Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel Level 1 / Level 2 GCSE (9–1)

Tuesday 18 June 2024

Afternoon (Time: 1 hour 45 minutes) | **Paper reference** **1AS0/02**

Astronomy

Paper 2
Telescopic Astronomy

You must have:
Formulae and Data Sheet (enclosed)
Calculator, ruler

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*.
- Calculators may be used.
- Any diagrams may NOT be accurately drawn, unless otherwise indicated.
- You must **show all your working out** with **your answer clearly identified** at the **end of your solution**.

Information

- The total mark for this paper is 100.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*

Advice

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

Turn over

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Pearson

Formulae and Data Sheet

Formulae

Equation of Time = Apparent Solar Time (AST) – Mean Solar Time (MST)	
Kepler's 3rd law:	$\frac{T^2}{r^3} = \text{a constant}$
Magnification of telescope:	$\text{magnification} = \frac{f_o}{f_e}$
Distance modulus formula:	$M = m + 5 - 5\log d$
Redshift formula:	$\frac{\lambda - \lambda_0}{\lambda_0} = \frac{v}{c}$
Hubble's law:	$v = H_0 d$

Data

Mass of Earth	6.0×10^{24} kg
Mean diameter of Earth	13 000 km
Mean diameter of Moon	3500 km
Mean diameter of Sun	1.4×10^{6} km
One Astronomical Unit (AU)	1.5×10^{8} km
Mean Earth to Moon distance	380 000 km
One light year (l.y.)	9.5×10^{12} km
One parsec (pc)	3.1×10^{13} km = 3.26 l.y.
Sidereal day of Earth	23 h 56 min
Synodic day of Earth	24 h 00 min
Temperature of solar photosphere	5800 K
Hubble Constant	68 km/s/Mpc
Speed of light in vacuum	3.0×10^{8} m/s

Name	Type of body	Mean distance from Sun/AU	Sidereal period/Earth year	Mean temperature /°C	Diameter /1000 km	Mass/ Earth mass	Ring systems	Moons
Mercury	planet	0.38	0.24	170	4.9	0.055	no	none
Venus	planet	0.72	0.62	470	12.1	0.82	no	none
Earth	planet	1.0	1.0	15	12.8	1.00	no	1: the Moon
Mars	planet	1.5	1.9	–50	6.9	0.11	no	2 small moons: Deimos and Phobos
Ceres	dwarf planet	2.8	4.6	–105	0.95	1.5×10^{-4}	no	none
Jupiter	planet	5.2	11.9	–150	143	318	yes	4 major moons: Ganymede, Callisto, Europa, Io >60 others
Saturn	planet	9.5	29.5	–180	121	95	yes	5 major moons: including Titan, Iapetus >55 others
Uranus	planet	19.1	84.0	–210	51	15	yes	5 major moons: including Titania, Oberon >20 others
Neptune	planet	30.0	165	–220	50	17	yes	1 major moon: Triton >12 others
Pluto	dwarf planet	39.5	248	–230	2.4	2.2×10^{-3}	no	1 major moon: Charon >4 other moons
Haumea	dwarf planet	43.1	283	–241	1.4	6.7×10^{-4}	no	2
Eris	dwarf planet	67.8	557	–230	2.3	2.8×10^{-3}	no	at least 1

Answer ALL questions. Write your answers in the spaces provided.

Some questions must be answered with a cross in a 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) An astronomer photographs some astronomical objects through a telescope.

Identify each object from its photograph.

(i) The object shown in Figure 1.

(1)

Figure 1

☐ **A** binary star

☐ **B** comet

☐ **C** galaxy

☐ **D** globular cluster

(ii) The object shown in Figure 2.

(1)

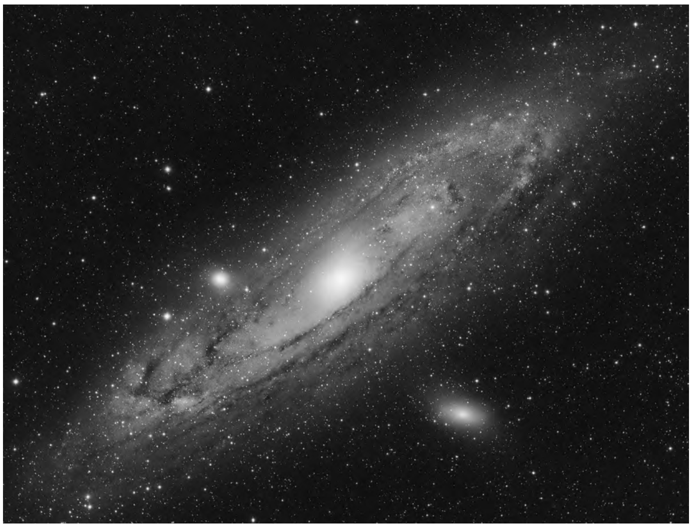

Figure 2

- ☐ **A** binary star
- ☐ **B** comet
- ☐ **C** galaxy
- ☐ **D** globular cluster

(b) An astronomer studies some astronomical objects through a telescope.

