



GuideMyGrades

— YOUR GOALS. OUR EXPERTISE. —

EDEXCEL INTERNATIONAL GCSE PHYSICS: QUESTIONS BY TOPIC

Astrophysics (8)

IGCSE Physics Topic 8

33 questions · 247 marks · Mark schemes included

Pearson Edexcel International GCSE (9-1) Physics 4PH1, Papers 1P/1PR & 2P/2PR, 2019-2025

 guidemygrades.com

 [@Guidemygrades](https://www.instagram.com/Guidemygrades)

 [@Guidemygrades](https://twitter.com/Guidemygrades)

 [@Guidemygrades](https://www.youtube.com/Guidemygrades)

 info@guidemygrades.com

 Piccadilly Business Centre, Unit C, Aldow Enterprise Park
Blackett Street, Manchester, M12 6AE

HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic and run from the lowest mark tariff to the highest within each one.

Click any row below to jump straight to that sub-topic or question.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

QUESTION	SOURCE	MARKS	PAGE
8.1 MOTION IN THE UNIVERSE: GRAVITY AND ORBITS		11 Qs · 79 marks	4
1. Q1	Paper 2P June 2019	3	5
2. Q3	Paper 1PR January 2021	5	6
3. Q1	Paper 1P June 2024	5	7
4. Q12	Paper 1P January 2020	7	8
5. Q1	Paper 1PR November 2020	7	10
6. Q2	Paper 1PR June 2023	7	12
7. Q11	Paper 1PR June 2023	7	14
8. Q1	Paper 1PR June 2019	10	16
9. Q8	Paper 1P November 2021	10	18
10. Q11	Paper 1P November 2020	11	20
11. Q8	Paper 1PR June 2025	7	22
8.2 STELLAR EVOLUTION AND THE HERTZSPRUNG-RUSSELL DIAGRAM		16 Qs · 126 marks	24
12. Q4	Paper 1PR January 2020	5	25
13. Q6	Paper 2P January 2021	5	26
14. Q1	Paper 1P June 2021	5	28
15. Q1	Paper 2P June 2024	5	30
16. Q1	Paper 2PR June 2024	5	32
17. Q4	Paper 2PR June 2019	6	34
18. Q1	Paper 1P January 2021	6	36
19. Q6	Paper 2P January 2020	7	37
20. Q3	Paper 1P November 2020	7	38
21. Q1	Paper 2P June 2021	7	39
22. Q4	Paper 1P June 2024	9	41
23. Q4	Paper 1PR June 2024	9	43
24. Q4	Paper 1PR November 2020	10	45
25. Q6 <i>also Topic 2</i>	Paper 1P June 2019	12	47
26. Q8	Paper 2PR June 2023	15	49
27. Q2	Paper 1P June 2025	13	53
8.3 COSMOLOGY, RED-SHIFT AND THE BIG BANG		6 Qs · 42 marks	56
28. Q1	Paper 2P November 2021	5	57
29. Q7	Paper 2P June 2019	6	58
30. Q6	Paper 2PR January 2021	6	59



QUESTION		SOURCE	MARKS	PAGE
31.	Q8	Paper 2PR November 2020	7	60
32.	Q8	Paper 2P June 2025	8	61
33.	Q6 <i>also Topic 3</i>	Paper 2PR June 2025	10	63



QUESTIONS

33 questions · 247 marks · 3 sub-topics



SUB-TOPIC 8.1

MOTION IN THE UNIVERSE: GRAVITY AND ORBITS

Sub-topic 8.1 · 11 questions · 79 marks · lowest tariff first



1 (a) Which force is responsible for keeping satellites in orbit?

(1)

- ☐ A electrostatic
- ☐ B gravitational
- ☐ C magnetic
- ☐ D nuclear

(b) Which of these is the largest?

(1)

- ☐ A galaxy
- ☐ B planet
- ☐ C star
- ☐ D universe

(c) Which of these represents the brightness of stars at a standard distance?

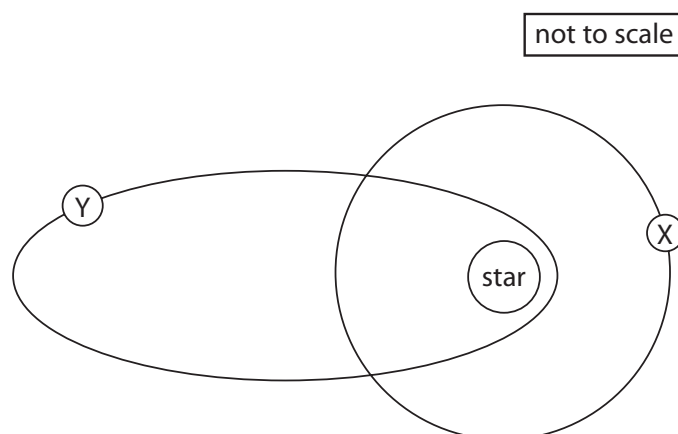
(1)

- ☐ A absolute magnitude
- ☐ B colour
- ☐ C diameter
- ☐ D temperature

(Total for Question 1 = 3 marks)



3 The diagram shows two objects orbiting a star.



(a) Object X has a circular orbit around the star.

State the type of object that has a circular orbit around a star.

(1)

(b) Object Y has an elliptical orbit around the star.

State the type of object that has an elliptical orbit around a star.

(1)

(c) Object X completes an orbit of the star in 35 days.

The radius of its orbit is 1.5×10^{11} m.

Calculate the orbital speed of object X.

(3)

orbital speed = ... m/s

(Total for Question 3 = 5 marks)



1 This question is about the motion of objects in the solar system.

(a) (i) Draw a labelled diagram showing the Moon orbiting the Earth.

(2)

(ii) Give the name of the force that causes the Moon to orbit the Earth.

(1)

(iii) Give the name of another object that orbits the Earth.

(1)

(b) A planet and a comet both orbit a star.

Give a difference between the orbit of a planet and the orbit of a comet.

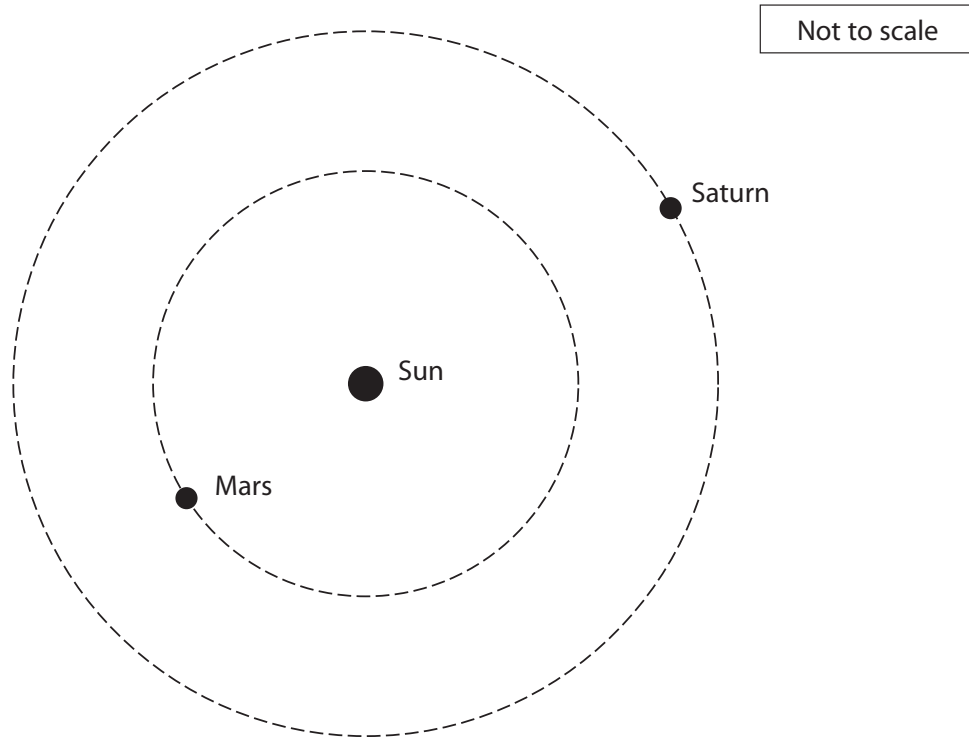
(1)

(Total for Question 1 = 5 marks)



12 The planets Mars and Saturn orbit around the same star, the Sun.

(a) The diagram shows the orbital paths of Mars and Saturn.



Draw an orbital path of a comet on the diagram.

(2)

(b) The table gives some information about the orbits of Mars and Saturn.

	Mars	Saturn
Orbital radius in km	2.28×10^8	1.43×10^9
Orbital speed in km/s	24.1	9.70

Mars completes a number of orbits in the time it takes for Saturn to complete one orbit.

Calculate the number of orbits that Mars completes in the time it takes for Saturn to complete one orbit.

(5)

number of orbits = ...

(Total for Question 12 = 7 marks)



1 This question is about astrophysics.

(a) Complete the sentences by writing a suitable word or phrase in each blank space.

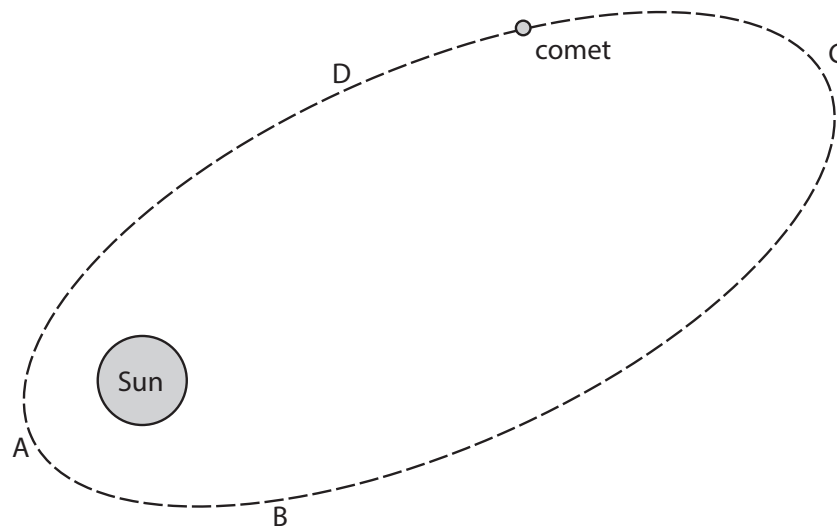
(3)

Space and all the galaxies in it is called the

A large collection of billions of stars is called a

The Sun and its collection of planets and moons is called the

(b) The diagram shows the orbit of a comet around the Sun.



(i) At which point in its orbit is the comet moving fastest?

(1)

☐ A

☐ B

☐ C

☐ D

(ii) Name the force that keeps the comet in orbit around the Sun.

(1)

(c) The boxes give some units of time and some definitions.

Draw a straight line from each unit of time to its correct definition.

(2)

Unit of time

Definition

1 day

1 year

• the time for the Moon to orbit the Earth

• the time for the Earth to rotate once

• the time for the Sun to rotate once

• the time for the Earth to orbit the Sun

(Total for Question 1 = 7 marks)



2 The photograph shows the International Space Station (ISS) in orbit around the Earth.



(Source: © Dima Zel/Shutterstock)

(a) The ISS orbits the Earth in a circular orbit.

