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)

Wednesday 21 June 2023

Morning (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

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 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: Triton $>$12 others
Pluto	dwarf planet	39.5	248	–230	2.4	2.2×10^{-3}	no	1 major: 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

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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 small, bright disc with four fainter points of light in a line, as shown in Figure 1.

(1)

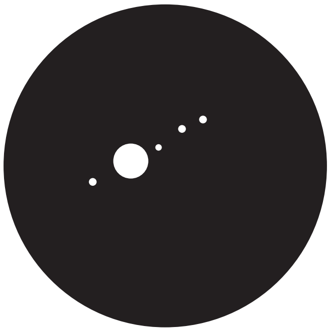

Figure 1

☒ **A** a comet

☒ **B** a galaxy

☒ **C** a globular cluster

☒ **D** Jupiter and its moons

(ii) Many thousands of stars forming a tightly packed, spherical ball, as shown in Figure 2.

(1)

Figure 2

☒ **A** a binary star system

☒ **B** a globular cluster

☒ **C** an open cluster

☒ **D** Jupiter and its moons

(iii) Two stars that appear very close to each other, as shown in Figure 3.

(1)

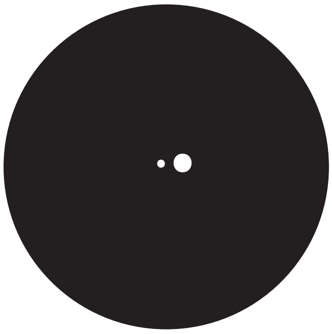

Figure 3

☒ **A** a binary star system

☒ **B** a galaxy

☒ **C** a globular cluster

☒ **D** an open cluster

(b) A student views some astronomical objects through a small telescope.
The student writes a description of each object.

Identify each object from its description and image.

(i) A fuzzy object that has spiral arms, as shown in Figure 4.

(1)

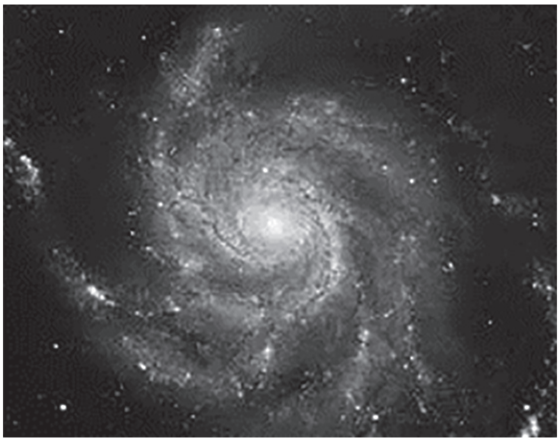

Figure 4

☒ **A** the aurora

☒ **B** a comet

☒ **C** a galaxy

☒ **D** an open cluster

(ii) Hundreds of stars forming an irregularly-shaped group, as shown in Figure 5.

(1)

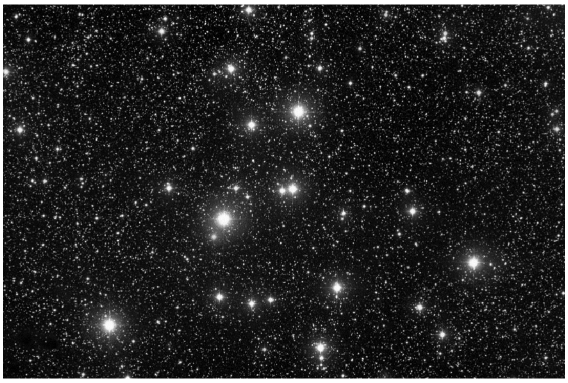

Figure 5

- ☒ **A** a binary star system
- ☒ **B** a globular cluster
- ☒ **C** a galaxy
- ☒ **D** an open cluster

(iii) A fuzzy object that has two tails, as shown in Figure 6.

(1)

Figure 6

- ☒ **A** the aurora
- ☒ **B** a comet
- ☒ **C** a galaxy
- ☒ **D** an open cluster

(Total for Question 1 = 6 marks)

2 (a) Which **one** of the following is **not** an internal division of the Moon?

(1)

- ☒ **A** coma
- ☒ **B** crust
- ☒ **C** mantle
- ☒ **D** outer core

(b) There are different theories of the Moon's origin.

Identify each theory from the following short descriptions.

(i) The gravitational attraction of the Earth brought the passing Moon into the Earth's orbit.

(1)

- ☒ **A** Capture Theory
- ☒ **B** Co-accretion Theory
- ☒ **C** Convergence Theory
- ☒ **D** Giant Impact Theory

(ii) The Earth and the Moon formed at the same time due to the gravitational attraction of material orbiting the Sun.

