Please check the examination details below before entering your candidate information

Candidate surname	Other names

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

Centre Number	Candidate Number

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.
- Good luck with your examination.

Turn over ▶

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Pearson

Formulae and Data Sheet

Formulae

Equation of Time = Apparent Solar Time (AST) – Mean Solar Time (MST)	
Kepler's 3rd law:	$\frac{T^2}{r^3} = \text{a constant}$
Magnification of telescope:	$\text{magnification} = \frac{f_\text{o}}{f_\text{e}}$
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

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 Figure 1 shows four images taken with the Hubble Space Telescope.

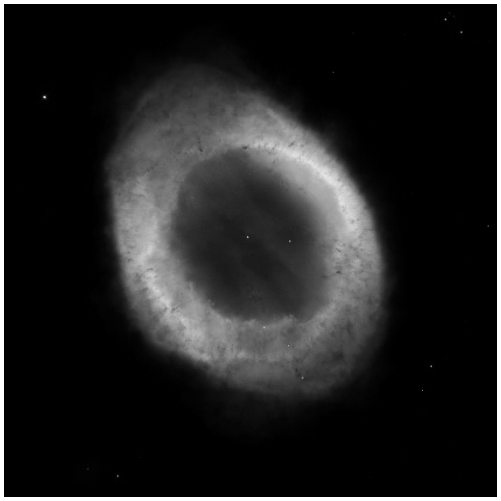

Image A

Image B

Image C

Image D

Figure 1

(a) (i) Which image shows a galaxy?

(1)

- ☒ **A** Image A
- ☒ **B** Image B
- ☒ **C** Image C
- ☒ **D** Image D

(ii) Which image shows a globular cluster?

(1)

- ☒ **A** Image A
- ☒ **B** Image B
- ☒ **C** Image C
- ☒ **D** Image D

(iii) Which image shows a planetary nebula?

(1)

- ☒ **A** Image A
- ☒ **B** Image B
- ☒ **C** Image C
- ☒ **D** Image D

(iv) Which image shows an emission nebula?

(1)

- ☒ **A** Image A
- ☒ **B** Image B
- ☒ **C** Image C
- ☒ **D** Image D

(b) (i) Astronomers have obtained images of the far side of the Moon.

State **one** method used for doing this.

(1)

.....

.....

(ii) Which **one** of the following is **not** a possible explanation for the Moon's origin?

(1)

☒ **A** Capture Theory

☒ **B** Co-accretion Theory

☒ **C** Giant Impact Hypothesis

☒ **D** Steady State Theory

(Total for Question 1 = 6 marks)

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2 (a) (i) Which **one** of the following designs of telescope has a flat secondary mirror?

(1)

- ☒ **A** Cassegrain reflector
- ☒ **B** Galilean refractor
- ☒ **C** Keplerian refractor
- ☒ **D** Newtonian reflector

(ii) Which **one** of the following designs of telescope has a hole in the centre of its objective?

(1)

- ☒ **A** Cassegrain reflector
- ☒ **B** Galilean refractor
- ☒ **C** Keplerian refractor
- ☒ **D** Newtonian reflector

(iii) Which **one** of the following designs of telescope uses a concave (diverging) eyepiece?

(1)

- ☒ **A** Cassegrain reflector
- ☒ **B** Galilean refractor
- ☒ **C** Keplerian refractor
- ☒ **D** Newtonian reflector

(b) A telescope's objective lens has a focal length of 1.20 m and gives a magnification of 24 times (24 x).

What is the focal length of its eyepiece lens?

(1)

- ☒ **A** 0.05 mm
- ☒ **B** 20 mm
- ☒ **C** 50 mm
- ☒ **D** 60 mm

(c) Julie's telescope has an objective mirror with a diameter of 10 cm.

Matthew's telescope has an objective mirror with a diameter of 20 cm.

Describe how the light grasp of Matthew's telescope is different to Julie's telescope.

(2)

.....

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.....

(Total for Question 2 = 6 marks)

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3 (a) Messier 87 (M87) is a galaxy in the constellation of Virgo.

Its Hubble classification is elliptical (E).

(i) State **two** other Hubble classifications for galaxies.

(2)

1 .....

2 .....

(ii) It takes 20 000 million days for light to travel from M87 to the Earth.

Calculate the distance between the Earth and M87 in millions of light years.

(1)

Distance = ... million light years

(b) Figure 2 shows the first ever image of a black hole, taken in 2019.

This black hole is in the galaxy M87.