Which of these also orbits the Earth?

(1)

- ☐ A a comet
- ☐ B Mars
- ☐ C the Moon
- ☐ D the Sun

(b) Which of these forces causes the ISS to orbit the Earth?

(1)

- ☐ A air resistance
- ☐ B electrostatic
- ☐ C friction
- ☐ D gravitational

(c) The ISS completes one orbit of the Earth in a time period of 93 minutes.

(i) The orbital radius of the ISS is 6.8×10^3 km.

Calculate the orbital speed of the ISS in km/s.

(3)

orbital speed = ... km/s

(ii) Show that the ISS completes approximately 15 orbits of the Earth each day.

(2)

(Total for Question 2 = 7 marks)



11 The gravitational field strength of a planet decreases with increasing distance from the planet.

The table shows the value of the gravitational field strength of Mars at different distances from the centre of Mars.

Distance from centre of Mars in km	Gravitational field strength in N / kg
4000	2.66
5000	1.70
6000	1.18
7000	0.87
8000	0.67
9000	0.53

(a) A student finds this formula in a textbook, which links distance from the centre of a planet to its gravitational field strength

$$\text{gravitational field strength} \times \text{distance}^2 = \text{constant}$$

Use data from the table to justify this formula.

(4)

(b) Olympus Mons is the tallest mountain on Mars.

The distance between the centre of Mars and the peak of Olympus Mons is 3410 km.

Calculate the gravitational field strength at the peak of Olympus Mons.

(3)

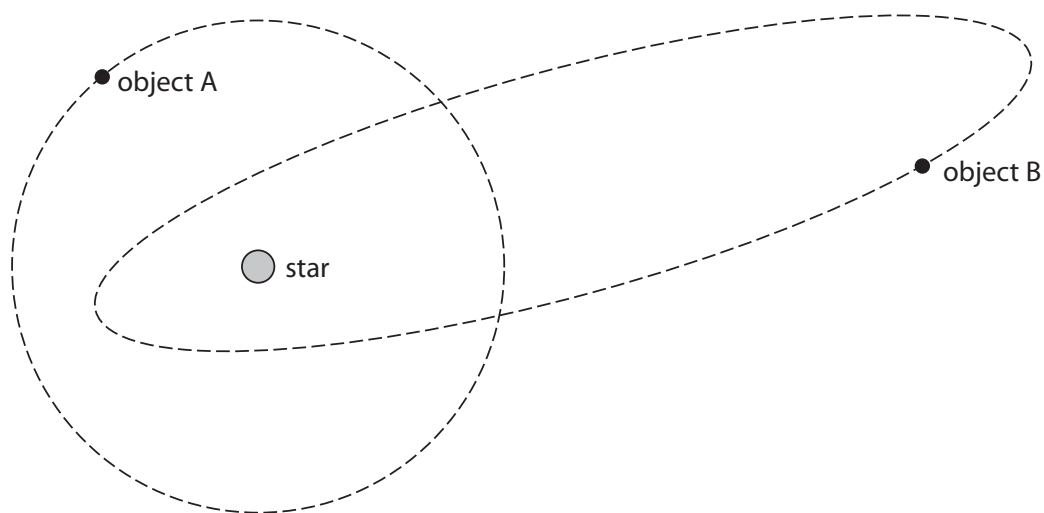
gravitational field strength = ... N/kg

(Total for Question 11 = 7 marks)



1 This question is about stars.

(a) The diagram shows the orbits of two astronomical objects around a star.



(i) Add a labelled arrow to the diagram to show the type of force from the star acting on object A.

(2)

(ii) What is object A?

(1)

☐ **A** a comet

☐ **B** a galaxy

☐ **C** a moon

☐ **D** a planet

(iii) What is object B?

(1)

☐ **A** a comet

☐ **B** a galaxy

☐ **C** a moon

☐ **D** a planet

(b) State the name given to a large collection of billions of stars.

(1)

(c) Physicists classify stars according to their colour.

Each group of stars of similar colour is called a spectral class.

The table gives information about colour and surface temperature for three spectral classes of stars.

The Sun belongs to spectral class G.

Spectral class	Colour	Surface temperature in kelvin
B	blue-white	
G	yellow	5600
M	orange-red	

Complete the table by suggesting values for the missing surface temperatures.

(2)

(d) There are stars in the universe with masses much greater than the mass of the Sun.

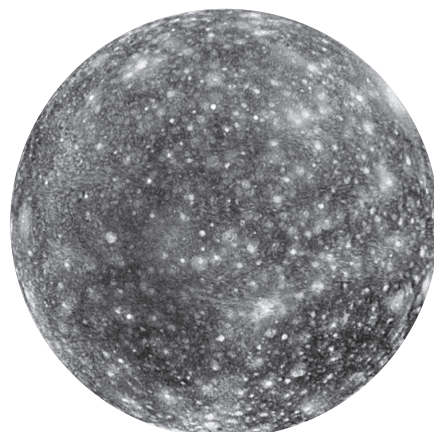
Describe what happens to these high-mass stars when they leave the main sequence stage of their evolution.

(3)

(Total for Question 1 = 10 marks)



- 8 The photograph shows Callisto, a moon of the planet Jupiter.



(Source: © Elena11/Shutterstock)

- (a) In the space below, draw a labelled diagram to show how Callisto orbits Jupiter.

(2)

- (b) Callisto orbits Jupiter at an orbital radius of 1 880 000 km and with an orbital period of 400 hours.

Calculate the orbital speed of Callisto in km/s.

Give your answer to 3 significant figures.

(4)

orbital speed = ... km/s

- (c) Callisto has a gravitational field strength of 1.2 N/kg at its surface.

The Earth's moon has a gravitational field strength of 1.6 N/kg at its surface.

- (i) Callisto has a larger mass than the Earth's moon.

Suggest why Callisto has a lower gravitational field strength than the Earth's moon.

(1)

.....

.....

.....

- (ii) An object has a weight of 59 N on the surface of the Earth's moon.

Calculate the weight of the same object if it were on the surface of Callisto.

(3)

weight = ... N

(Total for Question 8 = 10 marks)



11 This question is about satellites and their orbits.

(a) (i) State a difference between an artificial satellite's orbit and a planet's orbit.

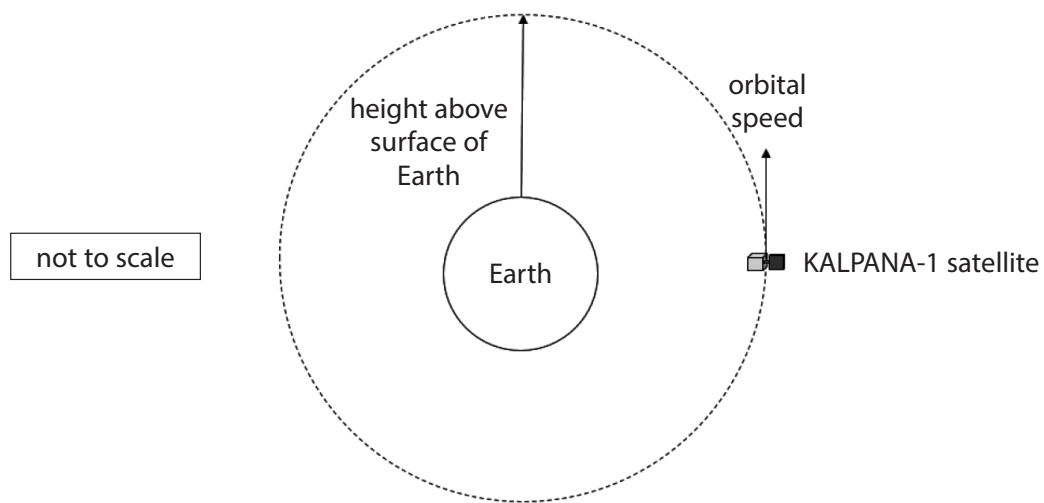
(1)

(ii) State a similarity between an artificial satellite's orbit and a moon's orbit.

(1)

(b) KALPANA-1 was an artificial satellite used to monitor the weather.

(i) The diagram shows the orbit of the satellite.



KALPANA-1 has an orbital speed of 3.1 km/s and completes one orbit in 24 hours.

Calculate the height of KALPANA-1's orbit above the Earth's surface.

[radius of Earth = 6400 km]

(4)

height above surface = ... km



- (ii) The Doppler effect occurs when there is relative motion between the source of waves and the observer of the waves.

Explain how the Doppler effect causes a change in the observed frequency of the waves.

(3)

- (iii) Suggest why the radio waves from KALPANA-1 detected on the Earth's surface are **not** affected by the Doppler effect.

(2)

(Total for Question 11 = 11 marks)



8 This is a question about the Solar System.

(a) Give the name of the galaxy the Solar System is in.

(1)

(b) Neptune is a planet in the Solar System.

(i) Triton is a moon that orbits the planet, Neptune.

Draw a diagram to show the orbit of Neptune and the orbit of Triton in the Solar System.

(2)



- (ii) Neptune orbits in the Solar System at an orbital speed of $5.4 \times 10^3 \text{ m/s}$ with an orbital radius of $4.5 \times 10^{12} \text{ m}$.

Pluto is another object in the Solar System. Pluto orbits with a time period of $7.8 \times 10^9 \text{ s}$.

Show that the ratio of the orbital time period of Neptune to the orbital time period of Pluto is 2 : 3

(4)

(Total for Question 8 = 7 marks)



SUB-TOPIC 8.2

STELLAR EVOLUTION AND THE HERTZSPRUNG-RUSSELL DIAGRAM

Sub-topic 8.2 · 16 questions · 126 marks · lowest tariff first



4 Betelgeuse is a red supergiant star.

Betelgeuse has a mass that is much larger than the Sun.

Describe the evolution of Betelgeuse through its entire life cycle.

