Mark Scheme

Write your name here

Surname	Other names

Centre Number | Candidate Number

Edexcel GCSE

Astronomy

Unit 1: Understanding the Universe

Thursday 9 June 2011 – Morning
Time: 2 hours

Paper Reference
5AS01/01

You must have:
Calculator

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 120.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Ladies and Gentlemen, I have made a serious attempt to abjure excessive "JF²" material. Sometimes, I have gone beyond the space provided. This has been to supply you with extra ideas.

DF
2011, September 3

Turn over

P38608A

5/6/5/4/

P 3 8 6 0 8 A 0 1 3 2

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Answer ALL questions.

Some questions must be answered with a cross in the box (☒).
If you change your mind about an answer, put a line through the box (~~☒~~) and then mark your new answer with a cross (☒).

1 (a) Which of these objects in the Solar System has the smallest diameter?

(1)

- ☐ **A** Earth
- ☐ **B** Jupiter
- ☒ **C** The Moon ✓
- ☐ **D** The Sun

(b) Which of these objects in the Solar System is closest to the Sun?

(1)

- ☐ **A** Earth
- ☐ **B** Mars
- ☒ **C** Mercury ✓
- ☐ **D** The Moon

(c) Which of these objects in the Solar System takes the longest time to orbit the Sun?

(1)

- ☐ **A** Earth
- ☐ **B** Neptune
- ☒ **C** Pluto ✓
- ☐ **D** Venus

(d) What is the name of the dwarf planet that orbits **closest** to the Sun?

(1)

Ceres (pronounced "Series")

(Total for Question 1 = 4 marks)

2 (a) What is the value of 1 astronomical unit?

(1)

☐ **A** 15 million km

☒ **B** 150 million km $= 1.5 \times 10^{8}$ km $= 1.5 \times 10^{11}$ m

☐ **C** 15 million miles

☐ **D** 150 million miles

(b) What is the name of the shape of the Earth's orbit around the Sun?

(1)

☐ **A** eccentric

☒ **B** eclipse

☐ **C** ecliptic

☐ **D** ellipse

(c) What is the name of the plane of the Earth's orbit around the Sun?

(1)

☒ **A** ecliptic

☐ **B** eclipse

☐ **C** zenith

☐ **D** zodiac

(d) How many hours and minutes does it take the Earth to rotate on its axis once?

(1)

A sidereal day 23 hours, 56 minutes.

(e) How long does it take the Moon to spin on its axis once?

(1)

☒ **A** 27.3 days

☐ **B** 28.0 days

☐ **C** 29.5 days

☐ **D** 31.0 days

(Total for Question 2 = 5 marks)

3 Figure 1 shows a rough sketch of the Moon.

Figure 1

(a) What is the phase of the Moon in the sketch?

(1)

Gibbous (Reject waning, waxing, Half- full)

(b) How many days into the lunar cycle is this?

(1)

- ☐ **A** 6 days
- ☐ **B** 10 days
- ☐ **C** 17 days
- ☐ **D** 28 days

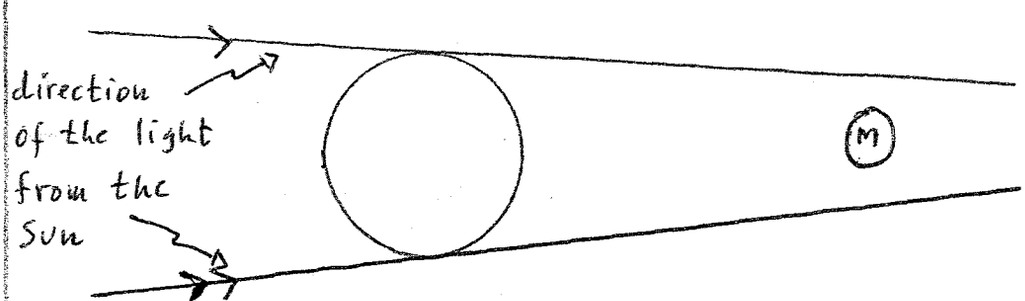
(c) What is the phase of the Moon during a **lunar** eclipse?

(1)

Full

(d) In the space below, sketch and label the relative positions of the Sun, Earth and Moon during a **lunar** eclipse.

