edexcel

GCSE (9-1) Astronomy

Sample Assessment Materials

Pearson Edexcel Level 1/Level 2 GCSE (9-1) in Astronomy (1AS0)

First teaching from September 2017

First certification from June 2019 | Issue 1

Pearson

Edexcel, BTEC and LCCI qualifications

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Contents

Introduction

The Pearson Edexcel Level 1/Level 2 GCSE (9-1) in Astronomy is designed for use in schools and colleges. It is part of a suite of GCSE qualifications offered by Pearson.

These sample assessment materials have been developed to support this qualification and will be used as the benchmark to develop the assessment students will take.

General marking guidance

- All candidates must receive the same treatment. Examiners must mark the last candidate in exactly the same way as they mark the first.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than be penalised for omissions.
- Examiners should mark according to the mark scheme – not according to their perception of where the grade boundaries may lie.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification/indicative content will not be exhaustive. However different examples of responses will be provided at standardisation.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, a senior examiner must be consulted before a mark is given.
- Crossed-out work should be marked **unless** the candidate has replaced it with an alternative response.

Marking guidance for levels based mark schemes

How to award marks

The indicative content provides examples of how students will meet each skill assessed in the question. The levels descriptors and indicative content reflect the relative weighting of each skill within each mark band.

Finding the right level

The first stage is to decide which level the answer should be placed in. To do this, use a 'best-fit' approach, deciding which level most closely describes the quality of the answer. Answers can display characteristics from more than one level, and where this happens markers must use the guidance below and their professional judgement to decide which level is most appropriate.

Placing a mark within a level

After a level has been decided on, the next stage is to decide on the mark within the level. The instructions below tell you how to reward responses within a level. However, where a level has specific guidance about how to place an answer within a level, always follow that guidance. Statements relating to the treatment of students who do not fully meet the requirements of the question are also shown in the indicative content section of each levels based mark scheme. These statements should be considered alongside the levels descriptors.

Write your name here

Surname	Other names

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

Centre Number | | | | | |

Candidate Number | | | | |

Astronomy

Paper 1: Naked-eye Astronomy

Sample assessment material for first teaching
September 2017
Time: 1 hour 45 minutes

Paper Reference
1AS0/01

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.
- 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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S 5 3 8 2 7 A 0 1 2 9

Pearson

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

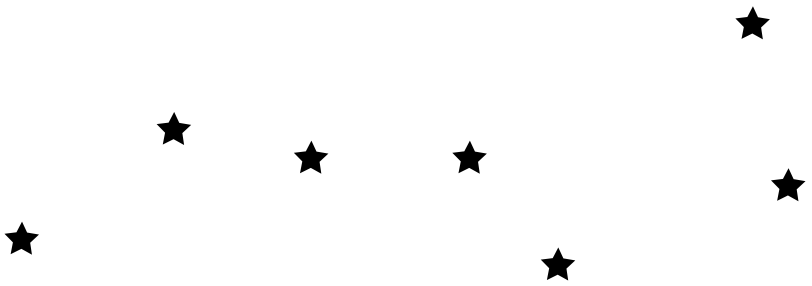
Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 A student made some naked-eye observations of the night sky.

(a) Identify each of the following three observations from the student's description.

(i) Seven bright stars in a 'saucepan' shape.

(1)



☒ **A** Orion's Belt

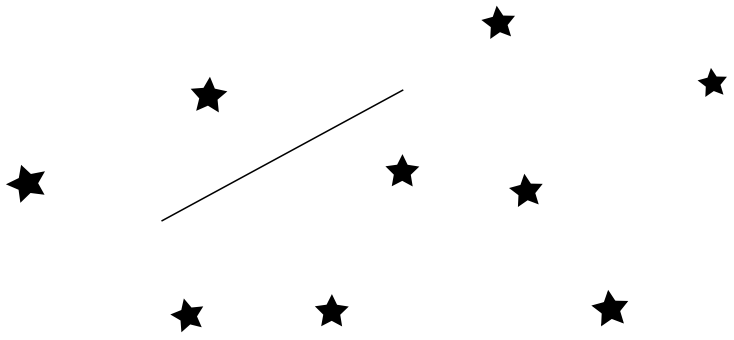
☒ **B** Dragon's Tail

☒ **C** The Plough

☒ **D** The Pleiades

(ii) A short, bright streak of light across the sky, lasting only a few seconds.

(1)



☒ **A** aircraft

☒ **B** comet

☒ **C** meteor

☒ **D** planet

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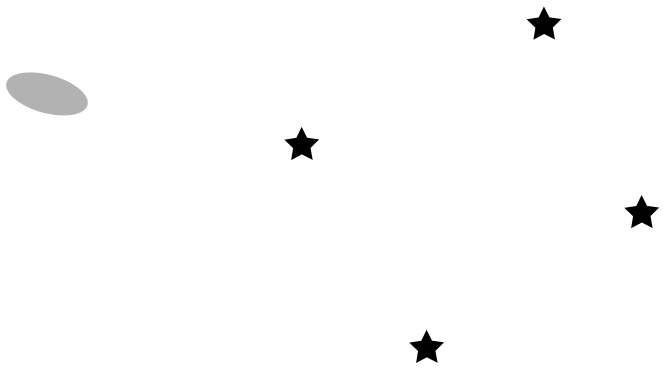
(iii) A fuzzy patch of light near the square of four bright stars in the constellation of Pegasus.

(1)



- ☒ **A** Andromeda Galaxy
- ☒ **B** Small Magellanic Cloud
- ☒ **C** The Pleiades
- ☒ **D** The Milky Way

(b) (i) State the appearance of the Orion Nebula to the naked eye.

(1)

.....

.....

(ii) State the appearance of an aurora to the naked eye.

(1)

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(c) Sketch how the Moon appears in the northern hemisphere, three days after the new moon.

(1)

(Total for Question 1 = 6 marks)

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2 (a) (i) Which of the following is a constellation?

(1)

- ☒ **A** Cassiopeia
- ☒ **B** Orion's Belt
- ☒ **C** Sirius
- ☒ **D** Summer Triangle

(ii) Which of the following is equal to one year?

(1)

- ☒ **A** The time for the Earth to rotate once
- ☒ **B** The time for the Moon to orbit the Earth
- ☒ **C** The time for the Sun to rotate once
- ☒ **D** The time for the Earth to orbit the Sun

(iii) Which of the following gives the highest water level?

(1)

- ☒ **A** Low tide
- ☒ **B** Neap tide
- ☒ **C** Spring tide
- ☒ **D** Winter tide

(b) (i) Explain why light pollution may affect some naked-eye observations of constellations.

(2)

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(ii) A student begins an observation at midnight on a clear moonless winter night.

Explain why the student notices that more stars are visible half an hour later.

(2)

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(Total for Question 2 = 7 marks)

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3 Figure 1 represents the orbits of the Earth and Venus.

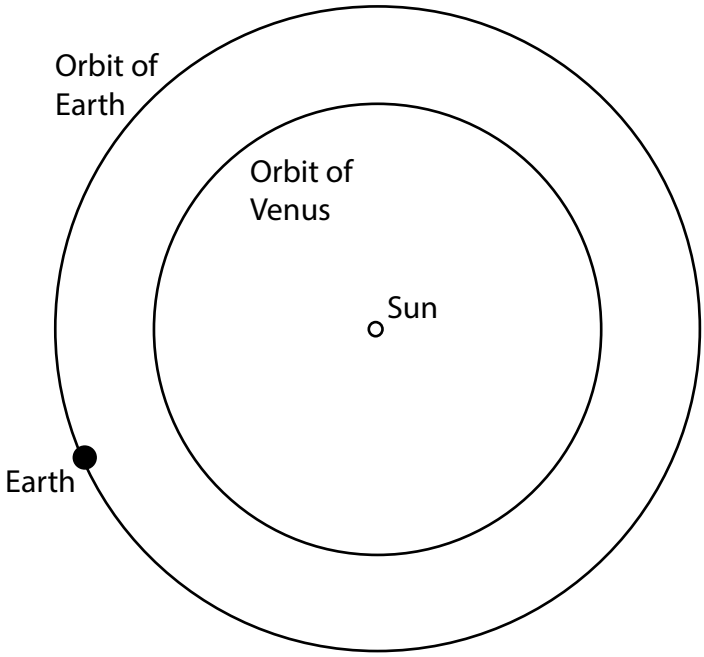

Figure 1

(a) (i) Label the position of Venus when it is at **superior** conjunction, on Figure 1.

Use the letter V.

(1)

(ii) Calculate the distance between the Earth and Venus when Venus is at **inferior** conjunction.

Give your answer in AU.

(2)

distance ..... AU

(b) Figure 2 represents the orbits of Earth and Venus.

(i) Describe how Venus will appear to an observer on the Earth when it is at point A in its orbit.

(2)

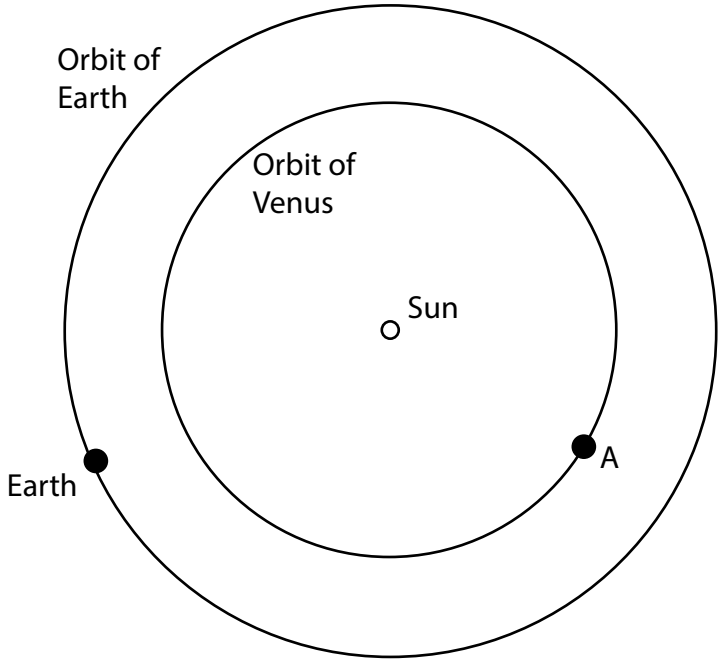

Figure 2

A student suggests that Venus is in the best position for observing from Earth when it is at position A in its orbit.

Position A is **not** the best place at which to observe Venus from Earth.

(ii) On Figure 2, label where Venus is best placed for observation from Earth.

Use the letter X.

(1)

(iii) Explain why position X is a better choice for observing Venus from the Earth than position A.

(3)

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(Total for Question 3 = 9 marks)

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4 Many ancient monuments were aligned with the rising and setting of the Sun and the Moon.

(a) State **two** ways in which ancient civilisations used these observations.

(2)

1 .....

2 .....

(b) Why are the effects of precession difficult to observe with the naked eye?

(1)

- ☒ **A** Precession happens very slowly
- ☒ **B** The Earth's orbit is elliptical
- ☒ **C** Stars can be observed only at night
- ☒ **D** Precession can be observed only near the Earth's poles

(c) An ancient monument was built so that a star in constellation X aligned with two of the stones during the solstice, as shown in Figure 3.

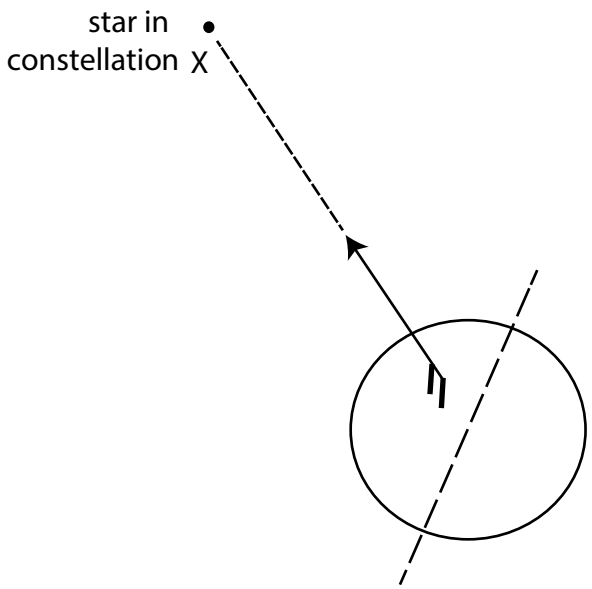

Figure 3

(i) These two stones are currently 35.4° from the star in constellation X.

Explain why precession would cause a star in constellation X to no longer be aligned with the stones during the solstice.

(2)

(ii) The average rate of precession is 1.38° per century.

Calculate an approximate date for the building of this ancient monument.

(2)

date .....

(iii) Today, Polaris is the pole star.

In the past, it was Thuban.

In the future, it will be Alderamin.

Explain why precession causes variation in pole stars.

(3)

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(Total for Question 4 = 10 marks)

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5 (a) Early civilisations used different names for their constellations.

One reason for this was they had different cultures and languages.

Explain **one** other reason.

(2)

(b) Figure 4 gives the coordinates of four locations on Earth, **A**, **B**, **C** and **D**.

Location	Latitude	Longitude
A	23.5° North	32.5° East
B	63.5° North	149.5° West
C	0.0° North	23.5° East
D	51.5° South	0.0° West

Figure 4

Analyse the data in Figure 4 to determine which location has the Sun overhead at midday on June 21st.

(2)

(c) What is the definition of the celestial equator?