(1)

- ☒ **A** Capture Theory
- ☒ **B** Co-accretion Theory
- ☒ **C** Convergence Theory
- ☒ **D** Giant Impact Theory

(c) The Moon's near side is the surface that can be observed from Earth.

State **one** physical feature that is more common on the Moon's near side than on its far side.

(1)

....

(d) An astronomer wanted to photograph the **shape** of some constellations.

The astronomer took a photograph through a correctly focussed telescope.

Figure 7 shows this photograph.

Figure 7

Explain how the astronomer could obtain a better photograph of the shape of these constellations.

(2)

....

....

....

....

(Total for Question 2 = 6 marks)

3 (a) Astronomers plan to send a space probe to the **surface** of the planet Mars.

(i) State **one** way that the Martian atmosphere will be an advantage for their mission.

(1)

....

....

(ii) State **one** way that the Martian atmosphere will be a disadvantage for their mission.

(1)

....

....

(b) The minimum distance from the Earth to Mars is 55 million km.

A space probe travelling from the Earth to Mars moves at a maximum speed of 11 000 km / h.

(i) Calculate the minimum time the space probe would take to travel from the Earth to Mars.

Use the equation:

$$\text{time} = \frac{\text{distance travelled}}{\text{average speed}}$$

Give your answer in days.

(3)

Minimum time = ... days

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(ii) State **one** reason why the space probe will actually take longer to travel from the Earth to Mars than the value calculated in part 3(b)(i).

(1)

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(Total for Question 3 = 6 marks)

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4 (a) Table 1 shows four types of nebula.

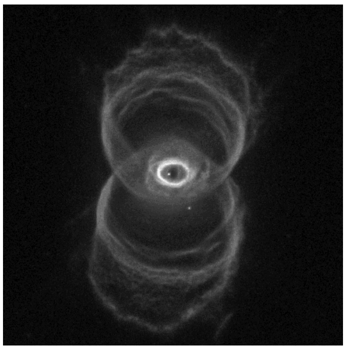
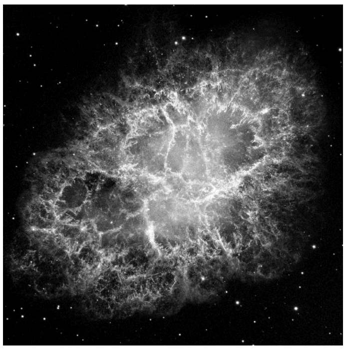
Type of nebula	Image (taken with visible light)
planetary	
absorption	
supernova remnant	
emission	

Table 1

(i) State which type of nebula is most likely to contain a white dwarf star.
Use information from Table 1.

(1)

....

(ii) State **two** types of nebula where main sequence stars are forming.
Use information from Table 1.

(1)

1 ....

2 ....

(iii) State **two** types of nebula that are expanding.
Use information from Table 1.

(1)

1 ....

2 ....

(iv) Figure 8 shows an image of a supernova remnant taken using visible light.

(3)