She writes a short description of each object.

Identify each object from its description.

(i) A reddish-coloured disc with white ice caps at its poles.

(1)

- ☐ **A** Mars
- ☐ **B** Mercury
- ☐ **C** Neptune
- ☐ **D** Pluto

(ii) A ball-shaped group of thousands of bright stars.

(1)

- ☐ **A** accretion disc
- ☐ **B** double star
- ☐ **C** globular cluster
- ☐ **D** planetary nebula

(iii) A rapidly-expanding shell of gas.

(1)

- ☐ **A** accretion disc
- ☐ **B** double star
- ☐ **C** globular cluster
- ☐ **D** planetary nebula

(c) A student makes a small telescope, similar in size to the one used by Galileo Galilei in 1609.

He uses the telescope to look at the planet Jupiter.

Sketch the appearance of Jupiter through this telescope.

(3)

(Total for Question 1 = 8 marks)

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2 (a) (i) Which of the following is the terrestrial planet with the largest mass?

(1)

- ☐ **A** Earth
- ☐ **B** Mars
- ☐ **C** Neptune
- ☐ **D** Uranus

(ii) Which of the following is the gas giant planet with the smallest mass?

(1)

- ☐ **A** Earth
- ☐ **B** Mars
- ☐ **C** Neptune
- ☐ **D** Uranus

(b) (i) Which of the following missions took astronauts to the surface of the Moon?

(1)

- ☐ **A** Apollo
- ☐ **B** Giotto
- ☐ **C** New Horizons
- ☐ **D** Voyager

(ii) Which of the following missions took the first detailed photographs of the surface of Pluto?

(1)

- ☐ **A** Apollo
- ☐ **B** Giotto
- ☐ **C** New Horizons
- ☐ **D** Voyager

(c) (i) Which of the following is thought to be the origin of long-period comets?

(1)

- ☐ **A** Asteroid Belt
- ☐ **B** Goldilocks Zone
- ☐ **C** Kuiper Belt
- ☐ **D** Oort Cloud

(ii) Which of the following contains the closest dwarf planet to the Earth?

(1)

- [ ] **A** Asteroid Belt
- [ ] **B** Goldilocks Zone
- [ ] **C** Kuiper Belt
- [ ] **D** Oort Cloud

(d) (i) Which of the following methods is the most accurate way to measure the distance to the Moon?

(1)

- [ ] **A** heliocentric parallax
- [ ] **B** measuring its redshift and using Hubble's Law
- [ ] **C** measuring the luminosity of a Cepheid variable
- [ ] **D** timing a beam of light reflected from its surface

(ii) Which of the following methods is the most accurate way to measure the distance to the Andromeda galaxy?

(1)

- [ ] **A** heliocentric parallax
- [ ] **B** measuring its redshift and using Hubble's Law
- [ ] **C** measuring the luminosity of a Cepheid variable
- [ ] **D** timing a beam of light reflected from its surface

(Total for Question 2 = 8 marks)

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QUESTION 3 BEGINS ON THE NEXT PAGE.

3 (a) Figure 3 is a drawing of an early design of refracting telescope, used by the astronomer Christiaan Huygens in the seventeenth century.