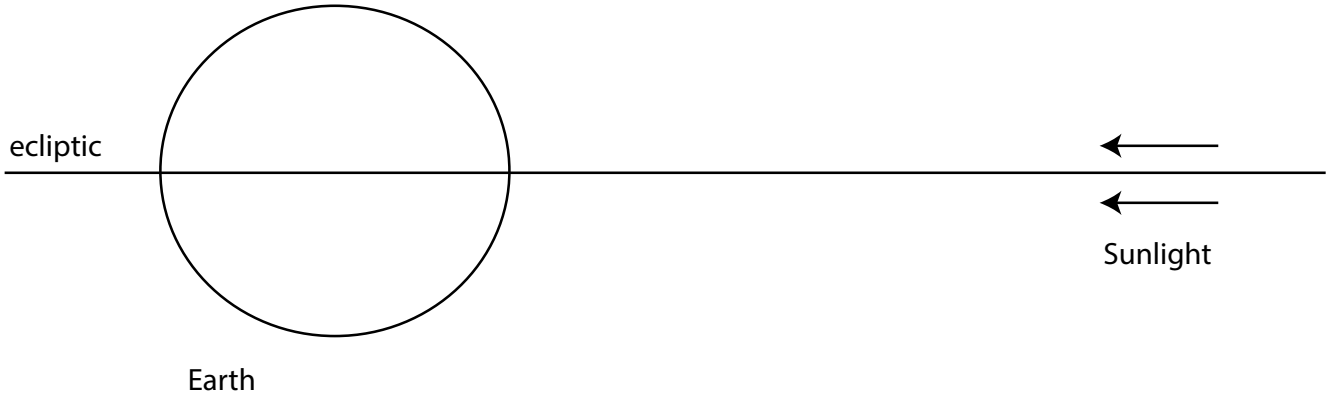
(1)

- ☒ **A** The line of places that receive equal lengths of day and night on every day of the year
- ☒ **B** The line of places that are half way between the North and South Poles
- ☒ **C** The projection onto space of the Earth's equator
- ☒ **D** The line in space where the Sun is on the meridian every day

(d) The latitude of the Tropic of Capricorn is 23.5° South.

Complete the diagram to show how the tilt of the Earth's axis determines this angle.

(2)



(e) A student in the northern hemisphere observed the times of sunrise and sunset for a week.

Figure 5 shows the results.

Day	Sunrise	Sunset	Day length
1	06:14	18:03	11 h 49 min
2	06:12	18:04	11 h 52 min
3	06:09	18:06	11 h 57 min
4	06:07	18:07	12 h 00 min
5	06:05	18:10	12 h 05 min
6	06:02	18:11	12 h 09 min
7	06:00	18:13	12 h 13 min

Figure 5

Analyse the data in Figure 5 to determine the date of Day 4.

(3)

(Total for Question 5 = 10 marks)

6 (a) Explain why a total lunar eclipse does not happen every month.

(3)

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(b) Figure 6 shows some data obtained from a total lunar eclipse.

The Greek astronomer, Eratosthenes, used similar data to calculate the diameter of the Moon compared to the Earth.

Calculate the ratio of the Earth's diameter to the Moon's diameter.

(3)

Umbral contact	Time
1st	18:12
2nd	19:45
3rd	22:50
4th	00:23

Figure 6

Answer .....

(c) The Greek astronomer, Aristarchus, calculated the diameter of the Sun from measurements of the apparent size of the Sun's disc.

He found that the diameter of the Sun was 28 times smaller than the distance from the Earth to the Sun.

He used a value for the Earth–Sun distance of 65 million km.

Using these data he calculated 2.3 million km for the diameter of the Sun.

(i) Calculate the percentage error in his value for the diameter of the Sun.

(2)

$$\% \text{ error} = \frac{(\text{calculated diameter} - \text{true diameter})}{\text{true diameter}} \times 100$$

Answer .....

(ii) Aristarchus' value of the diameter of the Sun is different from the true value.

Explain **one** reason for this.

(2)

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(Total for Question 6 = 10 marks)

7 Figure 7 shows a recent 'supermoon'.

A 'supermoon' can occur only when the Moon is at the point in its orbit where it is closest to the Earth.

(Source: © NASA)

Figure 7

(a) (i) How many days after this photograph will it be until the next full Moon?
Give your answer to 1 decimal place.

(1)

.....

(ii) How many days after this photograph will it be until the Moon is next at its closest to the Earth?
Give your answer to 1 decimal place.

(1)

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(b) Compare the effects that a 'supermoon' and libration have on the appearance of the Moon's disc, when viewed from Earth.

(3)

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(c) An observer wishes to make some naked-eye drawings to illustrate the effect of libration.

Design a suitable observing programme that will allow the observer to produce a series of drawings that show clearly the effect of libration.

(6)

(Total for Question 7 = 11 marks)

8 A student performed a shadow stick experiment.

Figure 8 shows the results that were obtained.

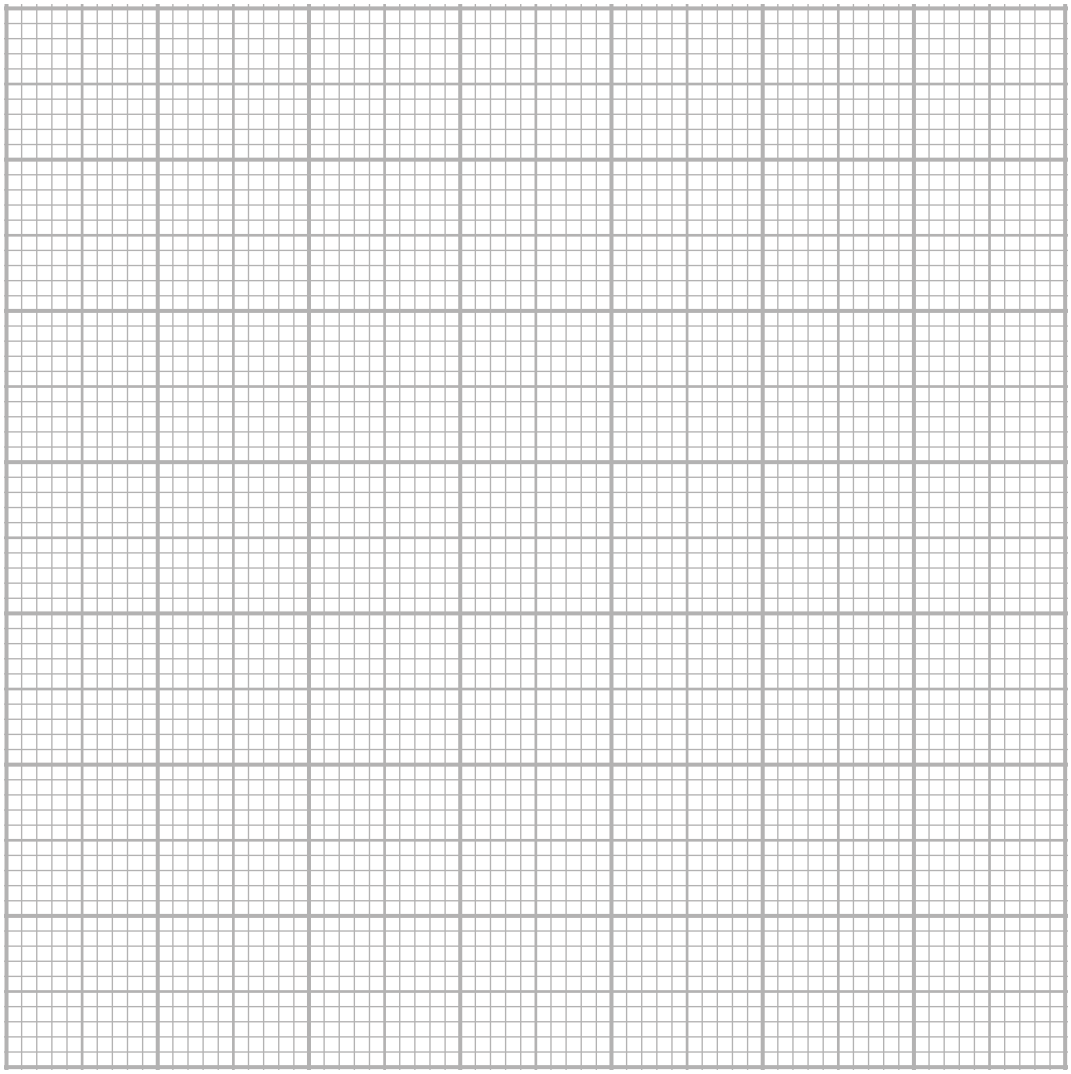
Clock time (GMT)	Shadow length/mm
11:30	25
11:40	24
11:50	23.5
12:00	23
12:10	22
12:20	22
12:30	24
12:40	25

Figure 8

The student made the following conclusions:
The shortest shadow is at 12:10 which is 10 min after Greenwich.
The longitude = 10 min ÷ 4 = 2.50°W.

(a) Plot a graph of the student's results.

(3)



(b) Evaluate the accuracy of the student's value for their longitude based on the observational procedures they have used.

(6)

(c) A ship has been sailing away from the Greenwich Meridian for some time.

Measurements of the Sun show that local mean time on the ship is 12:00 midday.

At the same time, an accurate clock on the ship, which shows GMT, reads 14:25.

Determine the ship's current longitude.

(3)

longitude .....

(Total for Question 8 = 12 marks)

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9 An astronomer made observations of the night sky from Edinburgh at midnight GMT in July.

Edinburgh has a latitude of 55°57′ N and a longitude of 3°15′ W.

Figure 9 shows data for three stars the astronomer observed.

At the time of the observation, Vega was due south on the observer's meridian.

Star	Right ascension	Declination
Arcturus	14 h 10 min	+19° 10′
Polaris	2 h 32 min	+89° 16′
Vega	18 h 30 min	+38° 45′

Figure 9

(a) (i) Determine the altitude and azimuth of the star Polaris at the time of this observation.

Give your answers to the nearest degree.

(2)

Altitude

.....

Azimuth

.....

(ii) Determine the altitude of Vega at the time of this observation.

(2)

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(iii) Determine the sidereal time at Greenwich at the time of this observation.

(3)

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(b) Analyse the data in Figure 9 in order to explain the difference in the paths through the night sky of Vega and Arcturus, when observed from Edinburgh.

(3)

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(c) Vega is a star in the constellation Lyra.

Figure 10 shows an astronomer's observations of Lyra from Edinburgh at midnight GMT in July.

Draw on Figure 10 the position of Lyra if observed at midnight from Edinburgh, six months later.

(2)

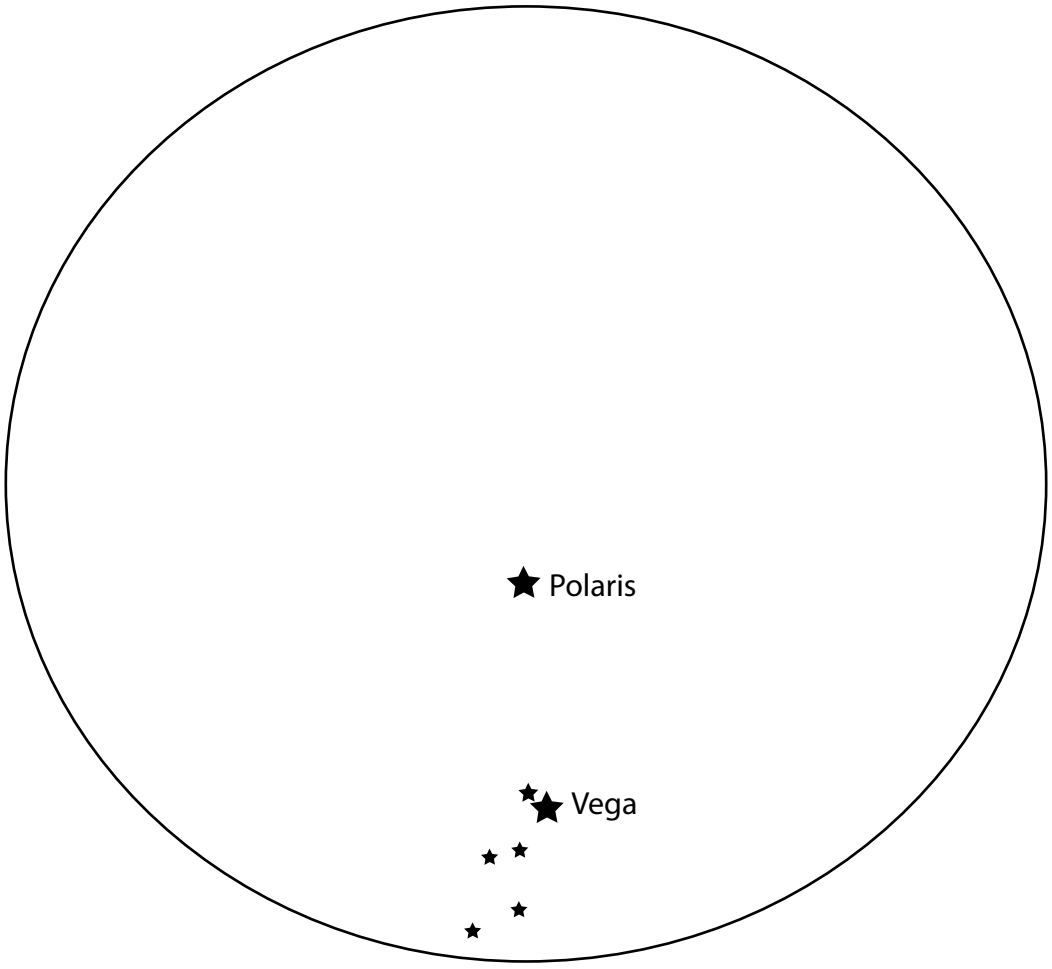

Figure 10

(Total for Question 9 = 12 marks)

10 All the planets in the Solar System have both a sidereal and synodic period.

(a) (i) Generally, the sidereal period of the superior planets is larger than their synodic period.

Explain why the sidereal period would be larger than the synodic period.

(3)

(ii) An astronomer claims to have discovered an object that orbits the Sun at a mean distance of 500 AU.

The astronomer thinks that the synodic period is close to 1 year.

Explain why the synodic period for this object would be close to 1 year.

(2)

(b) Figure 11 gives some data about two moons of Jupiter, Io and Europa.

Moon of Jupiter	Io	Europa
Orbital period / days	1.77	
Mean distance from Jupiter / km	421 600	670 900

Figure 11

(i) Calculate the time for Europa to complete one orbit of Jupiter.

