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)

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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P 6 8 8 2 5 R A 0 1 3 2

Pearson

Formulae and Data Sheet

Formulae

Equation of Time = Apparent Solar Time (AST) – Mean Solar Time (MST)	
Kepler's 3rd law:	$\frac{T^2}{r^3}$ = a constant
Magnification of telescope:	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 system	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 student used a telescope to make sketches of some astronomical objects.

(a) Identify each of the following objects from the student's sketches.

(i) A bright patch of light with a tail, visible in the sky for several weeks.

(1)

☒ **A** asteroid

☒ **B** comet

☒ **C** galaxy

☒ **D** planet

(ii) A spiral-shaped fuzzy patch of light.

(1)

☒ **A** asteroid

☒ **B** comet

☒ **C** galaxy

☒ **D** planet

(b) Identify each of the following astronomical objects from its description and photograph.

(i) The thin layers of gas stretching outwards from the Sun, only visible during a total solar eclipse, as shown in Figure 1.

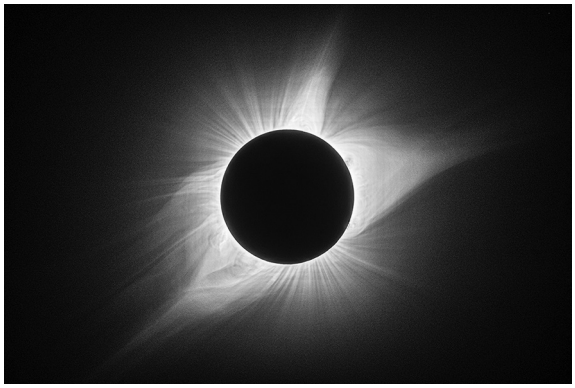

Figure 1

(1)

☒ **A** aurora

☒ **B** corona

☒ **C** nebula

☒ **D** photosphere

(ii) The glowing 'curtain' of coloured light in the night sky, as shown in Figure 2.

Figure 2

(1)

☒ **A** aurora

☒ **B** corona

☒ **C** nebula

☒ **D** photosphere

(iii) A sphere of expanding gas surrounding a star, as shown in Figure 3.

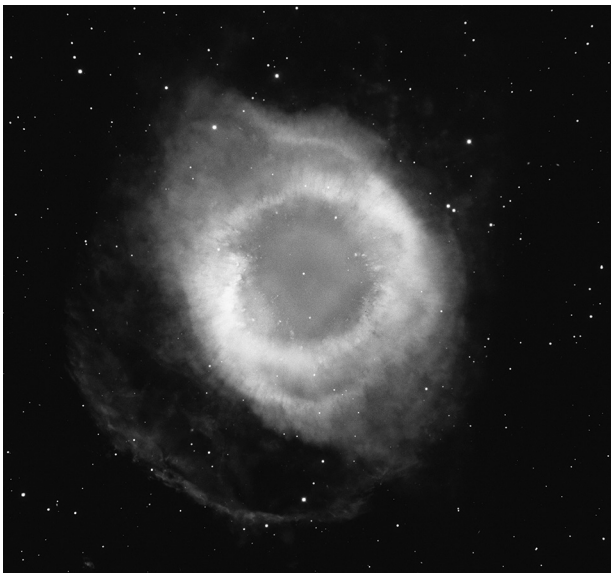

Figure 3

(1)

- ☒ **A** aurora
- ☒ **B** corona
- ☒ **C** nebula
- ☒ **D** photosphere

(c) Draw the appearance of the planet Saturn, when viewed through a telescope with an aperture of 25 cm.

(2)

(Total for Question 1 = 7 marks)

2 (a) (i) Which **one** of the following types of star is most likely to be the youngest?

(1)

- ☒ **A** main sequence
- ☒ **B** neutron star
- ☒ **C** red giant
- ☒ **D** white dwarf

(ii) Which **one** of the following types of star is the smallest in size?

(1)

- ☒ **A** main sequence
- ☒ **B** neutron star
- ☒ **C** red giant
- ☒ **D** white dwarf

(b) (i) Which **one** of the following are Small Solar System Objects (SSSO)?