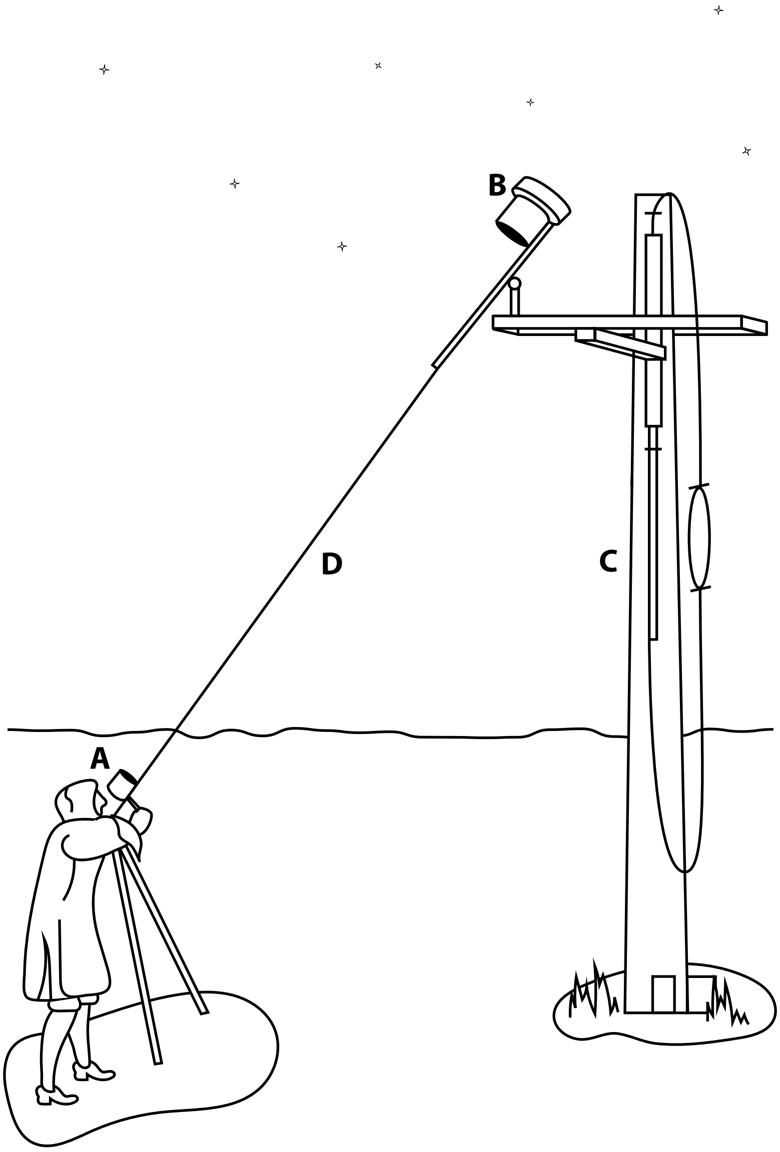

Figure 3

The eyepiece lens **(A)** is mounted on a tripod in front of the astronomer.

The objective lens **(B)** is mounted high up on a tall pole **(C)**.

The two lenses are connected by a piece of string **(D)**.

(i) Suggest a reason for the piece of string between the two lenses.

(1)

Table 1 shows some information about a telescope of this design.

Aperture	20cm
Focal length of objective lens	64m
Focal length of eyepiece lens	130cm

Table 1

(ii) Calculate the magnification of this telescope.

Use information from Table 1.

(2)

Magnification =

(iii) An astronomer plans to use this telescope to make detailed observations of the planet Uranus.

Comment on the suitability of this telescope for observing Uranus.

Use information from Figure 3 and Table 1.

(3)

(b) State **one** advantage of using a reflecting, rather than a refracting, telescope for astronomical observation.

(1)

(Total for Question 3 = 7 marks)

4 (a) Figure 4 shows two drawings of the Moon, made in the seventeenth century using early telescopes.

The left-hand drawing was made by Thomas Harriot in July 1609.

The right-hand drawing was made by Galileo Galilei in November 1609.

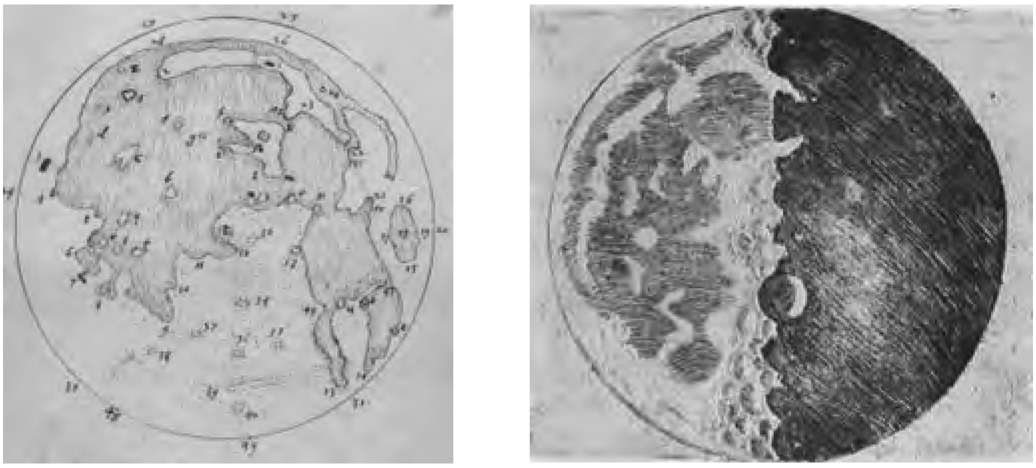

Figure 4

(i) Compare the amount of information about the surface of the Moon shown by the two drawings in Figure 4.

(3)

(ii) Explain why drawings like those shown in Figure 4 were considered to be evidence that the Earth was not the centre of the solar system.

(2)

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(b) Galileo Galilei also made a series of drawings of the planet Venus.

His drawings are shown in Figure 5.