(2)



(Total for Question 3 = 5 marks)

4 Figure 2 shows the near side of the Moon.

Note: through a telescope, the image would be inverted with respect to this photograph

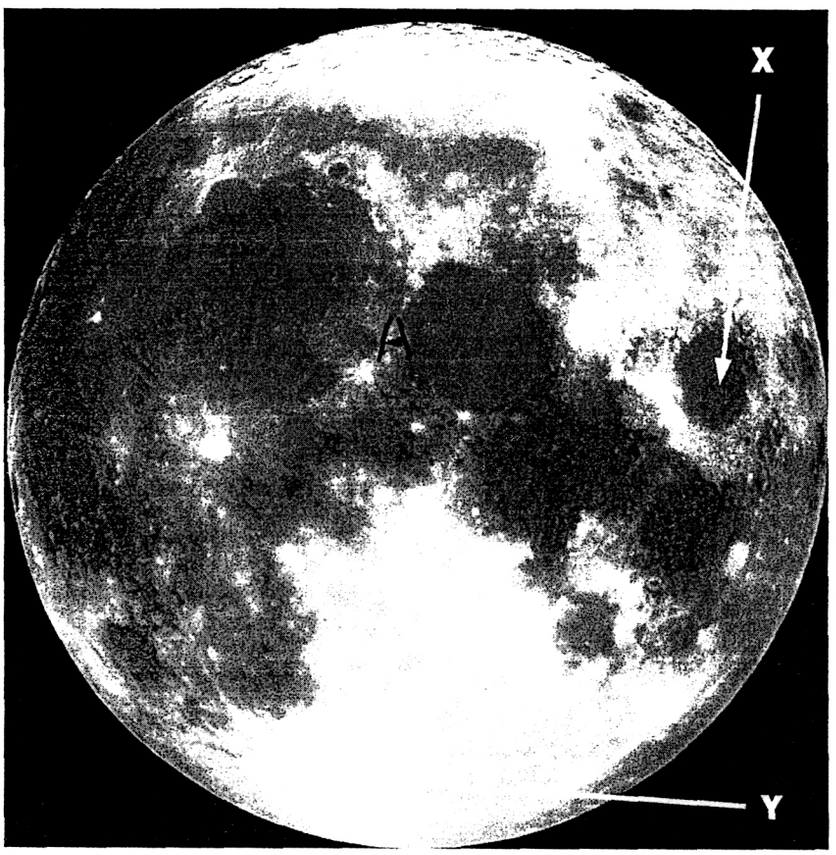


Figure 2

(a) What is the name of feature **X**?

(1)

- ☐ **A** Bay of Rainbows
- ☐ **B** Ocean of Storms
- ☒ **C** Sea of Crises
- ☐ **D** Sea of Tranquility

(b) What is the name of crater **Y**?

(1)

- ☐ **A** Copernicus
- ☐ **B** Galileo
- ☐ **C** Kepler
- ☒ **D** Tycho

(c) On Figure 2, indicate the location of the Apennine mountain range.

Use the letter **A**.

(1)

(d) The Moon's far side is not visible from the Earth.

How do astronomers know what the far side looks like?

(1)

space probes / astronauts / lunar satellites have orbited, and photographed, the far side.

*(e) State **two** ways in which the appearance of the Moon's far side differs from the near side.

(3)

More craters

More highlands / mountains

Lighter in appearance

Fewer major maria / rilles

Reject:
Darker
Invisible from Earth

(Total for Question 4 = 7 marks)

5 (a) The planet Saturn is well-known for its prominent ring system.

Name **two** other planets that have ring systems.

(2)

1 Jupiter / Neptune

2 Uranus

(b) Which planet has two small satellites that astronomers believe are captured asteroids?

(1)

Mars

(c) The atmosphere of Venus can be used to demonstrate the danger of extreme global warming on Earth.

State **two** properties of the atmosphere of Venus responsible for this.

(2)

1 Large quantity of Carbon dioxide

2 Extremely high surface temperature

3. Dense atmosphere / clouds

(Total for Question 5 = 5 marks)

4. Effective at preventing the escape of infra-red radiation emitted from the planet.

Reject:

Temperature (by itself)

"Greenhouse effect"

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Turn over for Question 6

6 (a) A student observed the star Polaris in the night sky.

(i) In which direction was the student looking?

(1)

☒ **A** North

☐ **B** South

☐ **C** East

☐ **D** West

(ii) State the declination of Polaris.

(1)

+ 90°

(iii) The latitude of the student was 55° N.

What was the angle of elevation of Polaris above the student's horizon?

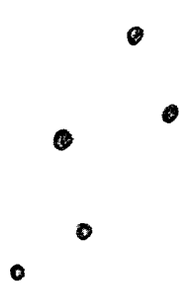
(1)

55°

(b) The student observed the constellation Cassiopeia.
From the student's latitude, the stars in this constellation are circumpolar.

(i) In the space below, sketch Cassiopeia.

(1)



Reject:
Just lines, showing the shape of the constellation, without the stars.

(ii) What are circumpolar stars?

(1)

* Stars which never set from the place of observation

(iii) State whether a star of declination +60° would be circumpolar from the student's latitude.

Give a reason for your answer.

(2)

** For this student, Polaris will be 55° above the horizon. It follows that the angular distance between Polaris and the overhead point (or zenith distance) = (90° − 55°)

= 35°

(Total for Question 6 = 7 marks)

To an observer in the Northern hemisphere of the Earth, a star is at its lowest point in the sky when it is due North. From latitude 55° N, a star will be circumpolar if its declination is (90° − 55°) = 35° N, or greater. That is, any star which is "below" the Pole by the amount of one's latitude will just scrape the Northern horizon at its lowest point. If it is nearer the Pole than that, it will never set and be circumpolar.