(1)

- ☒ **A** asteroids
- ☒ **B** dwarf planets
- ☒ **C** exoplanets
- ☒ **D** moons

(ii) The orbit of an object in the Solar System is observed for several months.

The orbit is found to be at an angle of 60° to the ecliptic.

The object is most likely to be:

(1)

- ☒ **A** a comet
- ☒ **B** a planet
- ☒ **C** the Moon
- ☒ **D** the Sun

(c) A star's position on the Hertzsprung–Russell Diagram is determined by its:

(1)

- ☒ **A** absolute magnitude and spectral class
- ☒ **B** apparent magnitude and size
- ☒ **C** colour and temperature
- ☒ **D** temperature and spectral class

(d) Edwin Hubble's observations of distant galaxies showed that the Universe:

(1)

- ☒ **A** began with a Big Bang
- ☒ **B** is contracting
- ☒ **C** is expanding
- ☒ **D** will end with a Big Crunch

(e) The Search for Extra-Terrestrial Intelligence (SETI) detects:

(1)

- ☒ **A** gamma rays
- ☒ **B** infrared radiation
- ☒ **C** radio waves
- ☒ **D** X-rays

(Total for Question 2 = 7 marks)

3 Before 1609 most astronomers assumed that the Sun and the planets orbited the Earth.

(a) A theory where the Sun and the planets orbit the Earth is called:

(1)

- ☒ **A** elliptical
- ☒ **B** geocentric
- ☒ **C** heliocentric
- ☒ **D** terrestrial

(b) In 1609 Galileo Galilei made observations of the night sky using a small telescope. His observations were evidence that the Sun and the planets did **not** orbit the Earth.

(i) Galileo made drawings of four moons orbiting the planet Jupiter, as shown in Figure 4.

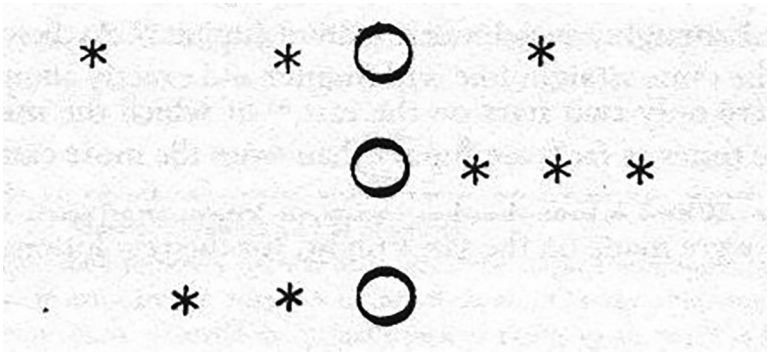

Figure 4

Explain how Galileo used the drawings in Figure 4 as evidence that the Sun and planets did **not** orbit the Earth.

(2)

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(ii) Galileo made drawings of the changing appearance of the planet Venus, as shown in Figure 5.

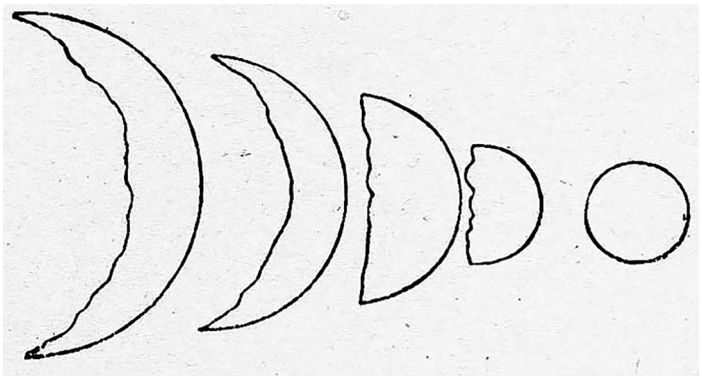

Figure 5

Explain how Galileo used the drawings in Figure 5 as evidence that the Sun and planets did **not** orbit the Earth.