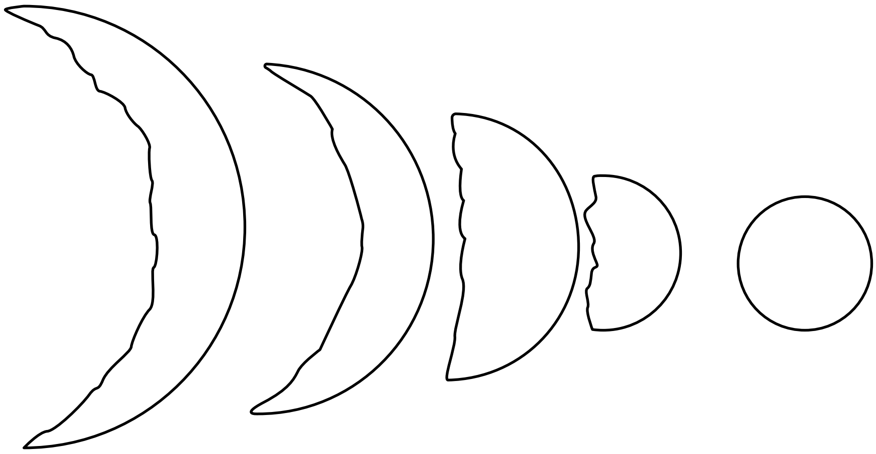

Figure 5

(i) Explain why the drawings shown in Figure 5 were considered to be evidence that the Earth was not the centre of the solar system.

You may include a clearly labelled diagram in your answer.

(2)

(ii) Explain how observations of a transit of Venus can be used to calculate an accurate value for the Astronomical Unit.

You may include a clearly labelled diagram in your answer.

(3)

(Total for Question 4 = 10 marks)

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QUESTION 5 BEGINS ON THE NEXT PAGE.

5 (a) Figure 6 shows the Earth and the direction of the incoming solar wind.

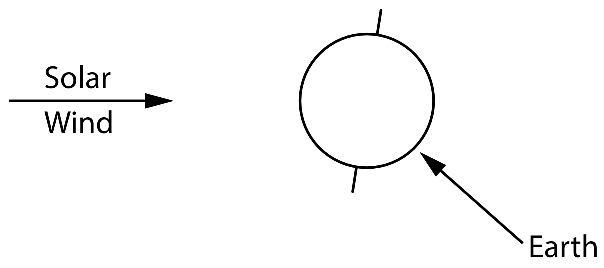

Figure 6

(i) Sketch on Figure 6 the shape and position of the Earth's magnetosphere.

(2)

(ii) Label on Figure 6 the position of the Van Allen belts.

Use the label **V**.

(1)

(iii) Label on Figure 6 a position on Earth where an aurora is most likely to be seen.

Use the label **A**.

(1)

(b) (i) The likelihood of seeing an aurora is linked to the Sun's sunspot cycle.

Explain the link between aurorae and the Sun's sunspot cycle.

You may include a clearly labelled diagram in your answer.

(3)

(ii) Describe how the solar wind can affect human activities such as communication or space travel.

(2)

(iii) The solar wind can affect bodies in the solar system, other than the Earth.

State **one** other effect of the solar wind, elsewhere in the solar system.

(1)

(Total for Question 5 = 10 marks)

6 (a) Figure 7 shows the Lovell radio telescope at the Jodrell Bank Observatory.

It has a large metal dish with a diameter of 76m.

Figure 7

Explain why the dish in this radio telescope needs to have a much larger diameter than the mirror in a large optical telescope.

(3)

(b) The Very Large Array radio telescope contains 28 dishes, as shown in Figure 8.

The dishes are spread out over a distance of 21km.

Figure 8

Each dish in the Very Large Array has a diameter of 25m.

(i) Show that the area of the dish in the Lovell telescope is about nine times larger than each of the dishes in the Very Large Array.

(2)

(ii) Despite the smaller size of its dishes, the Very Large Array has a much higher resolution than the Lovell Telescope.

Explain how the Very Large Array is able to achieve this.

(3)

(iii) The Lovell Telescope has an angular resolution of half an arcminute (0.5′).

Estimate the angular resolution of the Very Large Array.

Give your answer in arcseconds (″).

(2)

Angular resolution = ″

(Total for Question 6 = 10 marks)

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QUESTION 7 BEGINS ON THE NEXT PAGE.

7 (a) An astronomer observes five stars.

Data on these five stars are given in Table 2.

Star	Apparent magnitude	Absolute magnitude	Spectral class	Mass (Sun = 1)
61 Virginis	4.74	5.07	G7	0.93
Proxima Centauri	10.5	15.6	M5	0.12
Rigel	0.12	-7.84	B8	18
Aldebaran	0.85	-0.64	K5	1.16
Sirius A	-1.46	1.43	A0	2.1

Table 2

The astronomer wishes to identify the star that is a red giant.

Evaluate which of these five stars is most likely to be a red giant star.

(6)

(b) Figure 9 shows some stars from a constellation.