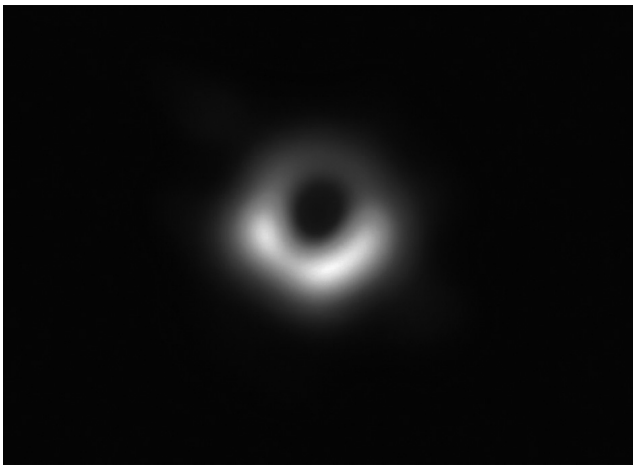

Figure 2

The astronomers who produced the image in Figure 2 used a group of eight radio telescopes located around the world.

Explain why more than one radio telescope was needed to produce the image in Figure 2.

(2)

.....

.....

.....

.....

(c) Describe **one** other method astronomers have used to gather evidence for the existence of black holes.

(2)

.....

.....

.....

.....

(Total for Question 3 = 7 marks)

4 (a) (i) State **one** difference between a binary star system and a double star system.

(1)

.....

.....

(ii) Figure 3 shows a student's drawing of a light curve for an eclipsing binary star system. The two stars in the system have the same brightness.

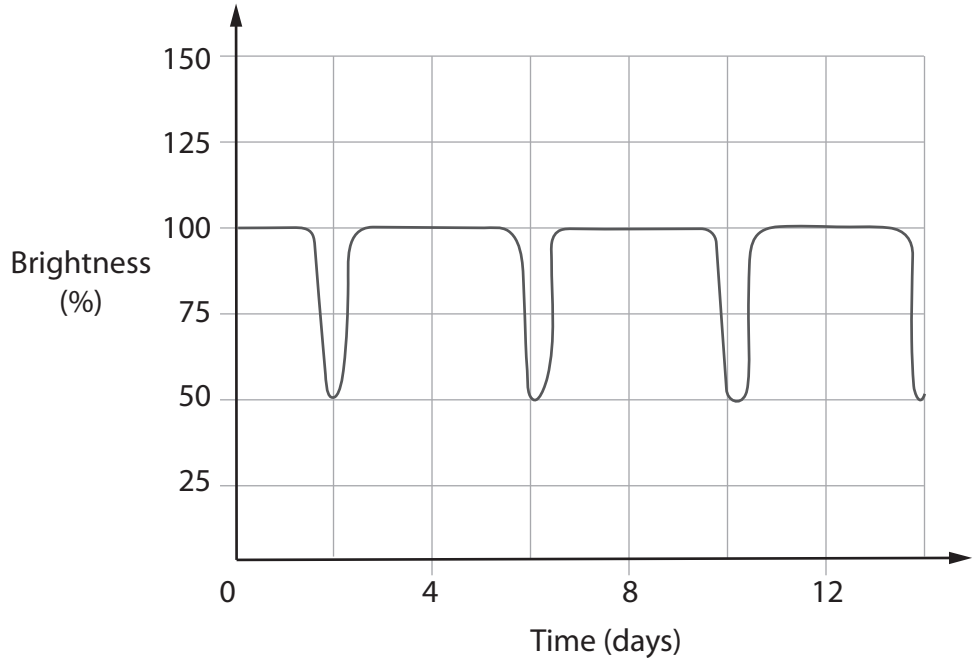

Figure 3

Draw on Figure 3, the light curve for this eclipsing binary star system if one star was twice as bright as the other.

You may assume that the period of the system remains the same.

(3)

(b) (i) Plotting the light curve of a **single** star can be used to find exoplanets.

Describe how exoplanets can be found in this way.

You may include a clearly labelled diagram in your answer.

(2)

.....

.....

.....

.....

(ii) Some exoplanets may be suitable places for life to exist.

State **three** surface conditions on an exoplanet that could support life.

(3)

1 .....

2 .....

3 .....

(Total for Question 4 = 9 marks)

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5 (a) The Crab Nebula is a supernova remnant in the constellation of Taurus.

A supernova can produce either a neutron star or a black hole.

Figure 4 shows the Crab Nebula.

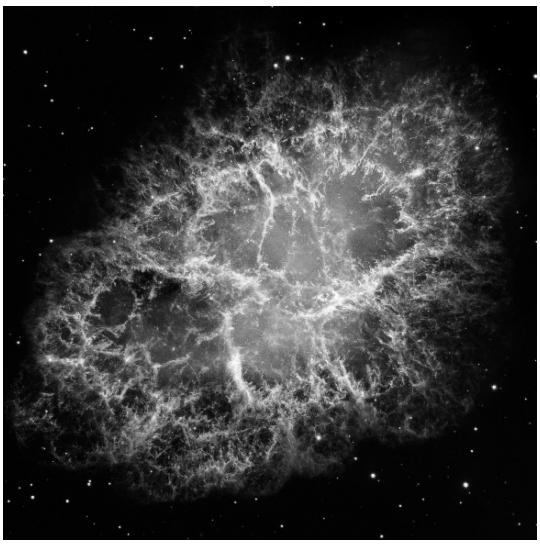

Figure 4

(i) Give **one** reason why a supernova would produce a neutron star instead of a black hole.