(5)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

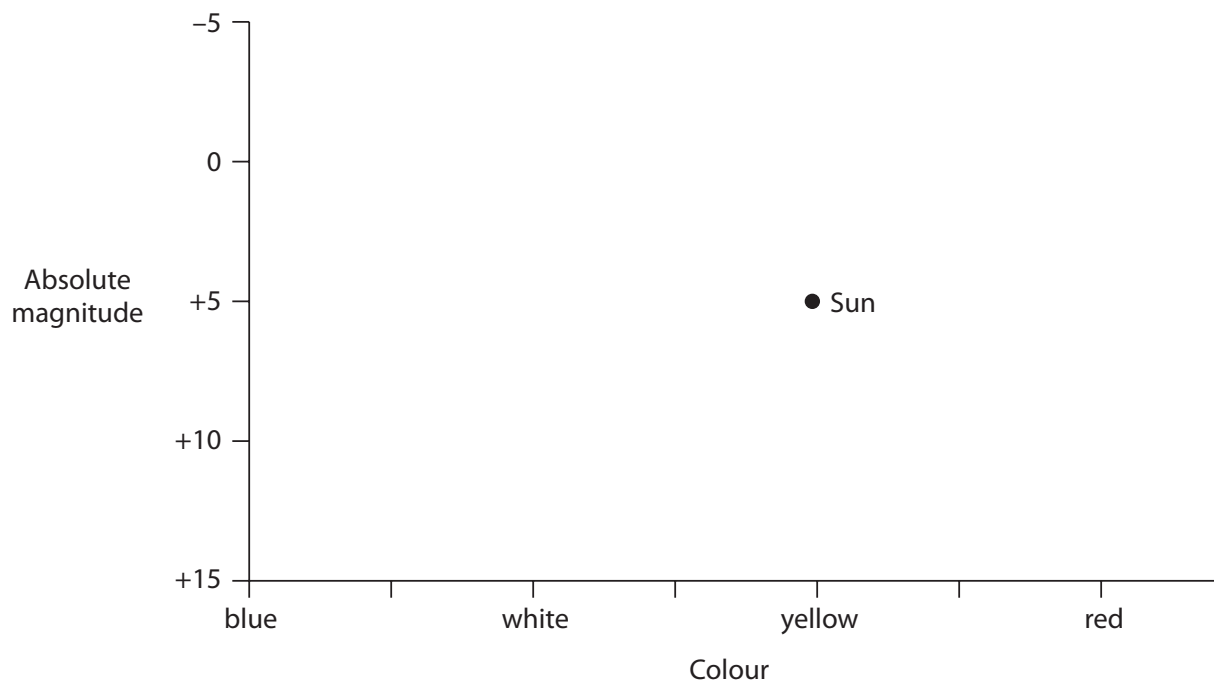
.....

.....

.....

(Total for Question 4 = 5 marks)

- 6 The Hertzsprung-Russell diagram shows the relationship between the absolute magnitude and colour of stars.



The position of the Sun is shown on the Hertzsprung-Russell diagram.

- (a) Star W is a white dwarf.

Add a W to the Hertzsprung-Russell diagram to show the position of star W.

(1)

- (b) Star X is a red giant.

Add an X to the Hertzsprung-Russell diagram to show the position of star X.

(1)

- (c) Star Y is a main sequence star that is much larger than the Sun.

Add a Y to the Hertzsprung-Russell diagram to show the position of star Y.

(1)

- (d) Star Z has the same surface temperature as the Sun, but would be dimmer than the Sun if it were the same distance away from Earth as the Sun.

Add a Z to the Hertzsprung-Russell diagram to show the position of star Z.

(1)

(e) The Moon is the brightest object in the night sky.

Suggest why the Moon cannot be shown on the Hertzsprung-Russell diagram.

(1)

(Total for Question 6 = 5 marks)



1 (a) (i) Which of these coloured stars has the highest surface temperature?

(1)

- ☐ **A** orange
- ☐ **B** red
- ☐ **C** white
- ☐ **D** yellow

(ii) Which of these is a stage in the life cycle of the Sun?

(1)

- ☐ **A** black hole
- ☐ **B** neutron star
- ☐ **C** supernova
- ☐ **D** white dwarf

(iii) Which of these is the stage nearest the end of the life cycle of a star with a mass much greater than the Sun?

(1)

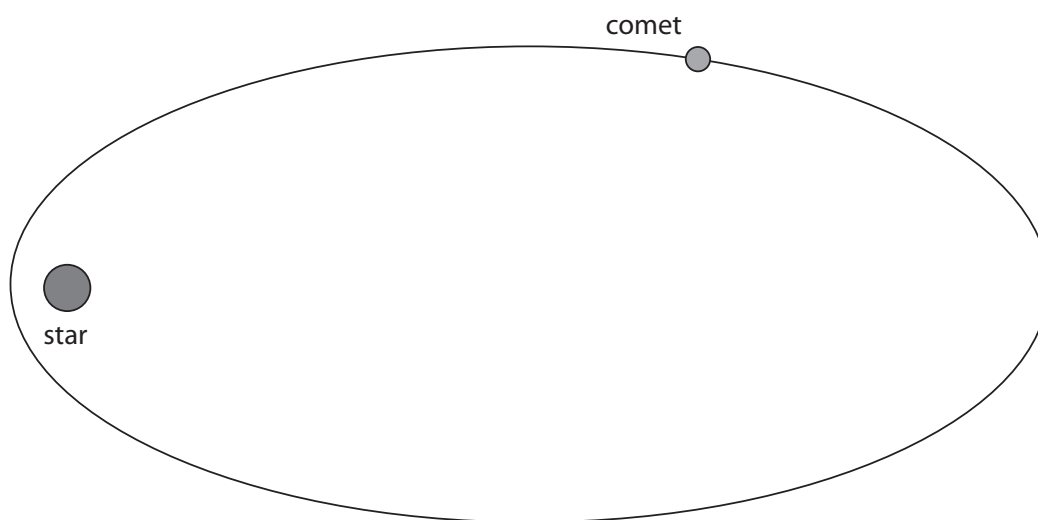
- ☐ **A** main sequence
- ☐ **B** protostar
- ☐ **C** supernova
- ☐ **D** white dwarf

(b) The diagram shows the orbit of a comet around a star.

Draw a labelled arrow to show the force acting on the comet due to the star.

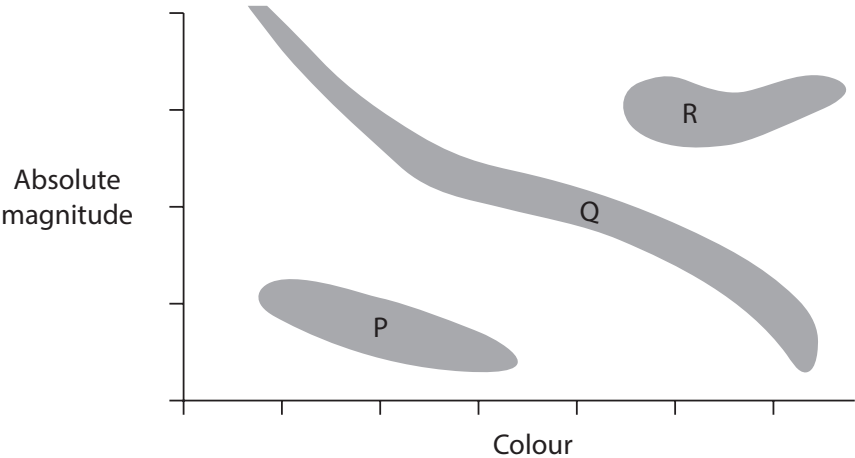
(2)

not to scale



(Total for Question 1 = 5 marks)

1 The Hertzsprung-Russell (HR) diagram shown can be used to classify stars.



(a) Three regions in the HR diagram are labelled P, Q and R.

The boxes show the three regions and different astronomical objects.

Draw a straight line from each region to the type of astronomical object contained in that region.

(3)

Region

Astronomical object

P

black hole

main sequence star

nebula

Q

neutron star

red giant star

R

supernova

white dwarf star



(b) Define the term **absolute magnitude**.

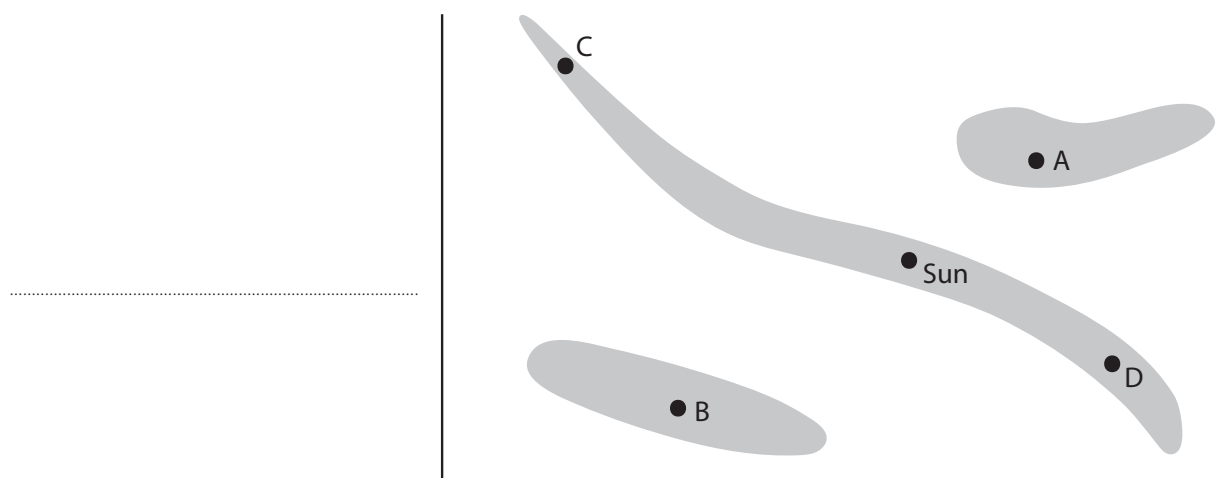
(2)

(Total for Question 1 = 5 marks)



1 This question is about stars.

The diagram shows an incomplete Hertzsprung-Russell (H-R) diagram.



(a) Label the axes on the diagram.

(2)

(b) There are three shaded areas on the diagram.

State the name of the shaded area that contains the Sun.

(1)

(c) Which star is a white dwarf?

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(d) At a standard distance from the Earth, which star is brighter than the Sun and has a greater surface temperature than the Sun?

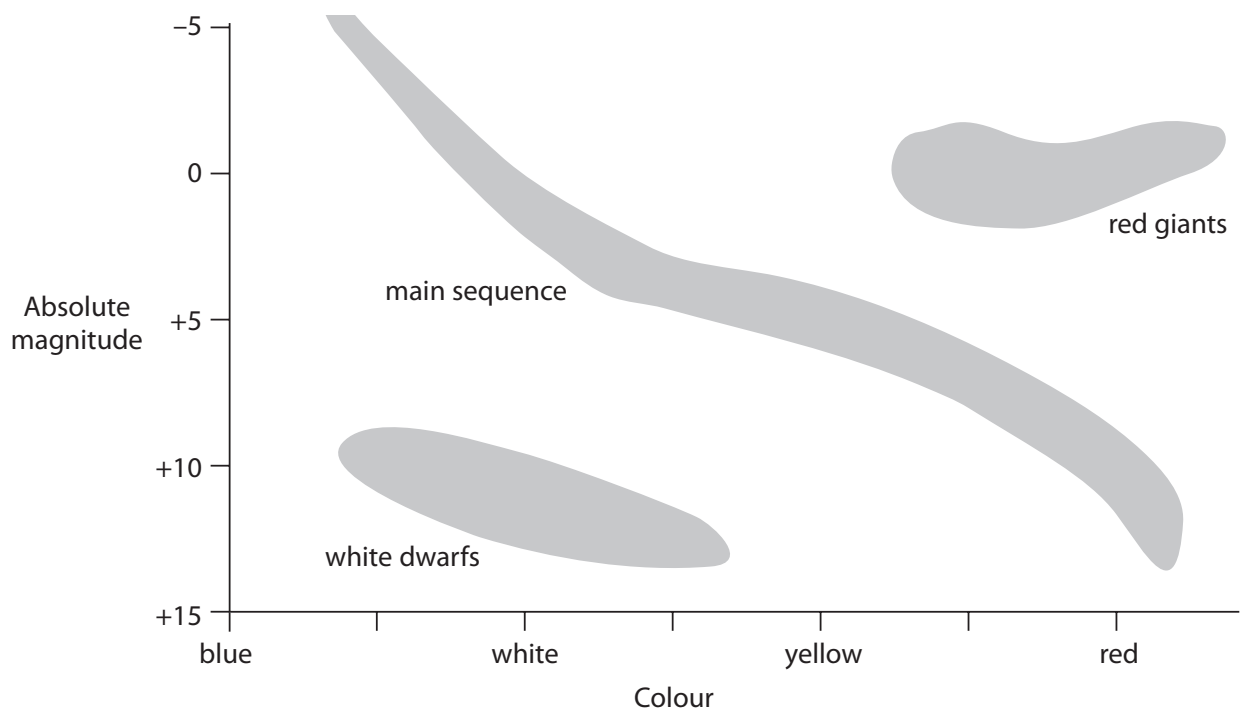
(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(Total for Question 1 = 5 marks)



- 4 A Hertzsprung-Russell diagram shows how different astronomical objects may be classified according to their colour and absolute magnitude.