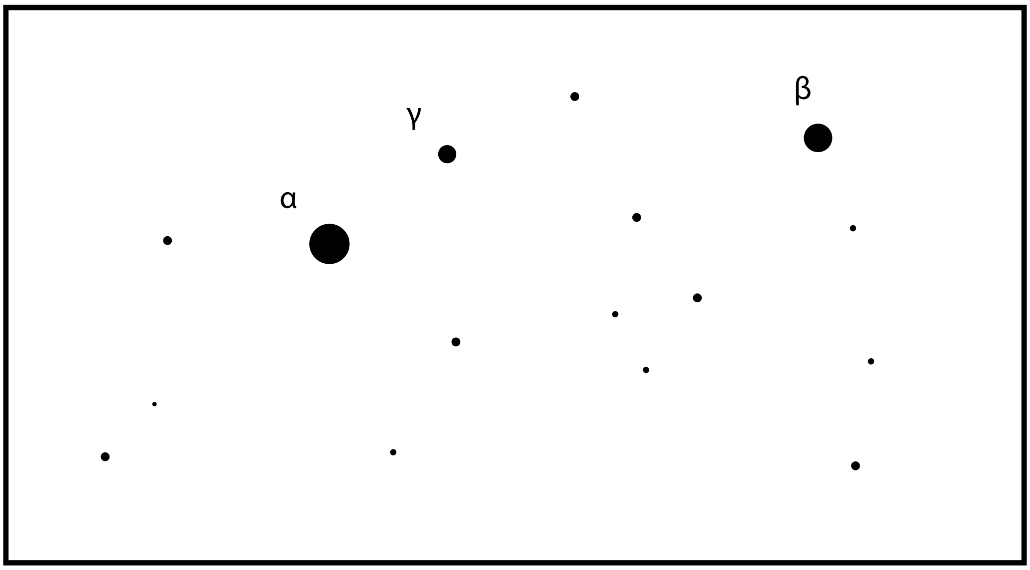

Figure 9

(i) State the meaning of the labels α, β and γ in Figure 9.

(1)

(ii) Star β has an absolute magnitude of -3.1 and is 60pc from Earth.

Calculate the apparent magnitude of star β.

Use the equation:

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

(2)

Apparent magnitude =

(iii) Star α and star γ have the same absolute magnitude.

The apparent magnitudes of the stars differ by 3.

Star α is 20pc from Earth.

Calculate the distance of star γ from Earth.

Give your answer in parsecs (pc).

(3)

Distance = pc

(Total for Question 7 = 12 marks)

8 (a) Figure 10 shows an image of Saturn's ring system.

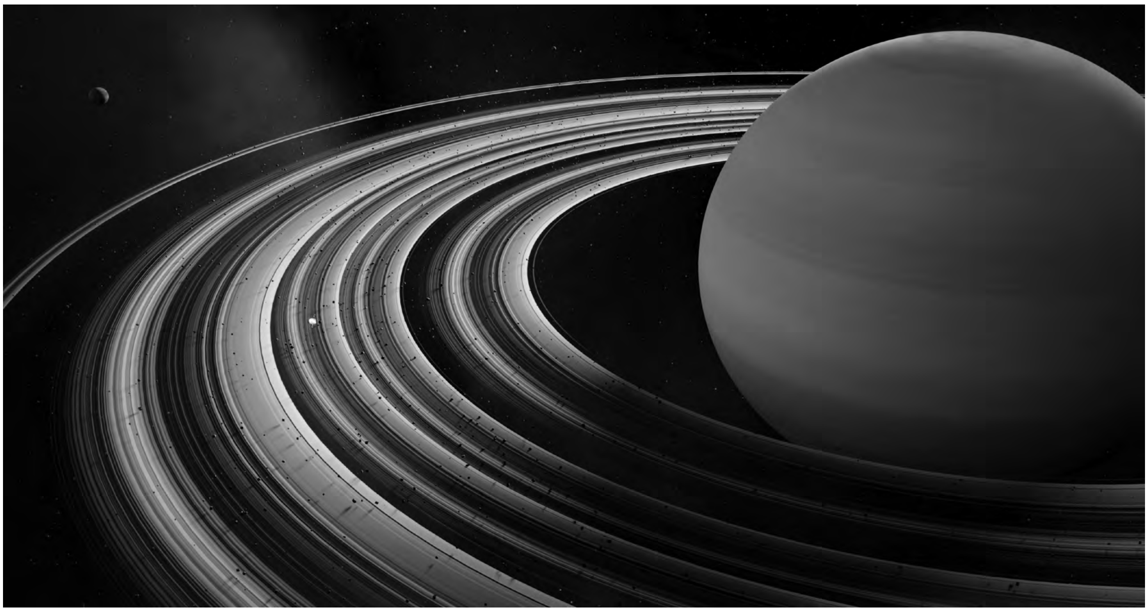

Figure 10

Explain how the force of gravity is believed to have created this ring system.

You may include a clearly labelled diagram in your answer.

(2)

(b) Figure 11 shows an image of Hyperion, a small moon of Saturn.

