Questions

Q1.

(i) An astronomer observes light from a distant galaxy.

As the galaxy moves away from us, the spectrum of the light is

(1)

☒ **A** blue-shifted

☒ **B** green-shifted

☒ **C** red-shifted

☒ **D** violet-shifted

(ii) The shift in the spectrum of light from the distant galaxy provides evidence for the expansion of the

(1)

☒ **A** Earth

☒ **B** Milky Way Galaxy

☒ **C** Solar System

☒ **D** Universe

(Total for question = 2 marks)

Q2.

Two theories about the Universe are the Steady State Theory and The Big Bang Theory.

(i) The table shows some ideas about the Universe.

Which row of the table applies to the Steady State Theory?
Put a cross (☒) in the box next to your answer.

(1)

	the Universe.....	the Universe.....
☐ A	... is not expanding	... had a beginning
☐ B	... is expanding	... had a beginning
☐ C	... is not expanding	... did not have a beginning
☐ D	... is expanding	... did not have a beginning

(ii) State the name of the discovery that persuaded most scientists to prefer the Big Bang Theory to the Steady State Theory.

(1)

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Q3.

This simplified diagram compares spectra of light from the Sun and two galaxies.

The light from galaxy 1 and galaxy 2 both show redshift.

Explain what these redshifts predict about the position and movement of the two galaxies.

(3)

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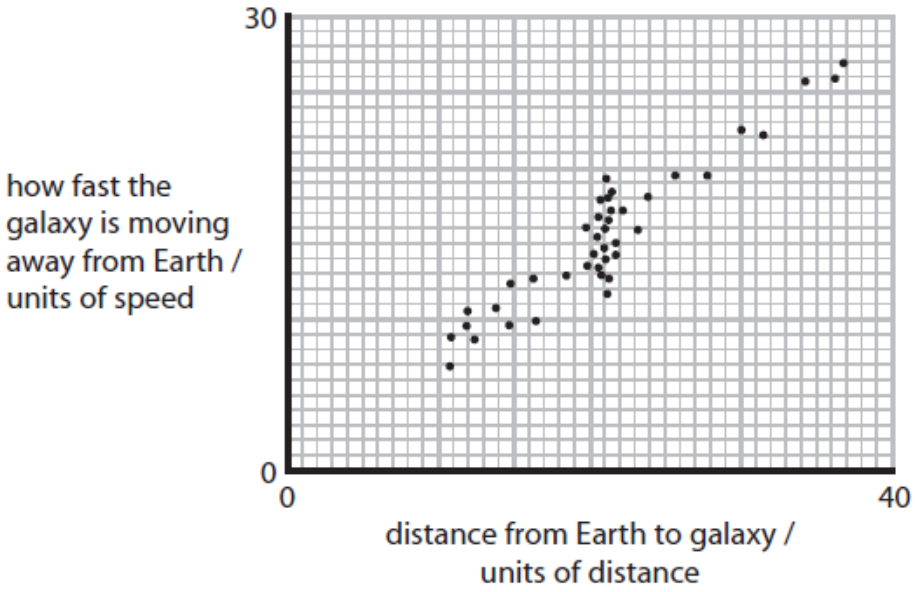
Q4.

(a) Hubble measured the distance of many galaxies from Earth.
He also measured the speed at which each galaxy moved away from Earth.

Hubble plotted his data on a graph like this.



(i) Plot the point: distance = 5 units, speed = 4 units

(1)

(ii) Draw the straight line of best fit.

(1)

(b) Hubble's work led to the theory of the Big Bang.

Describe what is meant by the Big Bang theory.

(2)

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Q5.

During the twentieth century red-shift and CMB radiation were discovered.

They have provided scientists with data to test theories of the origin of the Universe.

(i) Complete the following sentence.

(1)

.CMB is an abbreviation for.....

(ii) State which theory about the origin of the Universe is supported by the existence of CMB.