The diagram shows three stages of evolution for stars of similar mass to the Sun.

Describe the evolution of stars of similar mass to the Sun.

You should refer to the temperature and brightness of the stars in your answer.

(6)

(Total for Question 4 = 6 marks)



- 1 The passage describes the evolution of a star with a mass that is much larger than the mass of the Sun.

Use words or phrases from the box to complete the passage.

Each word or phrase may be used once, more than once, or not at all.

(6)

chemical	contract	expand	gravitational
kinetic	main sequence	neutron star	nuclear
protostar	supernova	vibrate	white dwarf

Hydrogen atoms in a nebula move towards each other due to the force of gravity.

As the atoms move towards each other, their energy store increases, which increases the temperature. If the temperature becomes high enough, nuclear fusion of hydrogen will start and the star enters the stage of its evolution.

When hydrogen fusion stops in the core of the star, the core of the star will start to This increases the temperature in a layer surrounding the core. Hydrogen fusion restarts in a layer surrounding the core.

This causes the star to and its surface temperature decreases. The star is now a red super giant. Eventually nuclear fusion stops in the core of the star and the star explodes as a

The core of the star collapses to form either a or a black hole.

(Total for Question 1 = 6 marks)



6 This question is about stars.

(a) Astronomers measure the absolute magnitude of stars.

State what is meant by the term **absolute magnitude**.

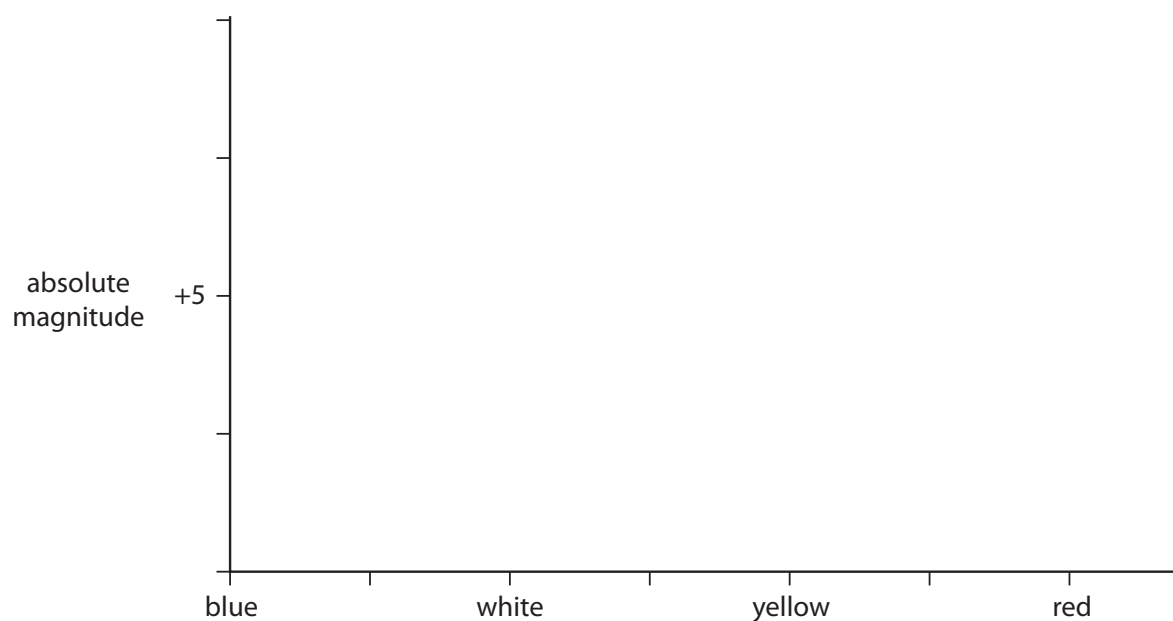
(2)

(b) The evolution of stars can be shown on a Hertzsprung-Russell diagram (HR diagram).

Complete the HR diagram by

- labelling the x-axis
- completing the absolute magnitude scale
- drawing the main sequence, red giant and white dwarf regions

(5)



(Total for Question 6 = 7 marks)

3 This question is about stars.

(a) Describe the stages in the evolution of a star similar in mass to the Sun.

(4)

(b) The process of energy release in the core of a star is different to the process of energy release in a nuclear reactor in a power station.

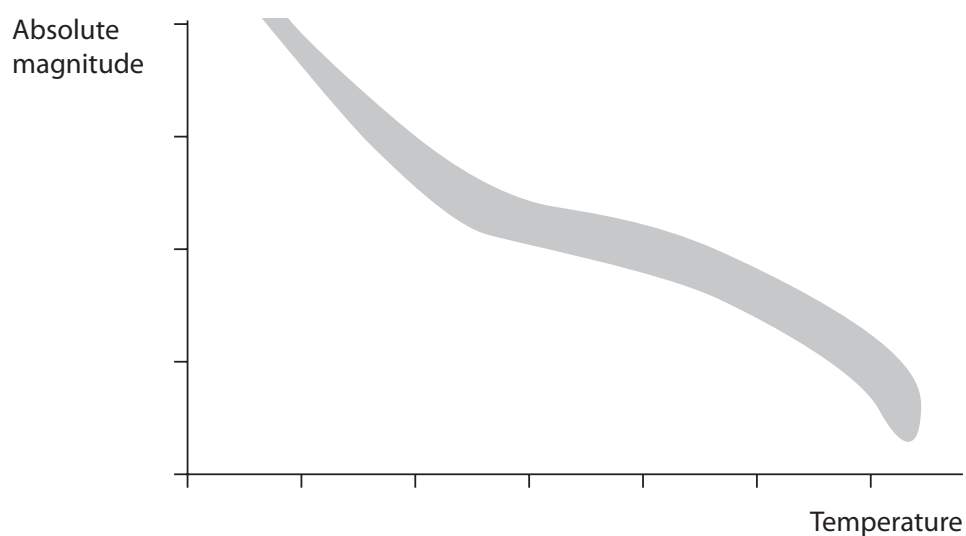
Describe how these processes of energy release are different.

(3)

(Total for Question 3 = 7 marks)



1 (a) This is an incomplete Hertzsprung-Russell diagram.



(i) Which of these is in the shaded area of the diagram?

(1)

- ☐ A black holes
- ☐ B main sequence stars
- ☐ C neutron stars
- ☐ D protostars

(ii) On the diagram, draw the area to show the position of white dwarf stars.

Label this area WD.

(1)

(iii) On the diagram, draw the area to show the position of red giant stars.

Label this area RG.

(1)

(iv) State what is meant by the term **absolute magnitude**.

(2)

.....

.....

.....

.....

(b) The Sun emits various parts of the electromagnetic spectrum.

(i) Which part of the electromagnetic spectrum causes damage to human surface skin cells?

(1)

☐ **A** microwaves

☐ **B** radio waves

☐ **C** ultraviolet

☐ **D** visible light

(ii) Which of these increases the risk of damage to human surface skin cells?

(1)

☐ **A** sunbathing

☐ **B** using protective sun cream

☐ **C** very cloudy weather

☐ **D** wearing sunglasses

(Total for Question 1 = 7 marks)



4 This question is about the evolution of a star.

(a) A main sequence star is created in a collapsing region of a nebula.

The table gives different energy stores for the gases in the collapsing nebula, from when the nebula starts to collapse to just before the main sequence star is created.

Complete the table by placing ticks (✓) to show whether each energy store increases, decreases or stays the same.

(4)

Energy store	Increases	Decreases	Stays the same
chemical			
gravitational potential			
nuclear			
thermal			

(b) At the end of the main sequence stage of a star’s evolution, the star can become a red giant or a red supergiant.

Give the property of a star that determines whether it becomes a red giant or a red supergiant.

(1)



(c) A red giant star eventually becomes a white dwarf star.

Discuss the differences between a red giant star and a white dwarf star.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

(Total for Question 4 = 9 marks)



- 4 This question is about the Sun.
- (a) The table shows the different stages in the evolution of stars of different masses.
- Complete the table by adding ticks (✓) to show which stages of evolution occur in the life cycle of the Sun.

(4)

Stage of evolution	Occurs in the life cycle of the Sun
black hole	
main sequence	
nebula	
neutron star	
red giant	
red supergiant	
supernova	
white dwarf	

- (b) When viewed from Earth, the surface of the Sun is yellow in colour.
- The surface of another star, Betelgeuse, is red in colour.
- Explain the difference between the Sun and Betelgeuse, based on the different colours of their surfaces.

(2)

(c) The Sun transfers energy to the Earth by radiation.

- (i) Give a reason why energy is not transferred from the Sun to the Earth by conduction or convection.

(1)

- (ii) A satellite orbiting the Earth contains sensitive equipment that can be damaged if it gets too hot.

Explain which colour would be most appropriate for the outer surface of the satellite to protect the equipment.

(2)

(Total for Question 4 = 9 marks)



4 This question is about Rigel, a very large star with a high surface temperature.

(a) Stars can appear as different colours because of their different surface temperatures.

Which of these colours shows the highest surface temperature for a star?

(1)

- ☐ A blue-white
- ☐ B orange
- ☐ C red
- ☐ D yellow

(b) Describe how a star is formed in a nebula.

(2)

.....

.....

.....

.....

.....

.....

(c) Rigel is a main sequence star.

A star joins the main sequence when nuclear fusion of hydrogen starts in its core.

Describe the process of nuclear fusion in a star.

(3)

.....

.....

.....

.....

.....

.....

(d) Astronomers think that Rigel will become a supernova in the future.

(i) Which property of a star determines whether it will become a supernova?

(1)

- ☐ A colour
- ☐ B distance from Earth
- ☐ C mass
- ☐ D temperature

(ii) Describe the evolution of Rigel after it leaves the main sequence.

(3)

.....

.....

.....

.....

.....

.....