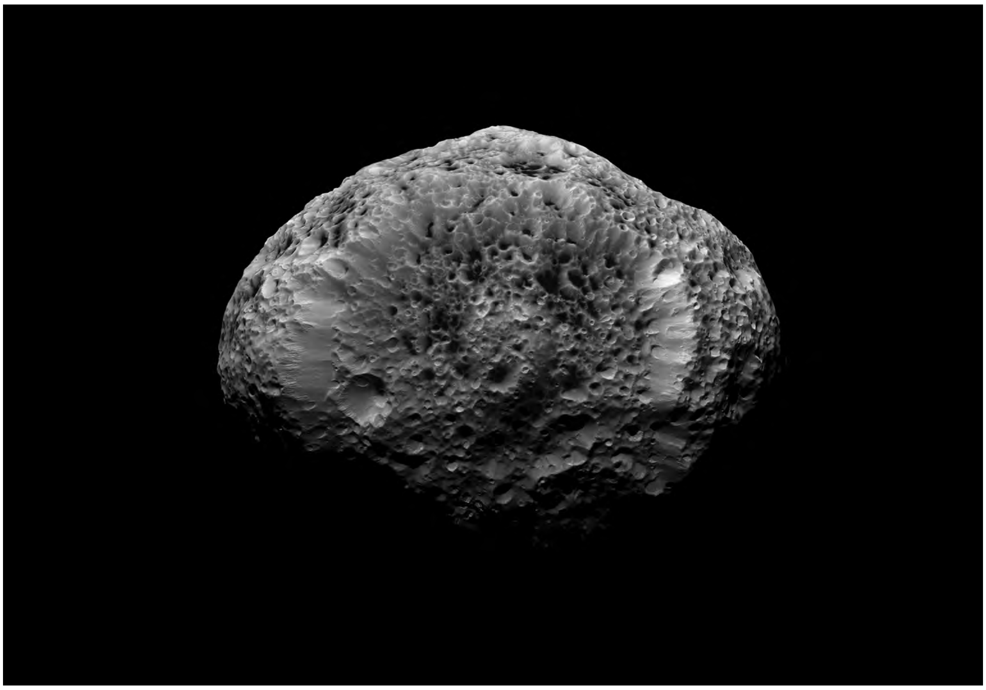

Figure 11

Hyperion follows a predictable orbit around Saturn but spins in an unpredictable way.

Explain why Hyperion spins in an unpredictable way.

(2)

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(c) Figure 12 shows a chart of the sizes of the orbits of the asteroids in the Asteroid Belt.

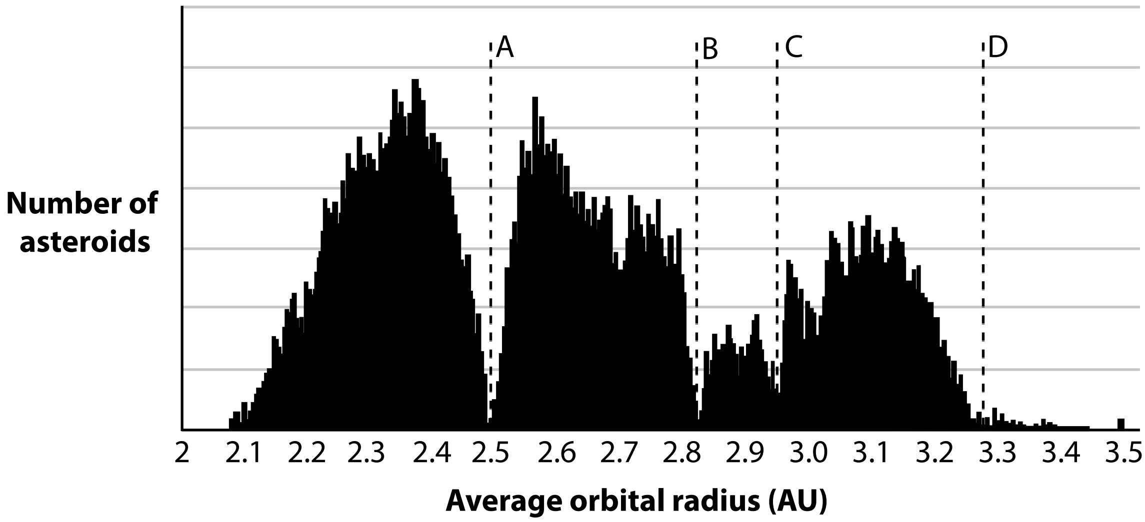

Figure 12

Figure 12 shows that almost no asteroids have the orbital radii labelled A, B, C or D.

Explain why there are these 'gaps' in the orbital sizes within the Asteroid Belt.

(3)

(d) Figure 13 shows a diagram of the Earth's orbit around the Sun, with five important points (1, 2, 3, 4 and 5) labelled.