(5)

time .....

(ii) The small moon Mimas orbits the planet Saturn once every 0.9 days at a mean distance of 0.0012 AU.

Calculate the ratio of the mass of Jupiter to the mass of Saturn.

(3)

answer .....

(Total for Question 10 = 13 marks)

TOTAL FOR PAPER = 100 MARKS

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

Astronomy

Paper 1: Naked-eye Astronomy

Sample assessment material for first teaching September 2017
Formulae and Data Sheet

Paper Reference
1AS0/01

Do not return this Formulae and Data sheet with the question paper.

Turn over ▶

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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: 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

Paper 1: Naked-eye Astronomy mark scheme

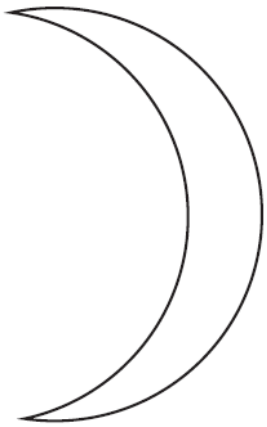
Question number	Answer	Mark
1(a)(i)	C	(1)

Question number	Answer	Mark
1(a)(ii)	C	(1)

Question number	Answer	Mark
1(a)(iii)	A	(1)

Question number	Answer	Additional guidance	Mark
1(b)(i)	Small (dim) patch of light	Accept: fuzzy patch of light	(1)

Question number	Answer	Mark
1(b)(ii)	Curtains/streamers of (coloured) light	(1)

Question number	Answer	Mark
1(c)	The moon should be drawn halfway between new moon and half-full moon  Day 3	(1)

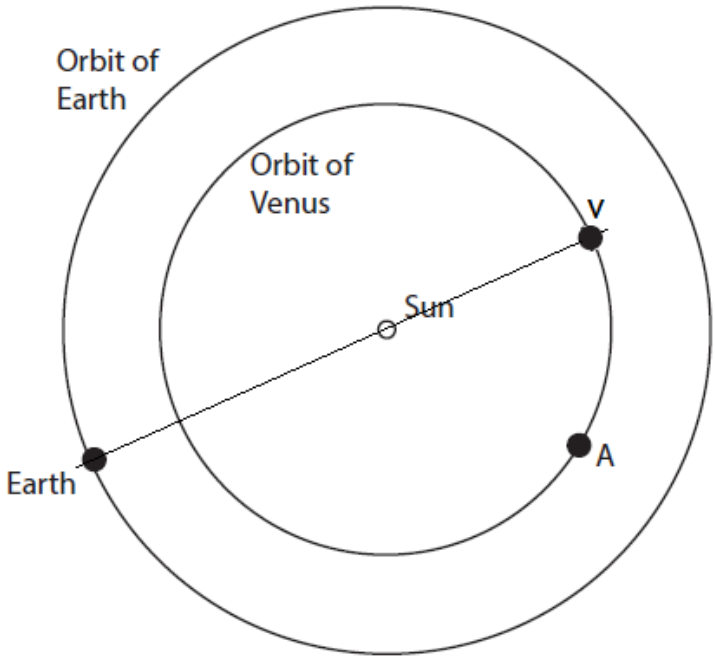
Question number	Answer	Mark
2(a)(i)	A	(1)

Question number	Answer	Mark
2(a)(ii)	D	(1)

Question number	Answer	Mark
2(a)(iii)	C	(1)

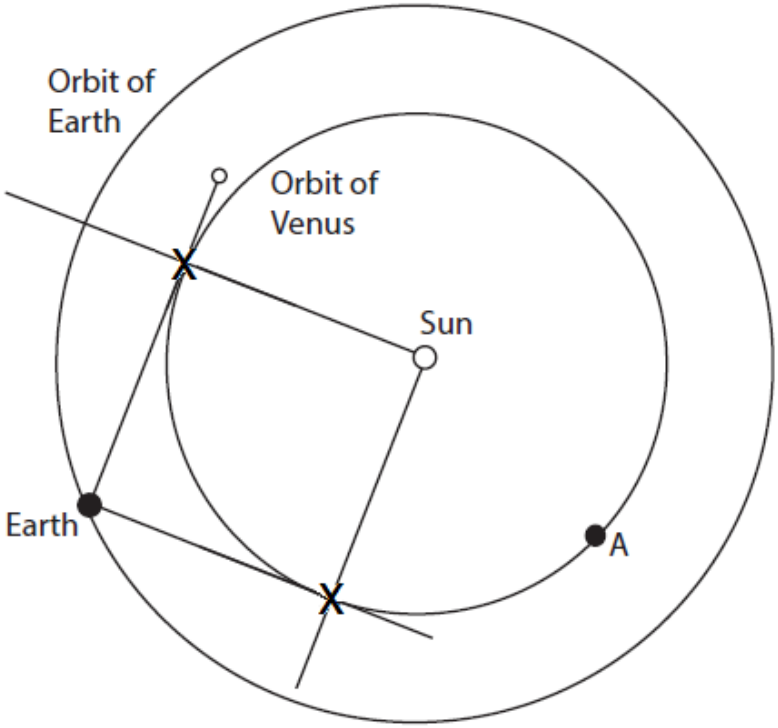
Question number	Answer	Mark
2(b)(i)	An explanation that combines identification – knowledge (1 mark) and reasoning/justification – understanding (1 mark): (Light pollution) makes the sky brighter/reduces contrast (1) so fainter stars (in the constellation) are not seen (1)	(2)

Question number	Answer	Additional guidance	Mark
2(b)(ii)	An explanation that combines identification – knowledge (1 mark) and reasoning/justification – understanding (1 mark): {Dark adjustment/adaption of human eye/the aperture of the eye is larger} (1) which {allows more light in/makes the eye more sensitive to light} from faint stars (1)	Reject: sky getting darker/stars 'coming out'	(2)

Question number	Answer	Mark
3(a)(i)	**V** marked directly opposite Earth (on Venus' orbit)  	**(1)**

Question number	Answer	Additional guidance	Mark
3(a)(ii)	Use of correct data (1) *Working:* 1 – 0.72 = 0.28 (1)	Award full marks for correct numerical answer without working Allow 0.3 for full marks	**(2)**

Question number	Answer	Mark
3(b)(i)	An answer that combines the following points of application of knowledge and understanding to provide a logical description: Quarter phase/D-shape (1) reversed (1)	**(2)**

Question number	Answer	Mark
3(b)(ii)	**X** marked where tangent from Earth touches Venus' orbit  	**(1)**

Question number	Answer	Additional guidance	Mark
3(b)(iii)	An explanation that combines identification – application of knowledge (1 mark) and reasoning/justification – application of understanding (2 marks): Angle between Sun and Venus (from Earth) is larger for X than for A (1) This means that Venus appears in a darker sky (1) so contrast is greater (1)	Do not accept a description of the appearance and location of Venus Accept: it is safer to view Venus further from the Sun (in place of contrast)	**(3)**

Question number	Answer	Mark
4(a)	Any two from: Agriculture/sowing crops/harvesting crops (1) Religious observance/ceremonies (1) Time/calendar (1) Accept any other appropriate response	**(2)**

Question number	Answer	Mark
4(b)	A	**(1)**

Question number	Answer	Mark
4(c)(i)	An explanation that combines identification – application of knowledge (1 mark) and reasoning/justification – application of understanding (1 mark): Direction of the axial tilt has shifted since the building of the monument (1) so the star in constellation X would be located at a different place in the sky during the solstice now (1)	**(2)**

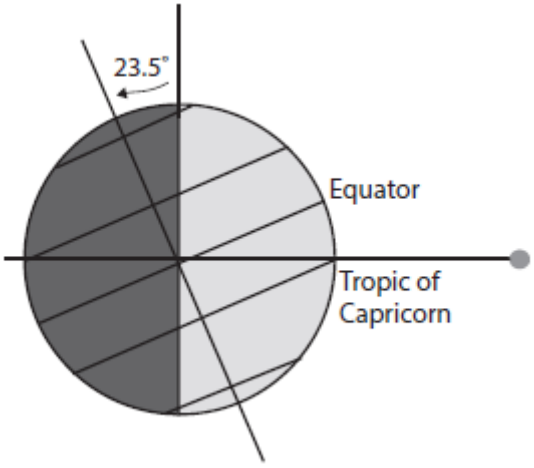
Question number	Answer	Additional guidance	Mark
4(c)(ii)	35.4 ÷ 1.38 = 25.7 centuries (2570 y) (1) 554 BCE (1)	Award full marks for correct numerical answer without working Accept: BC Accept answers in the range of 560 BCE to 484 BCE	**(2)**

Question number	Answer	Mark
4(c)(iii)	An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (2 marks): The Earth's axis points to the pole star (Polaris) rather than the pole of the ecliptic which stays fixed (1) which means that precession causes the Earth's axis to describe a circle round the pole of the ecliptic every 26 000 years (1) and so the Earth's axis will point to different stars (e.g. Thuban/Alderamin) on the circle at different times (1).	**(3)**

Question number	Answer	Mark
5(a)	An explanation that combines identification – knowledge (1 mark) and reasoning/justification – understanding (1 mark): Early civilisations existed at a variety of different latitudes (1) so they would have seen mostly different stars from which to form their constellations (1).	**(2)**

Question number	Answer	Mark
5(b)	An answer that combines points of analysis to come to a conclusion: For the Sun to be directly overhead at midday, the location must be between the tropics/between 23° north and 23° south, and for this to happen on June 21st, it must be in the Northern hemisphere (1) so the only place that fits this set of criteria is location **A** (1)	**(2)**

Question number	Answer	Mark
5(c)	C	**(1)**

Question number	Answer	Mark
5(d)	Axis and correct angle shown in either hemisphere (1) Tropic of Capricorn shown perpendicular to axis and meeting the ecliptic (1)  	**(2)**

Question number	Answer	Additional guidance	Mark
5(e)	An answer that combines points of analysis to come to a conclusion: Day length = 12h so Equinox (1) Day length increasing so must be Vernal/Spring (Equinox) (1) So the date must be March 21st (1)	Accept: ±1 day from March 21st, Spring/Vernal Equinox Reject: First Point of Aries	**(3)**

Question number	Answer	Mark
6(a)	An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (2 marks): Total lunar eclipse does not occur unless the Earth, Moon and Sun are aligned (at full Moon) (1) Because the Moon's orbit is {tilted/inclined} to {ecliptic/Solar System plane} (1) Which means that the Moon doesn't fall in the Earth's shadow every month (so not always a total eclipse) (1)	**(3)**

Question number	Answer	Additional guidance	Mark
6(b)	*Working:* 1st to 2nd contact time: 18:12 to 19:45 = 1 h 33 min = 93 min (1) 1st to 3rd contact time: 18:12 to 22:50 = 4 h 38 min = 278 min (1) $\frac{278}{93} = 2.99$ Earth is 3 times larger (1)	Award full marks for correct numerical answer without working Accept 2nd to 4th contact time in place of 1st to 3rd contact time: 2nd to 4th contact time: 19:45 to 00:23 = 4 h 38 min = 278 min (1) Accept values that round to 3	**(3)**

Question number	Answer	Additional guidance	Mark
6(c)(i)	Difference in diameters (1) 2.3 million km – 1.4 million km = 0.9 million km Express as a percentage of true value (1) $\left(\frac{0.9}{1.4}\right) \times 100 = 64\%$	Award full marks for correct numerical answer without working Accept values that round to 64%	**(2)**

Question number	Answer	Additional guidance	Mark
6(c)(ii)	An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (1 mark): The angular size of the Sun was determined incorrectly (1) because (unaided) observation near the Sun is very difficult/dangerous due to very high brightness (1)	Reject: he miscalculated/made an error in his calculation	**(2)**

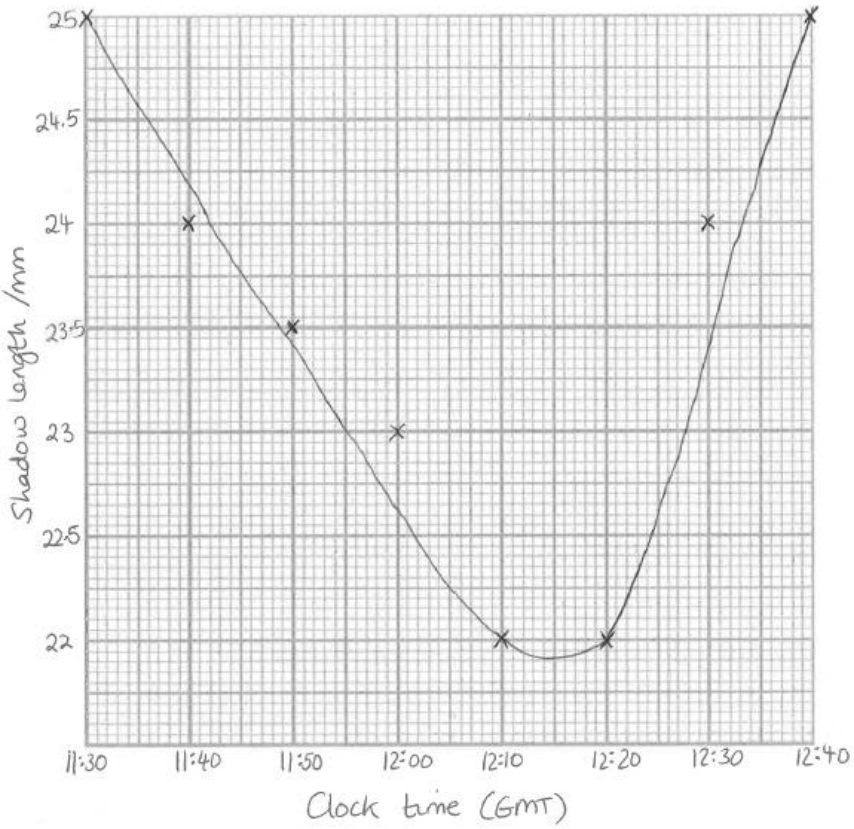
Question number	Answer	Additional guidance	Mark
7(a)(i)	29.5 days	Reject: one month, 29 days, 30 days	**(1)**