(Total for Question 4 = 10 marks)

- 6 (a) (i) A student investigates how current varies with voltage for a metal filament lamp.

Draw a diagram of the circuit that a student could use for this investigation.

(4)

- (ii) Describe a method the student could use for their investigation.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(b) The student extends the investigation by recording additional data for the lamp.

This is her method.

For each voltage

- switch the current on for 45 seconds
- record the current and colour of the lamp
- calculate the power and the energy transferred by the lamp

The table shows the student's results.

Voltage in V	Current	Power in W	Energy in J	Colour of lamp
0.0	0.00	0.0	0.0	off
2.0	0.40	0.8	36	red
4.0	0.90	3.6		orange
6.0	1.60	9.6	430	yellow
8.0	2.80	22.4	1000	white

(i) State the unit for current.

(1)

(ii) Calculate the missing value of energy for the voltage of 4.0 V.

Give your answer to 2 significant figures.

(2)

energy = ... J

(iii) The colour of a star is related to its surface temperature.

The Sun is yellow.

Use the student's results to identify a colour for a star that is cooler than the Sun.

(1)

(Total for Question 6 = 12 marks)



8 This question is about stars.

(a) The table gives some information about four stars.

Star	Mass in solar masses	Colour	Absolute magnitude
A	0.7	orange	+7.5
B	1.0	yellow	+4.8
C	2.0	blue	+1.4
D	17.1	blue	−16.8

(i) Star C is much more powerful than star A.

Stars A and C appear to have the same brightness when viewed from Earth.

Suggest how this is possible.

(1)

.....

.....

.....

(ii) Using information from the table, explain which star is in the supernova stage of its evolution.

(3)

.....

.....

.....

.....

.....

.....

(b) Explain how a main sequence star evolves into a supernova.

(3)



(c) Astronomers have used supernovas in distant galaxies to investigate the expansion of the universe.

- (i) Light emitted from a supernova at a wavelength of $7.774 \times 10^{-7} \text{ m}$ was detected at Earth with a wavelength of $7.780 \times 10^{-7} \text{ m}$.

Calculate the speed at which the galaxy containing this supernova was moving away from the Earth.

[speed of light = $3.0 \times 10^8 \text{ m/s}$]

(4)

speed = ... m/s



- (ii) The astronomers investigated supernovas that showed a red-shift in the wavelengths detected in different galaxies.

The astronomers discovered that the red-shifted light detected from supernovas in nearby galaxies had shorter wavelengths than the red-shifted light detected from supernovas in galaxies further away.

Explain how this discovery supports the Big Bang theory.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

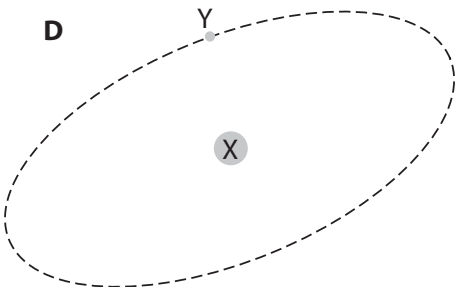
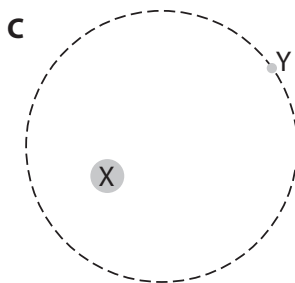
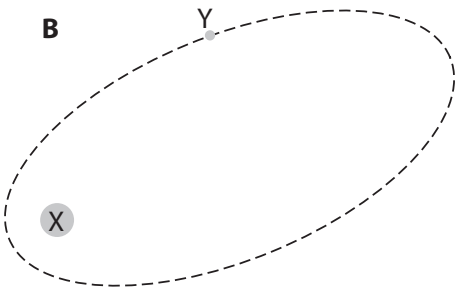
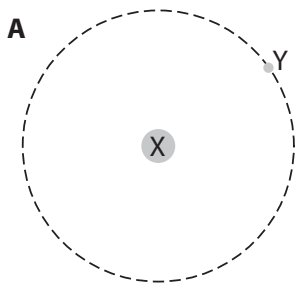
.....

.....

(Total for Question 8 = 15 marks)



- 2 This question is about astrophysics.
- (a) Diagrams A, B, C and D show different orbital paths for object Y orbiting object X.



- (i) Table 1 gives some possible names for object X and object Y.
- Complete the table by placing **one** tick (✓) in each row to show which orbital path is correct for each combination of object X and object Y.
- Each orbital path may be used once, more than once, or not at all.

(3)

Object X	Object Y	Orbital path			
		A	B	C	D
the Earth	the Moon				
the Sun	a comet				
the Sun	the Earth				

Table 1



(ii) Give the name of the force that causes one object to orbit another object in space.

(1)

(b) Table 2 gives information about four different stars in the same galaxy as the Sun.

Star	Colour	Evolutionary stage
Antares	red	red supergiant
Capella	yellow	main sequence
Sirius B	white	white dwarf
Vega	blue-white	main sequence

Table 2

(i) Give the name of the galaxy that contains the Sun and the stars shown in table 2.

(1)

(ii) Explain how the stars in table 2 can be classified according to their colour.

(3)



(iii) Describe the likely future evolution of Antares.

(3)

(iv) Describe what additional information is needed to predict the next evolutionary stage for Vega.

(2)

(Total for Question 2 = 13 marks)

SUB-TOPIC 8.3

COSMOLOGY, RED-SHIFT AND THE BIG BANG

Sub-topic 8.3 · 6 questions · 42 marks · lowest tariff first



1 This question is about astrophysics.

(a) The table lists some statements about the universe.

Place ticks (✓) in the table to show which statements support the Big Bang theory.

(2)

Statement	Supports the Big Bang theory
black holes are formed from extremely massive stars	
cosmic microwave background radiation is detected in all directions	
cosmic rays from space are detected at the Earth's surface	
each galaxy contains billions of stars	
most galaxies show a red-shift in the light detected from them	

(b) The Sun will become a red giant star when it leaves the main sequence.

Which row correctly describes how the surface temperature and brightness of the Sun will change when it becomes a red giant?

(1)

	Surface temperature	Brightness
☐ A	decreases	decreases
☐ B	decreases	increases
☐ C	increases	decreases
☐ D	increases	increases

(c) Astronomical objects can be classified by their absolute magnitude.

State what is meant by the term **absolute magnitude**.

(2)

.....

.....

.....

.....

(Total for Question 1 = 5 marks)



7 (a) Give two pieces of evidence for the Big Bang theory.

(2)

(b) Explain how this evidence supports the Big Bang theory.

(4)

(Total for Question 7 = 6 marks)



6 The Big Bang theory describes the evolution of the universe.

- (a) Explain how cosmic microwave background radiation (CMBR) supports the Big Bang theory.

(2)

- (b) Hydrogen gas in a laboratory on Earth emits light with a wavelength of 605 nm.

A distant galaxy contains hydrogen which emits light of the same wavelength.

The wavelength of the light from the distant galaxy is measured as 683 nm on Earth.

Calculate the speed of the distant galaxy.

[speed of light = 3.0×10^8 m/s]

(4)

speed = ... m/s

(Total for Question 6 = 6 marks)



8 The Big Bang theory suggests that the Universe is approximately 14 billion years old.

(a) Describe the evolution of the Universe from the Big Bang until the present day.

(3)

(b) Describe the evidence that supports the Big Bang theory.

(4)

(Total for Question 8 = 7 marks)



8 This question is about cosmology.

(a) Give two pieces of evidence that support the Big Bang theory.

(2)

1

.....

2

.....

(b) The galaxy NGC 300 is moving away from the Earth at a speed of 1.44×10^5 m/s.

Hydrogen atoms in NGC 300 emit light with a reference wavelength of 4.3405×10^{-7} m.

Calculate the wavelength of this light when it is detected at Earth.

Give your answer to five significant figures.

[speed of light in a vacuum, $c = 3.00 \times 10^8$ m/s]

(4)

wavelength = ... m



(c) Another galaxy, Centaurus A, is much further away from the Earth than NGC 300.

Explain how the wavelength of light detected from hydrogen atoms in Centaurus A is different from the wavelength of light detected from hydrogen atoms in NGC 300.

(2)

(Total for Question 8 = 8 marks)



6 This question is about cosmic microwave background radiation (CMBR) and the Big Bang.

(a) CMBR has a mean frequency of 1.6×10^{11} Hz.

(i) State the formula linking wave speed, frequency and wavelength.

(1)

(ii) Show that the mean wavelength of CMBR is about 2 mm.

[speed of light = 3.0×10^8 m/s]

(3)

(b) CMBR was first released after the Big Bang.

When CMBR was first released it had a wavelength of about 9×10^{-5} mm, but now it has a wavelength of about 2 mm.

Using this information, explain how CMBR supports the Big Bang theory.

(2)

.....

.....

.....

.....

.....

.....



(c) Explain how the cosmological red-shift of galaxies also supports the Big Bang theory.

(4)

(Total for Question 6 = 10 marks)



MARK SCHEMES

official mark schemes



Question number	Answer	Notes	Marks
1 (a)	B – gravitational; A is incorrect because there are no charges C is incorrect because there are no magnetic fields D is incorrect because nuclear forces are short range		1
(b)	D – universe; A is incorrect because the universe contains billions of galaxies B is incorrect because each solar system contains several planets C is incorrect because galaxies contain billions of stars		1
(c)	A – absolute magnitude; B is incorrect because colour determines the surface temperature of a star C is incorrect because diameter determines the power of a star D is incorrect because temperature determines the power of a star		1

Question number	Answer	Notes	Marks
3 (a)	planet;		1
(b)	comet;	accept planet	1
(c)	substitution into given formula; conversion of 35 days into seconds; evaluation; e.g. $v = 2 \times \pi \times 1.5 \times 10^{11} / (35 \times 24 \times 60 \times 60)$ $v = 310\,000 \text{ m/s}$	allow full credit for 2.6927937×10^{10} if unit changed to m/day. 311665.93(7)8 Answer for incorrect/no conversion of days → seconds $2.69\text{etc} \times 10^{10}$ scores 2 -1 for POT error	3

(Total for Question 3 = 5 marks)

Question number	Answer	Notes	Marks
1 (a) (i)	labelled diagram showing a moon in circular orbit around Earth; Earth approximately at the centre of the path;	allow planet for Earth judge circular by eye ignore attempts at 3D drawing allow planet for Earth	2
(ii)	gravitational (force);	allow gravity ignore weight, centripetal, centrifugal reject gravitational potential, gravitational field strength	1
(iii)	satellite / space station;	allow other suitable object e.g. (rocket) debris etc. reject comet	1
(b)	planet's orbit is circular/slightly elliptical but comet's orbit is elliptical/oval; OR planet has constant speed but comet has variable speed;	clear comparison needed allow comet orbit is more elliptical ignore references to period/length of orbits allow idea that planet has constant orbital radius but comet has variable orbital radius	1