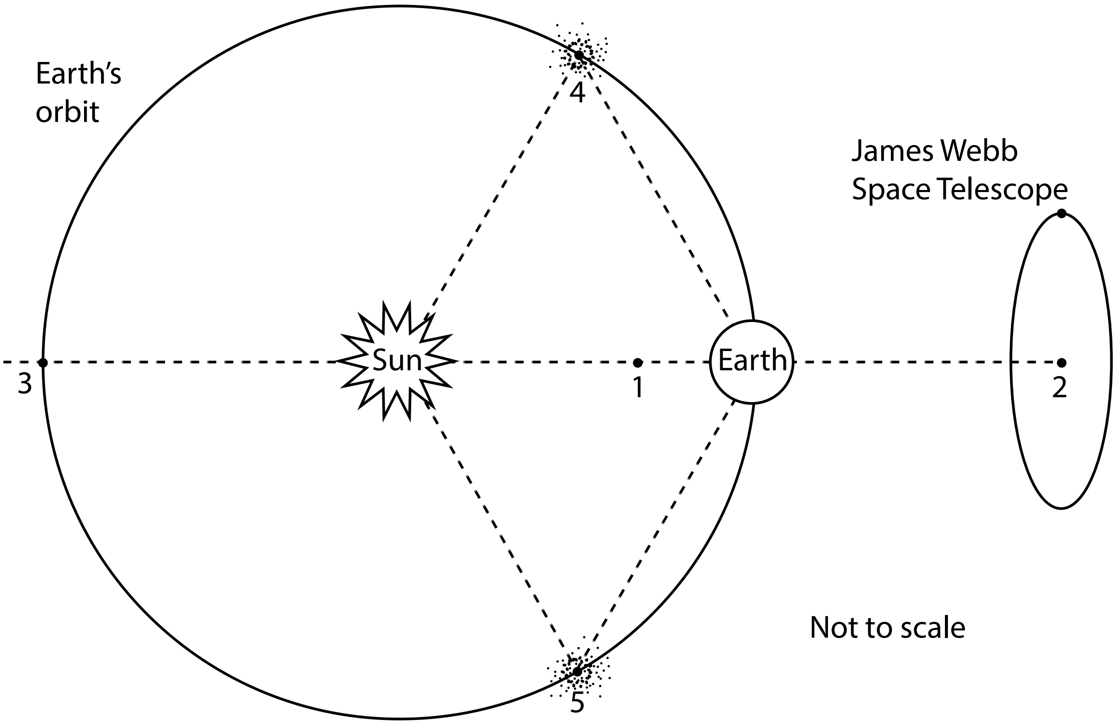

Figure 13

(i) Explain why a group of small asteroids is found at points 4 and 5 on Figure 13.

(2)

(ii) A number of space probes have been placed at some of the points labelled 1-5 in Figure 13.

State **one** advantage of placing space probes at one of these points.

(1)

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(iii) The James Webb Space Telescope is an infrared telescope.

It has been placed in an orbit around point 2 in Figure 13.

State **one** advantage of placing an infrared telescope in this orbit.

(1)

(Total for Question 8 = 11 marks)

9 (a) Hanaya uses a camera mounted on a tripod to take a star trail photograph of the night sky.

She uses an exposure time of 98 minutes. Her photograph is shown in Figure 14.