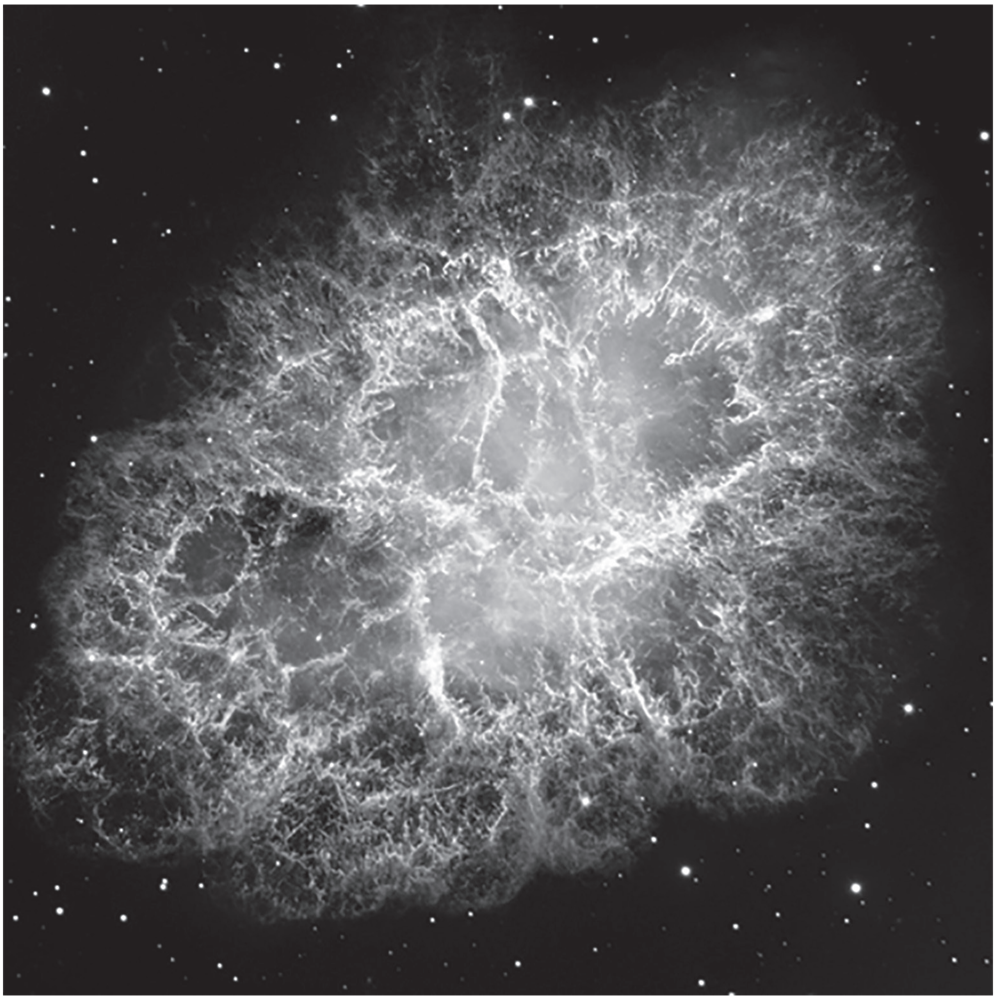


Figure 8

Give **three** reasons why a black hole cannot be seen at the centre of this image.

1 ....

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2 ....

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3 ....

....

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(b) Figure 9 shows a Hertzsprung–Russell diagram.

The positions of five stars (V, W, X, Y, Z) are shown on the diagram.

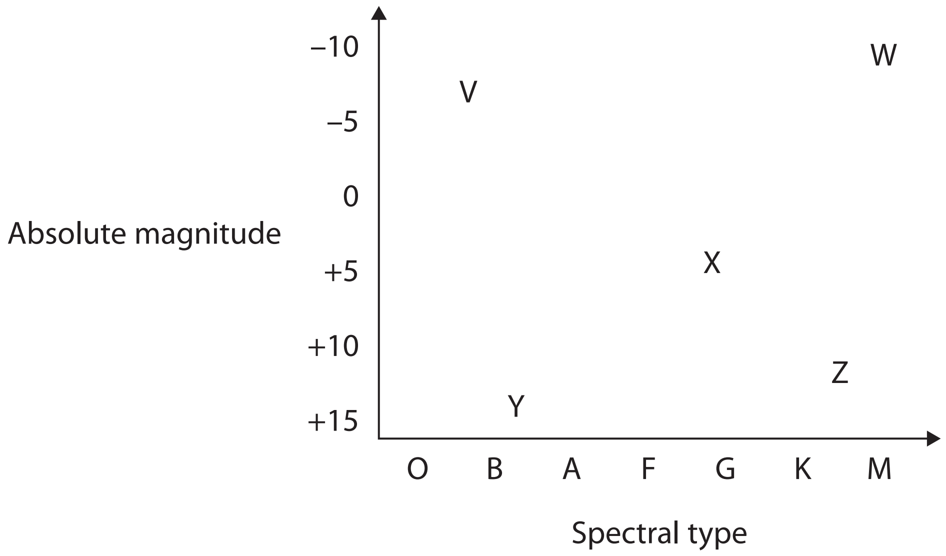

Figure 9

(i) Which star is a supergiant?

(1)

☒ **A** star V

☒ **B** star W

☒ **C** star Y

☒ **D** star Z

(ii) Which star lies on the main sequence and has the highest surface temperature?

(1)

☒ **A** star V

☒ **B** star W

☒ **C** star X

☒ **D** star Z

(iii) Which star outputs more power than the Sun and has molecular absorption lines in its spectrum?

(1)

- ☒ **A** star V
- ☒ **B** star W
- ☒ **C** star X
- ☒ **D** star Y

(Total for Question 4 = 9 marks)

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5 (a) (i) Which galaxy classification is **not** used in the Hubble classification system?

(1)

- ☒ **A** barred spiral
- ☒ **B** elliptical
- ☒ **C** globular
- ☒ **D** irregular

(ii) Explain why it is difficult for astronomers to determine the Hubble classification of the Milky Way galaxy.

(2)

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....

(b) (i) Figure 10 shows a sketch of the Milky Way galaxy viewed from the side.

