

PHYSICS



EXAM QUESTION PACK

TOPIC 7: ASTRONOMY (PACK 1)

SCORE

/64

PERCENTAGE

%

STEMUP

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Q1.

The table shows some data about the Earth's orbit of the Sun.

orbital radius (R)	$1.5 \times 10^8 \text{ km}$
time for one orbit (T)	$3.2 \times 10^7 \text{ s}$

Use the following equation to calculate the orbital speed, v , of the Earth.

$$v = \frac{2 \times \pi \times R}{T}$$

(3)

$v = \dots\dots\dots \text{ m/s}$

(Total for question = 3 marks)

Q2.

The Sun has a mass of $2.0 \times 10^{30} \text{ kg}$.

A white dwarf has a mass of $3.4 \times 10^{29} \text{ kg}$.

Calculate the value of

$$\frac{\text{mass of this white dwarf}}{\text{mass of the Sun}}$$

(2)

value = ...

(Total for question = 2 marks)

Q3.

The Asteroid Belt is part of our Solar System.

Vesta is an asteroid in the Asteroid Belt.

Vesta has an orbital speed of 1.9×10^4 m/s.

Vesta travels a distance of 2.2×10^{12} m when it orbits the Sun once.

Calculate the time taken for Vesta to orbit the Sun once.

(2)

time = ... s

(Total for question = 2 marks)

Q4.

A long time ago scientists thought that the Universe never changed.

Now there is evidence to show that stars progress through various stages and that the Universe is expanding.

(a) Our Sun is in its main sequence stage.

(i) Complete the sentence by putting a cross (X) in the box next to your answer.

A star of much greater mass than the Sun will eventually become

(1)

☐ **A** a black hole

☐ **B** a protostar

☐ **C** a red dwarf

☐ **D** a white dwarf

(ii) Describe how the Sun reached its main sequence stage.

(3)

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(iii) Scientists can estimate the age of a star. They want to find the age of the oldest star.

Suggest why knowing the age of the oldest star is not enough to tell scientists the age of the Universe.

(2)

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*(b) Edwin Hubble discovered that the Universe was expanding.

He did this by using observations of red-shift.

Explain what red-shift is and how it provides evidence that the Universe is expanding.

(6)

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(Total for Question = 12 marks)

Q5.

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 (☒).

The Big Bang and Steady State are two theories of the origin of the Universe.

Red shift and cosmic microwave background (CMB) radiation have been discovered by observing the Universe.

Which line of the table links the evidence to the theory it supports?

		evidence		
		theory	red shift	CMB
☐	A	Big Bang	Yes	No
☐	B	Steady State	Yes	Yes
☐	C	Big Bang	Yes	Yes
☐	D	Steady State	No	Yes

(Total for question = 1 mark)

Q6.

The Big Bang theory and the Steady State theory are two theories about the origin of the universe.

The discovery of CMB led scientists to accept only one of the theories.

Explain why red shift supports both theories but CMB supports only one of them.

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(Total for question = 3 marks)

Q7.

The Big Bang theory is one theory for the origin of the Universe.

The Big Bang theory suggests:

- the Universe had a beginning
- the Universe is still expanding.

The Steady State theory is also a theory about the origin of the Universe.

Give **one** similarity and **one** difference when comparing the Big Bang theory with the Steady State theory.

(2)

similarity

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difference

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(Total for question = 2 marks)

Q8.

Describe the significance of microwave radiation in the development of a theory of the origin of the universe.

(2)

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(Total for question = 2 marks)

Q9.

Stars may originate as a nebula.

(i) Describe the process that then occurs to produce the conditions necessary for nuclear fusion in a new star.

(3)

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(ii) The energy, E , released in nuclear fusion is equivalent to loss in mass, m , according to the equation.

$$E = mc^2$$

where c is the velocity of light.

$$c = 3.00 \times 10^8 \text{ m/s}$$

In 1 second, the energy radiated by the Sun is $3.86 \times 10^{26} \text{ J}$.

Calculate the loss in mass of the Sun in 1 second.

(2)

loss in mass = ... kg

(Total for question = 5 marks)

Q10.

The Sun reaches its highest point in the sky on Midsummer's day.

Describe how you could use this fact to measure the time it takes for the Earth to orbit the Sun once.

(2)

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(Total for question = 2 marks)

Q11.

A scientist records the sounds made by a dolphin as it swims towards him.

The dolphin stops swimming but continues to emit the sounds.