(1)

.....

.....

(ii) State **two** physical properties of a neutron star.

(2)

1 .....

2 .....

(iii) Describe how astronomers can observe neutron stars.

You may include a clearly labelled diagram in your answer.

(2)

.....

.....

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(b) Figure 5 shows how the absolute magnitude of a supernova changes with time.

At its brightest, this supernova reached an absolute magnitude of –19.6.

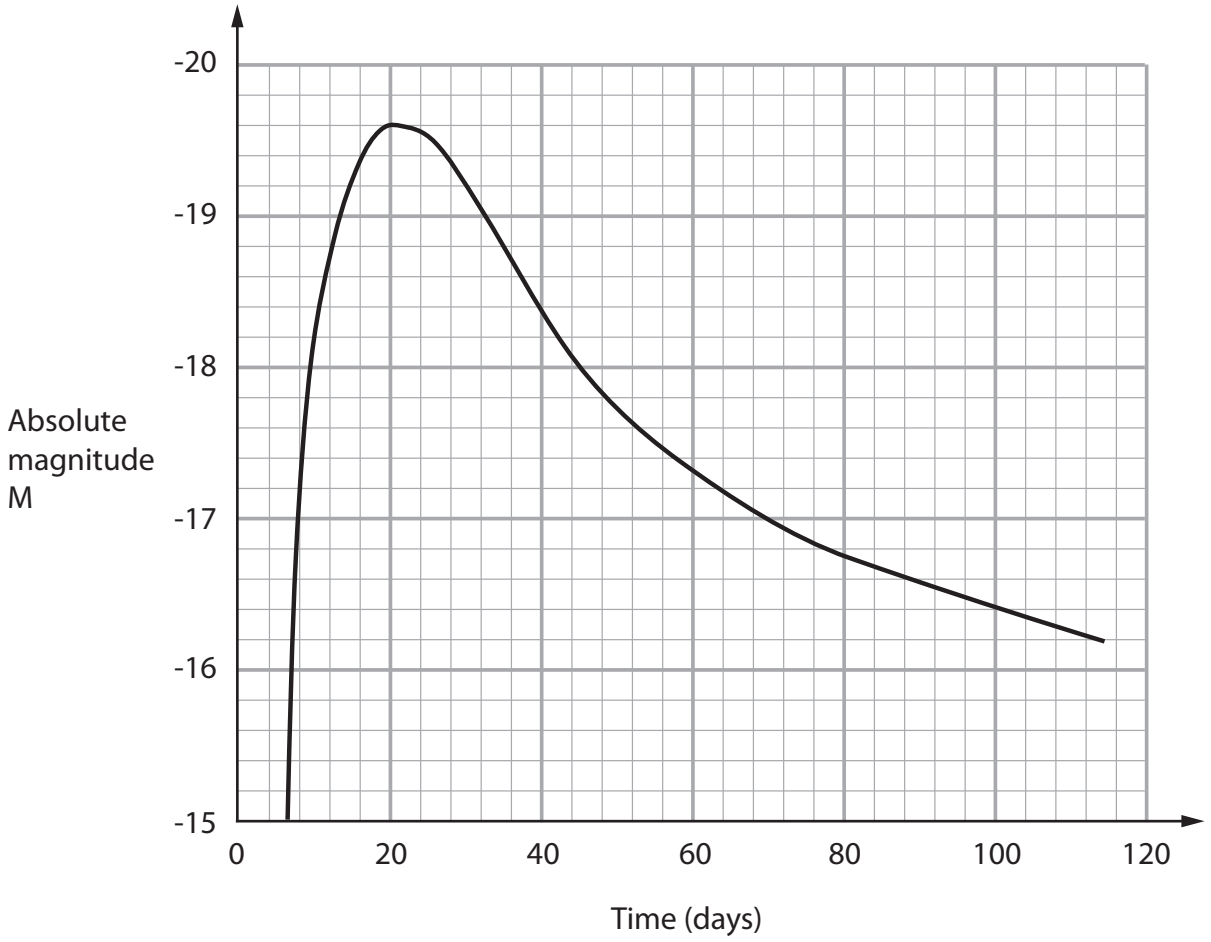


Figure 5

Calculate the time it takes for the supernova's brightness to drop to one sixteenth ($\frac{1}{16}$) of its maximum value.

Give your answer in days.

(2)

Time = ... days

(c) Some astronomers have suggested that the brightest absolute magnitude for all supernovae has a range between –19 and –20.

Calculate the brightest possible apparent magnitude for a supernova at a distance of 1000 pc from Earth.

Use the equation:

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

(2)

Brightest apparent magnitude = ...

(Total for Question 5 = 9 marks)

6 (a) (i) Some planets in our solar system have a ring system.

State the most common chemical in these planets.

(1)

.....

.....

(ii) Which **one** of the following can be found within planetary ring systems?

