowledge regarding CMBR, perhaps expecting the marker to select the parts which were relevant to the question.

force from the Big Bang resulted in ~~[illegible]~~ expanding from that point.

(b) Explain how the discovery of the Cosmic Microwave Background radiation in 1965 helped to support the Big Bang theory.

(2)

The Cosmic Microwave Background is thought to be the remenants of the energy produced by the Big Bang.

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Examiner Comments

This candidate has correctly stated that the CMBR is thought to represent radiation 'left over' from the Big Bang.

Question 19 (c)

As with Q19b, a number of candidates appeared to have written down a long series of facts about quasars, rather than selecting those which helped to support the Big Bang theory of the universe.

Question 20 (a)

Following the strong cue given by the term Local Group, most candidates proposed that it was the group of galaxies closest to the Milky Way. However, fewer included the fact that it is a group of gravitationally linked galaxies – an important distinction for cosmology.

Question 20 (b) (i)

Although this question required candidates to put the relevant numbers into the correct places in the supplied equation, there were a number of points which required careful attention from the candidate. The one which was most commonly overlooked was that the question supplied the distance to the Andromeda Galaxy in kpc, rather than pc as required by the equation.

(b) (i) The Andromeda galaxy has an absolute magnitude of –21.5. Use this information to calculate its apparent magnitude.

Use the equation:

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

(3)

$M = m + 5 - 5 \log d$ $\qquad$ $m =$ ~~31.5~~ -11.5

$-21.5 = m + 5 - 5 \log 1000$

$-21.5 - m = 5 - 5 \log 1000$

$-21.5 - m = -10$

$+(-21.5)$ $\quad -m =$ ~~31.5~~ 11.5

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Examiner Comments

Although working carefully through the calculation and showing their working very clearly, this candidate has entered the distance in kiloparsecs (kpc) instead of parsecs, as required by the equation.

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Examiner Tip

Showing your working clearly ensures that your answer can gain the maximum credit, even if you have made a mistake.

Question 20 (b) (ii)

This question can be solved simply by deducing that a ten-fold increase in distance will cause a 100 times decrease in brightness, which is equivalent to five points on the magnitude scale. Many candidates came to the same result by re-calculating the magnitude from the equation supplied in the previous part of this question.

Question 20 (b) (iii)

Most candidates were able to recognise that a magnitude of – 1.5 would represent a bright object in the night sky.

Paper Summary

Based on their performance on this paper, candidates are offered the following advice. Specific questions which illustrate each of these points are given in parentheses:

- Candidates should ensure that their answers are focused on the specific requirements of the question. They should not simply write a list of all the things that they know about the topic in question (Q.19b&c)
- Candidates should pay close attention to the 'command' word at the start of each question such as, State, Describe or Explain. These words are always closely reflected in the Mark Scheme and should therefore be a guide to what is written in the candidate's answer. In particular, when a question asks for an Explanation, there will be little or no credit given for a Description. (Q.9d, Q.15bii)
- Candidates should be aware that no credit can be given for information which has already been provided in the question (Q.12aiii, Q.15bii, Q.17bi).
- In questions where a diagram forms part of the answer, full credit will only be given if it is carefully drawn (with a ruler where appropriate) and fully labelled. (Q.7b, Q13a, Q.15bii)
- Candidates should avoid very general answers which could apply to a wide range of situations and include specific details wherever possible. (Q.8)
- Questions which ask candidates to show how a final result is obtained require an explanation of the astronomical principles behind each step, rather than a re-calculation of the final answer. (Q.12aiii).

Describing the appearance of astronomical objects in the sky requires some care since almost all bodies appear as a 'patch of light' or similar (Q.4). When answering questions of this type, candidates answers could be improved by describing the object's:

- Brightness
- Angular size
- Colour
- Apparent movement.

Grade Boundaries

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