Question number	Answer	Additional guidance	Mark
7(a)(ii)	27.3 days	Reject: one month, 27 days, 28 days	**(1)**

Question number	Answer	Mark
7(b)	An answer that demonstrates understanding by making reference to any three of the following comparative points: Both allow more than 100% of the Moon's surface to be seen (1) Supermoon (perigee of eclipse) makes the Moon appear larger whereas libration does not (1) Libration increases areas of Moon's surface visible whereas a supermoon does not (1) Libration visible only over many months but the effect of the supermoon is immediate (1) Supermoon occurs at full moon but libration can be seen at other phases (1)	(3)

Question number	Indicative content	Mark
7(c)	**Marking instructions** Markers must apply the descriptors in line with the general marking guidance and the qualities outlined in the levels-based mark scheme below. **Indicative content guidance** The indicative content below is not prescriptive and candidates are not required to include all of it. Other relevant material not suggested below must also be credited. Relevant points may include: • The observations should take place over many months. As libration is a gradual effect, it will take time to observe slight changes in amount of lunar disc visible. • The observation should concentrate on the edges of the lunar disc (limb), as the effects will be more noticeable here. • Detailed drawings of features near the east and west limb will be required, in terms of longitude, so that the findings can be cross-referenced. • Detailed drawings of features near the north and south limb will be required, in terms of lunar latitude, so that the findings can be cross-referenced. • Need to observe the full Moon when it is rising and setting (diurnal libration), as it appears larger so features are easier to observe. • The ideal location for the observations is one of moderate latitude, so the Moon is high in the sky.	(6)

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	• A plan of the observational procedures may be attempted but with limited analysis of the scientific information/ideas. Generalised comments made. (AO3) • The plan is incomplete and contains basic information with some attempt made to show linkages to the given context. Lines of reasoning may be attempted but are incomplete or lack clarity. (AO3)
Level 2	3–4	• A plan of the observational procedures is given with occasional evidence of analysis of the scientific information/ideas and attempts to synthesise and integrate relevant knowledge. (AO3) • The plan is adequate and shows some linkages and lines of scientific reasoning with some structure. (AO3)
Level 3	5–6	• A plan of the observational procedures is given which is supported throughout by evidence from the analysis of the scientific information/ideas and demonstrates the skills of synthesising and integrating relevant knowledge throughout the response. (AO3) • The plan is comprehensive and shows a well-developed, sustained line of scientific reasoning which is clear, coherent and logically structured. (AO3)

Question number	Answer	Mark
8(a)	Axes labelled and sensible scales chosen (1) All points correctly plotted to +/− half a square (1) Curve of best fit passing through most points (1) The example below is not prescriptive. Other appropriate presentations of data must be credited if the marking criteria have been met. 	**(3)**

Question number	Indicative content	Mark
8(b)	**Marking instructions** Markers must apply the descriptors in line with the general marking guidance and the qualities outlined in the levels-based mark scheme below. **Indicative content guidance** The indicative content below is not prescriptive and candidates are not required to include all of it. Other relevant material not suggested below must also be credited. Relevant points may include: • The shadow lengths have been taken at equal intervals, which is good practice. However, the intervals between the readings are too large to show the required detail. • It is good that the shadow lengths have been taken before and after noon but not enough readings have been taken to show a trend. • The variation in the shadow length is very small because too short a stick has been used and/or it has been carried out in the summer. • The estimate of the shortest shadow is imprecise (it lies between 12:10 and 12:20). • The Equation of Time has not been allowed for. • The student has used the correct conversion between minutes and degrees, using 4 min/degree and correctly concluded that it is west of Greenwich (not east). • Ultimately, the student has reached a conclusion that is generally sound, but could improve their observational techniques.	(6)

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	• Basic interpretation and evaluation of the method may be attempted but will be limited and narrow in scope. (AO3) • The response will contain basic information with little linkage between points made. Lines of reasoning may be attempted but are incomplete or lack clarity. A conclusion may be attempted but lacks support. (AO3)
Level 2	3–4	• Interpretation and evaluation of the method that attempts to synthesise and integrate relevant knowledge. (AO3) • The response shows some linkages and lines of reasoning with some structure, leading to a conclusion that is partially supported. (AO3)
Level 3	5–6	• Comprehensive interpretation and evaluation of the method that demonstrates the skills of synthesising and integrating relevant knowledge throughout the response. (AO3) • The response shows a well-developed, sustained line of scientific reasoning, which is clear, coherent and logically structured, leading to a supported conclusion. (AO3)

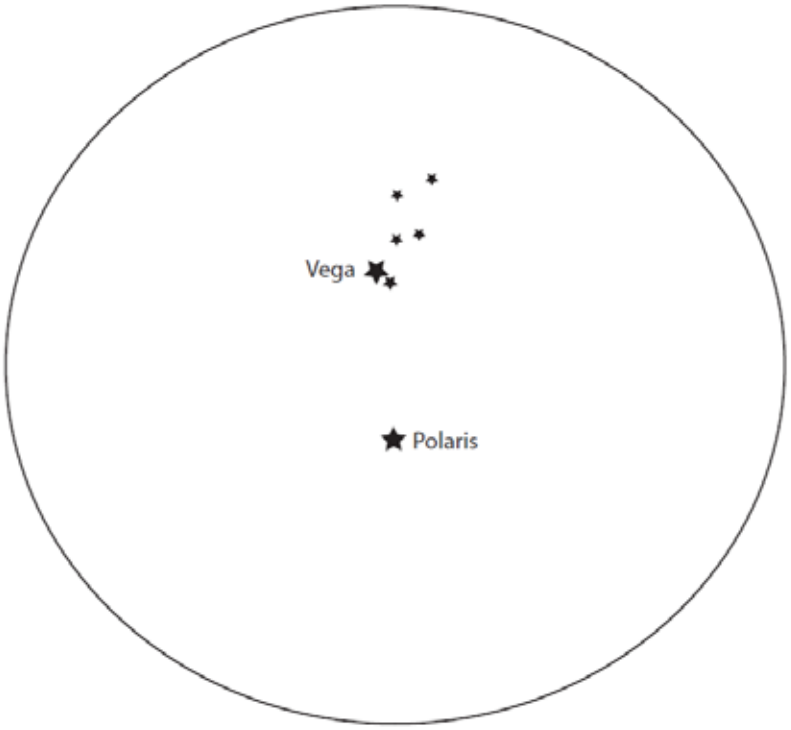
Question number	Answer	Additional guidance	Mark
8(c)	Working: Time difference = 14:25 to 12:00 midday = 2 h 25 min = 145 min (1) $\frac{145}{4} = 36.25°$ (1) W/west (1)	Award full marks for correct numerical answer without working Accept values that round to 36.3°	**(3)**

Question number	Answer	Additional guidance	Mark
9(a)(i)	Altitude of Polaris = latitude (to nearest degree) = 56° (1) Polaris is the North Star hence azimuth = 0° (due North) (1)	Accept 360° for azimuth	**(2)**

Question number	Answer	Additional guidance	Mark
9(a)(ii)	Working: Celestial equator has meridian altitude of 90 – 55°57′ = 34°03′ (1) + Vega's declination of 38°45′ = 72°48′ (1)	Award full marks for correct numerical answer without working	**(2)**

Question number	Answer	Additional guidance	Mark
9(a)(iii)	Local Sidereal Time (in Edinburgh) = RA of meridian = 18 h 30 min (1) Greenwich is 3°15'' east of Edinburgh which adds 3°15'' × 4 = 13 min (1) hence Greenwich ST = LST + adjustment for longitude of Edinburgh = 18 h 30 min + 13 min = 18 h 43 min (1)	Award full marks for correct numerical answer without working	**(3)**

Question number	Answer	Mark
9(b)	An explanation that combines identification – application of knowledge (1 mark) and reasoning/justification – application of understanding (2 marks): Vega is circumpolar/will be visible all night and Arcturus is not circumpolar/will not be visible all night (1) as 90° – 55°57′ = 34°03′ < declination of Vega 38°45′ (Vega's declination is greater than the co-latitude of Edinburgh/declination of Vega + latitude of Edinburgh > 90°) (1) whereas 90° – 55° 57′ = 34°03′ > declination of Arcturus 19°10′ (Arcturus's declination is less than the co-latitude of Edinburgh/declination of Arcturus + latitude of Edinburgh < 90°) (1)	**(3)**

Question number	Answer	Mark
9(c)	Lyra located in correct position (on opposite side of Polaris) (1) Orientation of Lyra and Vega correct (180° rotation about Polaris) (1)  	**(2)**

Question number	Answer	Mark
10(a)(i)	An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (2 marks): The superior planets take longer to orbit the Sun than the Earth does/the Earth's orbital period is less than the orbital period of superior planets (1) so they will return to same position in relation to the Earth before they complete a single orbit (1) which means that the superior planets have multiple smaller synodic periods within the time it takes to complete one larger sidereal period (1)	**(3)**

Question number	Answer	Mark
10(a)(ii)	An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (1 mark): A value of 500 AU is towards the edge of the Solar System (1) So the object will not have progressed in its orbit much in the time it takes the Earth to orbit the Sun (1 year) (1)	**(2)**

Question number	Answer	Additional guidance	Mark
10(b)(i)	Working: Use of $\frac{T^2}{r^3}$ T^2 for Io = (1.77 days)^2 = 3.13 days (1) r^3 for Io = (421 600 km)^3 = 7.49 × 10^{27} (1) $\frac{T^2}{r^3}$ = Constant X for Io = same constant X for Europa = 4.17638 × 10^{-17} (1) r^3 for Europa = 670 900^3 = 3.02 x 10^{17} (1) T^2 for Europa = 12.6 T for Europa = 3.55 days (1)	Award full marks for correct numerical answer without working Accept values that round to 4 days	**(5)**

Question number	Answer	Additional guidance	Mark
10(b)(ii)	Convert to km from AU 0.0012 AU = 180 000 km (1) Calculation of $\frac{T^2}{r^3}$ for Mimas $\frac{0.9^2}{180\ 000^3} =$ $= 1.388 \times 10^{-16}$ (1) Divide this by the value for constant X from (b)(i) to find the ratio: $\frac{1.388 \times 10^{-16}}{4.176 \times 10^{-17}}$ Jupiter's mass = 3.325 (3⅓) × Saturn's mass (1)	Allow ecf Award full marks for correct numerical answer without working Accept values that round to 3.3	**(3)**

Write your name here

Surname	Other names

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

Centre Number | | | | | |

Candidate Number | | | | |

Astronomy

Paper 2: Telescopic Astronomy

Sample assessment material for first teaching
September 2017
Time: 1 hour 45 minutes

Paper Reference
1AS0/02

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.
- 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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S 5 3 8 2 8 A 0 1 2 7

Pearson

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) Figure 1 shows a cross-section through the Milky Way Galaxy.

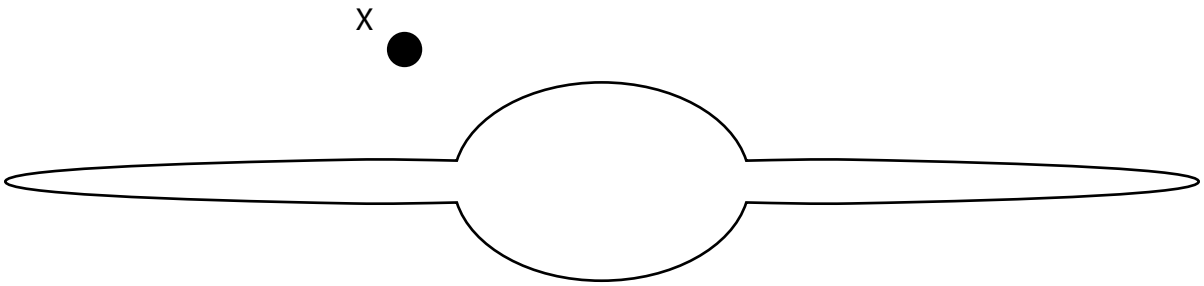


Figure 1

(i) Label the position of the Sun on Figure 1. Use the letter S.

(1)

(ii) Which of the following objects could be found at position X?

(1)

- ☒ **A** asteroid
- ☒ **B** comet
- ☒ **C** exoplanet
- ☒ **D** globular cluster

(b) Which of the following is the approximate diameter of the Milky Way Galaxy?

(1)

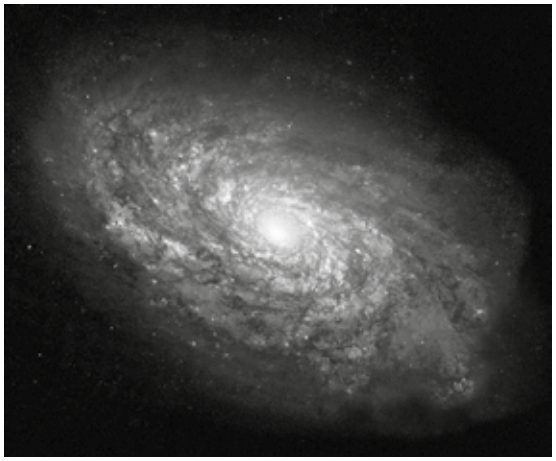
- ☒ **A** 15 kpc
- ☒ **B** 15 Mpc
- ☒ **C** 30 kpc
- ☒ **D** 30 Mpc

(c) (i) What type of galaxy is the Milky Way?'.

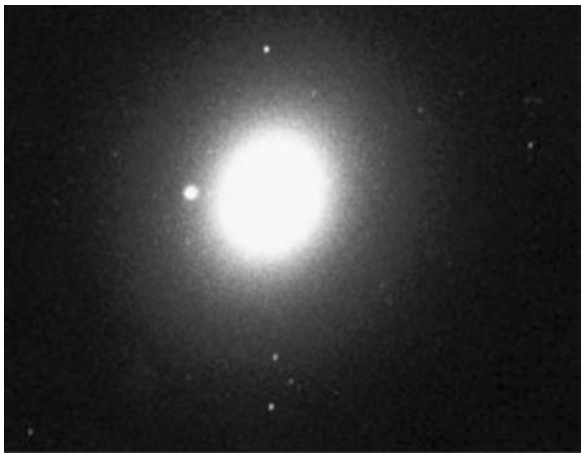
(1)

.....