(1)

- ☒ **A** comets
- ☒ **B** dwarf planets
- ☒ **C** meteorites
- ☒ **D** small moons

(iii) State **one** other main component of planetary ring systems.

(1)

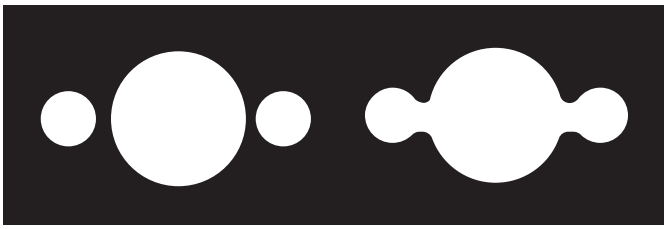
.....

(b) In the seventeenth century astronomers did not understand the appearance of the planet Saturn when they looked at it through a telescope.

The Dutch astronomer Christiaan Huygens collected a series of observations of Saturn, made by other astronomers between 1610 and 1650.

They were all made using early refracting telescopes with apertures of up to 10 cm. Some of these observations are shown in Figure 6.

1610–1620



1620–1640

1640–1650

Figure 6

Analyse Figure 6 and evaluate whether early refracting telescope observations were useful in helping astronomers to understand the structure of the planet Saturn.

(3)

(c) Describe how the Roche Limit can be used to explain the formation of planetary ring systems.

You may include a clearly labelled diagram in your answer.

(3)

(d) Figure 7 shows an image of the planet Uranus.

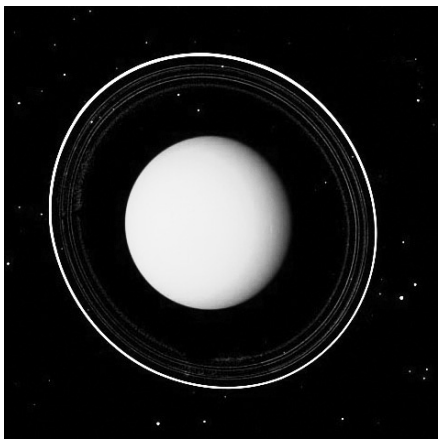


Figure 7

The existence of a ring system around Uranus was confirmed during an occultation of a star by Uranus in 1977. During this occultation, Uranus was observed to pass in front of this star.

A graph of the light curve of this star during the occultation is shown in Figure 8.

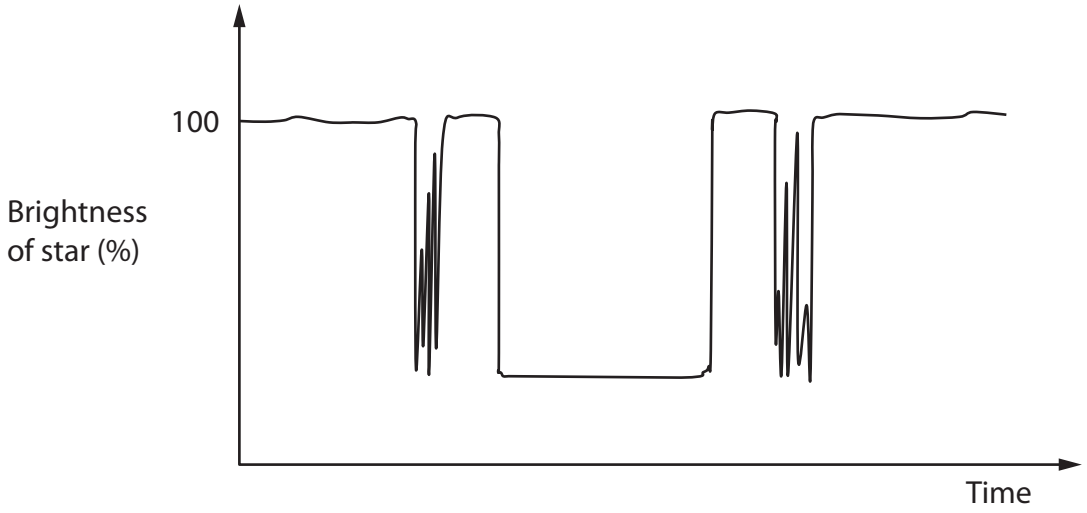


Figure 8

Explain how the graph in Figure 8 shows the existence of a ring system around Uranus.

(2)

.....

.....

.....

.....

(Total for Question 6 = 11 marks)

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7 (a) (i) Describe what is meant by the term 'Local Group'.

(2)

(ii) Which **one** of the following is **not** a member of the Local Group.

(1)

- ☒ **A** Andromeda galaxy
- ☒ **B** Seyfert galaxy
- ☒ **C** Small Magellanic Cloud
- ☒ **D** Triangulum galaxy

(b) An astronomer states that, '*We appear to be living in an expanding universe*.'

Explain what is meant by this statement.

You may include a clearly labelled diagram in your answer.