(2)

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(iii) Galileo made drawings of the appearance of the Moon's disc, as shown in Figure 6.

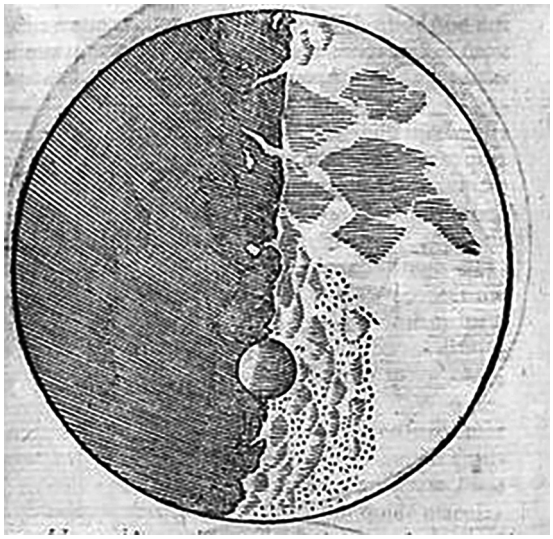

Figure 6

Explain how Galileo used the drawing in Figure 6 as evidence that the Sun and planets did **not** orbit the Earth.

(2)

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(c) Four hundred years after Galileo, twenty-first century astronomers use telescopes to produce much higher quality images of Jupiter, Venus and the Moon.

Table 1 shows some information about these telescopes.

	Galileo's telescope (1609)	Twenty-first century telescope
Aperture	3.5 cm	11 m
Focal length	98 cm	17.5 m

Table 1

Analyse the data in Table 1 in order to explain how the images from twenty-first century telescopes are better than those obtained by Galileo in 1609.

(2)

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(Total for Question 3 = 9 marks)

4 (a) Astronomers have identified a number of planets orbiting a nearby star.

This star is very similar to our Sun.

Table 2 shows some information about these planets.

Planet	Distance from star (AU)	Radius (km)	Mean surface temperature (°C)
A	0.2	4000	210
B	0.9	13000	20
C	7.0	150000	–170
D	14.0	75000	–200

Table 2

Identify, using the information in Table 2, which planet is:

(i) most likely to support life.

(1)

- ☒ **A** Planet A
- ☒ **B** Planet B
- ☒ **C** Planet C
- ☒ **D** Planet D

(ii) most similar to Jupiter.

(1)

- ☒ **A** Planet A
- ☒ **B** Planet B
- ☒ **C** Planet C
- ☒ **D** Planet D

(iii) orbiting the star in the shortest time.

(1)

- ☒ **A** Planet A
- ☒ **B** Planet B
- ☒ **C** Planet C
- ☒ **D** Planet D

(iv) orbiting the star with a period of 18.5 years.

(1)

- ☒ **A** Planet A
- ☒ **B** Planet B
- ☒ **C** Planet C
- ☒ **D** Planet D

(b) One method for finding planets orbiting other stars is to take very careful measurements of the star's brightness as the planet transits the star.

Figure 7 shows a set of measurements taken in this way.