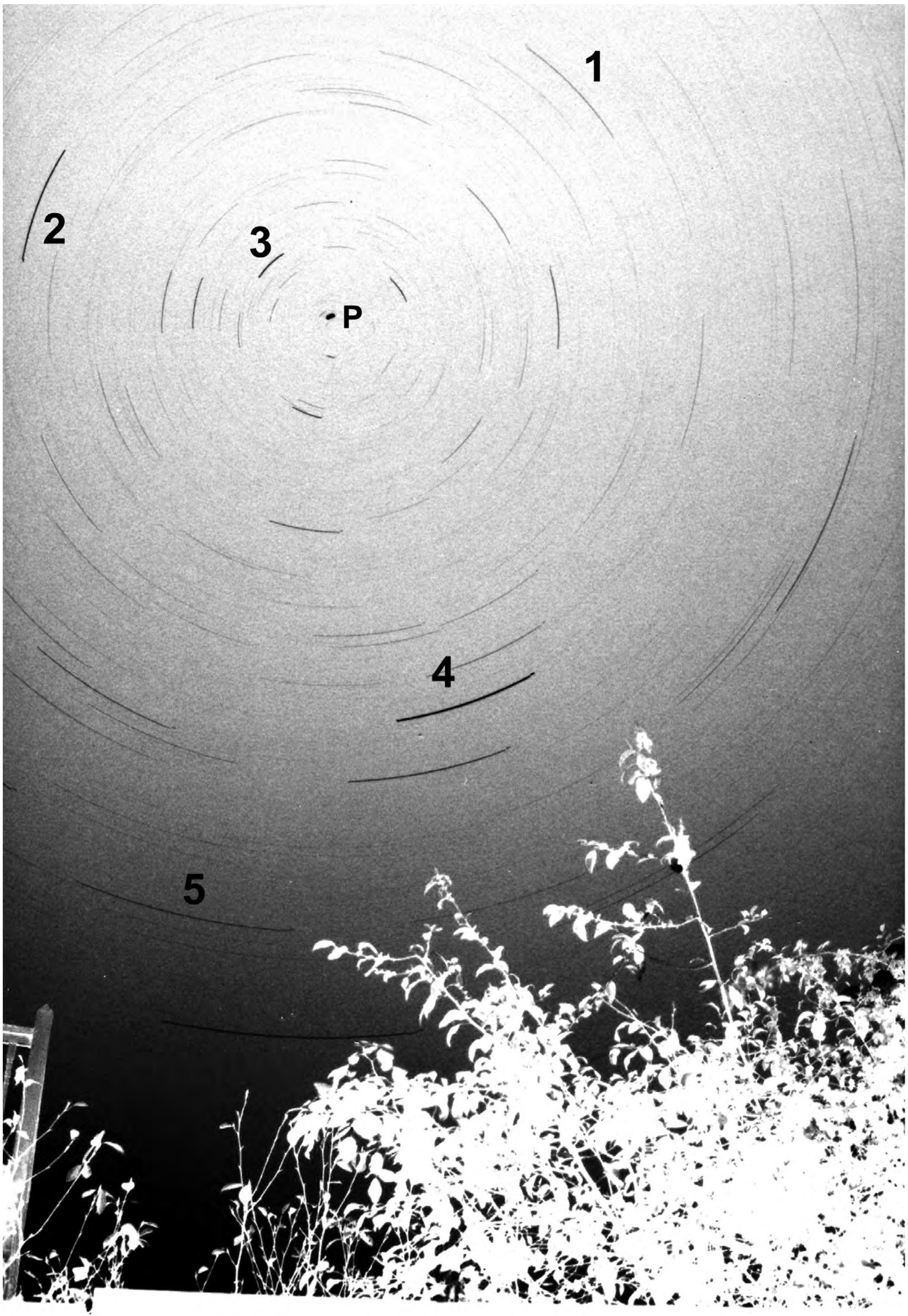

Figure 14

Hanaya measures the angle covered by some of the bright star trails in her photograph.

Her measurements are shown in Table 3.

Star Trail	Angle (°)
1	23
2	26
3	28
4	24
5	25

Table 3

Analyse the information in Figure 14 and Table 3 in order to calculate a value for the Earth's rotation period.

Give your answer in hours and minutes.

(3)

Rotation period = h min

(b) Evaluate ways to improve Hanaya's observations in order to obtain a more accurate value for the Earth's rotation period.

(6)

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(c) Hanaya's method gives a value for the length of the sidereal day.
Explain the difference between the sidereal and synodic day.
You may include a clearly labelled diagram in your answer.

(2)

(d) The image of the Pole Star is labelled **P** in the photograph in Figure 14.
Explain why the Pole Star does not appear as a dot in the star trail photograph in Figure 14.

(2)

(Total for Question 9 = 13 marks)

10 (a) The Drake Equation can be used to estimate the number of civilisations in the Milky Way galaxy with which communication might be possible.

The Drake Equation can be written in the following way:

$$N = R_{*} \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

where:

N = the number of civilisations in the Milky Way galaxy with which communication might be possible

R_{*} = the average rate of star formation in the Milky Way galaxy

f_p = the fraction of those stars that have planets

n_e = the average number of planets that could support life, orbiting each of these stars

f_l = the fraction of planets that could support life that actually develop life

f_i = the fraction of planets with life that actually develop intelligent life

f_c = the fraction of civilisations that develop a technology that releases detectable signs of their existence

L = the average length of time for which these civilisations release detectable signals.

Astronomers are not certain about the correct value to use for each of the quantities in the Drake Equation.

(i) Explain why the accuracy of the data for estimating f_p and n_e has improved greatly since the equation was proposed in 1961.

(2)

(ii) Describe the evidence that f_l is close to 1.0.

(1)

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(iii) Explain why it is very difficult for astronomers to agree on accurate values for quantities such as f_l, f_i and f_c.

(2)

(b) Table 4 shows some information related to three of the quantities in the Drake Equation.

Quantity	Estimate
Rate of star formation in the Milky Way galaxy	1.1 per year
Fraction of these stars **without** planets	0.6
Average number of habitable planets orbiting each star with planets	2

Table 4

(i) Show that the expected number of habitable planets forming in the Milky Way galaxy each year is approximately 0.9.

Use the data in Table 4.

(2)

(ii) Table 5 shows estimates for the other quantities in the Drake Equation.

Quantity	Estimate
f_l	1.0
f_i	1.0
f_c	0.15
L	50 000 000

Table 5

The expected number of habitable planets forming in the Milky Way galaxy each year is approximately 0.9.

Analyse the data in Table 4 and in Table 5 in order to determine a value for N, the number of civilisations in the Milky Way galaxy with which communication might be possible.

(2)

Number of civilisations =

(c) The radio telescope shown in Figure 15 is part of the SETI (Search for Extra-Terrestrial Intelligence) programme.

Figure 15

These telescopes monitor the sky for artificial radio signals from beyond the Earth.

State **two** reasons why the SETI programme searches for artificial signals with wavelengths of around 21cm.

(2)

1

2

(Total for Question 10 = 11 marks)

TOTAL FOR PAPER = 100 MARKS

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