(2)

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(c) An absorption line has a wavelength of 625.05 nm.

When this absorption line is observed in the spectrum of a galaxy, it appears to have a wavelength of 625.65 nm.

Calculate the velocity of this galaxy in km/s.

(Speed of light c = 300 000 km/s)

(2)

Velocity = ... km/s

(d) Figure 9 shows the velocities and distances from Earth of some galaxies.

Velocity (km/s)	Distance (Mpc)
0	0
6	500
12	900
15	1200
20	1500
24	1700
30	2400

Figure 9

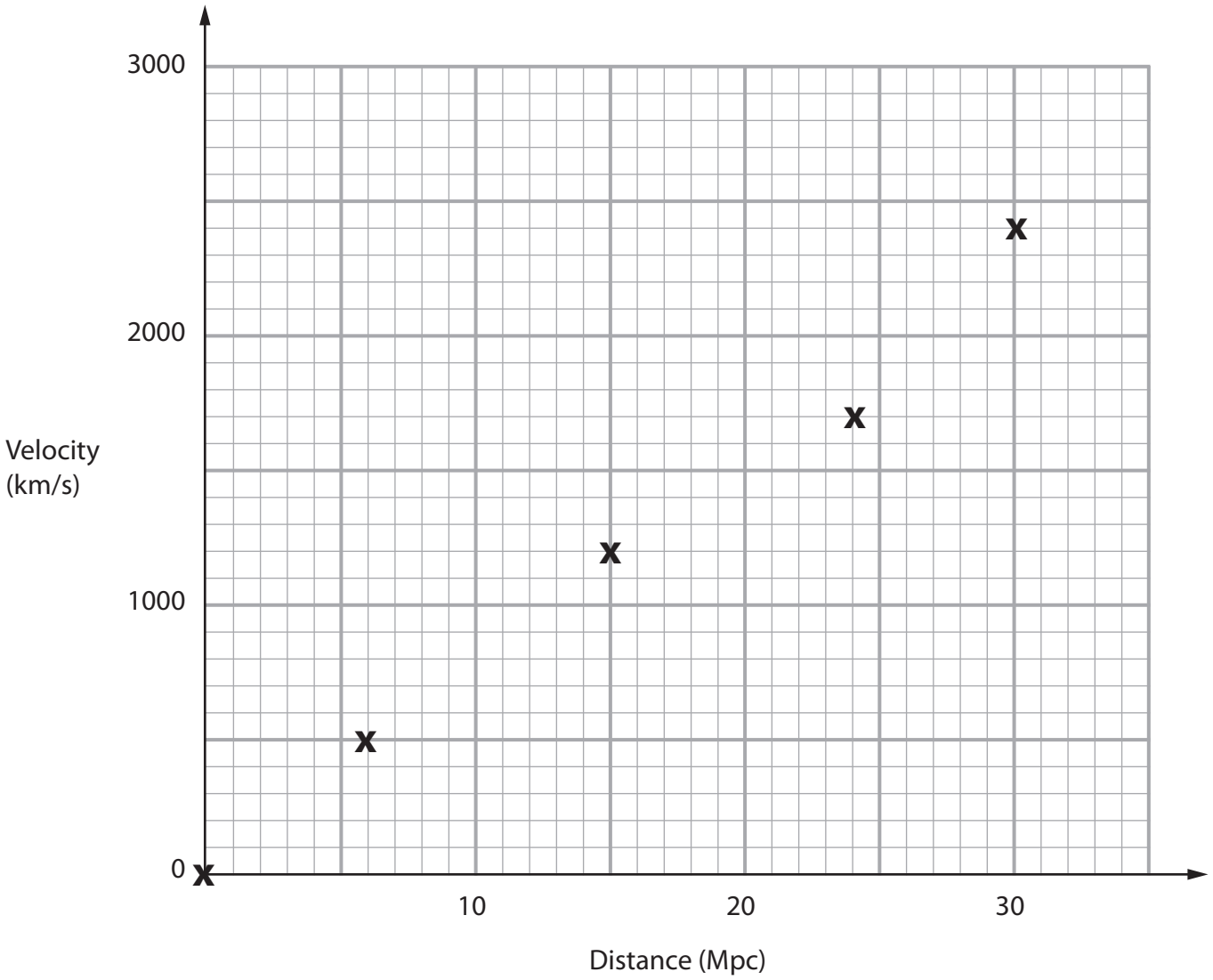

Figure 10

Figure 10 shows a graph of **some** data from Figure 9.

(i) Complete the graph in Figure 10 by plotting the missing data points from Figure 9.

Draw a line of best fit.

(3)

(ii) Calculate the Hubble constant (H_0), using data from Figure 10.

(2)

H_0= ..... km/s/Mpc

(iii) State how the Hubble constant is related to the age of the Universe.

(1)

.....

.....

(Total for Question 7 = 13 marks)

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8 (a) Which **one** of the following is **not** a suitable safe method of observing the Sun?