Figure 10

Label clearly on Figure 10 a possible position of the Sun.

Use the label **S**.

(1)

(ii) Figure 11 shows a sketch of the Milky Way galaxy viewed from above.

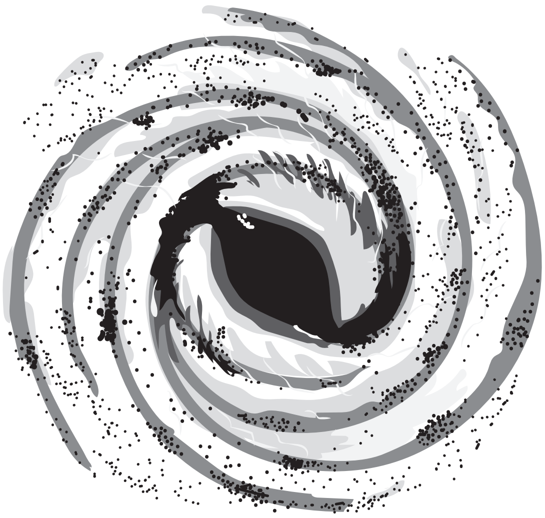

Figure 11

Draw on Figure 11 the **area** where dark matter is most likely to be located.

(1)

(iii) An astronomer needs to show the location of globular clusters.

Explain why the astronomer chose the view of the Milky Way in Figure 10 rather than the view in Figure 11 to show the location of globular clusters.

You may include a clearly labelled diagram in your answer.

(2)

(c) Astronomers are trying to predict the future evolution of the Universe.

Figure 12 shows how the mean distance between galaxies changes as the Universe evolves.

Two possible predictions are shown.

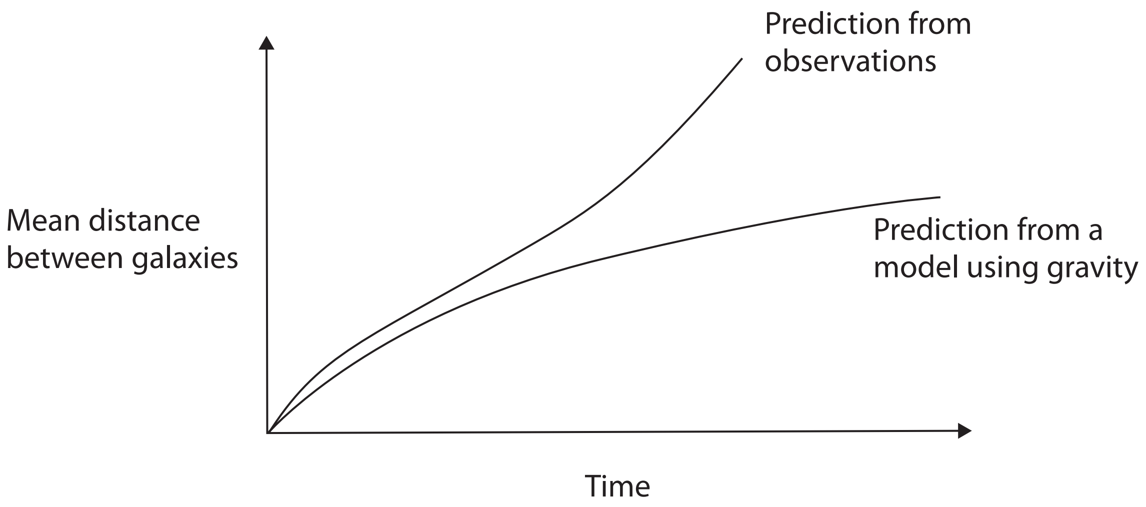

Figure 12

Analyse Figure 12 in order to explain why astronomers have suggested the existence of dark energy.

(2)

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(Total for Question 5 = 9 marks)

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6 (a) (i) Which of the Sun's internal divisions has the lowest temperature?

(1)

☒ **A** convective zone

☒ **B** core

☒ **C** photosphere

☒ **D** radiative zone

(ii) In which of the Sun's internal divisions does the proton-proton cycle occur?

(1)

☒ **A** convective zone

☒ **B** core

☒ **C** photosphere

☒ **D** radiative zone

(b) Figure 13 shows a graph of the temperature of the Sun's atmosphere at different heights above its surface.