* Reject:

Orbit Polaris
visible all day
Always visible

** Sorry - I have been unable to explain within the provided confines — a mere five lines

7 (a) An astronomer observes sunspots using a telescope fitted with a H-alpha filter.

(i) Describe the appearance of the sunspots. (1)

Dark patches on the surface of the Sun.

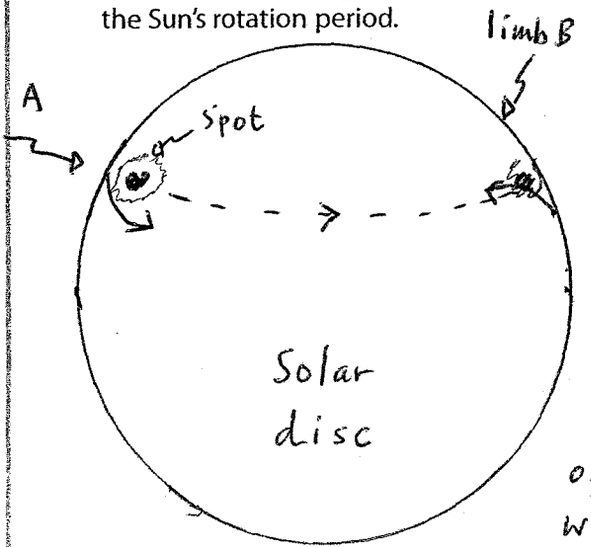
(ii) Name **one** other feature that the astronomer might observe. (1)

Solar flares, prominences, filaments, plage, active regions, limb darkening (rarely mentioned)

(iii) Why does the H-alpha filter improve the astronomer's observations of the sunspots? (1)

* Sharper contrast / narrow-band filter.

(b) With the aid of a diagram(s), explain how astronomers use sunspots to determine the Sun's rotation period. (2)



The simplest way involves observing a group of sunspots, recording their position(s) and timing how many days later the spots return to the same position.

Or, observe over a period of a few days, if the weather is bad, and estimate the fraction of a complete rotation the Sun has undergone.

For example, the spot(s) moving from limb A to limb B would indicate half of one complete rotation

Different parts of the photosphere rotate with periods ranging from about 25 days to 36 days.

* Reject:
Less bright

(c) Sunspots are thought to be a possible origin of the solar wind, which can cause aurorae.

(i) Describe the appearance of aurorae.

(1)

glows in the upper (terrestrial) atmosphere, due to charged particles from the Sun. Coloured "curtains" or streamers lights in the sky

(ii) Explain the connection between aurorae and the solar wind.

(2)

charged particles in the Solar Wind, taking about one day to travel from a disturbed region of the Sun to the Earth, interact with gas molecules in the atmosphere of the Earth.

(Total for Question 7 = 8 marks)

JF² (strictly)

At large distances from the Sun, its magnetic field lines extend so far that they appear to be unconnected, travelling away from the Sun. These field lines are often referred to as the interplanetary magnetic field, or I.M.F. *

The Solar Wind, consisting mainly of protons and electrons, interact with the I.M.F., so the flow of the Solar Wind is coupled to the I.M.F. As the Sun rotates, the field lines are carried with it and form a spiral shape, rather like jets of water from a garden sprinkler. The protons and electrons travel along the magnetic field lines on their way to the Earth.

* Not the International Money Fund

8 A group of students were observing the Perseid meteor shower that occurs annually in August. This shower is caused by a short-period comet.

(a) Where is the origin of most short-period comets?

(1)

☐ **A** Asteroid Belt

☒ **B** Kuiper Belt

☐ **C** Orion's Belt

☐ **D** Van Allen Belt

(b) Figure 3 shows the Earth's orbit around the Sun.

The scale of this diagram is woeful.

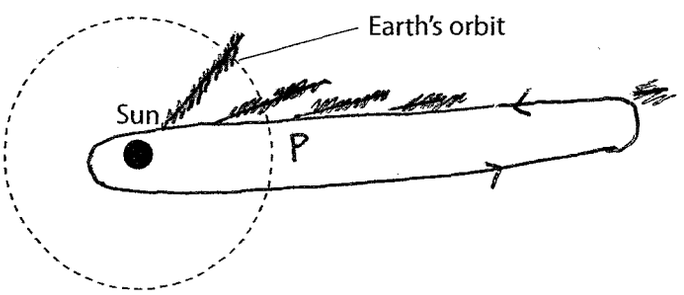


Figure 3

(i) On Figure 3, draw the orbit of a typical short-period comet.

(ii) On Figure 3, indicate a point at which this meteor shower could occur. Use the letter **P**.

(3)

P refers to the point at which the orbit of the Earth is intersected.