(1)

- ☒ **A** averted vision
- ☒ **B** H-alpha filter
- ☒ **C** pinhole camera
- ☒ **D** telescopic projection

(b) Draw and clearly label the appearance of a sunspot when observed through a large telescope at a high magnification.

(3)

(c) The angular diameter of the Sun, when observed from the Earth, is 30 minutes of arc (30′).

A sunspot has a diameter of 14 000 km.

Calculate the sunspot's maximum angular diameter when observed from the Earth.

Use information from the Formulae and Data Sheet.

Give your answer in seconds of arc (″).

(3)

Angular diameter = ... seconds of arc (″)

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(d) An astronomer wishes to observe in detail sunspots on the surface of the Sun.

Figure 11 shows some information about four possible telescopes that he could use.

Telescope	Cost (£)	Aperture (cm)	Accessories supplied with the telescope
A	2 000	10	Solar filter. Electric drive to track celestial objects.
B	800	20	Selection of five different eyepieces.
C	2 400	30	Electric drive to track celestial objects. Computerised database to find thousands of objects.
D	1 700	30	H-alpha filter. Finderscope with large field of view.

Figure 11

Evaluate which telescope would be best for the astronomer to use for his detailed observations of sunspots.

(6)

(Total for Question 8 = 13 marks)

9 (a) A space telescope measures the light intensity of a star.

Figure 12 shows this star's light intensity at different wavelengths.

The star is spectral type A.

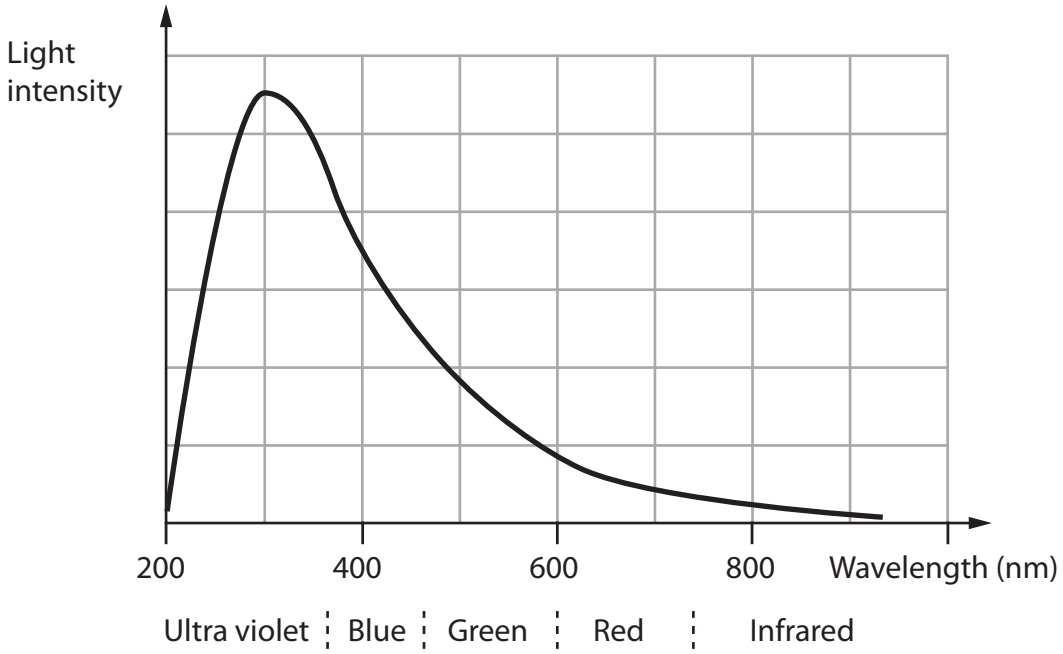

Figure 12

Analyse Figure 12 in order to determine:

(i) the wavelength at which the light intensity is a maximum.

(1)

.....

(ii) the colour that the star would appear to the unaided eye.

(1)

.....

(b) A ground-based telescope also measures the light intensity of the same star. Figure 13 shows these data. Some of this light has been absorbed.