Describe what happens to the frequency and wavelength of the sounds when the dolphin stops swimming.

(2)

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(Total for question = 2 marks)

Q12.

(i) A star with a mass very much larger than the Sun

(1)

- ☐ **A** has a longer main sequence than the Sun and ends as a white dwarf
- ☐ **B** has a longer main sequence than the Sun and ends as a black hole
- ☐ **C** has a shorter main sequence than the Sun and ends as a white dwarf
- ☐ **D** has a shorter main sequence than the Sun and ends as a black hole

(ii) Which row has two correct statements about black holes?

(1)

	the gravitational field of a black hole	a black hole is formed when
☐ A	allows only electromagnetic radiation to escape	a nebula collapses
☐ B	allows nothing to escape	a very large star collapses
☐ C	allows nothing to escape	a nebula collapses
☐ D	allows only electromagnetic radiation to escape	a very large star collapses

(Total for question = 2 marks)

Q13.

Figure 4 is a diagram giving some information about main sequence stars.
Luminosity is a measure of how bright something is.
An increase in luminosity means an increase in brightness.

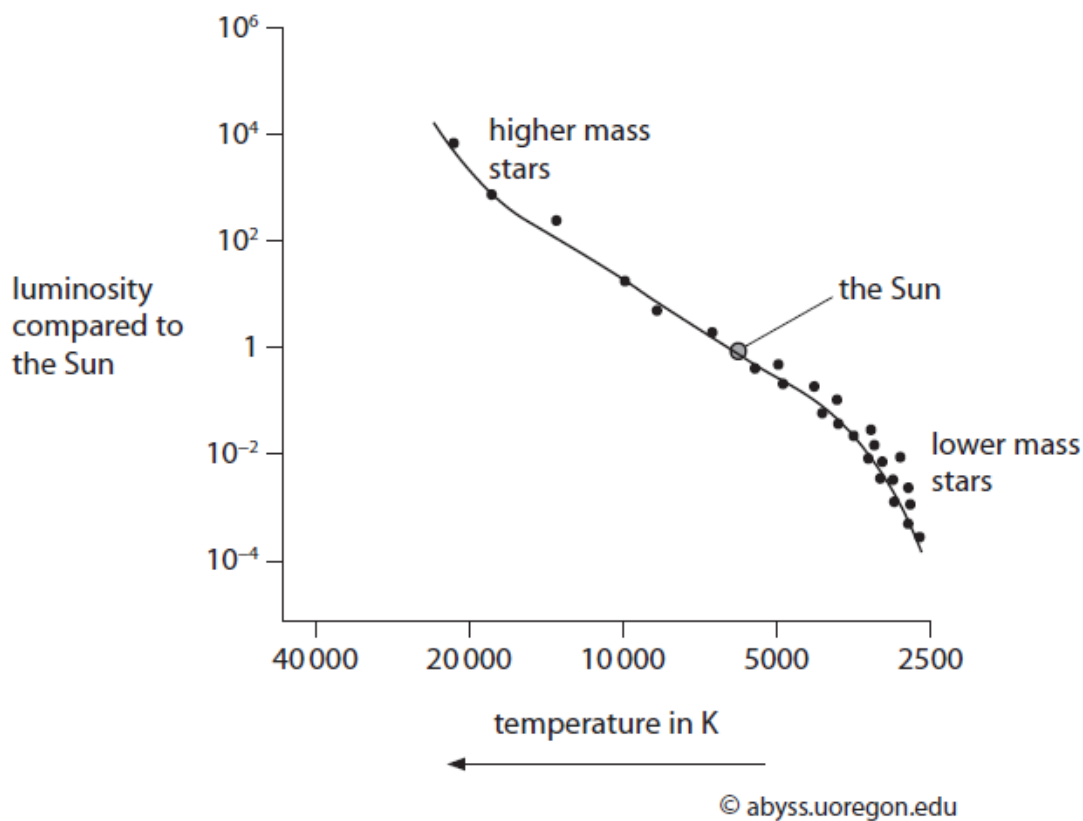


Figure 4

(i) Estimate the temperature of the Sun.

(1)

temperature of the Sun = ... K

(ii) State how the brightness of a main sequence star changes with its temperature.

(1)

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(iii) State how the brightness of a main sequence star changes with its mass.

(1)

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(Total for question = 3 marks)

Q14.

The Big Bang theory is one theory for the origin of the Universe.