(ii) Figure 2 shows two different types of galaxy.



Galaxy A



Galaxy B

(Sources: Creative Commons Attribution-ShareAlike License and www.ccvalg.pt/astronomia/galaxias/galaxias_elipticas/m49.jpg)

Figure 2

Identify the type of each galaxy shown in Figure 2.

(2)

Galaxy A

.....

Galaxy B

.....

(Total for Question 1 = 6 marks)

2 The Solar System contains dwarf planets, comets and asteroids as well as planets and moons

(a) Which of these dwarf planets is closest to the Sun?

(1)

- ☒ **A** Ceres
- ☒ **B** Eris
- ☒ **C** Haumea
- ☒ **D** Pluto

(b) An astronomer uses a telescope to observe a comet approaching the Sun. Its tails are clearly visible.

Five and a half years later, the same comet is observed again using the same telescope. Its tails are no longer visible.

Explain **one** reason for the change in the appearance of the comet.

(2)

.....

.....

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(c) Some of the meteorites that have been discovered on the Earth are thought to have originated from the planet Mars.

Describe how material from Mars could become a meteorite on Earth.

(3)

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.....

(Total for Question 2 = 6 marks)

3 The planet Saturn has a series of rings close to the planet.

Saturn also has several moons, further away from the planet.

Figure 3 shows the rings and some of the major moons of Saturn.

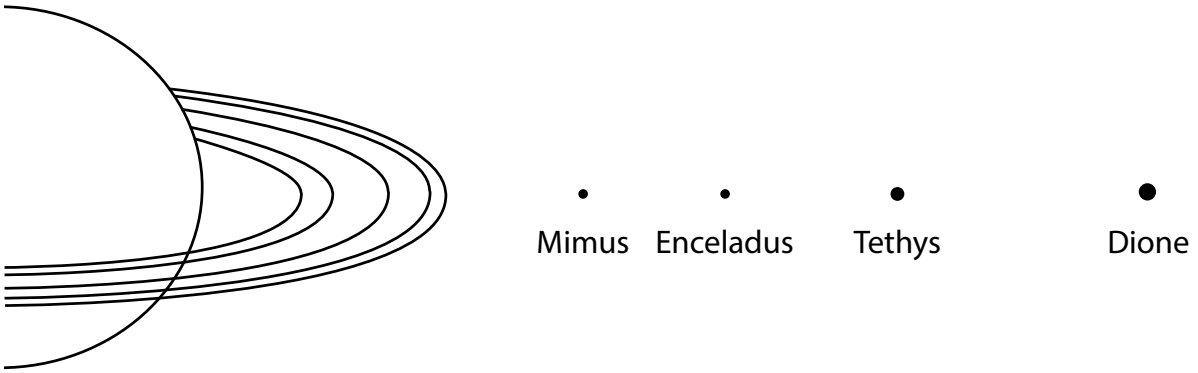

Figure 3

(a) Explain why major moons do not exist close to the planet.

(2)

.....

.....

.....

.....

(b) One of Saturn's moons is called Titan.

Some astronomers have proposed that there may be life on Titan, because it has an atmosphere.

State **two** other features of Titan that would be necessary to support life.

(2)

1 .....

.....

2 .....

.....

(c) Figure 4 gives some data for Titan and Phoebe, another moon of Saturn.

	Titan	Phoebe
Distance from Saturn	1 222 000 km	12 000 000 km
Relative mass	75	1
Surface temperature	95 K	75 K
Shape	spherical	irregular

Figure 4

Analyse the data in Figure 4 in order to explain why Titan has an atmosphere but Phoebe does not.

(2)

.....

.....

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.....

(Total for Question 3 = 6 marks)

4 The Sun has four internal divisions.

(a) Explain why nuclear fusion takes place in the Sun's core.

(2)

(b) Figure 5 shows the number of sunspots seen on the Sun over a period of years.

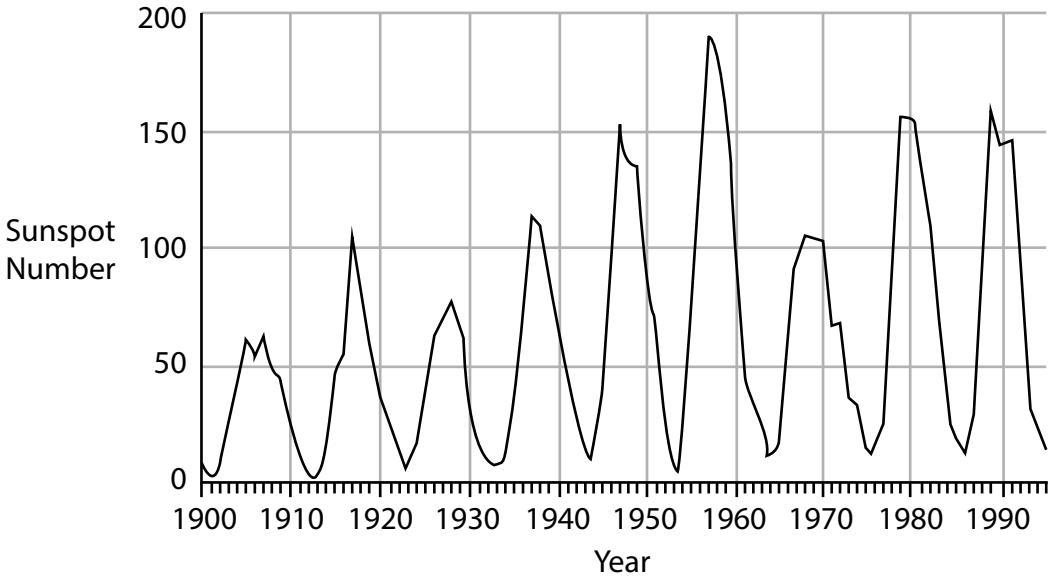


Figure 5

Determine the period of the solar sunspot cycle in Figure 5.

Give your answer to the nearest year.

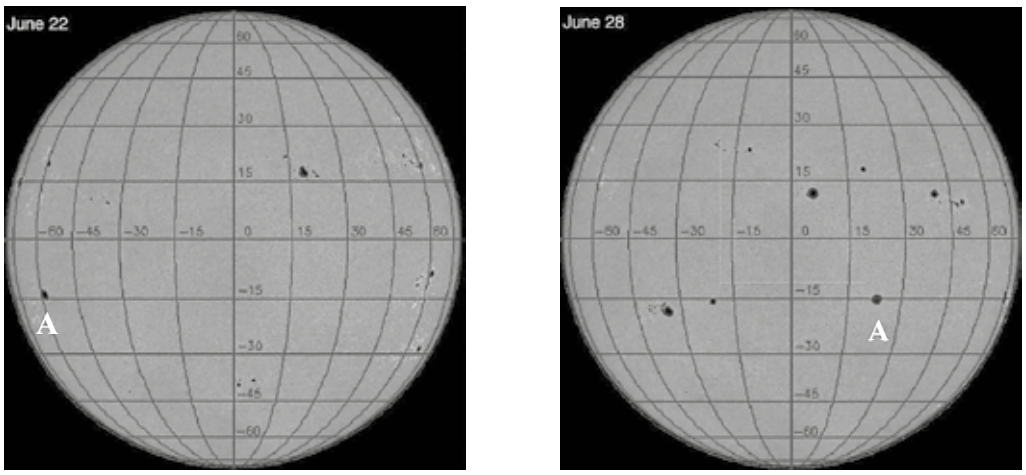
(1)

(c) A student observed sunspot activity on the Sun over a period of days.

The student took photographs of the same sunspots on 22nd June and 28th June.

Figure 6 shows the photographs taken by the student.

A grid has been overlaid on the Sun to show lines of longitude and latitude at 15° intervals.



(Source: NASA)

Figure 6

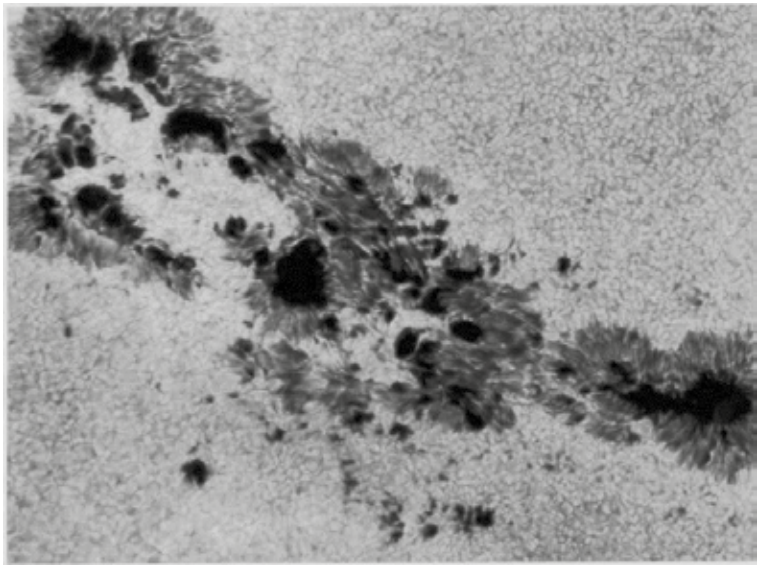
Determine the period of the rotation of the Sun using the sunspot labelled A.

Give your answer to the nearest day.

(3)

Period of rotation of the Sun ..... days

(d) Figure 7 is an enlarged photograph of a group of sunspots.



(Source: helios.gsfc.nasa.gov/sunspot.gif)

Figure 7

Explain why the sunspots appear dark on the Sun's surface.

(4)

(Total for Question 4 = 10 marks)

5 (a) Sirius is a binary star which is 2.6 parsecs from the Earth.

Calculate how long it takes light from Sirius to reach the Earth.

You should give your answer to 2 significant figures.

(2)

time taken = ... years

(b) Figure 8 shows a student's drawing of the light curve from another binary star.

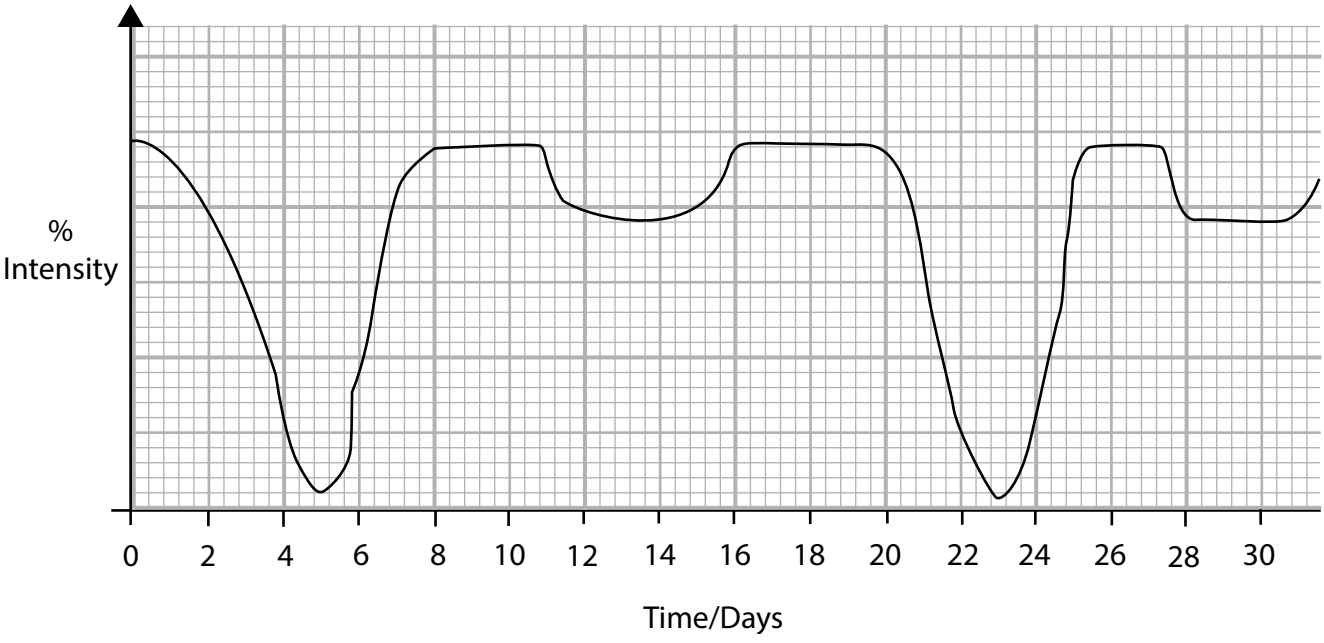


Figure 8

Determine the period of the binary star in Figure 8.

(1)

period = ... days

DO NOT WRITE IN THIS AREA

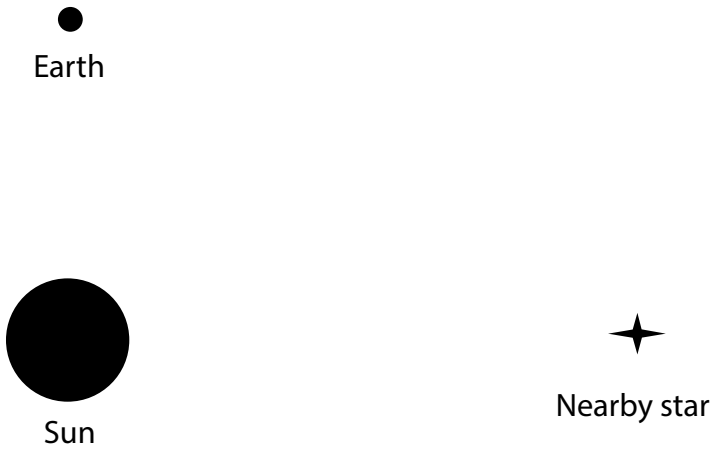
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(c) An astronomer observes nearby stars and wants to determine the distance to one of them.