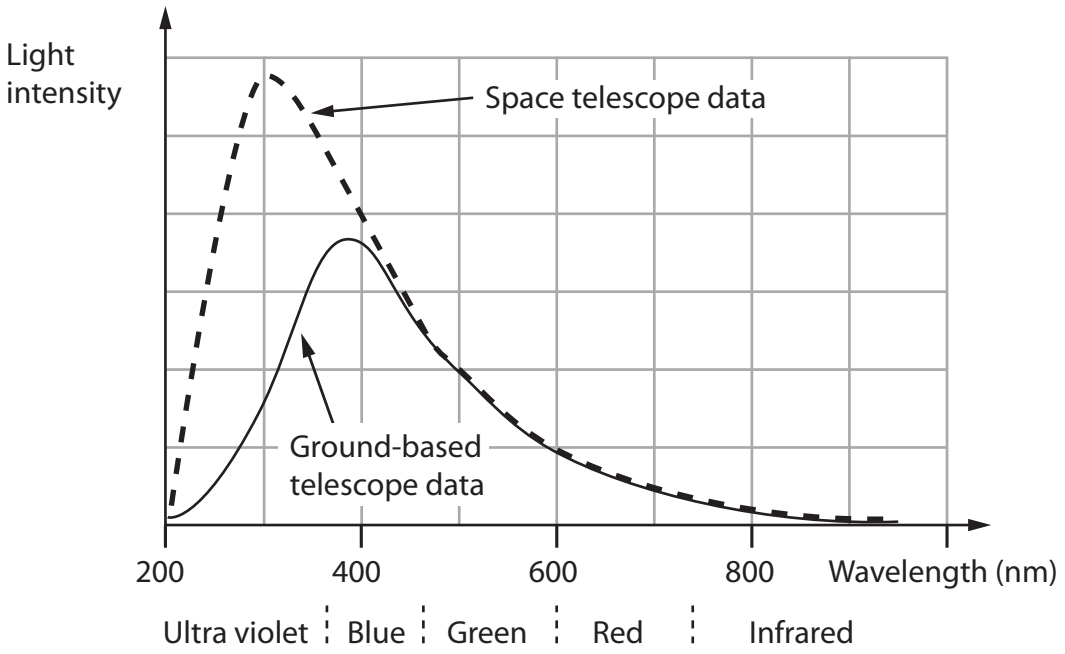

Figure 13

(i) Where in the spectrum is the greatest absorption?

(1)

- ☒ **A** blue
- ☒ **B** green
- ☒ **C** infrared
- ☒ **D** ultraviolet

(ii) State **one** cause of the light absorption shown in Figure 13.

(1)

.....

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(iii) An astronomer using the ground-based telescope estimates the star's spectral type **incorrectly**.

Analyse Figure 13 to explain why this has happened.

(3)

(c) Astronomers can classify a star's spectral type by studying the absorption lines that are present in its spectrum.

Figure 14 shows some of the main absorption lines in the spectra of stars of several spectral types.

Spectral type	Main absorption lines	Sketch of spectrum
O	Helium	
B	Hydrogen	
G	Metals, e.g. sodium	
M	Molecules	

Figure 14

Identify the main absorption lines for the following:

(i) a star that appears red in colour

(1)

- ☒ **A** Helium
- ☒ **B** Hydrogen
- ☒ **C** Metals, e.g. sodium
- ☒ **D** Molecules

(ii) a star that has the highest surface temperature

(1)

- ☒ **A** Helium
- ☒ **B** Hydrogen
- ☒ **C** Metals, e.g. sodium
- ☒ **D** Molecules

(iii) a star that has a surface temperature of 5800 K

(1)

- ☒ **A** Helium
- ☒ **B** Hydrogen
- ☒ **C** Metals, e.g. sodium
- ☒ **D** Molecules

(iv) Figure 15 shows a sketch of the spectrum obtained from a star.

Figure 15

The spectra of four spectral types of stars are shown in Figure 14.

Identify which spectral type most closely matches the spectrum in Figure 15.

(1)

.....

(d) Figure 16 shows three absorption lines in a star's spectrum, labelled A, B and C.

This spectrum becomes blueshifted.