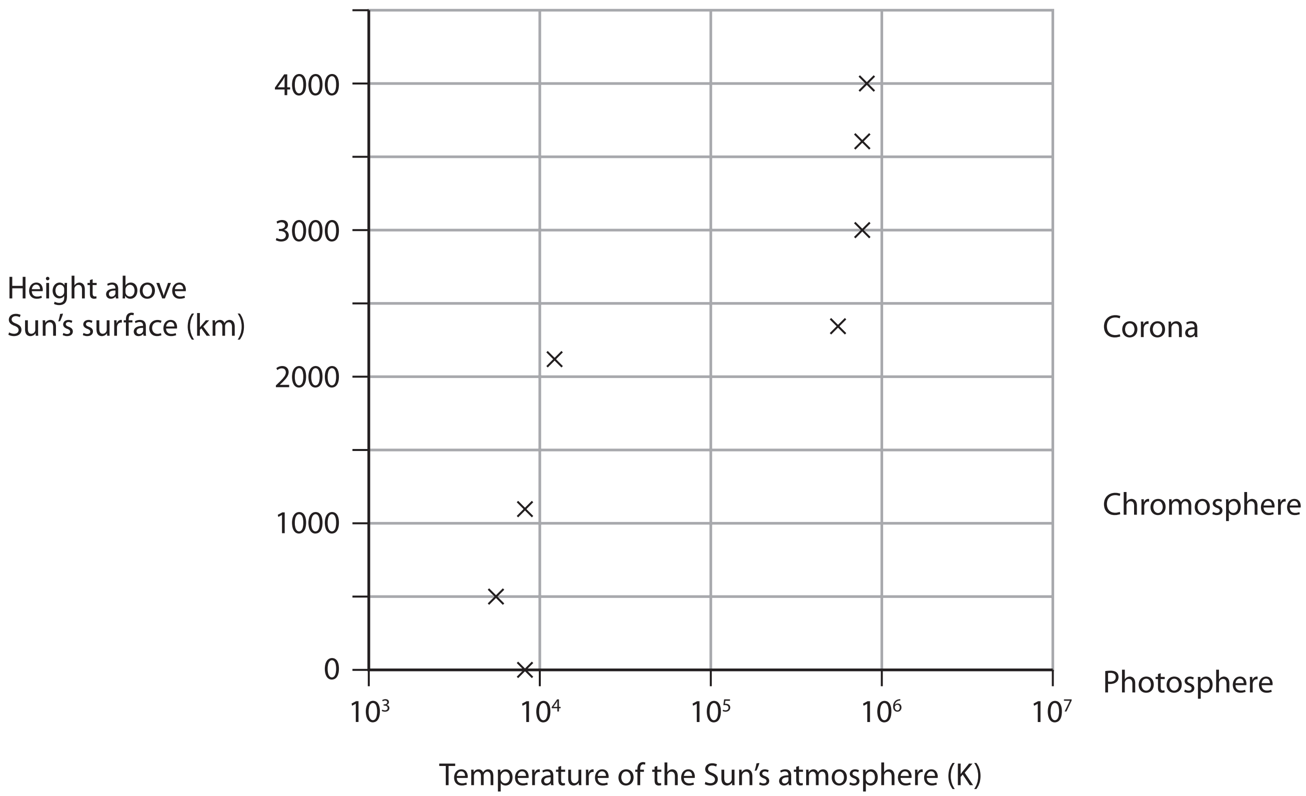

Figure 13

Table 2 shows two data points that have **not** been plotted on the graph in Figure 13.

Height above Sun's surface (km)	Temperature of the Sun's atmosphere (K)
1800	10^4
2300	10^5

Table 2

(i) Plot the remaining data points on the graph in Figure 13.

Use the information in Table 2.

Draw a line of best fit.

(3)

(ii) State the height above the Sun's surface where the temperature **change** with height is greatest.

(1)

....

(iii) Estimate the temperature at a height of 6000 km above the Sun's surface.

(1)

....

(iv) Explain with reference to Figure 13 why your estimate in 6(b)(iii) may not be accurate.

(2)

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....

(Total for Question 6 = 9 marks)

7 (a) (i) State **two** differences between a refracting telescope and a reflecting telescope.

(2)

1 ....

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2 ....

....

(ii) State **one** difference between a Galilean refracting telescope and a Keplerian refracting telescope.

(1)

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....

(b) In 1610, Galileo Galilei was the first astronomer to observe Saturn using a telescope. He was unable to resolve Saturn's ring system clearly.

Galileo saw a pair of objects on either side of the planet.

He wrongly thought that Saturn's ring system was a pair of moons.

Figure 14 shows Galileo's sketch of Saturn made in 1610.

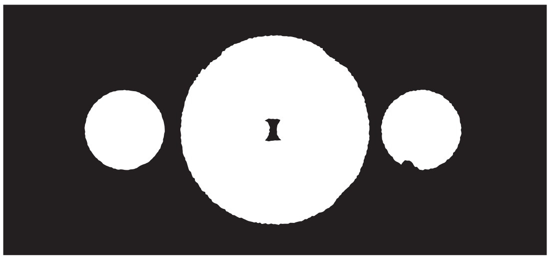

Figure 14

(i) Using the same telescope, Galileo observed Saturn two years later and was surprised to see that the 'two moons' had disappeared.