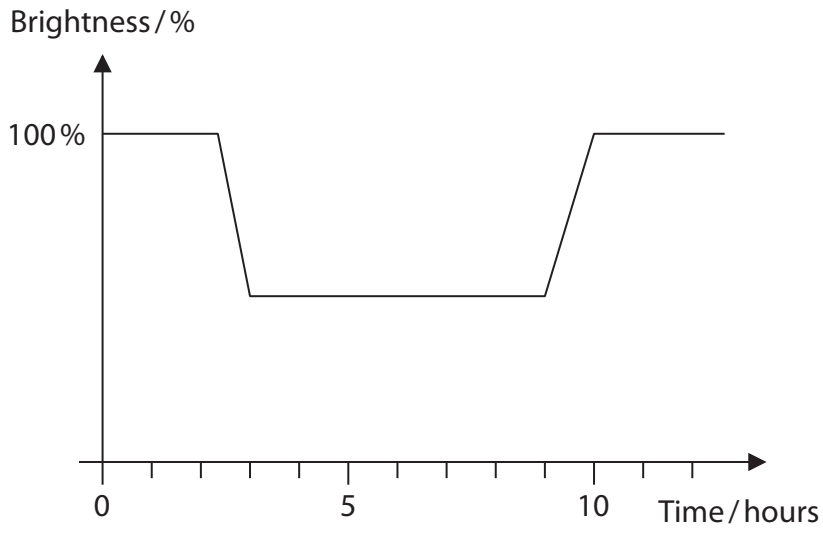

Figure 7

(i) Explain the shape of the graph in Figure 7.

You may include a clearly labelled diagram in your answer.

(2)

.....

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.....

(ii) The planet is known to be travelling at 140 000 km per hour in its orbit.

Evaluate the information in Figure 7 in order to estimate the diameter of the planet.

(3)

Diameter of planet = ...

(c) Describe a **different** method that astronomers use to find planets orbiting other stars.

You may include a clearly labelled diagram in your answer.

(2)

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(Total for Question 4 = 11 marks)

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5 (a) Figure 8 shows the first picture ever taken of the far side of the Moon.

It was taken by the Luna 3 probe in 1959.

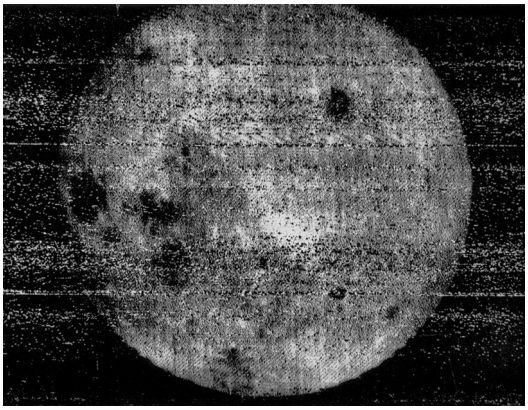

Figure 8

(i) The Luna 3 probe was an example of:

(1)

- ☒ **A** a fly-by probe
- ☒ **B** an impactor
- ☒ **C** a lander
- ☒ **D** an orbiter

(ii) Which **one** of the following statements about the far side of the Moon is correct?

(1)

- ☒ **A** it has more craters than the near side
- ☒ **B** it has more mare than the near side
- ☒ **C** it has no craters
- ☒ **D** it is colder than the near side

(b) In 1969 the Apollo 11 mission allowed astronauts to visit the surface of the Moon.

Figure 9 and Figure 10 show images taken during the mission.

Launch from Earth

Figure 9

Launch from Moon

Figure 10

Figure 9 shows the launch of the mission from Earth.

Figure 10 shows the launch of the mission from the Moon at the start of its return journey.

The rocket launching the mission from Earth was over two thousand times more powerful than the one launching it from the Moon.

(i) Explain why the launch from the Earth required a much more powerful rocket than the launch from the Moon.

(2)

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Figure 11 shows the Earth and the Moon, with the Apollo 11 launch and landing sites labelled.

Figure 11

(ii) Explain why the Apollo 11 mission did not travel in a straight line between its launch and landing sites.

(1)

.....

.....

(iii) Draw the path taken by the Apollo 11 mission on Figure 11.

(3)

(c) The Apollo missions provided astronomers with new information about the Moon.

State **two** pieces of new information about the Moon provided by the Apollo missions.

(2)

1 .....

2 .....

(Total for Question 5 = 10 marks)

6 (a) Figure 12 shows an image of the planet Jupiter.

Figure 12

Jupiter is 1300 times larger than the Earth.

Its mass is only 318 times as much as the Earth's.

Explain why Jupiter does **not** have a mass 1300 times as much as the Earth's.

(2)

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(b) Europa is one of the moons of Jupiter.

Figure 13 is an image of Europa orbiting Jupiter, taken by the Voyager 1 probe.