Complete the diagram below to show how the astronomer could use heliocentric parallax to determine the distance to a nearby star.

(4)



(d) A nearby star has a parallax angle of 6.7×10^{-6} degrees.

Determine the distance to this star.

(3)

distance ..... pc

(Total for Question 5 = 10 marks)

6 (a) The 'Giant Impact Hypothesis' is a theory about the origin of the Moon.

Which statement best describes the formation of the Moon?

(1)

- ☒ **A** The Moon formed from the debris left over from a collision with a planet-sized object.
- ☒ **B** The Moon split from the Earth and the area left on the Earth became the Pacific Ocean.
- ☒ **C** The Earth's gravitational pull captured the Moon and pulled it into an orbit around the Earth.
- ☒ **D** The Moon and Earth formed as two separate bodies at the same time, when the Solar System formed.

(b) Most of the far side of the Moon is never visible from the Earth.

State **one** way in which information about the far side of the Moon can be obtained.

(1)

.....

.....

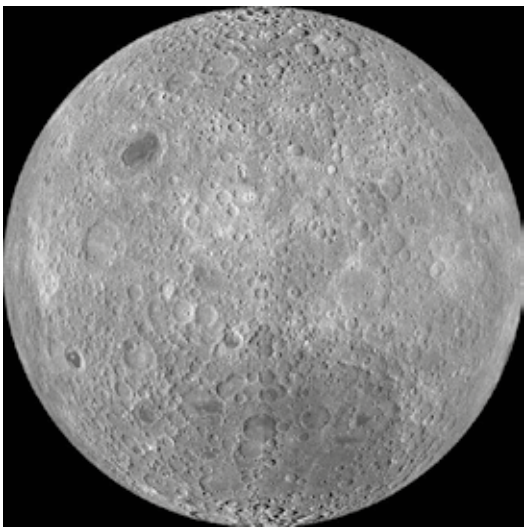
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(c) Figure 9 shows photographs of the Moon.

Near side



Far side

(Source: © NASA/GSFC/Arizona State University)

Figure 9

(i) Explain what can be deduced about the relative ages of the *maria* and the highlands on the near side of the Moon.

(2)

(ii) Suggest an explanation for lack of *maria* on the far side of the Moon.

(2)

(d) An astronomer takes a photograph of the Moon to determine the height of a mountain range.

Figure 10 shows this photograph.

(Source: © NASA/JPL)

Figure 10

Explain **two** reasons why the astronomer has chosen this time to take the photograph.

(4)

1 .....

.....

.....

2 .....

.....

.....

(Total for Question 6 = 10 marks)

7 The physical properties of stars include mass, temperature, luminosity and radius.

(a) Figure 11 shows the axes of a luminosity-temperature graph for stars.

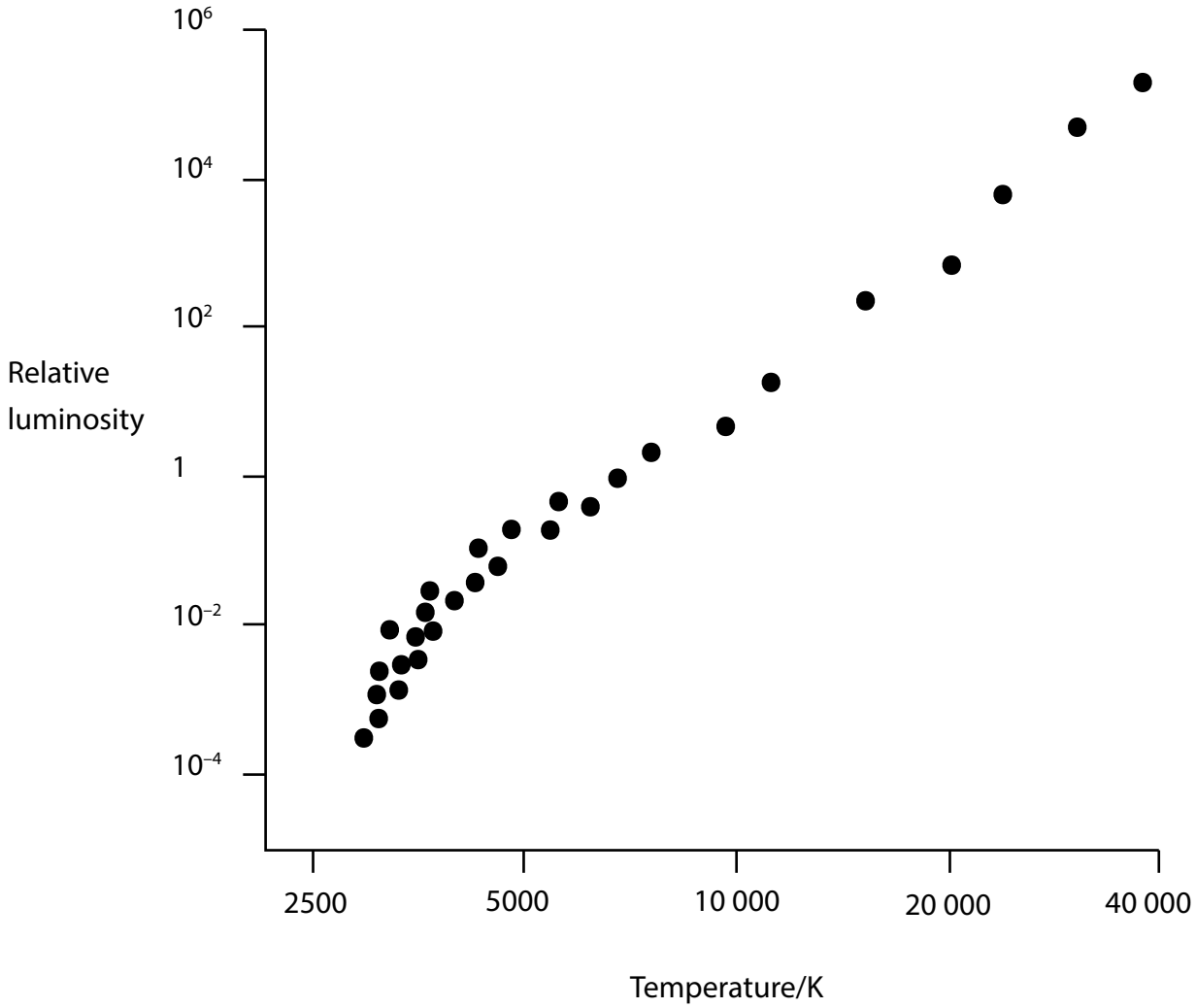


Figure 11

(i) Label the position of the Sun on the Figure 10.

Use the letter S.

(1)

(ii) Label the position of red giant stars on Figure 10.

Use the letter R.

(1)

(iii) Label the position of white dwarf stars on Figure 10.

Use the letter W.

(1)

(b) Explain why the observed physical properties of red giants require them to have a large surface area.

(3)

(c) Figure 12 gives some data on two stars, Star X and Star Y.

	Star X	Star Y
Luminosity (relative to the Sun)	0.1	20 000
Mass (relative to the Sun)	0.7	15
Temperature of photosphere	4500 K	35 000 K

Figure 12

Compare the evolutionary paths for Star X and Star Y.

(4)

(d) A student observes the five brightest stars that are catalouged in a constellation, using a telescope.

Figure 13 shows the student's estimations of apparent magnitude and colours.

Star	Apparent magnitude	Colour
Alpha	0.57	Yellow
Beta	–0.54	Blue
Gamma	1.02	Orange
Delta	3.11	Green
Epsilon	2.85	Red

Figure 13

Analyse the data in Figure 13 in order to comment on the student's observational method.

(2)

.....

.....

.....

.....

(Total for Question 7 = 12 marks)

8 (a) One piece of information that can be found from the spectrum of a star is radial velocity.

State **two** other pieces of information about a star that can be found from its spectrum.

(2)

1 .....

2 .....

(b) Figure 14 shows the spectrum obtained from a distant galaxy and a spectrum from a laboratory reference source.

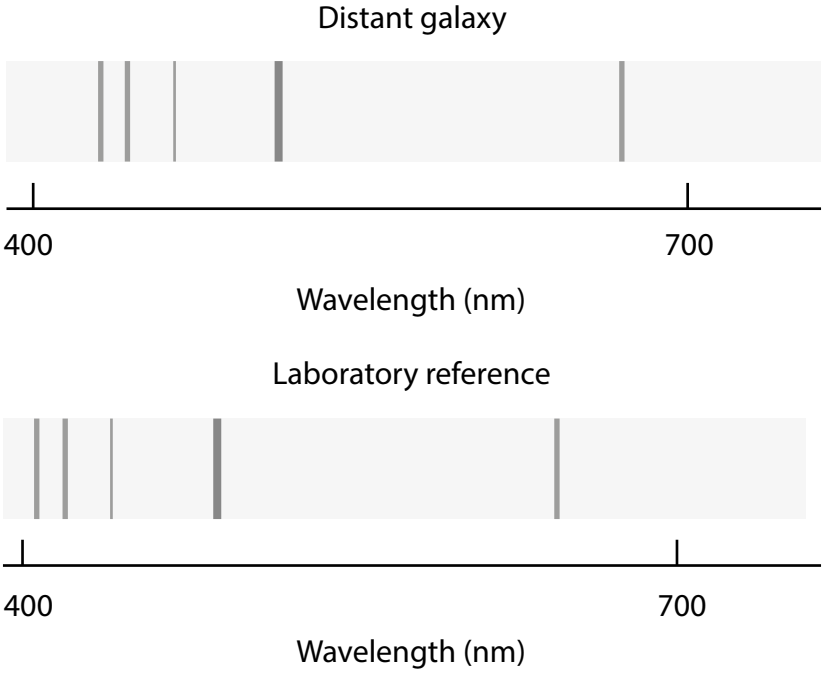


Figure 14

One line in the spectrum from the distant galaxy has a wavelength of 510 nm.

The same line in the reference spectrum has a wavelength of 490 nm.

Calculate the radial velocity of the distant galaxy.

Givie your answers to 2 significant figures.

(4)

Radial velocity = ... m/s

(c) Edwin Hubble investigated the relationship between the velocity at which a galaxy was moving relative to Earth and its distance away from the Earth.

Figure 15 shows the results he obtained.

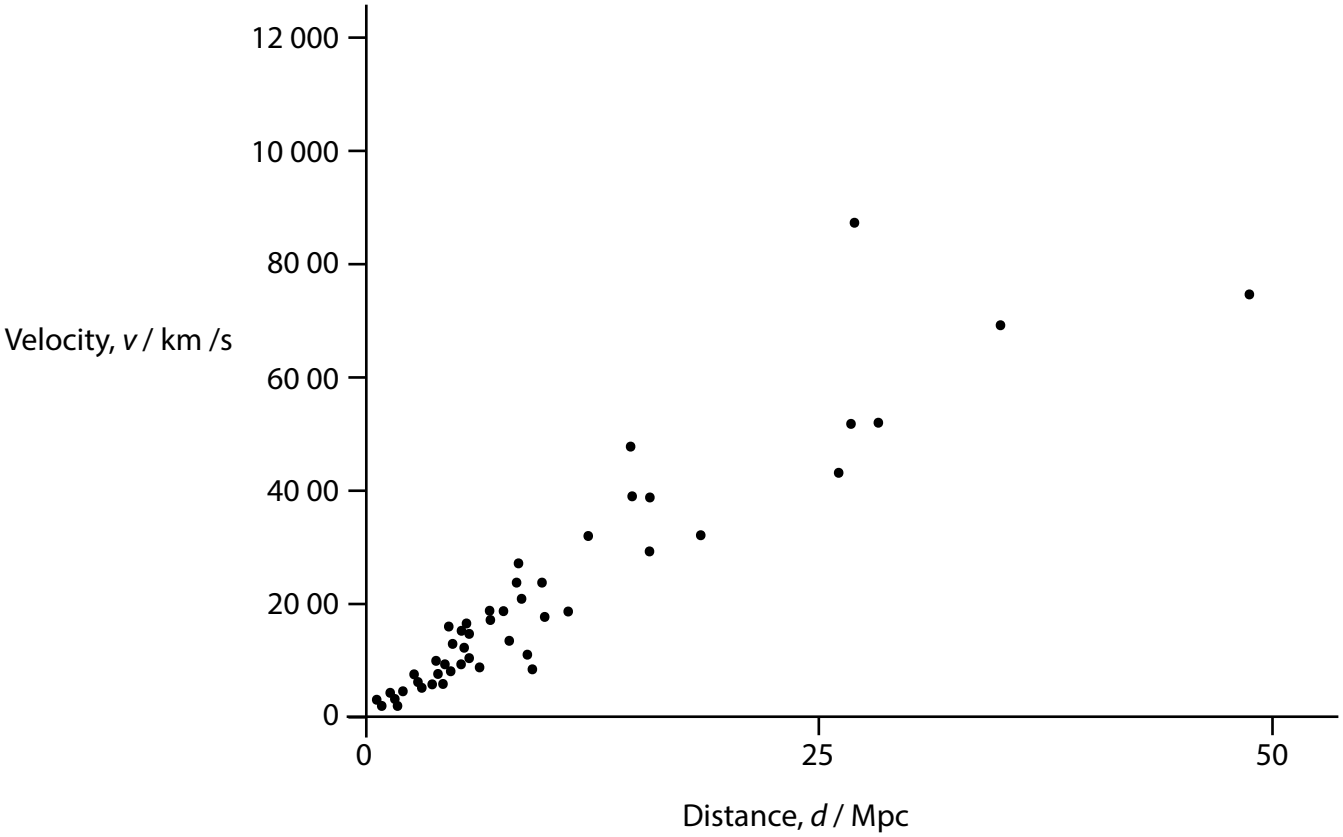


Figure 15

(i) State the type of relationship shown in Figure 15 between velocity of a galaxy and its distance from Earth.