The Big Bang theory suggests:

- the Universe had a beginning
- the Universe is still expanding.

Observations of the expanding Universe have shown that the further away a galaxy is from the Earth, the faster the galaxy is moving away from the Earth.

Figure 4 shows how the velocity of galaxies is related to their distance from the Earth.

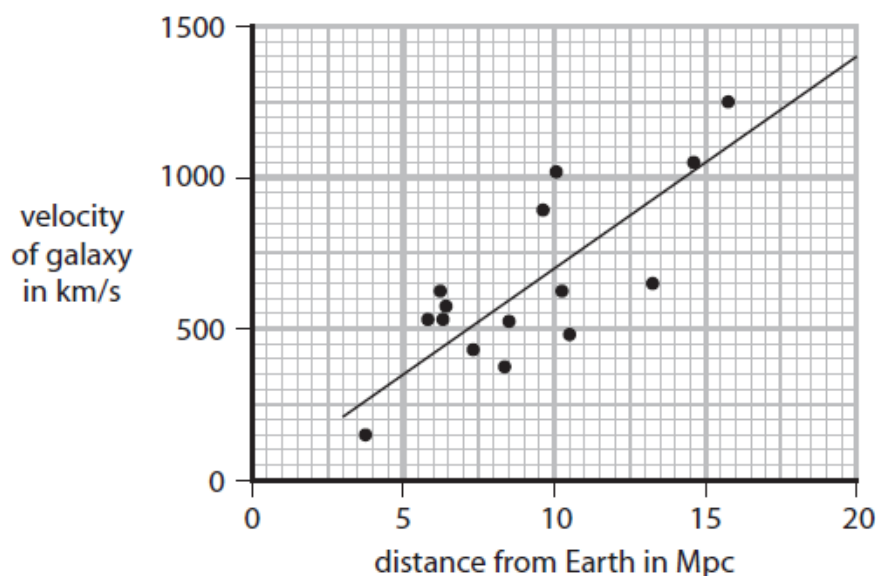


Figure 4

Mpc is a unit of distance used for large distances in space.

(i) Use Figure 4 to estimate the velocity of a galaxy that is 15 Mpc away from the Earth.

(1)

velocity = ... km/s

(ii) Calculate the gradient of the line shown in Figure 4.

State the unit.

(3)

gradient = ... unit

(iii) The gradient of the line in Figure 4 can be used to estimate the age of the Universe.

Explain why the gradient of the line in Figure 4 can only provide an **estimate** of the age of the Universe.

(2)

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(Total for question = 6 marks)

Q15.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ~~☒~~ and then mark your new answer with a cross ☒ .

The Big Bang theory is one theory for the origin of the Universe.

The Big Bang theory suggests:

- the Universe had a beginning
- the Universe is still expanding.

Which of these provides evidence that the Universe had a beginning?

(1)

- ☐ **A** the discovery of other galaxies
- ☐ **B** the discovery of the moons of Jupiter
- ☐ **C** the discovery of planets orbiting distant stars
- ☐ **D** the discovery of cosmic microwave background (CMB) radiation

(Total for question = 1 mark)

Q16.

A nebula may evolve into a main sequence star, such as the Sun.

Explain how a nebula may evolve into a main sequence star.

(3)

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(Total for question = 3 marks)

Q17.

The Big Bang theory gives an explanation for the origin of the Universe.

Explain how evidence supports the ideas that

- the Universe is expanding
- the Universe began at a single point.

(6)

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(Total for question = 6 marks)

Q18.

The Big Bang theory is one theory for the origin of the Universe.

The Big Bang theory suggests:

- the Universe had a beginning
- the Universe is still expanding.

Evidence that the Universe is still expanding comes from observations of light from distant galaxies.

Describe how light from distant galaxies shows that the Universe is still expanding.

(2)

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(Total for question = 2 marks)

Q19.

Scientists no longer accept the geocentric model of the universe but it was the accepted theory for hundreds of years.

Explain why the evidence available at the time supported the geocentric model.

(3)

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(Total for question = 3 marks)

Q20.

* Figure 14 shows two ice skaters during a sequence in their performance.



Figure 14

The man stays at the same place on the ice throughout the sequence.

At the start of the sequence, the woman is moving at a constant speed around the man while the man holds her arm.

After she has gone round the man several times, the man lets go of the woman's arm. The sequence ends a few seconds later.

Explain the motion of the woman, in terms of the forces acting and the effects on her motion, for the whole sequence.