Total for Question 1 = 5 marks

Question number	Answer	Notes	Marks
12 (a)	comet drawn in orbit around the Sun; orbital path is elliptical;	judge by eye allow partially drawn ellipse Sun need not be at a focus of the ellipse, but should not be at the centre of the ellipse	2
(b)	attempted use of orbital speed formula; valid substitution into orbital speed formula; correct evaluation of time period for either planet; attempt to divide T for Saturn by T for Mars; correct final evaluation of ratio; e.g. $v = 2 \times \pi \times r / T$ $24.1 = 2 \times \pi \times 2.28 \times 10^8 / T$ $T_{\text{Mars}} = 5.94 \times 10^7 \text{ (s)}$ OR $T_{\text{Saturn}} = 9.26 \times 10^8 \text{ (s)}$ $n = T_{\text{Saturn}} / T_{\text{Mars}}$ 15.6	allow for either planet seen anywhere in working $9.70 = 2 \times \pi \times 1.43 \times 10^9 / T$ 5.944... 9.2628... allow range of 15-16	5

Total for Question 12 = 7 marks

Question number	Answer	Notes	Marks
1 (a)	Universe; galaxy Solar System;	allow named galaxy e.g. Milky Way	3
(b) (i)	A; B is incorrect because it is further from the Sun and speed decreases with distance C is incorrect because it is further from the Sun and speed decreases with distance D is incorrect because it is further from the Sun and speed decreases with distance		1
(ii)	gravity;	allow gravitational force, gravitational pull reject gravitational potential, gravitational field strength, g	1
(c)	one mark for each correct line;; Unit of time 1 day 1 year the time for the Moon to orbit the Earth the time for the Earth to rotate once the time for the Sun to rotate once the time for the Earth to orbit the Sun	-1 for each additional line Definition	2

Total for Question 1 = 7 marks

Question number	Answer	Notes	Marks
2 (a)	C (the Moon); A is incorrect because comets orbit stars B is incorrect because Mars orbits the Sun D is incorrect because the Sun orbits in the Milky Way galaxy		1
(b)	D (gravitational); A is incorrect because there is no air in space; B is incorrect because the ISS is not charged; C is incorrect because friction would act in the opposite direction to motion, not towards Earth		1
(c) (i)	substitution into given formula ($v = 2\pi r/T$); conversion of minutes to seconds; evaluation; e.g. orbital speed = $2 \times \pi \times 6.8 \times 10^3 / 93(\times 60)$ 93 minutes = 93×60 (= 5580 seconds) (orbital speed =) 7.7 (km/s)	mark independently -1 for POT errors if km/s changed to m/s unnecessarily	3
(ii)	successful conversion of orbital period and a day into the same unit; evaluation of ratio to 15.48... to at least 3 sf; e.g. 1 day = 24×60 = 1440 minutes $1440/93 = 15.5$	allow 7.656... 459.4, 15.31, 27565, 7.6 scores 2 marks e.g. 1 day = 24 hours = 1440 mins = 86400 seconds, 1 orbit = 0.0645 days = 1.55 hours = 5580 seconds, allow use of number of orbits = distance travelled in 24 hours ÷ circumference of orbit	2

Total for question 2 = 7 marks

Question number	Answer	Notes	Marks																					
11 (a)	substitution into given formula; evaluation of constant; evaluation of constant for a second set of data; conclusion consistent with candidate's evidence; e.g. calculated value of constant doesn't change (much) so formula is justified constant decreases so formula isn't justified <table><tr><th>Distance from centre of Mars in km</th><th>Gravitational field strength in N/kg</th><th>Constant</th></tr><tr><td>4000</td><td>2.66</td><td>42560000</td></tr><tr><td>5000</td><td>1.70</td><td>42500000</td></tr><tr><td>6000</td><td>1.18</td><td>42480000</td></tr><tr><td>7000</td><td>0.87</td><td>42630000</td></tr><tr><td>8000</td><td>0.67</td><td>42880000</td></tr><tr><td>9000</td><td>0.53</td><td>42930000</td></tr></table>	Distance from centre of Mars in km	Gravitational field strength in N/kg	Constant	4000	2.66	42560000	5000	1.70	42500000	6000	1.18	42480000	7000	0.87	42630000	8000	0.67	42880000	9000	0.53	42930000	allow any consistent PoT DOP	4
Distance from centre of Mars in km	Gravitational field strength in N/kg	Constant																						
4000	2.66	42560000																						
5000	1.70	42500000																						
6000	1.18	42480000																						
7000	0.87	42630000																						
8000	0.67	42880000																						
9000	0.53	42930000																						
(b)	rearrangement of given formula; substitution of constant and distance; evaluation; e.g. gravitational field strength = constant / distance² gravitational field strength = 42 700 000 / 3410² gravitational field strength = 3.67 (N/kg)	allow ecf from (a) allow mean constant condone 3.7 allow range of 42 500 000 to 42 900 000 for constant allow range of 3.65-3.69	3																					

Total for Question 11 = 7 marks

Question number	Answer	Notes	Marks
1 (a) (i)	arrow originating at object A and directed towards the star by eye; arrow labelled gravitational (force);	allow weight, gravitational force, pull or force of gravity condone gravity	2
(ii)	D - (a planet); A is incorrect because comets have comets have elliptical orbits B is incorrect because galaxies do not orbit anything C is incorrect because moons orbit planets		1
(iii)	A - (a comet); B is incorrect because galaxies do not orbit anything C is incorrect because moons orbit planets D is incorrect because planets have circular orbits		1
(b)	galaxy;	allow named galaxy e.g. Andromeda, Milky Way ignore universe	1
(c)	spectral class B to have any temperature higher than 5600 K; spectral class M to have any temperature lower than 5600 K;		2
(d)	star becomes a red (super) giant; (then) a supernova; (leaving) a neutron star / black hole;	allow "supergiant" allow pulsar Max 2 for incorrect order	3

Total for Question 1 = 10 marks

Question number	Answer	Notes	Marks
8 (a)	Callisto drawn with a circular orbit around Jupiter; Jupiter positioned at the centre of the orbit;	judge circular shape by eye	2
(b)	conversion of time from hours to seconds; substitution into orbital speed formula; evaluation; final answer given to 3s.f.; e.g. time = $(400 \times 60 \times 60 =) 1\,440\,000$ (s) (orbital speed =) $2 \times \pi \times 1\,880\,000 / 1\,440\,000$ (orbital speed =) 8.203... (km/s) (orbital speed =) 8.20 (km/s)	allow use of 1 440 000 seen anywhere allow ecf from incorrect time conversion mark independently	4
(c) (i)	any one from: MP1. Callisto has a larger radius; MP2. Callisto has a lower density; MP3. Callisto has a smaller core;	allow RA allow Callisto is larger ignore references to orbital radius/distance from Sun	1
(ii)	use of weight = mass $\times$ g; setting up ratio OR evaluation of mass of object; evaluation of weight on Callisto; e.g. $W = m \times g$ $W_c / g_c = W_m / g_m$ OR $m = 37$ (kg) ($W_c =$) 44 (N)	seen anywhere in working answer of 78-79 gets 2 marks allow 44.3, 44.25	3

Total for Question 8 = 10 marks

Question number	Answer	Notes	Marks
11 (a) (i)	any one from: satellite orbits a planet/Earth, planet orbits a star/Sun; orbital radius/time period of planet is greater than satellite;	both aspects of the comparison required allow RA allow planet's orbit is larger	1
(ii)	any one from: both orbit a planet/Earth; both have same shape of orbit;	allow circular or elliptical	1
(b) (i)	substitution into $v = 2\pi \times r / T$; conversion of 24 hours into seconds; rearrangement and evaluation of orbital radius; evaluation of height; e.g. $3.1 = 2 \times \pi \times r / [24 \times (60 \times 60)]$ $T = (24 \times 60 \times 60 =) 86\,400 \text{ (s)}$ $r = 42\,628 \text{ (km)}$ (height = $42\,628 - 6\,400 =$) $36\,000 \text{ (km)}$	ignore units allow 86 400 seen anywhere allow 36228.05996 (km)	4
(ii)	any three from: MP1. speed of waves constant; MP2. if source moving away, wavefronts spread out / wavelength increases; MP3. speed = frequency $\times$ wavelength; MP4. (higher wavelength and constant speed of waves) gives lower frequency;	allow RA for source approaching allow RA for source approaching	3
(iii)	idea that there is no (relative) motion between point on Earth's surface and satellite; (therefore) no wavelength/frequency change;	allow distance to satellite from Earth does not change DOP	2

Total for Question 11 = 11 marks

Question number	Answer	Notes	Marks
8 (a)	Milky Way;		1
(b) (i)	Neptune orbits the Sun; Triton orbits Neptune;		2
(ii)	substitution into $v = 2\pi r/T$; rearrangement; evaluation of T for Neptune; setting up ratio of T for Pluto and Neptune that leads to 2:3; e.g. $5.4 \times 10^3 = 2\pi \times 4.5 \times 10^{12} / T$ $T = 2\pi \times 4.5 \times 10^{12} / 5.4 \times 10^3$ (T =) 5.2×10^9 (s) ratio = $5.2 \times 10^9 / 7.8 \times 10^9$ (= 2:3)	data for Neptune seen allow substitution and rearrangement in either order accept 5.2×10^9 following correct working for first 3 marks accept $5.23(\dots) \times 10^9$ without correct working for first three marks	4

Total for Question 8 = 7 marks

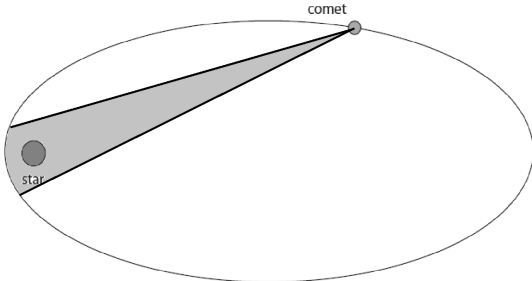
Question number	Answer	Notes	Marks
4	MP1 nebula/gas cloud; MP2 protostar; MP3 main sequence (then red supergiant); MP4 supernova; MP5 neutron star/ black hole;	1 mark penalty for any incorrect sequence	5

Total for Question 4 = 5 marks



Question number	Answer	Notes	Marks
6 (a)	W marked between +10 and +15 absolute magnitude and between blue and white/yellow colour marks;		1
(b)	X marked between 0 and -5 absolute magnitude and between yellow/red and end of colour scale;		1
(c)	Y marked above and to the left of the Sun;	judge by eye	1
(d)	Z marked vertically in line with and below the Sun;	judge by eye	1
(e)	Any one from: MP1. idea that the Moon does not emit its own light; MP2. Idea that the Moon is not a star MP3. idea that the (surface) temperature of the Moon is too low / does not fit on the scale;		1

Total for Question 6 = 5 marks

Question number	Answer	Notes	Marks
1 (a) (i)	C (white); A is incorrect because its temperature is the second lowest B is incorrect because its temperature is the lowest D is incorrect because its temperature is the second highest		1
(ii)	D (white dwarf); A is incorrect because the Sun is not massive enough to form a black hole B is incorrect because the Sun is not massive enough to form a neutron star C is incorrect because the Sun is not massive enough to form a supernova		1
(iii)	C (supernova); A is incorrect because this is during the middle of the life cycle B is incorrect because this is an early stage of the life cycle D is incorrect because this is a late stage in the life cycle of stars like our Sun		1
(b)	arrow pointing from the comet to the star; force labelled 'gravitational'; 	accept any arrow pointing from comet to star within shaded area ignore starting position of arrow allow 'gravity' or 'weight'	2