After two more years, he observed that the 'two moons' had reappeared.

Suggest an explanation for these observations.

You may include a clearly labelled diagram in your answer.

(2)

(ii) Table 3 shows details of one of Galileo's telescopes.

focal length of eyepiece lens	50 mm
focal length of objective lens	98.0 cm

Table 3

Calculate the magnification of this telescope.

Use information from the Formulae and Data Sheet.

(2)

Magnification = ...

(iii) Galileo's telescope had a very small field of view, making accurate observations difficult.

Explain why a very small field of view should **not** affect observations of Saturn's rings.

(2)

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....

(c) Modern telescopes can resolve Saturn's rings.

The following equation can be used to calculate the diameter of Saturn's rings.

$$\text{diameter of Saturn's rings in km} = \frac{\text{wavelength of light}}{\text{diameter of telescope lens}} \times \text{minimum distance between Saturn and Earth in km}$$

Calculate the diameter of Saturn's rings.

Use the following data and information from the Formulae and Data Sheet.

wavelength of light = 5.0×10^{-7} m
diameter of telescope lens = 0.0037 m
minimum distance between Saturn and Earth = 8.5 AU.

Give your answer in km.

(2)

Diameter of Saturn's rings = ... km

(d) Figure 15 shows photographs of Saturn taken by two different modern telescopes.

The telescopes were correctly focussed.

The photographs were taken with the same camera and had the same exposure time.

Photograph of Saturn taken by Telescope 1

Photograph of Saturn taken by Telescope 2

Figure 15

Analyse Figure 15 in order to comment on the differences between the telescopes that could explain the differences between the images produced.

(3)

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(Total for Question 7 = 14 marks)

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8 Astronomers use different techniques to measure the distance to stars.

These techniques include:

- heliocentric parallax
- the period of Cepheid variables
- use of the Hertzsprung–Russell diagram.

(a) State **one** problem or limitation of each of these three techniques.

(3)

Heliocentric parallax

....

....

The period of Cepheid variables

....

....

Use of the Hertzsprung–Russell diagram

....

....

(b) Figure 16 shows the Period–Luminosity relationship for Cepheid variable stars.

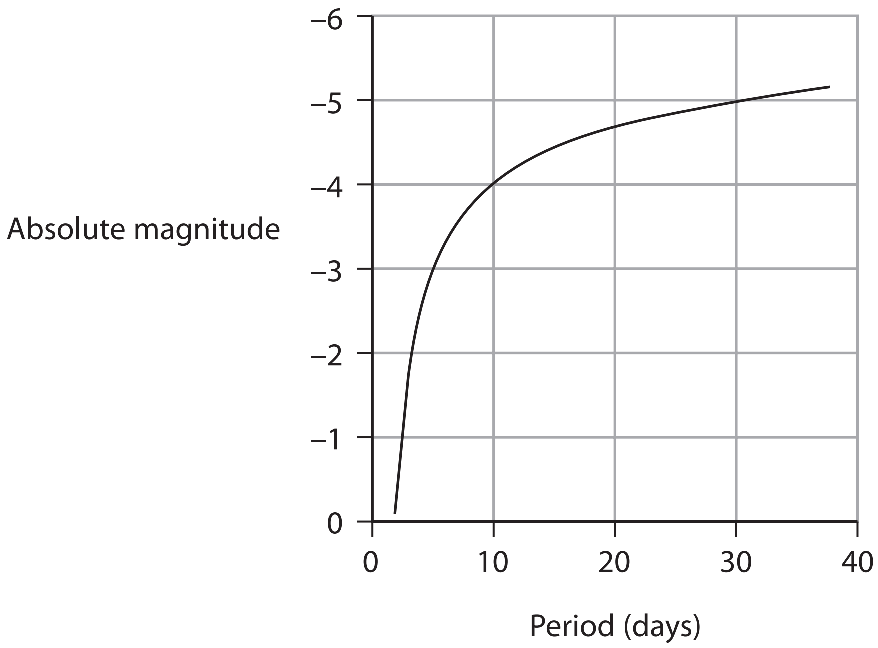

Figure 16

A Cepheid variable star has a period of 30 days.

The star has a mean apparent magnitude of 5.0.

Calculate the distance to the Cepheid variable star.

Use Figure 16 and information from the Formulae and Data Sheet.

Use the equation:

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

Give your answer in light years (l.y.).

(4)

Distance to Cepheid Variable = ... l.y.