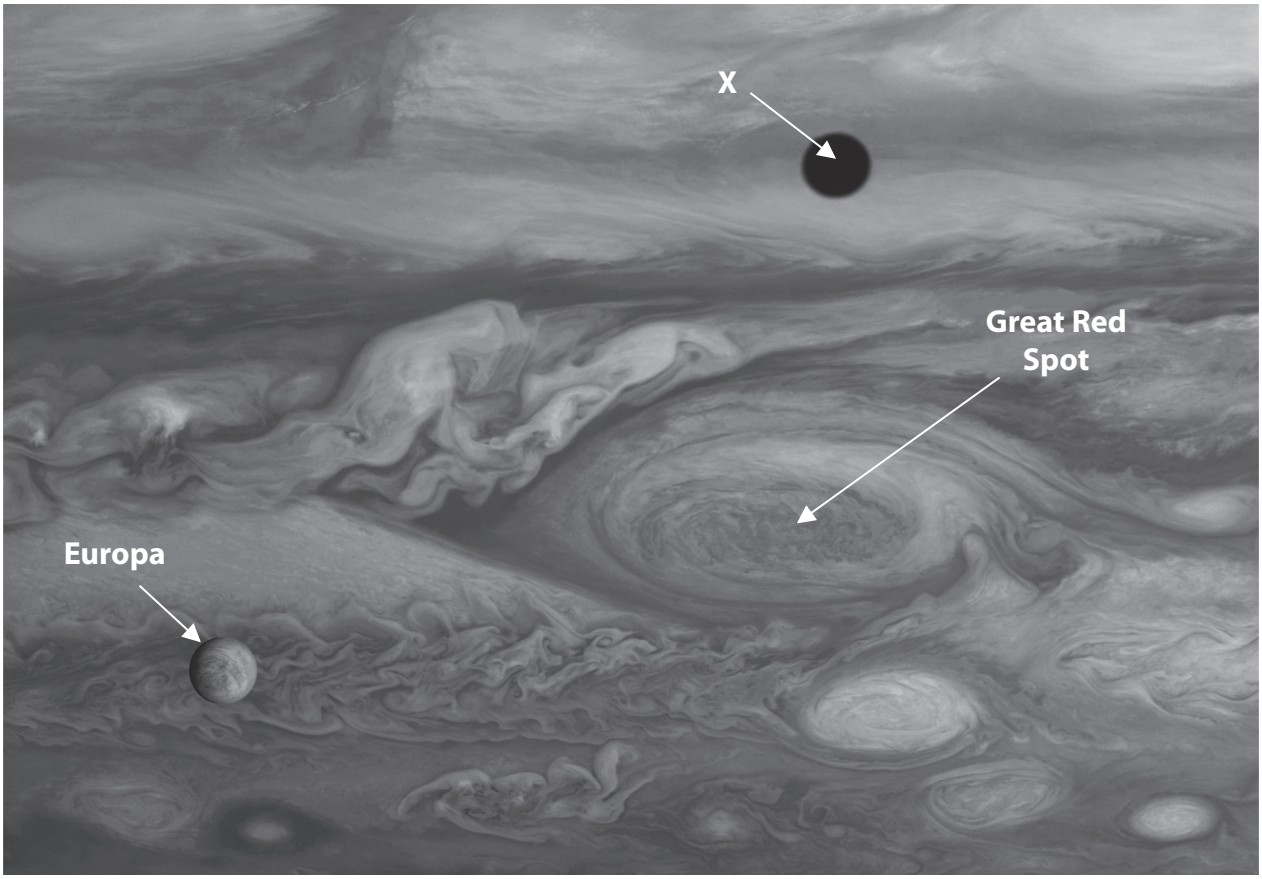

Figure 13

(i) Explain the cause of the dark circle labelled 'X' in Figure 13.

(2)

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.....

(ii) Jupiter's Great Red Spot is also labelled in Figure 13.

The Great Red Spot is a large, reddish-coloured spot, first observed in 1878.

State **two other** physical properties of the Great Red Spot.

(2)

1 .....

2 .....