Total for Question 1 = 5 marks

Question number	Answer	Notes	Marks
1 (a)	one mark for each correct line; Region P Q R Astronomical object black hole main sequence star nebula neutron star red giant star supernova white dwarf star	reject mark if more than one line drawn from region	3
(b)	(a measure of) brightness; (of a star) at a {standard / fixed / same / set} distance;	allow power, luminosity, intensity ignore description of scale for idea of magnitude allow correct distance e.g. 10 parsecs/32(.6) light years ignore incorrect distance	2

Total for Question 1 = 5 marks

Question number	Answer	Notes	Marks
1 (a)	y-axis: one from • luminosity; • <u>absolute</u> magnitude; x-axis: one from • temperature; • colour; • spectral class;	ignore brightness allow magnitude <u>absolute</u> 1 mark if <u>both</u> labels correct but on the wrong axes	2
(b)	main sequence;		1
(c)	B; A is incorrect because it is a red giant C is incorrect because it is a hot main sequence star D is incorrect because it is a cool main sequence star		1
(d)	C; A is incorrect because red giants are cooler than the Sun B is incorrect because white dwarf stars are fainter than the Sun D is incorrect because this star is both cooler and fainter than the Sun		1

Total for Question 1 = 5 marks

Question number	Answer	Notes	Marks
4	a description including any six from: MP1. nebula collapses / forms protostar; MP2. temperature / brightness of nebula / protostar increases; MP3. (when temperature becomes hot enough) fusion starts and star becomes main sequence; MP4. brightness / temperature of main sequence star depends on its mass; MP5. (when hydrogen runs out) main sequence star becomes red giant; MP6. red giants are brighter (than main sequence); MP7. red giants (surfaces) are cooler (than most main sequence stars); MP8. red giant becomes white dwarf; MP9. white dwarfs are less bright (than red giant / main sequence stars); MP10. white dwarfs are hotter (than red giant / most main sequence stars);	allow 'contracts' allow 'size' for mass	6

Total for Question 4 = 6 marks

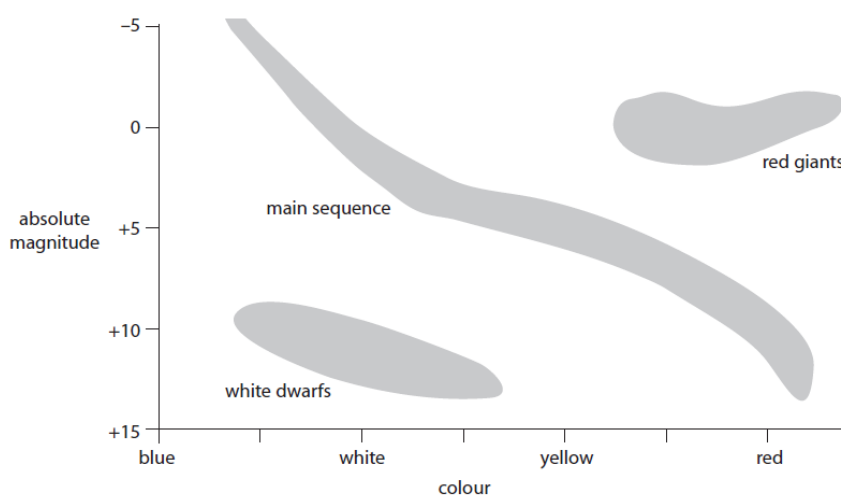


Question number	Answer	Notes	Marks
1	kinetic; main sequence; contract; expand; supernova; neutron star;		6

Total for Question 1 = 6 marks



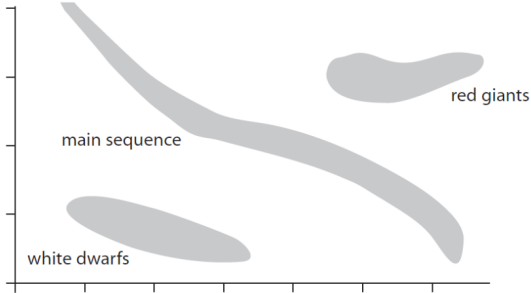
Question number	Answer	Notes	Marks
6 (a)	(a measurement of) the brightness (of a star); at a standard distance;	allow measurement of luminosity/power of a star apparent magnitude allow at 10 pc/32.6 ly. condone incorrect distance.	2
(b)	correct absolute magnitude scale; x-axis labelled 'colour'; main sequence top-left to bottom-right with clear flatter region in the middle; white dwarf region in bottom-left corner with part of it in line with 'white' label on x-axis; red giant region in top-right corner with part of it in line with 'red' label on x-axis;	i.e. going from +15 to -5 in regular intervals condone 'temperature'	5



Total for Question 6 = 7 marks

Question number	Answer	Notes	Marks
3 (a)	any four correctly linked stages in star's evolution: MP1. nebula to protostar; MP2. protostar to main sequence; MP3. main sequence to red giant; MP4. red giant to white dwarf; MP5. white dwarf to black dwarf;	limit to 2 marks max. if incorrect stages given e.g. red supergiant, supernova, neutron star, black hole allow cloud of dust/gas for nebula allow main stage for main sequence allow 1 marking point if stage missing e.g. nebula to main sequence gets either MP1 or MP2 since protostar is missing	4
(b)	stars use <u>fusion</u>, reactor uses <u>fission</u>; fusion detail e.g.; • (fusion is the) joining of nuclei • involves light nuclei e.g. hydrogen fission detail e.g.; • (fission is the) splitting of nuclei • involves heavy nuclei e.g. uranium/plutonium	both needed condone atoms for nuclei condone atoms for nuclei	3

Total for Question 3 = 7 marks

Question number	Answer	Notes	Marks
1 (a) (i)	B - main sequence stars; A is not correct as black holes do not appear on the HR diagram C is not correct as neutron stars are not part of the main sequence. D is not correct as protostars are not part of the main sequence		1
(ii)	bottom left area of the HR diagram;	unlabelled scores 0	1
(iii)	top right hand area of HR diagram; 	unlabelled scores 0	1
(iv)	a measure of brightness/luminosity; idea that a star would be at a standard distance (10 parsecs/32(.6) light years);	accept power ignore lack of or incorrect value for distance	2
(b) (i)	C - ultraviolet; A is not correct as microwaves cause internal heating B is not correct as radio waves do not give skin burns D is not correct as visible light cannot harm skin cells.		1
(ii)	A - sunbathing; B, C and D are not correct as all reduce the absorption of UV by skin.		1

Total for Question 1: 7 marks

Question number	Answer	Notes	Marks																				
4 (a)	one mark for each correct row;;; <table border="1"> <thead> <tr> <th>Energy store</th><th>Increases</th><th>Decreases</th><th>Stays the same</th></tr> </thead> <tbody> <tr> <td>Chemical</td><td></td><td></td><td>✓</td></tr> <tr> <td>Gravitational potential</td><td></td><td>✓</td><td></td></tr> <tr> <td>Nuclear</td><td></td><td></td><td>✓</td></tr> <tr> <td>Thermal</td><td>✓</td><td></td><td></td></tr> </tbody> </table>	Energy store	Increases	Decreases	Stays the same	Chemical			✓	Gravitational potential		✓		Nuclear			✓	Thermal	✓			reject mark for row if more than one tick given	4
Energy store	Increases	Decreases	Stays the same																				
Chemical			✓																				
Gravitational potential		✓																					
Nuclear			✓																				
Thermal	✓																						
(b)	mass;	ignore size, weight	1																				
(c)	any four from: MP1. red giant has greater brightness than white dwarf; MP2. (nuclear) fusion takes place in red giant (core) but not in white dwarf (core); MP3. red giant is larger than white dwarf; MP4. red giant has lower (surface) temperature than white dwarf; MP5. white dwarf is denser than a red giant; MP6. white dwarf has a planetary nebula but a red giant does not;	allow RA for all marking points allow absolute magnitude, luminosity, power for brightness allow red giant emits more light allow red giant has more hydrogen condone red giant has more mass than white dwarf allow red giant is cooler	4																				

Total for Question 4 = 9 marks



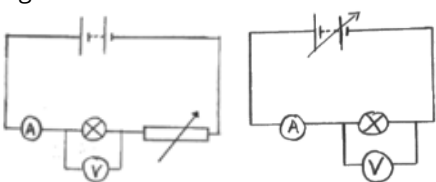
Question number	Answer	Notes	Marks																		
4 (a)	one mark for each correct tick;;;; <table><tr><th>Stage of evolution</th><th>Features in the life cycle of the Sun</th></tr><tr><td>black hole</td><td></td></tr><tr><td>main sequence</td><td>✓</td></tr><tr><td>nebula</td><td>✓</td></tr><tr><td>neutron star</td><td></td></tr><tr><td>red giant</td><td>✓</td></tr><tr><td>red supergiant</td><td></td></tr><tr><td>supernova</td><td></td></tr><tr><td>white dwarf</td><td>✓</td></tr></table>	Stage of evolution	Features in the life cycle of the Sun	black hole		main sequence	✓	nebula	✓	neutron star		red giant	✓	red supergiant		supernova		white dwarf	✓	if 5 or more ticks given then -1 for each additional tick	4
Stage of evolution	Features in the life cycle of the Sun																				
black hole																					
main sequence	✓																				
nebula	✓																				
neutron star																					
red giant	✓																				
red supergiant																					
supernova																					
white dwarf	✓																				
(b)	idea of the temperatures being different; Sun is hotter than Betelgeuse;	also scores first mark allow RA	2																		
(c) (i)	idea that there are no particles in space (between Sun and Earth);	allow space is a vacuum	1																		
(ii)	shiny / white / silver; poor absorber of (IR) radiation;	accept good reflector of radiation accept 'does not absorb' ignore references to emission ignore references to conduction allow 'heat' or 'energy' for 'radiation'	2																		

Total for Question 4 = 9 marks



Question number	Answer	Notes	Marks
4 (a)	A (blue-white); B is incorrect because orange stars are cooler than blue-white stars C is incorrect because red stars are cooler than blue-white stars D is incorrect because yellow stars are cooler than blue-white stars		1
(b)	any two from: gas collapses / gas particles attract each other; temperature (of the gas) increases; fusion starts /eq;	condone 'dust' for 'gas' allow particles increase in <u>KE</u>	2
(c)	two (small) nuclei ; join together (to produce a large nucleus); releasing energy;	allow gamma radiation	3
(d) (i)	C (mass); A is incorrect because colour is determined by the surface temperature B is incorrect because distance determines its apparent brightness D is incorrect because temperature determines the spectral class		1
(ii)	any three from: MP1. Rigel will become a red supergiant; MP2. then contracts rapidly; MP3. (explodes as a supernova) leaving a neutron star; MP4. (or) black hole;		3