JF2

The short-period comets which have been "caught" from the Kuiper Belt, have periods ranging from 3·3 years (Encke's comet) out to more than 150 years. They are seen regularly and we know when to expect them. Encke's comet, first seen in 1786, has now been followed over fifty perihelions. Since it never moves as far as Jupiter, it can now be followed, with a large telescope, throughout its orbit.

(c) (i) What is the name of the point from which meteors appear to diverge?

(1)

The radiant

(ii) In which constellation does the point for this meteor shower occur?

(1)

Perseus

(d) During their observations, the students also saw a fireball.

What is the difference between a fireball and a meteor?

(1)

A fireball is spectacularly bright

(Total for Question 8 = 7 marks)

JF²

As a meteoroid travels through the (terrestrial) atmosphere, it eventually reaches a level at which atmospheric gases surrounding the incoming body become ionized and form a plasma.

As the body continues to move, this produces a streak of light known as a meteor. Typically, meteors appear at an altitude of 90 km. to 120 km., and become extinguished at about 20 km.

Occasionally, the Earth passes through a particularly well-populated part of a meteoroid stream (cometary debris) and the rate of meteors seen in a shower can increase significantly

9 (a) What is the approximate diameter of our Galaxy?

(1)

☐ **A** 30 AU

☐ **B** 30 pc

☒ **C** 30 kpc

☐ **D** 30 Mpc

(b) Figure 4 shows a sketch of our Galaxy.

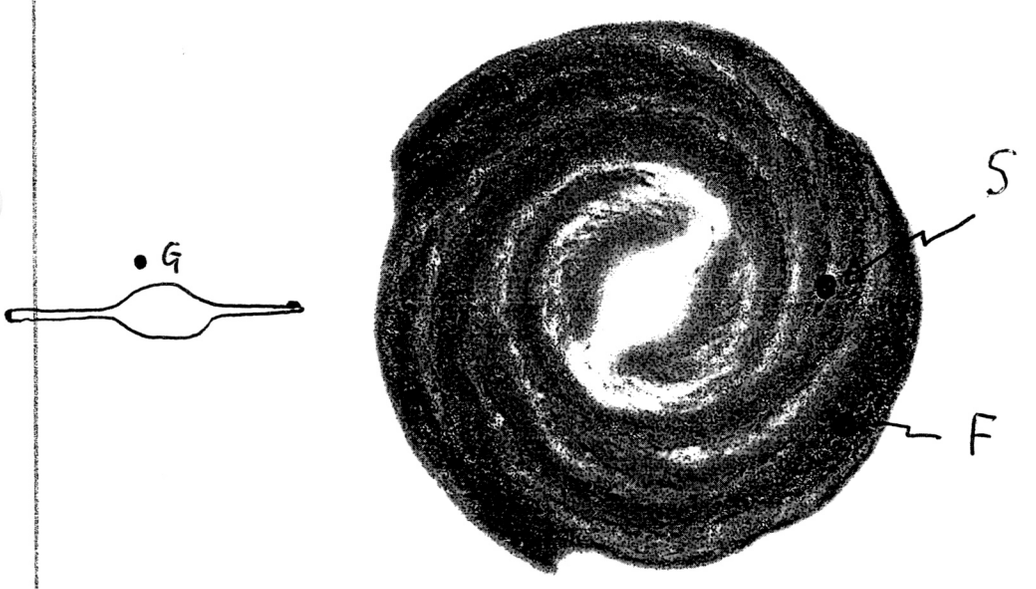


Figure 4

On Figure 4, indicate the position of:

(3)

(i) the Sun (use the letter **S**)

(ii) a typical site of star formation (use the letter **F**)

(iii) a typical globular cluster (use the letter **G**).

(Total for Question 9 = 4 marks)

10 A group of students were using a star chart to plan a naked-eye observing session of the region of the sky close to the constellation Pegasus.

Figure 5 shows the Great Square of Pegasus, some other stars and a faint, fuzzy patch of light **X**. Some stars are labelled with Greek letters.