(iii) Explain why the Great Red Spot was **not** observed until 1878.

(2)

.....

.....

.....

(c) Some astronomers have suggested that, since the formation of the Solar System, Jupiter has changed its position amongst the other planets.

Give **two** pieces of evidence for this suggestion.

(2)

1 .....

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2 .....

.....

(Total for Question 6 = 10 marks)

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7 (a) A student makes a scale model of the Solar System.

He places the models of the Earth and the Sun 1 cm apart.

(i) Calculate the distance from the model of the Sun to the point where the model of Neptune should be placed.

Use information from the Formulae and Data Sheet.

Give your answer in cm.

(1)

Distance from model of Sun = ... cm

(ii) The most distant objects in the Oort Cloud are thought to orbit approximately 0.8 l.y. from the Sun.

Calculate the distance from the model of the Sun to the point where the model of an Oort Cloud object should be placed.

Use information from the Formulae and Data Sheet.

(2)

Distance from model of Sun = ...

(b) In 1772 the German astronomer Johann Bode noticed a similarity between the radii of the orbits of the planets in the Solar System and a simple sequence of numbers.

He started with this sequence of numbers (which are doubling each time):

0 3 6 12 24 48 96 192 384 …

He then added four to each number and divided the result by ten to give:

0.4 0.7 1.0 1.6 2.8 5.2 10 19.6 38.8 …

He noticed that these numbers were very similar to the radii of the orbits of the planets when measured in AU.

The data for this comparison are summarised in Table 3.

Name	Bode's prediction (AU)	Actual radius of orbit (AU)	Difference (AU)
Mercury	0.4	0.38	0.02
Venus	0.7	0.72	−0.02
Earth	1.0	1.0	0
Mars	1.6	.....	.....
.....	2.8	2.8	0
Jupiter	5.2	5.2	0
Saturn	10	.....	.....
Uranus	19.6	19.1	0.5
Neptune	38.8	30.0	8.8

Table 3

(i) Complete Table 3 by filling in the missing **name** and **numbers**.

Use information from the Formulae and Data Sheet.

(3)

(ii) It has been suggested that Bode's number pattern matches the actual radii of the orbits of the planets.

Evaluate this statement using the data in Table 3.

(6)

(Total for Question 7 = 12 marks)

8 Figure 14 is an X-ray image of the night sky. The image was taken using the eROSITA X-ray telescope, on board a satellite orbiting the Earth.
Light areas indicate bright X-ray sources and darker areas indicate weaker X-ray sources.