(6)

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(Total for question = 6 marks)

Q21.

Observations of the Universe can be made using telescopes on Earth.
Explain why some telescopes are located on satellites that orbit the Earth.

(2)

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(Total for question = 2 marks)

Q22.

* The Sun is likely to remain as a main sequence star for 2000 million years.

Explain why the Sun does not explode now.

(6)

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(Total for question = 6 marks)

Mark Scheme

Q1.

Question number	Answer	Additional guidance	Mark
	$v = \frac{2\pi R}{T}$ unit conversion (1) $10^8 \text{ km} = 10^{11} \text{ m}$ substitution (1) $v = \frac{2\pi \times 1.5 \times 10^{11}}{3.2 \times 10^7}$ evaluation (1) $v = 2.9 \times 10^4 \text{ (m/s)}$	Allow values which round to 2.9×10^4 full marks will be awarded for correct numerical answer without working	(3)

Q2.

Question number	Answer	Additional guidance	Mark
	substitution (1) $\frac{3.4 \times 10^{29}}{2.0 \times 10^{30}}$ evaluation (1) 0.17	award 1 mark for 1.7 to any incorrect power of 10 ignore any units given award full marks for the correct answer without working	(2)

Q3.

	Answer	Additional guidance	Mark
	rearrangement and substitution (1) $(t =) \frac{2.2 (\times 10^{12})}{1.9 (\times 10^4)}$ evaluation (1) $1.2 \times 10^8 \text{ (s)}$	allow numbers that round to 1.2×10^8 e.g. 1.1579×10^8 award full marks for correct answer without working.	(2) AO2

Q4.

Question Number	Answer	Acceptable answers	Mark
(a)(i)	A a black hole (1)		(1)

Question Number	Answer	Acceptable answers	Mark
(a)(ii)	A description including three from: MP1 in a nebula (1) MP2 (particles) attracted / come together by (force of) gravity (1) MP3 pe/ke transferred to thermal/heat energy (gas begins to glow and forms protostar) (1) MP4 until {hot / pressure / dense} enough to start nuclear reaction /fusion (1)	gas / gas and dust core becomes hot / pressure increases / density increases until fusion of hydrogen starts hydrogen starts to become helium condone "hydrogen burning"	(3)

Question Number	Answer	Acceptable answers	Mark
(a)(iii)	A suggestion involving two from: MP1 the oldest star had not yet appeared when the {Big Bang happened / universe started}(1) MP2 the Universe is older than the oldest star MP3 star takes time to form (1) MP4 can't be certain of this time (1)	stars formed after the Big Bang the age of the oldest star is the minimum age of the Universe estimation is not the same as accurate measurement can't be sure there isn't an older star	(2)

Question Number	Indicative Content	Mark
QWC * (b)	An explanation including some of the following points • light shifted to red end of spectrum • light waves are stretched so wavelength increases • reference to black or spectral lines moving to 'red end' (of absorption spectrum) • frequency of wave from a moving source changes • decrease in frequency means source moving away • increase in frequency means source moving towards us • red shift shows galaxies are moving away from us • greater red shift indicates galaxy moving away faster • further away galaxies give greater red shift • (nearly) all galaxies show red-shift • red shift shows decrease in frequency • blue shift shows increase in frequency • therefore galaxies are moving apart • [mention of Doppler effect] • [outline of Doppler effect]	(6)

Level	0	No rewardable content
1	1 - 2	- a limited explanation e.g. (light from) {galaxy / planet / object} moving away from us is shifted to red end of the spectrum OR red shift means {galaxy / planet / object} is moving away from us - the answer communicates ideas using simple language and uses limited scientific terminology e.g. correct use of change of colour and movement - spelling, punctuation and grammar are used with limited accuracy
2	3 - 4	- a simple explanation involving detail of meaning of different red shifts OR involving frequency / wavelength e.g. red shift shows galaxies moving away from us. More distant galaxies give greater red shift showing they are travelling faster away. OR light from galaxies/stars moving away is shifted to red end of the spectrum because of an (apparent) {increase in the wavelength/decrease in the frequency} (of light). - the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately e.g. correct use of the terms galaxy/star, frequency, wavelength - spelling, punctuation and grammar are used with some accuracy
3	5 - 6	- a detailed explanation correctly interpreting the (apparent) drop in frequency / increase in wavelength e.g. light from (most) galaxies is shifted towards the red end of the spectrum because of an {increase in the wavelength/decrease in the frequency}. This indicates that (most) galaxies are moving away from us, hence showing the Universe is expanding - the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately e.g. linkages must be clear between red-shift, movement and expansion of the Universe - spelling, punctuation and grammar are used with few errors

Q5.