(1)

.....

.....

(ii) A galaxy has a measured velocity of 20 000 km/s.

Use the formulae and data sheet to estimate the distance from the Earth to the galaxy, in Mpc.

(3)

Distance from Earth ..... Mpc

(d) The Steady State Theory and the Big Bang Theory are two theories about the expansion of the Universe.

Evidence for these two theories can come from observation of the Universe.

Explain **two** reasons why the Big Bang Theory has overtaken the Steady State Theory as the accepted theory.

(4)

1 .....

.....

.....

.....

2 .....

.....

.....

.....

(Total for Question 8 = 14 marks)

9 (a) (i) State what is meant by the term **absolute magnitude** of a star.

(1)

.....

.....

.....

.....

(ii) A star has an apparent magnitude of 12 and is at a distance of 2000 parsecs.

Calculate the absolute magnitude of the star.

(3)

Absolute magnitude.....

(b) Give **three** advantages of connecting radio telescopes together as an array.

(3)

1 .....

.....

2 .....

.....

3 .....

.....

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(c) An astronomer wants to buy a telescope to take photographs of Messier objects, such as the Pleiades and the Orion Nebula.

Figure 16 gives the details of four telescopes.

The telescopes are listed in order of cost, with **A** being the cheapest and **D** the most expensive.

Telescope	Aperture / cm	Field of view / arcmin	Accessories
A	5	30	Zoom eyepiece – for greater magnification
B	15	30	Finderscope an additional telescope with wider field of view
C	20	150	Electric drive – to track celestial objects
D	40	150	Electric drive – to track celestial objects App – to automatically position telescope

Figure 16

Evaluate which telescope would be most appropriate for the astronomer to buy.

(6)

(Total for Question 9 = 13 marks)

10 (a) Which statement is correct about a refracting telescope?

(1)

- ☒ **A** The telescope uses a single curved mirror to form an image.
- ☒ **B** The telescope uses a series of flat and curved mirrors to form an image.
- ☒ **C** The telescope uses a series of lenses to form an image.
- ☒ **D** The telescope uses lenses and mirrors to form an image.

(b) A telescope with a magnification of × 23 has an objective lens with a focal length of 108 cm.

Calculate the focal length of the eyepiece.

(2)

Focal length ..... cm

(c) Figure 17 shows the relative penetration of waves from different regions of the electromagnetic spectrum through the Earth's atmosphere.

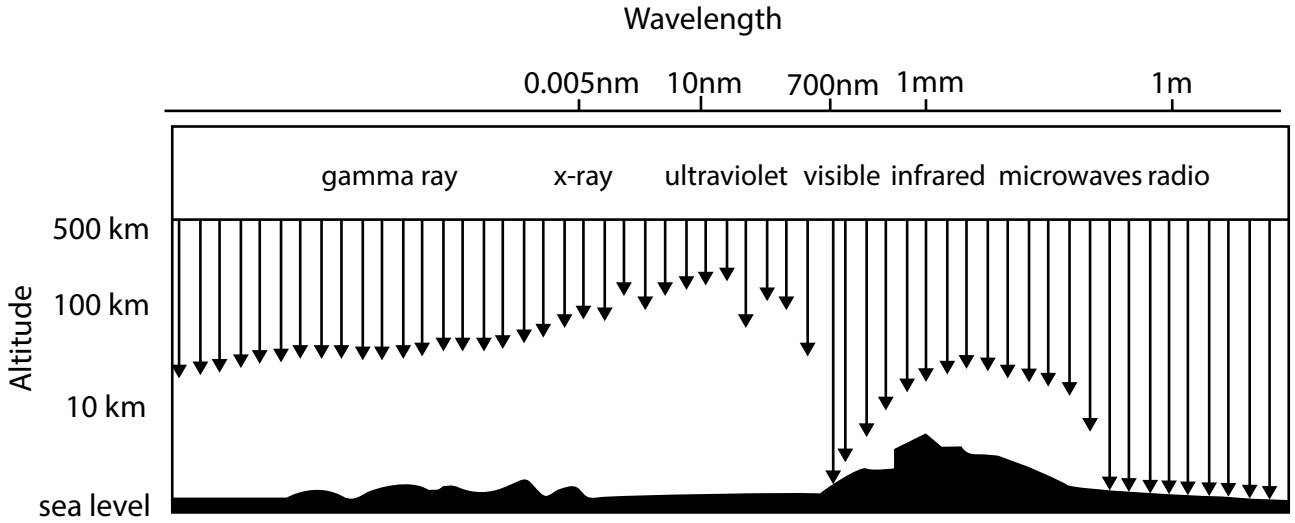

Figure 17

Analyse the data in Figure 17 to explain the best positions to observe astronomical bodies and events that emit x-rays and those that emit near-infrared radiation.

(4)

X-rays

Near-infrared

(d) A student uses a camera to photograph the star trails around Polaris.

The photograph will be used to measure the length of the sidereal day.

Figure 18 shows the student's time-exposure photograph.

(Source: © Michael Bolte—NASA/Zuma Press)

Figure 18

Evaluate ways to improve the observation in order to obtain an accurate value for the length of the sidereal day.

(6)

(Total for Question 10 = 13 marks)

TOTAL FOR PAPER = 100 MARKS

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

Astronomy

Paper 2: Telescopic Astronomy

Sample assessment material for first teaching September 2017
Formulae and Data Sheet

Paper Reference
1AS0/02

Do not return this Formulae and Data Sheet with the question paper.

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Pearson

Formulae and data sheet

Formulae

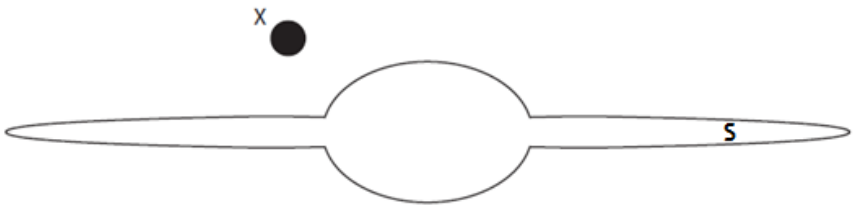
Equation of Time = Apparent Solar Time (AST) – Mean Solar Time (MST)	
Kepler's 3rd law:	$\frac{T^2}{r^3} = \text{a constant}$
Magnification of telescope:	$\text{magnification} = \frac{f_o}{f_e}$
Distance modulus formula:	$M = m + 5 - 5\log d$
Redshift formula:	$\frac{\lambda - \lambda_0}{\lambda_0} =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

Paper 2: Telescopic Astronomy mark scheme

Question number	Answer	Additional guidance	Mark
1(a)(i)	The letter S approximately two thirds of the way along from the central bulge (1)	On either side of the central bulge or the other but not both	(1)
			

Question number	Answer	Mark
1(a)(ii)	D	(1)

Question number	Answer	Mark
1(b)	C	(1)

Question number	Answer	Additional guidance	Mark
1(c)(i)	Barred Spiral/SB/SBb	Accept spiral/S/Sb	(1)

Question number	Answer	Mark
1(c)(ii)	Galaxy A – Spiral/S (1) Galaxy B – Elliptical/E (1)	(2)

Question number	Answer	Mark
2(a)	A	**(1)**

Question number	Answer	Mark
2(b)	An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (1 mark): The comet is now further from the Sun (1) and the solar wind has less effect (1) The comet may have lost material when close to the Sun (1) and so it is not able to produce as large a tail (1) The Sun is at a minimum in its cycle (1) and so the solar wind is reduced (1)	**(2)**

Question number	Answer	Mark
2(c)	An answer that provides a description by making reference to: a large asteroid/astronomical object collided with/struck the surface of Mars early in the life of the Solar System (1) with a force that was large enough for some (small) rocks to escape from Mars' gravitational pull (1) the Earth passed through the debris and some of the rocks fell to Earth/survived their journey through our atmosphere to land on Earth (1)	**(3)**

Question number	Answer	Additional guidance	Mark
3(a)	An explanation that combines identification – knowledge (1 mark) and reasoning/justification – understanding (1 mark): For the major moons, gravitational forces are larger than tidal forces (1) because tidal forces decrease with distance from the planet (1)	Accept reverse argument Major moons are outside the Roche limit (1), which means they would not have been pulled apart by tidal forces (1)	**(2)**

Question number	Answer	Mark
3(b)	Any two from: Liquids present (1) Internal source of heat/energy (1) Suitable temperature range (1) Accept any other appropriate response	**(2)**

Question number	Answer	Additional guidance	Mark
3(c)	An answer that combines points of interpretation/evaluation to provide a reasoned explanation: Mass of Titan is larger (1) so provides a larger enough gravitational field strength/pull to keep the atmospheric gases around Titan (1)	Accept: Titan has a spherical shape (1), which suggests a larger pull of gravity on its atmosphere (1) Accept reverse arguments to those given	**(2)**

Question number	Answer	Mark
4(a)	An explanation that combines identification – knowledge (1 mark) and reasoning/justification – understanding (1 mark): Very high temperatures and very high pressures/density (1) Allow hydrogen nuclei/protons to get close enough together to fuse/overcome mutual repulsion (1)	**(2)**

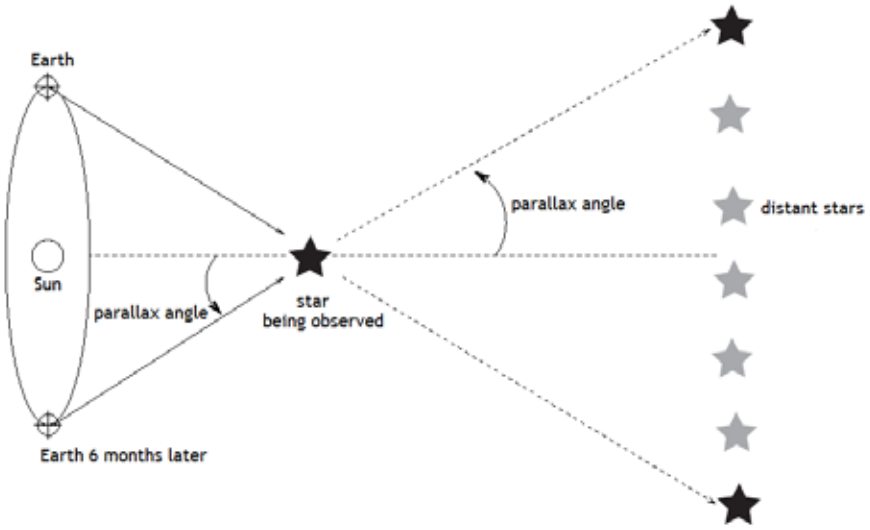
Question number	Answer	Additional guidance	Mark
4(b)	11 years	(±1 year)	**(1)**

Question number	Answer	Additional guidance	Mark
4(c)	Spot A moves from −60 to +22 in 6 days = 82 (1) So in 1 day Sun rotates 82 ÷ 6 = 13.67 (1) Hence rotation period = 360 ÷ 13.67 = 26.3 days To the nearest day, rotation period = 26 days (1)	Award full marks for correct numerical answer without working Accept answers in the range of 24 to 28 days	**(3)**

Question number	Answer	Mark
4(d)	An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (3 marks): (The sunspots appear dark because) they radiate less than the surrounding area (1) as they are relatively cooler regions (1) because sunspots are areas of strong magnetic fields (1), which reduce convection from gases in the Sun (1)	**(4)**

Question number	Answer	Additional guidance	Mark
5(a)	Conversion from parsec to light years (1) 2.6 × 3.26 evaluation to 2 sf (1) 8.5 y	Award full marks for correct numerical answer without working	**(2)**

Question number	Answer	Additional guidance	Mark
5(b)	Identifying 5 and 23 days from the graph 23 − 5 = 18 days (1)	Award full marks for correct numerical answer without working Accept answers in the range of 17.5 to 18.5 days	**(1)**

Question number	Answer	Mark
5(c)	 Distant background stars labelled (1) Star being observed from Earth drawn in one position (1) Earth drawn at another position 6 months later on the opposite side of the Sun (1) Angle measured from each star position/parallax angle labelled (1)	**(4)**

Question number	Answer	Additional guidance	Mark
5(d)	Conversion of degrees to arcsec requires multiplying by 60 × 60 (3600) (1) $(6.7 \times 10^{-6}) \times 3600 = 0.02412$ (arcsec) (1) $\frac{1}{0.02412} = 41\,(\text{pc})$ (1)	Award full marks for correct numerical answer without working Accept answers that round to 41	**(3)**

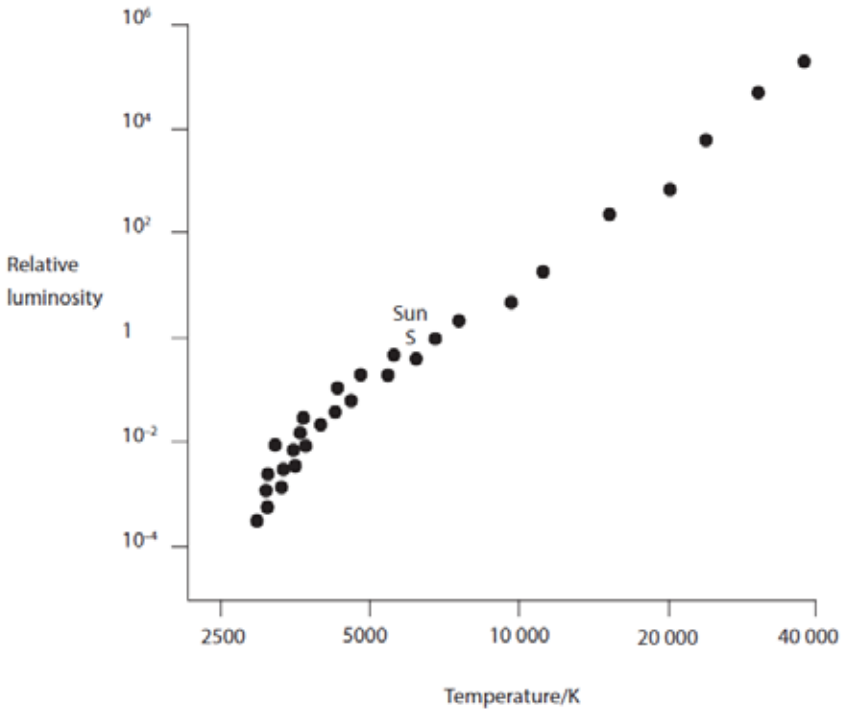
Question number	Answer	Mark
6(a)	A	**(1)**