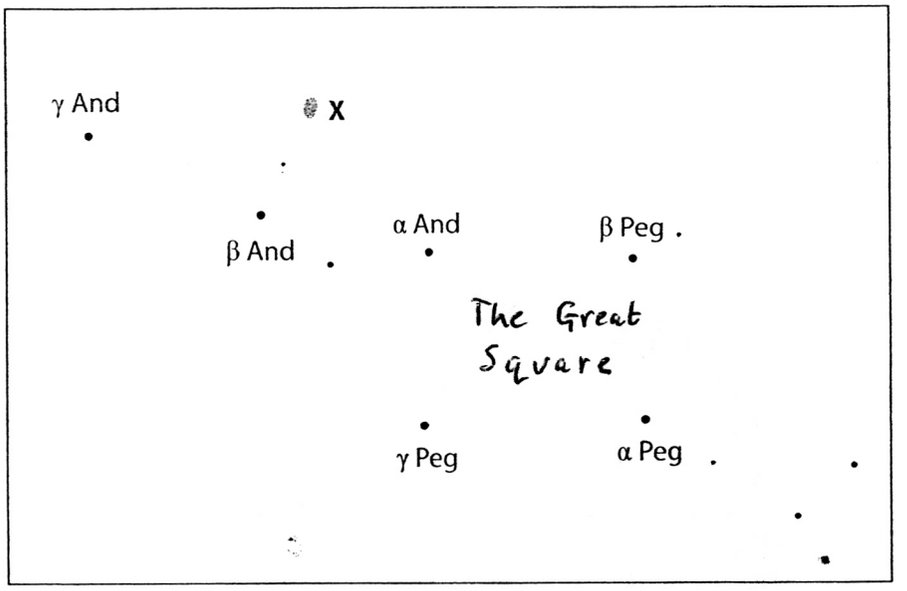


Figure 5

(a) In addition to the star chart, state **two** other **sources** of information that the students might need in order to plan the observing session.

(2)

1 The Weather forecast

2 Astronomical magazine

(3) The internet
(4) Specialized software
(5) Planisphere
(6) Details of the co-ordinates

(b) On Figure 5, indicate with an arrow how stars in the Great Square of Pegasus can be used to locate the star Fomalhaut.

(1)

This star in the Square of Pegasus, used to be known as Delta Pegasi, but has now been given a free transfer to Andromeda and has become Alpha Andromedae. Why? I have no idea. It clearly belongs to the Pegasus pattern.

I needed a different scale for (10)(b); Fig. 5 is unsuitable.

Formalhaut (the Southernmost first-magnitude star ever visible from Britain. Even from Southern England it is always very low; from Northern Scotland it barely rises at any time. It is a strange choice of star in this question).

(c) What is the name of faint object **X**?

(1)

☒ **A** Andromeda Galaxy

☐ **B** Orion Nebular

☐ **C** Oort Cloud

☐ **D** The Pleiades

(d) The group of students observed object **X** with **averted vision**.

What is averted vision?

Reject: "corner of the eye" (1)

To turn away, or aside; to utilise one's peripheral vision.

(e) Name **one** other naked-eye observing technique to help observe object **X**.

Reject: (1) Any optical aid

Fully accommodated and darkness-adapted eye

(f) The students planned to observe object **X** on a future date using a robotic telescope.

State **two** reasons why the use of such a telescope might improve their observations.

(2)

1 Clearer images (4) Images in greater colour

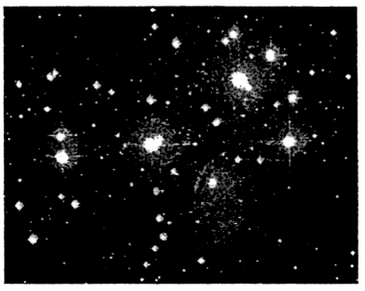
* 2 Great resolution (5) Analysis of spectra

(3) Data can be stored

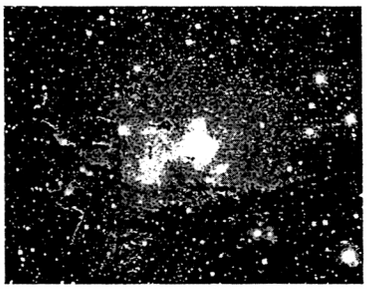
(Total for Question 10 = 8 marks)

* The ability to discern detail is not the same as angular magnification. An enlarged retinal image, unless the objective is gathering a lot of light, will not convey much information

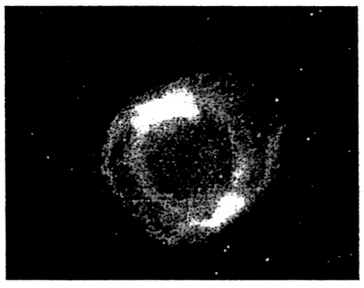
11 The four images labelled **A** to **D** in Figure 6 show different stages in the evolution of a solar-mass star.



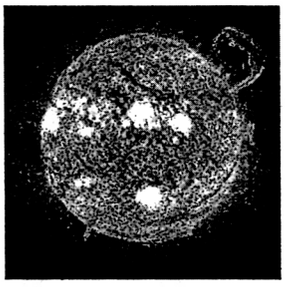
A The Pleiades, an open cluster



B NGC 281, an emission nebula



C The Helix Nebula, a planetary nebula



D The Sun, a main sequence star

Figure 6

(a) Arrange the letters of the images in Figure 6 in order of evolution, starting with the youngest.

B A D C

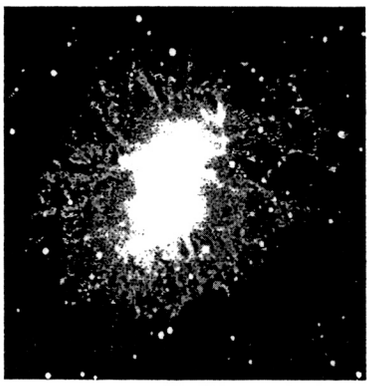
(3)

(b) What type of object lies at the centre of a planetary nebula?