Question Number	Answer	Mark
	C both Redshift and CMB can be explained by the Big Bang theory <i>A is not correct because CMB can be explained by the Big Bang</i> <i>B is not correct because the Steady State theory cannot explain CMB</i> <i>D is not correct because the Steady state theory can explain red shift</i>	(1) AO1

Q6.

Question number	Answer	Additional guidance	Mark
	An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (2 marks): - both theories predict an expanding universe and the Big Bang theory also predicts that the universe had a beginning (1) - the red shift theory indicates that the universe is expanding so supports both theories (1) - whereas CMB also indicates that the universe had a beginning, so supports Big Bang theory (1)	provided evidence that the Steady State theory was incorrect	(3)

Q7.

Question number	Answer	Additional guidance	Mark
	similarity (both have) expanding <u>Universe</u> (1) difference one from: Steady State, Universe has no beginning (1) Steady State theory requires the continual formation of new matter, the Big Bang theory does not (1)	different interpretation of CMBR	(2) AO1

Q8.

Question number	Answer	Mark
	An answer that combines 2 points of understanding to provide a logical description: - Discovery of cosmic background microwave radiation (1) - Could be explained as resulting from Big Bang (1) - Could not be explained by steady state theory (1)	(2)

Q9.

Question Number	Answer	Additional guidance	Mark
(i)	a description to include: nebula collapses (1) under gravity (1) plus any one from: GPE converted into KE (1) OR (very) high temperatures/pressures reached (1)	allow gas/dust for nebula allow condensing/coming together for collapses allow gravitational force producing (large) increase in KE of particles / more (frequent) collisions Ignore references to hot / heat	(3)

Question Number	Answer	Additional guidance	Mark
(ii)	rearrangement and substitution (1) $(m =) \frac{3.86 \times 10^{26}}{(3.00 \times 10^8)^2}$ evaluation (1) $(m =) 4.29 \times 10^9 \text{ (kg)}$	ignore Power Of Ten (POT) error until evaluation allow numbers that round to $4.3 \times 10^9 \text{ (kg)}$ award full marks for the correct answer without working 4.3 to any other power of ten scores 1 mark	(2)

Q10.

Question number	Answer	Additional guidance	Mark
	An answer that combines the following points of application of knowledge and understanding to provide a logical description: - start the clock when the Sun is at the highest point (1) - finish the clock when the Sun is at the highest point again (1)	Shadow is shortest	(2)

Q11.

Question Number	Answer	Additional guidance	Mark
	an answer that provides a description by making reference to: - the frequency is lower (1) - the wavelength is longer (1)	award one mark for doppler shift if no other mark is awarded	(2)

Q12.

Question number	Answer	Mark
(i)	B	(1)

Question number	Answer	Mark
(ii)	B	(1)

Q13.

Question number	Answer	Additional guidance	Mark
(i)	accept any temperature between 5500 and 7500 (K) (1)		(1)

Question number	Answer	Additional guidance	Mark
(ii)	the greater the temperature the higher the brightness	or reverse argument allow luminosity for brightness allow heat for temperature	(1)

Question number	Answer	Additional guidance	Mark
(iii)	the greater the mass the higher the brightness	or reverse argument allow luminosity for brightness allow bigger/heavier for greater mass in this context	(1)

Q14.

Question number	Answer	Additional guidance	Mark
(i)	1050 ± 20 (km/s)		(1) A03

Question number	Answer	Additional guidance	Mark
(ii)	attempt at $\frac{\Delta y}{\Delta x}$ (1) evaluation (1) 70 ± 5 unit (1) km/s/Mpc	could be seen on graph award 2 marks for correct answer without working independent mark km/s Mpc s^{-1} or per second	(3) A03

Question number	Answer	Additional guidance	Mark
(iii)	an explanation linking: points are scattered widely about the line (on graph) (1) giving wide range of possible gradients (1)	there are many possible best fit lines	(2) A03

Q15.

Question number	Answer	Mark
	The only correct answer is D the discovery of cosmic microwave background (CMB) radiation A is not correct because it does not indicate the Universe had a beginning B is not correct, it is evidence against the geocentric model of the Universe C is not correct, it is evidence for other solar systems	(1) AO1

Q16.