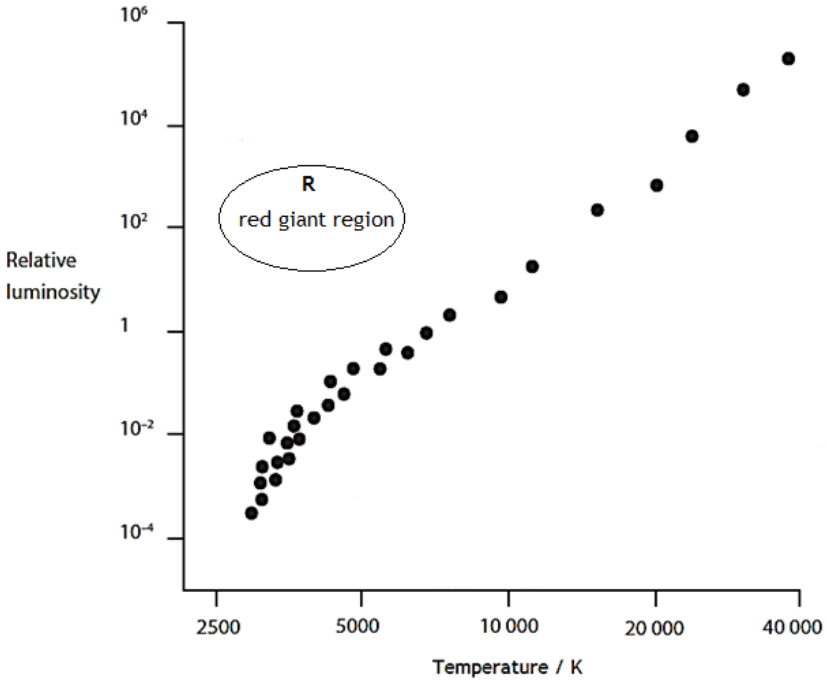
Question number	Answer	Mark
6(b)	Any one from: Satellites/space probes (put into orbit) around the Moon (1) Information from *Luna 3* robotic mission (1) Manned missions that orbited/passed over the far side of the Moon (1) Accept any other appropriate response	**(1)**

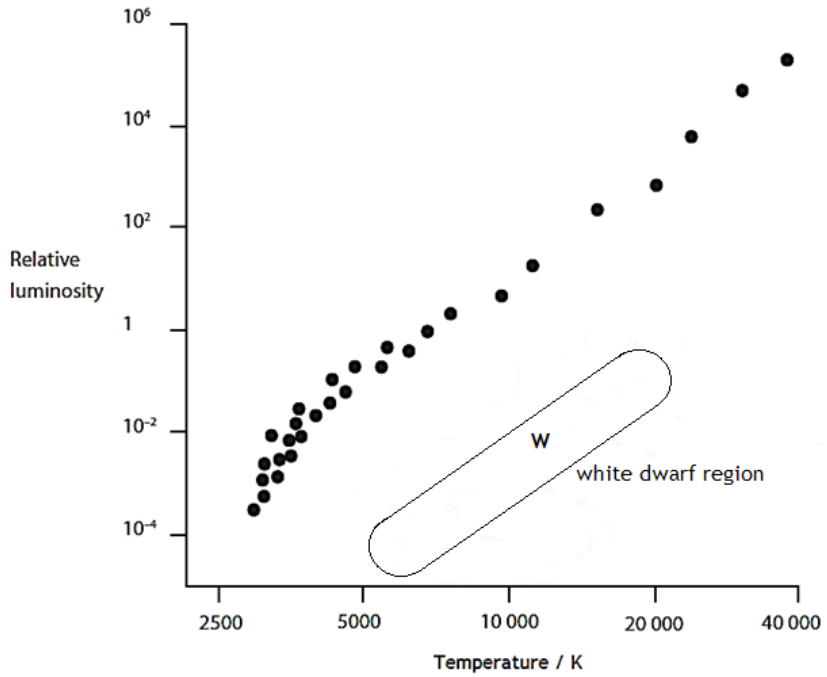
Question number	Answer	Mark
6(c)(i)	An explanation that combines identification – application of knowledge (1 mark) and reasoning/justification – application of understanding (1 mark): Seas/*maria* have fewer craters (1), which means that they are younger (1) Highlands have more craters (1), which means that they are older (1)	**(2)**

Question number	Answer	Mark
6(c)(ii)	An explanation that combines identification – application of knowledge (1 mark) and reasoning/justification – application of understanding (1 mark): The main reason for lack of *maria* on the far side is due to Earth's tidal influence on the Moon early in its life (1). This resulted in the near side having a thinner crust and therefore more volcanic eruptions leading to the formation of the *maria*/the far side's thicker crust prevented or reduced volcanic eruptions which resulted in no *maria* forming (1).	(2)

Question number	Answer	Mark
6(d)	An answer that combines points of interpretation/evaluation to provide two reasoned explanations: It is a half-moon (1) so the Sun is shining at an angle (and it causes a shadow to be cast) (1) The mountain range is near the terminator (1), which means the Sun is low on the horizon (which means a shadow is cast) (1)	(4)

Question number	Answer	Mark
7(a)(i)		(1)

Question number	Answer	Mark
7(a)(ii)	 Accept any answers that are within the region shown.	(1)

Question number	Answer	Mark
7(a)(iii)	 Accept any answers that are within the region shown.	(1)

Question number	Answer	Mark
7(b)	An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (2 marks): Red Giants are very luminous but cool stars (1) even though cool stars are usually dim (1), which means the surface area has to be large enough to compensate for its relatively low temperature (1)	**(3)**

Question number	Answer	Mark
7(c)	An answer that combines the following comparative points by applying knowledge and understanding. Star X begins as a low mass star (which is below the Chandrasekhar Limit) but Star Y begins as a high mass star (which is above the Chandrasekhar Limit) (1) Star X will stay on the main sequence line for longer than Star Y (1) Star X will become a red giant but Star Y will become a red supergiant (1) Star X will end as a white dwarf but Star Y will end as a neutron star/black hole (1)	**(4)**

Question number	Answer	Mark
7(d)	An answer that includes points of interpretation/evaluation to provide a reasoned account of the data: The stars should be named in order of the brightest to dimmest star (from alpha to epsilon) (1) Estimates of magnitude are inappropriately precise (1) The colours are subjective unless the light is sent through a spectroscope (1)	**(2)**

Question number	Answer	Mark
8(a)	Any two from: Temperature (1) Chemical composition (1) Stellar density (1) Accept any other appropriate response	**(2)**

Question number	Answer	Additional guidance	Mark
8(b)	Transposition (1) $\frac{\lambda - \lambda_0}{\lambda_0} = \frac{v}{c}$ $v = c \times \left(\frac{\lambda - \lambda_0}{\lambda_0} \right)$ Substitution (1) $v = 3.0 \times 10^8 \times \left(\frac{510 - 490}{490} \right)$ Evaluation (1) v = 1.224… × 10^7 m/s Correct sig figs (1) v = 1.2 × 10^7 m/s	Award full marks for correct numerical answer without working	**(4)**

Question number	Answer	Mark
8(c)(i)	(The velocity of the galaxy is) directly proportional to (the distance away)	**(1)**

Question number	Answer	Additional guidance	Mark
8(c)(ii)	Rearrangement of $v = Hd$ $d = \frac{v}{H}$ (1) $distance = \frac{20\ 000}{68}$ (1) Evaluation (1) 294.1 (Mpc)	Award full marks for correct numerical answer without working Accept answers that round to 294 (Mpc)	**(3)**

Question number	Answer	Mark
8(d)	An explanation that combines identification – understanding (2 marks) and reasoning/justification – understanding (2 marks): The evidence of Cosmic Microwave Background Radiation (CMBR) shows that there is background radiation in all directions (1), which suggests that 'a single event' created the Universe (1) Hubble Deep Field image and quasar distribution show that the oldest stars observed are 13.8 billion years old (1), however the Steady State Theory predicted older stars would exist (1) Theoretical models of the Big Bang Theory predict that hydrogen and helium were produced in the ration 3:1 (1). Observations are in good agreement with this prediction (1).	**(4)**

Question number	Answer	Mark
9(a)(i)	The brightness/apparent magnitude of an object as seen at a distance of 10 parsecs away	**(1)**

Question number	Answer	Additional guidance	Mark
9(a)(ii)	Substitution (1) M = m + 5 − 5 log d M = 12 + 5 − 5 log 2000 (1) Evaluation of log d (1) log 2000 = 3.3 Evaluation of M (1) M = 0.49	Award full marks for correct numerical answer without working Accept answer that rounds to M = 0.5	**(3)**

Question number	Answer	Mark
9(b)	It can detect weaker sources (of radio waves) (1) It gives a higher resolution/amount of detail, due to larger baseline (1) It enables greater collaboration between astronomers (1)	**(3)**

Question number	Indicative content	Mark
9(c)	**Marking instructions** Markers must apply the descriptors in line with the general marking guidance and the qualities outlined in the levels-based mark scheme below. **Indicative content guidance** The indicative content below is not prescriptive and candidates are not required to include all of it. Other relevant material not suggested below must also be credited. Relevant points may include: • Messier objects do not have a high magnitude so need a large aperture to collect sufficient light to give a bright image • Telescopes C and D provide suitable aperture size • Messier objects are diffuse (not pin point objects) so need a large field of view to observe the whole object • Telescopes C and D provide a suitable field of view • Most of the Messier objects can be found with the naked eye so an app to find them is not essential • Telescopes A, B and C are suitable because they don't contain a non-essential feature • The electric drive allows you to track the object over a period of time which is important for taking photographs • Telescopes C and D are suitable as the they include this feature that supports the astronomer's intended observations • Overall, telescope C fulfils all the criteria without including non-essential features • Telescope D would also fulfil the astronomer's needs, but is listed as the most expensive	(6)

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	• Basic interpretation and evaluation of the data/information may be attempted but will be limited and narrow in scope. (AO3) • The response will contain basic information with little linkage between points made. Lines of reasoning may be attempted but are incomplete or lack clarity. A conclusion may be attempted but lacks support. (AO3)
Level 2	3–4	• Interpretation and evaluation of the data/information that attempts to synthesise and integrate relevant knowledge. (AO3) • The response shows some linkages and lines of reasoning with some structure, leading to a conclusion that is partially supported. (AO3)
Level 3	5–6	• Comprehensive interpretation and evaluation of the data/information that demonstrates the skills of synthesising and integrating relevant knowledge throughout the response. (AO3) • The response shows a well-developed, sustained line of scientific reasoning which is clear, coherent and logically structured, leading to a supported conclusion. (AO3)

Question number	Answer	Mark
10(a)	C	**(1)**

Question number	Answer	Additional guidance	Mark
10(b)	Rearrangement (1) $\text{magnification} = \frac{f_o}{f_e}$ $f_e = \frac{f_o}{\text{magnification}}$ Substitution and evaluation (1) $f_e = \frac{108}{23} = 4.695$ f_e = 4.7 cm	Award full marks for correct numerical answer without working	**(2)**

Question number	Answer	Mark
10(c)	An answer that combines points of interpretation/evaluation to provide a reasoned explanation: X-rays have a typical wavelength of 5 nm and cannot penetrate the Earth's atmosphere (1) so the telescope must be in space/on a satellite (1). Near-infrared radiation has a typical wavelength of 1000 nm and can penetrate the atmosphere down to about 6 km above the surface of the Earth (1) so high-altitude aircraft, balloons or observatories on high mountains can be used for observations (1).	**(4)**

Question number	Indicative content	Mark
10(d)	**Marking instructions** Markers must apply the descriptors in line with the general marking guidance and the qualities outlined in the levels-based mark scheme below. **Indicative content guidance** The indicative content below is not prescriptive and candidates are not required to include all of it. Other relevant material not suggested below must also be credited. Relevant points may include: **Obstructions** • The most significant improvement would be taking an image of the sky that is not partially obscured by a mountain, so that Polaris is visible. This would enable more accurate angle measurements to be taken. • It would improve the observation slightly to move away from flight paths, as aircrafts leave trails in the image, interrupting the view of the star arcs. • It would improve the observation to ensure that the image was taken with a clean lens, as the photograph has some blurry sections, which could distort measurements. **Exposure** • It would greatly improve the accuracy to use a longer exposure time so that the arc angle is bigger and percentage error is less/easier to measure. **Latitude** • It would improve the accuracy slightly to change the location of the observation to a location further from the equator, so that the pole star is higher in the sky. This would enable the student to see more star trails and therefore pick one that is clearer/more choice.	**(6)**

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	• Basic interpretation and evaluation of the method may be attempted but will be limited and narrow in scope. (AO3) • Appraisal of potential improvements is unsupported, with a limited attempt to link knowledge and understanding to the given context through. Lines of reasoning may be attempted but are incomplete or lack clarity. (AO3)
Level 2	3–4	• Interpretation and evaluation of the method that attempts to synthesise and integrate relevant knowledge. (AO3) • Appraisal of potential improvements is partially supported by evidence of analysis of the method, showing some linkages and lines of scientific reasoning with some structure. (AO3)
Level 3	5–6	• Comprehensive interpretation and evaluation of the method that demonstrates the skills of synthesising and integrating relevant knowledge throughout the response. (AO3) • Appraisal of potential improvements to the method is supported throughout by evidence from the analysis of the method, showing a well-developed, sustained line of scientific reasoning which is clear, coherent and logically structured. (AO3)

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