A small, hot, dense star (a white dwarf)

(1)

(c) Figure 7 shows one stage in the death of a star that has a much greater mass than the Sun.



Reject:
explosion

Figure 7

(i) What is the name of this stage?

(1)

* Supernova (This is a photograph of the Crab Nebula)

(ii) Name **one** possible type of object that lies at the centre of Figure 7.

(1)

Neutron star | black hole | pulsar

(Total for Question 11 = 6 marks)

* JF²

A stellar explosion on an incomprehensible scale (Type I); the complete destruction of the white dwarf component of a binary system (Type II); the collapse of a very massive star

12 (a) Recently, astronomers have discovered that many stars possess systems of planets (exoplanets).

(i) Describe **two** methods that astronomers use to detect the presence of exoplanets.

(2)

1 Astrometry: look for the second star (the exoplanet) making its presence felt on the proper motion of the other star —— "orbital wiggles"

2. The changing Doppler shifts in the spectral

(ii) Explain why astronomers find it difficult to detect **individual** planets.

(2)

① Small planets (low mass) do not perturb the more massive star

② The "parent" star is much brighter than the planet. Remember that the planet shines only by reflected light.

(b) The Drake Equation can be used to estimate the likelihood of intelligent life existing elsewhere in our Galaxy.

State **two** of the factors in the Drake Equation.

(2)

1 The number of stars in the Galaxy.

2. Estimation of the fraction of stars with planetary systems.

3. Number of planetary systems within the so-called "Goldilocks Zone".

(Total for Question 12 = 6 marks)

(12) (a) (i) continued

lines of one or both components of the binary system, as they orbit each other

3. Transit dimming.

(ii) Terrestrial atmospheric turbulence lessens the accuracy of astrometric measurements.

13 The table below lists the co-ordinates of some of the stars in the constellation Orion.

star	RA	dec / °
α Ori	5 h 55 min	+7
β Ori	5 h 15 min	−8
γ Ori	5 h 25 min	+6
δ Ori	5 h 32 min	0

(a) An astronomer observed Orion from the UK in December.

Which star appeared:

(i) the highest, α Orionis

(1)

(ii) the furthest east? α Orionis

(1)

(b) Explain why the astronomer would not be able to observe Orion from the UK in June.

(2)

Orion would lie in the same region of the sky as the Sun — it would be above our horizon during the day-time.

(c) The astronomer observed β Ori when it crossed her meridian at 16:40 GMT.

(i) What is meant by the term **meridian**?

The great circle on the celestial sphere, which passes through the zenith and both celestial poles. It cuts the observer's horizon at the exact north and south points.

(ii) Deduce the time at which α Ori would cross the astronomer's meridian.

(3)

(Total for Question 13 = 7 marks)

14 (a) Our knowledge about the Solar System is greatly increased through the use of space probes.

Describe briefly **one** major space mission, naming the mission, its 'target' and **one** key piece of information that was obtained.

(3)

Mission name Giotto | Apollo | Cassini | Magellan

'Target' Halley's comet | the Moon | Saturn | Venus

One piece of information

(1) The nature of cometary nuclei

(2) Nature of the Lunar surface | a detector to analyse the Solar wind.

(3) Structure and stability of the ring system.

(4) Features on the Cytherean surface.

(b) Manned exploration of the Solar System has so far been restricted to our immediate neighbourhood.

State **two** problems that astronauts are likely to face during a manned expedition to a planet such as Mars.

(2)

1 A wide range of psychological problems.

2 Muscle fatigue

3 Exposure to the increased intensity of (mainly) Solar radiation

4. Collisions with (micro) meteoroids

5. Health problems due to being in a state of free-fall (Avoid the term "weightlessness")

Reject: Food running out, not enough fuel, lack of oxygen, hostile atmosphere and the long journey.

(Total for Question 14 = 5 marks)

15 Martha measured the length of the shadow cast by a straight vertical stick at certain times of the day.
Some of her results are shown in the table below.

Time (GMT)	Shadow length / mm
11:30	527
11:40	512
11:50	505
12:00	494
12:10	480
12:20	495
12:30	502

(a) Use the table to determine the time at which the Sun appeared to be at its highest in the sky.

12:10 (shortest shadow length) (1)

(b) On the date that Martha carried out her shadow stick experiment, the Equation of Time was equal to – 6 min.

Calculate the Apparent Solar Time at which the Sun was highest in the sky.

Use the formula : Equation of Time = Apparent Solar Time – Mean Solar Time

(2)

∴ A.S.T. = 12:10 − 0:06

= 12:04

(c) Deduce the longitude from where Martha carried out her experiment.

(1)

The Sun culminated at Martha's location ten minutes after it reached its highest point on the Greenwich Meridian.

(d) Martha's friend Jojo carried out a similar experiment from a longitude of 3°W.

At what time (GMT) did the Sun appear highest in the sky to Jojo?