(c) An astronomy student decides to measure the period of the Cepheid variable star, delta Cephei.

He takes a photograph of this star and the surrounding night sky.

He then selects two reference stars that he can use to measure the brightness of delta Cephei.

Figure 17 shows the student's photograph and the labels that he added.

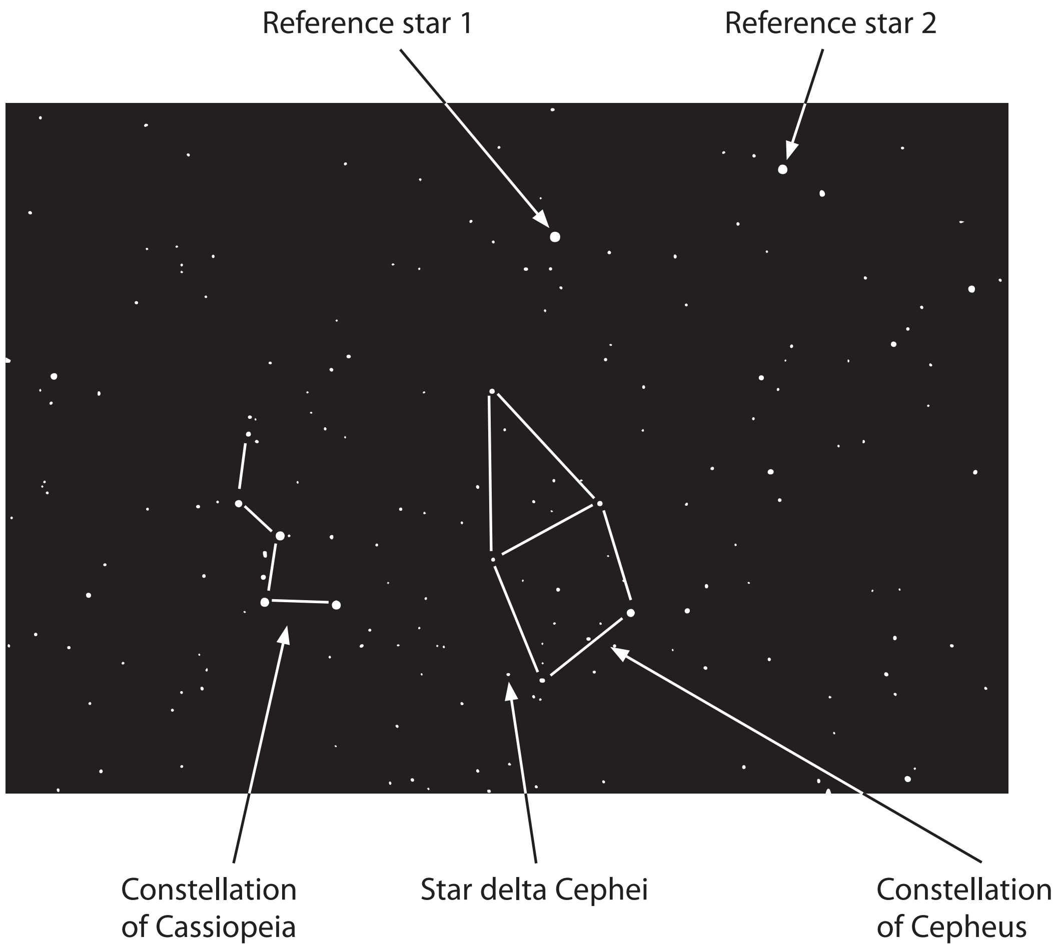

Figure 17

To determine the period of delta Cephei, the student then took similar photographs once a week for two months.

Evaluate ways to improve the student's observations in order to obtain a more accurate measurement for the period of delta Cephei.

(6)

(Total for Question 8 = 13 marks)

9 (a) The Drake Equation can be used to estimate the number of technological civilisations in our galaxy.

Which variable is **not** used in the Drake Equation?

(1)

- ☒ **A** average length of time for which civilisations can communicate
- ☒ **B** average rate of star formation
- ☒ **C** fraction of life-supporting planets that develop life
- ☒ **D** fraction of stars that are visible from Earth

(b) Figure 18 shows the first image of an exoplanet orbiting a brown dwarf.