Total for Question 4 = 10 marks

Question number	Answer	Notes	Marks
6 (a) (i)	circuit with symbols for ammeter, voltmeter, lamp, any power supply all correct; voltmeter in parallel with lamp; ammeter in series with lamp; correct means of varying voltage of lamp i.e. variable power supply/rheostat/potentiometer; e.g. 	variable power supplies or variable number of cells can be shown using labelled standard symbols if no lamp in circuit, allow ammeter drawn in series with power supply allow variable resistor in series with lamp	4
(ii)	any four from: MP1. record ammeter and voltmeter reading; MP2. repeat readings (for each voltage) and find average; MP3. idea of changing the voltage / current; MP4. plot a graph of voltage and current; MP5. switch off current/circuit between readings;	allow 'measure voltage and current' allow repeating experiment to find average allow described method that would change voltage or current e.g. adding more cells, changing circuit resistance etc. ignore "let lamp cool between readings"	4
(b) (i)	ampere / amp / A / mA;	reject I	1
(ii)	correctly evaluated energy; given to 2 significant figures; e.g. 162 (J) gets 1 mark 160 (J) gets 2 marks	DOP	2
(iii)	red or orange;		1

Total for Question 6 = 12 marks

Question number	Answer	Notes	Marks
8	(a) (i) idea that star A is closer (to Earth than star C);	allow RA	1
	(ii) star D; (because) it (is the only star that) has a mass (much) larger than the mass of the Sun; (because) it has a much lower value of absolute magnitude;	dependent on 1 st mark being awarded dependent on 1 st mark being awarded allow lowest value of absolute magnitude 2 marks max. if answer suggests that colour/temperature is relevant	3
	(b) any three from: MP1. (hydrogen) fusion stops (in core); MP2. core collapses; MP3. (which) restarts fusion (in core); MP4. star becomes red <u>supergiant</u> ; MP5. fusion of heavier elements stops (in core); MP6. star explodes (as supernova);	allow runs out of hydrogen allow core contracts allow idea that fusion of heavier elements starts allow super red giant allow planetary nebula formed	3
(c)	(i) evaluation of change of wavelength; substitution into $\Delta\lambda/\lambda = v/c$; rearrangement; evaluation of speed; e.g. $\Delta\lambda = (7.780 - 7.774) = 6 \times 10^{-10} \text{ (m)}$ $6 \times 10^{-10} / 7.774 \times 10^{-7} = v / 3.0 \times 10^8$ $v = 6 \times 10^{-10} / 7.774 \times 10^{-7} \times 3.0 \times 10^8$ (v =) $2.315 \times 10^5 \text{ (m/s)}$	-1 if 7.780×10^{-7} used as λ $2.314 \times 10^5 \text{ (m/s)}$ gets 3 marks only allow 2.3×10^5	4
	(ii) MP1. nearby galaxies show smaller {red-shift / change in wavelength}; MP2. nearby galaxies are travelling slower than further galaxies; MP3. (all light red-shifted) suggests universe is expanding; MP4. suggesting universe was once at a single point;	allow RA allow RA allow (all) galaxies are moving away from each other	4

Total for Question 8 = 15 marks



Question number	Answer	Notes	Marks																												
2 (a) (i)	one mark for each correct row;;; <table><tr><th rowspan="2">Object X</th><th rowspan="2">Object Y</th><th colspan="4">Orbital path</th></tr><tr><th>A</th><th>B</th><th>C</th><th>D</th></tr><tr><td>the Earth</td><td>the Moon</td><td>✓</td><td></td><td></td><td></td></tr><tr><td>the Sun</td><td>a comet</td><td></td><td>✓</td><td></td><td></td></tr><tr><td>the Sun</td><td>the Earth</td><td>✓</td><td></td><td></td><td></td></tr></table>	Object X	Object Y	Orbital path				A	B	C	D	the Earth	the Moon	✓				the Sun	a comet		✓			the Sun	the Earth	✓				reject mark for row if more than one tick shown allow alternative symbols instead of ticks	3
Object X	Object Y			Orbital path																											
		A	B	C	D																										
the Earth	the Moon	✓																													
the Sun	a comet		✓																												
the Sun	the Earth	✓																													
(ii)	gravity;	allow gravitational (force/pull/attraction) ignore weight, centripetal, g, G reject gravitational field strength, gravitational potential, GPE	1																												
(b) (i)	(the) Milky Way (galaxy);		1																												
(ii)	idea that colour depends on temperature; Antares / red is coolest; full (surface) temperature order given; e.g. in order of coolest to hottest - Antares, Capella, Sirius B, Vega - red, yellow, white, blue-white	allow idea that colour is how hot/cold the star is also scores MP1 allow Vega / blue-white / blue is hottest allow RA	3																												
(iii)	supernova; neutron star; black hole;	-1 if order of stages is incorrect or incorrect stages named allow pulsar for neutron star allow idea that Antares becomes black hole or neutron star	3																												
(iv)	idea that evolution depends on <u>mass</u> ; relative to the Sun;	idea that it depends on the solar mass(es) of Vega = 2 marks	2																												

Total for Question 2 = 13 marks



Question number	Answer	Notes	Marks
1 (a)	Observation	Supports the Big Bang theory	2
	Black holes are formed from extremely massive stars		
	Cosmic microwave background radiation is seen in all directions	✓	
	Cosmic rays from space are detected at the Earth's surface		
	Each galaxy contains billions of stars		
	Most galaxies show a red-shift in the light detected from them	✓	
	1 mark for each correct tick; -1 for each additional tick if more than two ticks seen 5 ticks scores zero		
(b)	B (decreases, increases); A is incorrect because a red giant is more powerful than a main sequence star C is incorrect because a red giant is cooler and more powerful than a main sequence star D is incorrect because a red giant is cooler than a main sequence star		1
(c)	the brightness/luminosity (of an object); idea of a standard distance;	allow 10 parsecs/32(.6) light years condone incorrect distance	2

Total for Question 1 = 5 marks

Question number	Answer	Notes	Marks
7 (a)	Cosmic Microwave Background Radiation (CMBR) (Cosmological) Red shift of <u>galaxies</u>	Allow one missing word Accept reference to Hubble's Law. Allow higher level idea of ratio of hydrogen to helium as alternative to either marking point.	2
(b)	<u>CMBR</u> MAX TWO from MP1 CMBR appears to be the same in all directions/is everywhere; MP2 Which implies all parts of the Universe were in contact a long time ago; MP3 Wavelength has increased as the universe has expanded; MP4 universe was (significantly) hotter long ago; <u>Red Shift of Galaxies</u> MAX TWO from MP5 The further the galaxy is from Earth, the greater the red-shift; MP6 The greater the red-shift, the faster the galaxy is moving away; MP7 Speed of galaxies increases (is directly proportional to) with increased distance; MP8 Relationship between speed and distance implies expansion from a single point or since the Big Bang;	Allow implication of idea of coming from single point Allow frequency has decreased Allow RA Condone "star" for "galaxy" for MP5 Allow 'red shift' for 'speed of galaxies' Allow 'galaxies moving apart from each other' for 'relationship between speed and distance'	4

Question number	Answer	Notes	Marks
6 (a)	any two from: MP1. CMBR appears to be the same in all directions / is everywhere; MP2. (which) implies all parts of the Universe were in contact a long time ago; MP3. wavelength has increased (as the universe has expanded); MP4. Universe was (significantly) hotter long ago;	allow implication of idea of coming from single point allow red-shift of radiation allow frequency has decreased allow RA	2
(b)	change in wavelength = 78 (nm); substitution; rearrangement; evaluation; e.g. (683 – 605 =) 78 (nm) $78 / 605 = v / c$ $v = 3.0 \times 10^8 \times (78/605)$ (v =) 3.9×10^7 (m/s)	ignore units -1 for POT error use of incorrect source wavelength gives 3.4×10^7 (m/s) = 3 marks allow $3.86... \times 10^7$ (m/s)	4

(Total for Question 6 = 6 marks)

Question number	Answer	Notes	Marks
8 (a)	Universe began as hot / dense point; Universe has expanded since the Big Bang; Universe has cooled since the Big Bang;	allow idea that Universe started as a single point	3
(b)	any four from: MP1. presence of cosmic microwave background radiation; MP2. CMBR comes from all directions; MP3. CMBR (began as gamma radiation and) wavelength increased (as Universe expanded); MP4. red-shift of galaxies; MP5. further/faster galaxies show a greater red-shift; MP6. red-shift indicates that galaxies are moving away from each other; MP7. relative abundance of helium; MP8. helium formed when Universe was hot enough to fuse protons;	allow CMBR allow CMBR is uniform allow large amount of helium	4

Total for Question 8 = 7 marks

Question number	Answer	Notes	Marks
8 (a)	cosmic microwave background radiation; red-shift of galaxies ;	allow CMBR condone one missing word or one missing letter from the acronym accept cosmological red-shift accept quasars for galaxies	2
(b)	substitution into $\frac{\lambda - \lambda_0}{\lambda_0} = \frac{v}{c}$; rearrangement; evaluation of λ ; evaluation of λ to 5s.f.; e.g. $\frac{\lambda - 4.3405 \times 10^{-7}}{4.3405 \times 10^{-7}} = \frac{1.44 \times 10^5}{3.00 \times 10^8}$ $\lambda = (0.0048 \times 4.3405 \times 10^{-7}) + 4.3405 \times 10^{-7}$ $\lambda = 4.34258344 \times 10^{-7} \text{ (m)}$ $\lambda = 4.3426 \times 10^{-7} \text{ (m)}$	take evaluation of the change in wavelength as evidence of MP1 and MP2 regardless of PoT NB correct change in wavelength is $2.0834... \times 10^{-10} \text{ (m)}$ accept any value that would round to $4.3426 \times 10^{-7} \text{ (m)}$ mark independently	4
(c)	 Centaurus A will have a greater red-shift; (so) wavelength from Centaurus A will be longer / eq;	allow idea of “further galaxies” for “Centaurus A” allow RA allow RA	2

Total for Question 8 = 8 mark



Question number	Answer	Notes	Marks
6 (a) (i)	(wave) speed = frequency × wavelength;	allow standard symbols and rearrangements i.e. $\lambda = v / f$ allow v, c and s for speed	1
(ii)	substitution; rearrangement; evaluation in mm to at least 2s.f.; e.g. $3.0 \times 10^8 = 1.6 \times 10^{11} \times \lambda$ $\lambda = 3.0 \times 10^8 / 1.6 \times 10^{11}$ $\lambda = (0.0019 \text{ (m)}) = 1.9 \text{ (mm)}$	allow 1.88, 1.875 (mm) condone 1.87 (mm)	3
(b)	idea that wavelength has increased (over time); because <u>Universe</u> is expanding;	allow wavelength has stretched ignore wavelength has expanded ignore red-shift	2
(c)	(most galaxies show a) red-shift because they are moving away (from Earth / each other); further galaxies show a greater red-shift; further galaxies are travelling (away from Earth) faster; idea that all matter must have originated from a single point;	condone use of stars, planets, objects for galaxies for this marking point only allow faster galaxies have greater red-shift	4

Total for Question 6 = 10 marks