(1)

(Total for Question 15 = 5 marks)

16 (a) State the difference between a binary star and an optical double star.

(2)

Binary stars are "locked" gravitationally.
That is, the two components are physically associated.
Double stars: two components due to a
(optical double) line-of-sight effect.

(b) The table below gives data for four stars in a constellation.

Star	Apparent magnitude
α	−0.6
β	1.4
δ	4.4
ε	6.8

(i) Which is the faintest star that could be seen with the naked eye?

(1)

4·4

(ii) How many times does star α appear brighter than star β?

(1)

$\Delta B = (2{\cdot}512)^{\Delta m} \therefore \Delta B = (2{\cdot}512)^{2{\cdot}0} = 6{\cdot}25$

(iii) The distance of star δ is 100pc. Calculate the absolute magnitude of δ.

Use the formula: $M = m + 5 - 5 \log d$

I hate this formula!
Let us do the calculation properly.

(2)

At a distance of 10 pc, δ would be ten times closer.

(Total for Question 16 = 6 marks)

∴ It would be one hundred times brighter (the inverse-square law)

$\therefore \quad 100 = (2{\cdot}512)^{\Delta m} \Rightarrow \Delta m = 5$

∴ δ would be five magnitudes brighter.

Hence $M = 4{\cdot}4 - 5$

$\therefore \quad M = -0{\cdot}6$

17 (a) (i) State **one** major source of light pollution.

Artificial lighting due to { streets / sports stadia (stadiums?) / security } (1)

(ii) Why does light pollution cause problems for amateur astronomers? (1)

(1) Reduces the number of celestial objects which should be visible, eg. stars

(2) Reduces contrast (3) The background sky is much less dark.

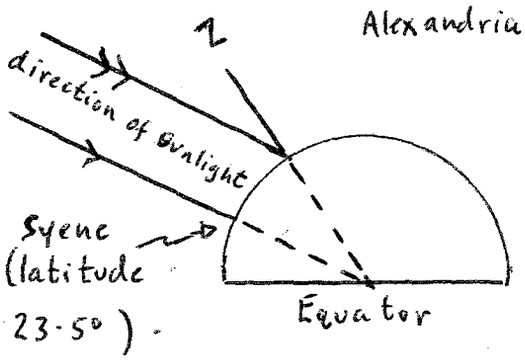
*(b) The Greek mathematician Eratosthenes was the first person to determine the circumference of the Earth. ~ 230 B.C.

Describe the observations and the method used by Eratosthenes to determine the Earth's circumference.

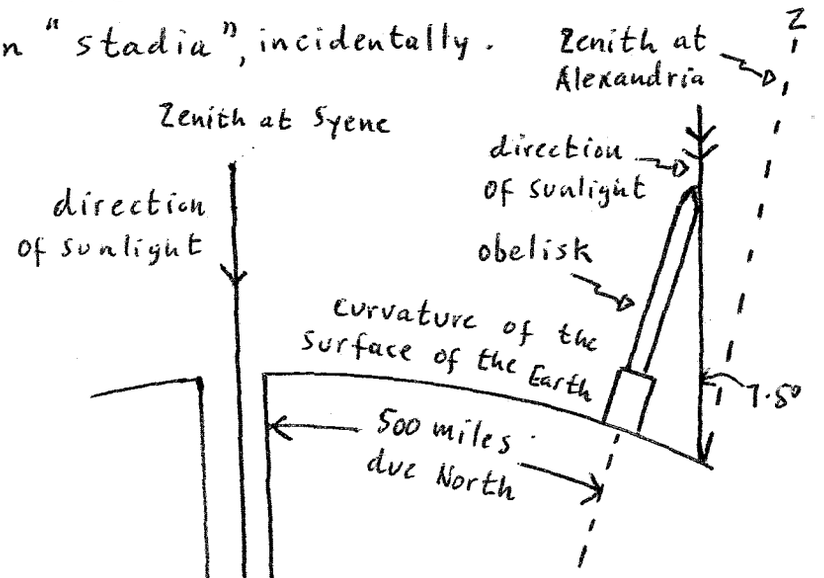
You may draw a diagram.

Eratosthenes knew that at noon on mid-summer day, the Sun is directly overhead, as seen from the town of Syene (the modern Aswan), and that it shone directly down to the bottom of a well, without casting a shadow.

It was also known that, at the same moment, from Alexandria (about 500 miles North of Syene), the Sun is 7·5° from the zenith, or overhead point. A full circle is 360° and 7·5° is $\left(\frac{1}{50}\right)$ of 360°. So, if the Earth is a sphere, its circumference must be 50 x distance between Alexandria and Syene. Eratosthenes' calculation yielded 39,984 km —— remarkably near the truth. He gave the distance in "stadia", incidentally.



The Sun was overhead on June 21.



The Sun, mirrored in the well at Syene.

From the length of the shadow cast by the obelisk, the altitude of the Sun was 82·5°

18 (a) Why do astronomers use 21 cm radio waves rather than visible light to determine the rotation of our Galaxy?