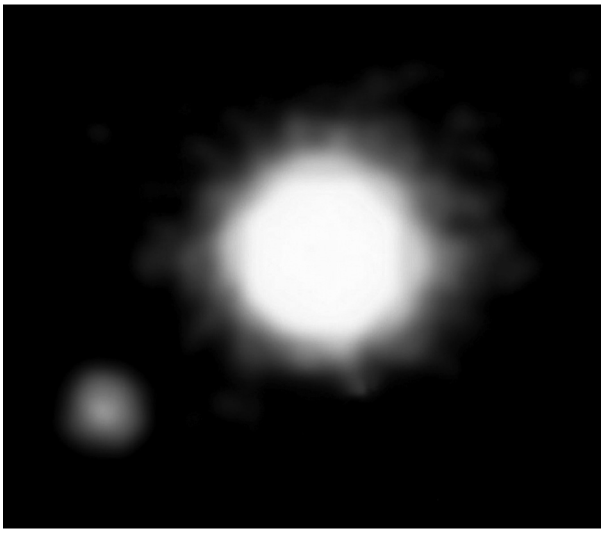

Figure 18

Brown dwarfs have a mass that is too small to start nuclear fusion and are called 'failed stars'.

Give **three** reasons why this exoplanet is unlikely to support life.

(3)

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2 ....

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3 ....

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(c) Astronomers have estimated that the Goldilocks (Habitable) Zone around the Sun lies between the orbits of Venus and Mars.

However, there are proposed missions to search for life on Enceladus, a moon of Saturn.

(i) Enceladus does not lie within the Sun's estimated Goldilocks Zone.

Explain why astronomers think that Enceladus may support life.

(2)

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(ii) Explain how the location of the Goldilocks Zone around a brown dwarf would be different from the Goldilocks Zone around the Sun.

(2)

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(d) Table 4 shows some information about four stars, A, B, C and D.

A planet orbits each of these stars.

Star	**Apparent magnitude**	**Absolute magnitude**	**Spectral type**	**Orbital distance between star and planet (AU)**
A	2	–5	G3	10
B	5	–8	O8	1
C	12	5	F9	1
D	8	13	B5	25

Table 4

Evaluate the data in Table 4 in order to identify which of the four stars is likely to have a planet that is located within the Goldilocks (Habitable) Zone.

Explain your reasoning.

(6)

(Total for Question 9 = 14 marks)

10 (a) Edwin Hubble concluded that the Universe is expanding.

Explain how the expansion of the Universe can support both the Big Bang theory and the Steady State theory.

(4)

Support for the Big Bang theory

....

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Support for the Steady State theory

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(b) Table 5 shows the redshift of different objects in the Universe and how the redshift changes with distance from the Earth.

Object	Redshift for close objects	Redshift for distant objects
galaxies	small	large
quasars	no quasars close to us	large

Table 5

Analyse the data in Table 5 in order to explain why observations of quasars do **not** support the Steady State theory.

(3)

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(c) An absorption line in the spectrum of two quasars, A and B, is measured.

The observed wavelength of the absorption line in the spectrum of quasar A is measured as 532.5 nm.

The observed wavelength of the same absorption line in the spectrum of quasar B is measured as 543.8 nm.

The absorption line has an emitted wavelength of 520.5 nm.

Calculate the difference in the radial velocity of the two quasars.

Use the equation:

$$\frac{\lambda - \lambda_0}{\lambda_0} = \frac{v}{c}$$

The speed of light is 3.0×10^5 km / s.

Give your answer in km / s.

(4)

Difference in radial velocity = ... km / s

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(d) The following is an extract from an article on the history of astronomical discovery.

'The first quasar was discovered using a radio telescope. However, astronomers could not pin-point which star-like object was emitting this radio signal. In 1962, the Moon passed through this region of the sky, causing an occultation and blocking the radio source. This fortunate event allowed astronomers to identify the quasar, using optical telescopes.'

Explain how astronomers used radio telescopes and optical telescopes to determine the precise location of the first quasar.

You may include a clearly labelled diagram in your answer.

(3)

(Total for Question 10 = 14 marks)

TOTAL FOR PAPER = 100 MARKS

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IMAGE CREDITS

Figure 4
Source: Credit: Heidi Schweiker, WIYN, NOAO, AURA, NSF

Figure 5
Credit: Heidi Schweiker, WIYN, NOAO, AURA, NSF

Figure 6
Credits: NASA/Johns Hopkins APL/Naval Research Lab/Parker Solar Probe/Brendan Gallagher

Figure 7
Source: http://blog.lumpydarkness.com/2014/08/star-trails-attempt.html

Table 1
CREDITS: Raghvendra Sahai and John Trauger (JPL), the WFPC2 science team, and NASA
Source: https://www.eso.org/public/images/eso0202a/
Source: NASA
Source: Karol R - https://www.astrobin.com/338343/?nc=user

Figure 14
Source: http://www.erasmatazz.com/library/the-mind/history-of-thinking/the-scientific-revolution/galileo-gets-the-ball-rolli.html

Figure 18
Credit: ESO