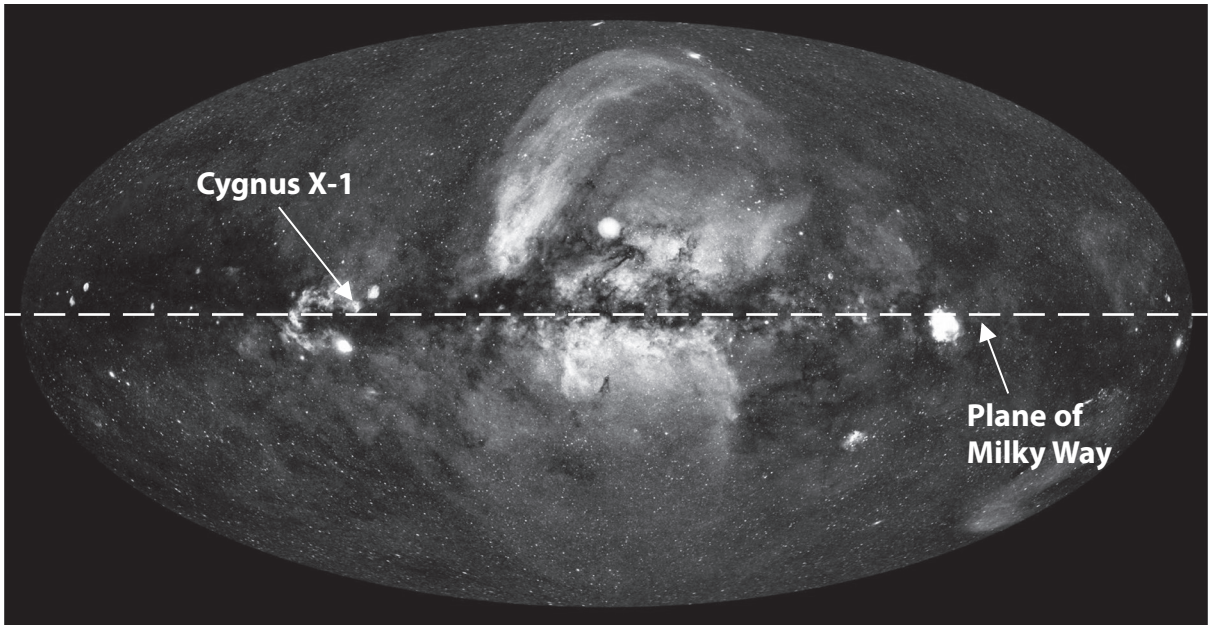

Figure 14

(a) Explain why the image in Figure 14 needed to be taken from a satellite.

(2)

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(b) The very bright X-ray source called Cygnus X-1 is labelled in Figure 14.
Cygnus X-1 is believed to be a binary star system containing a black hole.

(i) State the physical property of a black hole that makes it impossible for it to emit X-rays.

(1)

.....

(ii) Explain how the Cygnus X-1 system is such a bright emitter of X-rays.

You may include a clearly labelled diagram in your answer.

(3)

(c) (i) State the part of the Milky Way galaxy that is most likely to be the brightest X-ray source.

(1)

(ii) Explain your answer to (c)(i).

(2)

(d) Cygnus X-1 and the Milky Way galaxy are sources of X-rays.

State **two other** astronomical sources of X-rays.

(2)

1 .....

2 .....

(Total for Question 8 = 11 marks)

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9 A student used observations of sunspots to measure the length of the Solar Cycle.

She used a reflecting telescope with a solar filter.

She used a mobile phone camera to record the view through the eyepiece, as shown in Figure 15.

Figure 15

Details of her telescope are shown in Table 4.

Aperture	76 mm
Focal length of objective mirror	350 mm
Focal length of eyepiece lens	20 mm

Table 4

(a) Analyse the information in Figure 15 and Table 4 in order to comment on the suitability of her observing equipment.

(3)

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Her observations are summarised in Table 5.

Date	Number of sunspots
1st January 2014	52
2nd July 2014	42
3rd January 2015	33
1st July 2015	25
1st January 2016	18
1st July 2016	10

Table 5

(b) Evaluate ways to improve her observations in order to obtain a more accurate estimate of the length of the Solar Cycle.

(6)

(c) While completing her observations, she noticed that groups of sunspots change their appearance.

Describe how a group of sunspots changes its appearance over a period of one month.

(2)

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(Total for Question 9 = 11 marks)

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10 (a) The Sun has an apparent magnitude of approximately −27

The bright star Canopus has an apparent magnitude of approximately −1

The Sun appears approximately 20 billion times brighter than Canopus.

(i) Explain why the apparent magnitude of the Sun is only 27 times that of Canopus, even though it appears 20 billion times brighter.

(2)

(ii) Show that the Sun has an absolute magnitude of approximately +4.5

Assume that the Sun has an apparent magnitude of −27

Use information from the Formulae and Data Sheet.

Use the equation:

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

(4)

(iii) Explain why the Sun's apparent magnitude is so much brighter than its absolute magnitude.

(2)

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(b) Stars A and B appear to be the same brightness for an observer on the Earth.
Star A is three magnitudes brighter than Star B.

(i) State which one of these two stars is further from the Earth.

(1)

.....

(ii) Star A is 60 pc from the Earth.

Calculate the distance of Star B from the Earth.

Give your answer in parsecs (pc).

(3)

Distance of Star B = ... pc

(Total for Question 10 = 12 marks)

TOTAL FOR PAPER = 100 MARKS

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