(1)

Radio waves will penetrate dust in the spiral arms, because light is unable to penetrate the dust.

(b) Give **three** key facts about Cosmic Microwave Background radiation.

(3)

* 1. In 1965 Penzias and Wilson detected a microwave signal emanating from space, which did not vary across the sky

"Parameter" is a better word.

(c) Describe how astronomers use the value of the Hubble Constant to determine the age of the Universe.

(2)

(+) "H_0" refers to the Hubble Parameter now

(1) $v \propto d \longrightarrow$ (2) $v = H_0 d$

(3) Units of $H_0 = \dfrac{km\ s^{-1}}{Mpc}$

[A modern value for $H_0 = 70\ km\ s^{-1}\ (Mpc)^{-1}$]

(Total for Question 18 = 6 marks)

* 2. Slight spatial variations in the C.B.R. have been detected. These might correspond to variations in matter, the denser parts of which later became superclusters

3. Dipole anisotropy in the C.B.R. reveals the motion of the Earth relative to the expansion of the Universe.

4. The whole spectrum of the C.B.R. is a very accurate fit to a black body at a temperature of 2.73 K — the "echo" of a Big Bang.

(18) (c) continued.

Now, 100 Mpc $= 3.1 \times 10^{21}$ km, the velocity of recession of the galaxy $\approx 7000\ km\ s^{-1}$

$\therefore$ time $= \dfrac{\text{distance}}{\text{speed}}$

$= \dfrac{3.1 \times 10^{21}\ km}{7000\ km\ s^{-1}}$

$= 4.4 \times 10^{17}\ s$

The reciprocal of H_0

19 (a) Figures 8 and 9 show two galaxies, the Andromeda Galaxy and Large Magellanic Cloud respectively.

Figure 8

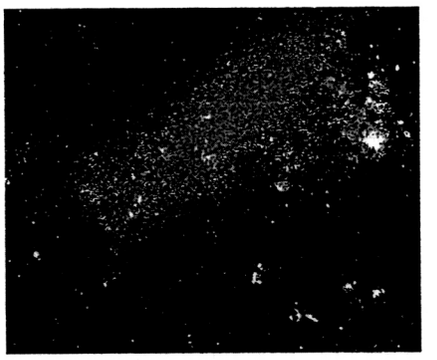


Figure 9

State the type of galaxy shown in:

(2)

(i) Figure 8 Spiral : S | Sa | Sb | Sc

Reject Barred spiral SB

(ii) Figure 9 Irregular | Irr

(b) The two galaxies shown in Figures 8 and 9 are members of our Local Group.

Give the names of **two** other galaxies in our Local Group.

(2)

1. Large and Small Magellanic Clouds
2. Pegasus, (3) Draco, (4) Ursa Minor
5. Wolf - Lundmark

The Local Group comprises ~ one hundred galaxies

(c) Some galaxies are described as 'active'.

Give **two** key facts about active galaxies.

(2)

1. The engine that powers the A.G.N. has to produce ~ 10^{11} times $P_{\odot}$.
2. Thought to be an accreting supermassive black hole.
3. Radiation emitted cannot be from stars alone.
4. Some show excessive emissions at the far infrared.
5. Are often very active in the radio spectrum.
6. They frequently have jets issuing from them.

(Total for Question 19 = 6 marks)

20 Quasars are distant galaxies with high redshifts.

(a) Describe briefly how quasars were discovered.

Allan Sandage, in 1960, was using the 200-inch Mount Palomar Telescope, to look for a star at the location of a strong radio source. These sources turned out to be very compact and their energy output exceeded that which would be accounted for by the stars they appeared to contain. (2)

(b) An astronomer obtained the following data for an absorption line in the spectrum of a quasar:

measured wavelength = 610 nm
true wavelength = 460 nm

At what fraction of the speed of light is the quasar receding?

Use the formula: $\frac{v}{c} = \frac{\lambda - \lambda_0}{\lambda_0}$

Rearranging: $v = \left(\frac{\lambda - \lambda_0}{\lambda_0}\right) c$ (3)

Substituting;

$$v = \left(\frac{1.5 \times 10^{-7}\ m}{4.6 \times 10^{-7}\ m}\right) \times c$$

$$= 0.32 \times c$$

(c) When the astronomer observed another galaxy, she found that its spectrum was blueshifted. What could the astronomer deduce from this?

(1)

- ☐ **A** The galaxy is in the southern hemisphere
- ☒ **B** The galaxy is moving towards us
- ☐ **C** The Universe is contracting
- ☐ **D** The Universe is expanding

(Total for Question 20 = 6 marks)

TOTAL FOR PAPER = 120 MARKS

20(a) continued.

They were too small to have their angular diameters measured. Optical observations confirmed the objects as star-like, rather than fuzzy. ~~Spectroscopic~~ analyses subsequently showed that the quasars are extremely luminous objects at immense distances, receding at an appreciable fraction of the speed of light.