Question number	Answer	Additional guidance	Mark
	An explanation to include any three from: nebula as a cloud of gas/dust (1) gas / atoms pulled together / towards each other (1) by gravitational force (1) temperature increase (1) hot enough for nuclear fusion (1)	density increase gravity (acting) (resultant) heating	(3)

Q17.

Question Number	Answer	Mark
	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.	(6)

	AO1 strand 1 (6 marks) evidence for expansion • red shift • light from distant galaxies/stars • shifted to red side of em spectrum • (observed) wavelength of light is longer • showing source moving away • (nearly) all galaxies show this • Doppler effect • (expanding at an increasing rate / dark energy) evidence for beginning at a point • CMBR • microwave radiation left over from beginning • the increase of recessional velocities with distance - (extrapolating) • microwaves because of cooling • detected from all over the sky	
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Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1-2	• Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • Presents an explanation with some structure and coherence. (AO1)
Level 2	3-4	• Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5-6	• Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Summary for guidance			
Level	Mark	Additional Guidance	General additional guidance – the decision within levels
	0	No rewardable material.	e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
Level 1	1–2	<u>Additional guidance</u> some element of physics about the expansion / single point origin	<u>Possible candidate responses</u> red shift shows expansion or CMBR connected with beginning
Level 2	3–4	<u>Additional guidance</u> more detail about one piece of evidence or basic detail about two pieces of evidence	<u>Possible candidate responses</u> red shift connected with galaxies moving away (from earth observer) CMBR to do with release of radiation at the beginning
Level 3	5–6	<u>Additional guidance</u> Understanding is detailed and fully developed. includes detail about both pieces of evidence (one may be stronger than the other but both should feature for level 3)	<u>Possible candidate responses</u> red shift connected with galaxies moving away (from earth observer) with the further they are away the faster they are moving away CMBR to do with release of (leftover) radiation at the beginning □ microwaves because of cooling – detected from all over the sky

Q18.

Question number	Answer	Additional guidance	Mark
	A description to include: wavelength (of the light) (1) appears to increase (1) [increase must be linked with wavelength]	Red shift/Doppler effect (Red shift) shows galaxy moving away accept answers in terms of frequency	(2) AO1

Q19.

Question number	Answer	Additional guidance	Mark
	An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (2 marks): • at the time, there was only naked-eye evidence (1) • which indicated Sun/Moon/planets appear to move across the sky (1) • in the same direction, same motion each day (1)	allow valid alternatives, e.g. references to comets	(3)

Q20.

Question number	Indicative content	Mark
*	The indicative content below is not prescriptive and candidates are not required to include all of the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. A01 (6 marks) • force needed to keep an object moving in a circle • when moving in a circle, direction of velocity changes • must be an acceleration • moving in a straight line with no resultant force at constant velocity A02 (6 marks) • the woman changing direction while circling the man • she is changing velocity (but not changing speed) • therefore she is accelerating • this requires a force towards the centre of her orbit • this is a centripetal force • when the man releases the woman, the centripetal force ceases • there is no resultant force on the woman (if friction from the ice can be ignored) • the woman therefore continue in a straight line • she is now travelling at a constant velocity	(6)

Level	Mark	Descriptor
	0	No awardable content
Level 1	1-2	• Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • The explanation attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. (AO2)
Level 2	3-4	• Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • The explanation is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. (AO2)
Level 3	5-6	• Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • The explanation is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. (AO2)

Q21.

	Answer	Additional guidance	Mark
	an explanation linking: telescopes are above Earth / in space / outside the Earth's atmosphere (1) less interference from dust / clouds (1) wavelengths that are absorbed by Earth's atmosphere (microwaves / IR / UV) (1) can view the whole sky (1)	allow any other sensible benefit allow atmospheric distortion/ (light/air) pollution accept named examples of satellites or waves do not accept idea that telescope is closer to object in space	(2) AO1

Q22.

Question number	Indicative content	Mark
*	Answers will be credited according to the candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. A01 (6 marks) • Gravity is an attractive force • Gravity pulls stellar matter inwards • Fusion reactions in the core release thermal energy • Thermal energy gives rise to expansion force • Sun is (currently) stable because these two forces are in equilibrium • Mass of Sun is important factor • Red supergiants explode in supernova • Sun does not have enough mass to be a red supergiant	(6)

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	• Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of science ideas lacks detail (AO1) • Presents an explanation with some structure and coherence (AO1)
Level 2	3–4	• Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5–6	• Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)