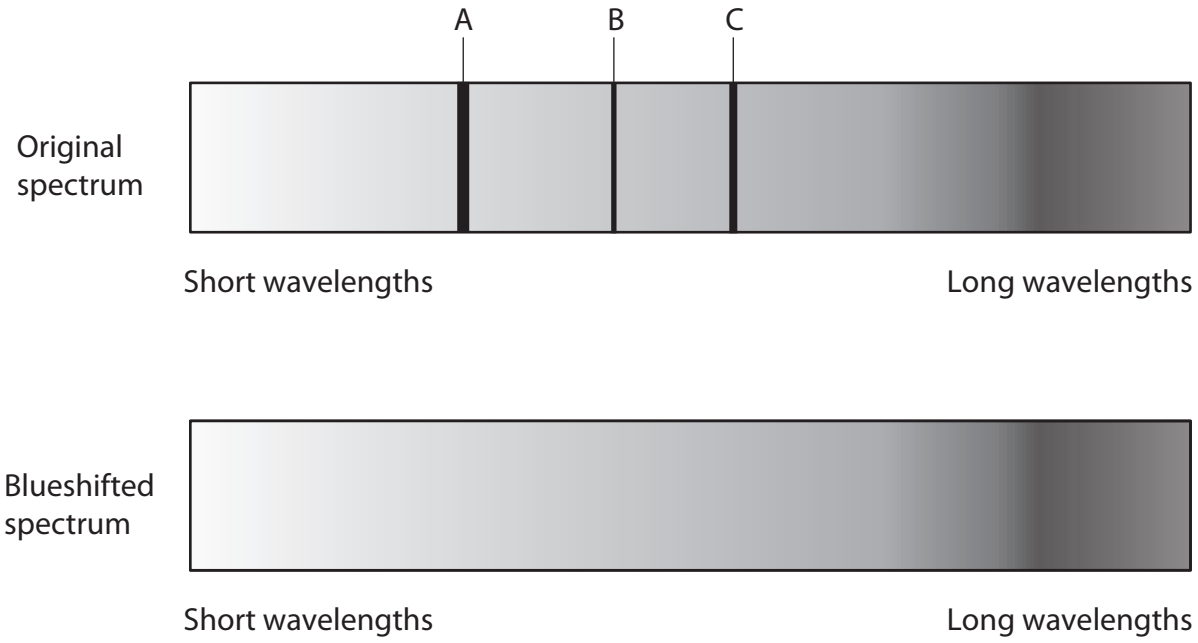

Figure 16

Complete Figure 16 by drawing the blueshifted position of the three absorption lines A, B and C.

Use the labels **A**, **B** and **C**.

(2)

(Total for Question 9 = 13 marks)

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10 Figure 17 shows a sketch of part of the Hertzsprung-Russell diagram.

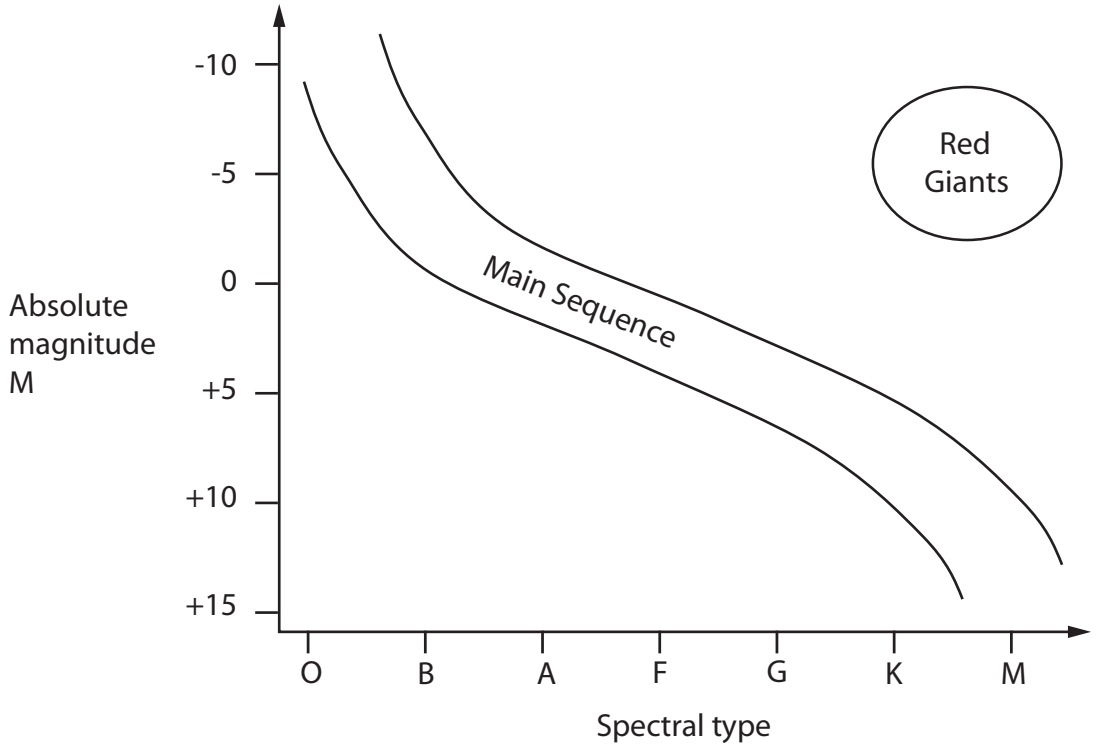

Figure 17

(a) Label on Figure 17 the position of:

(i) the Sun. Use the label **S**.

(1)

(ii) a **high mass** Main Sequence star. Use the label **H**.

(1)

(b) An astronomer has stated the following:

'If I first measure the spectral type of a star, it will then be possible to determine the star's distance using the Hertzsprung-Russell diagram shown in Figure 17.'

Evaluate the astronomer's method for measuring a star's distance.

Your answer should include:

- how the astronomer would calculate the star's distance using the Hertzsprung-Russell diagram
- any problems associated with this method and how they could be overcome.

(6)

(c) (i) Heliocentric parallax can be used to measure the distance to a star.

Explain why heliocentric parallax cannot be used to measure the distance to a galaxy.

(2)

.....

.....

.....

.....

(ii) Barnard's Star in the constellation of Ophiuchus is 6.0 light years from Earth.

Calculate the angle through which Barnard's Star will appear to move over a six-month period due to heliocentric parallax.

Show clearly the steps in your calculation.

Give your answer in seconds of arc (").

(3)

Angle ..... seconds of arc (″)

(Total for Question 10 = 13 marks)

TOTAL FOR PAPER = 100 MARKS

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