(1)

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(iii) There is a red-shift in the light received from some galaxies.
State what is meant by red-shift.

(1)

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(iv) Some galaxies show greater red-shift than others.
Explain what this suggests about the Universe.

(2)

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Q6.

* Describe how modern telescopes have contributed to our understanding of the Universe.

(6)

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Q7.

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)

Q8.

During the twentieth century red-shift and CMB radiation were discovered.

They have provided scientists with data to test theories of the origin of the Universe.

(a) (i) Complete the following sentence.

(1)

.CMB is an abbreviation for.....

(ii) State which theory about the origin of the Universe is supported by the existence of CMB.

(1)

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(iii) There is a red-shift in the light received from some galaxies.
State what is meant by red-shift.

(1)

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(iv) Some galaxies show greater red-shift than others.
Explain what this suggests about the Universe.

(2)

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(b) Stars have different stages in their evolution.

(i) Which of these gives the next stages in the evolution of the Sun?

Put a cross (☒) in the box next to your answer.

(1)

☒ **A** white dwarf then black hole

☒ **B** neutron star then white dwarf

☒ **C** red giant then supernova

☒ **D** red giant then white dwarf

(ii) Modern telescopes can provide us with more data than the telescopes used 100 years ago. Explain what additional data can be collected and processed using modern telescopes.

(2)

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(Total for Question = 8 marks)

Q9.

Satellites are used to gather data about the origin of the Universe.

The Big Bang theory is a theory about the origin of the Universe.

Evidence for the Big Bang theory is provided by red-shift and CMB radiation.

(i) Describe what is meant by red-shift.

(2)

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(ii) Explain how red-shift provides evidence for the Big Bang theory.

(2)

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(iii) The Cosmic Background Explorer (COBE) satellite observed CMB radiation from 1989 to 1993.

State what the 'M' in CMB radiation stands for.

(1)

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(iv) State what is meant by 'cosmic background radiation'.

(1)

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(v) Explain how the presence of CMB radiation provides evidence for the Big Bang theory.

(2)

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(Total for question = 8 marks)

Q10.

(a) Which row of the table shows these objects in the correct order of size?

Put a cross (☒) in the box next to your answer.

(1)

	smallest → biggest		
☒ **A**	Milky Way	Solar System	Universe
☒ **B**	Milky Way	Universe	Solar System
☒ **C**	Solar System	Universe	Milky Way
☒ **D**	Solar System	Milky Way	Universe

(b) Some visible light telescopes are located in space.

Other visible light telescopes are located on the Earth's surface.

Explain why the images produced by telescopes on Earth are less clear than the images produced by telescopes in space.

(2)

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(c) This simplified diagram compares spectra of light from the Sun and two galaxies.

The light from galaxy 1 and galaxy 2 both show redshift.

Explain what these redshifts predict about the position and movement of the two galaxies.

(3)

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(d) Scientists have studied stars to discover how stars evolve.

They know that stars form in a nebula when clouds of dust and gas are pulled together by gravity.

Describe how this process continues for stars much more massive than the Sun.

(4)

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(Total for Question is 10 marks)

Q11.

(a) Put a cross (☒) in the box next to your answer.

Which of these is the biggest?

(1)

☒ **A** the Solar System

☒ **B** a galaxy

☒ **C** a nebula

☒ **D** the Universe

(b) These are four stages in the evolution of a star similar to the Sun.

They are **not** in the correct order.

1. main sequence star
2. white dwarf
3. red giant
4. nebula

Write down the stages in the correct order.

(2)

The first stage has been done for you.

..... nebula .....

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(c) (i) The chart shows the electromagnetic (EM) spectrum.
Some parts of the spectrum have been labelled.

radio	**P**	**Q**	visible light	**R**	**S**	gamma rays

State the name of part **Q**.

(1)

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(ii) Three telescopes using different parts of the spectrum have been added to the chart.

radio	**P**	**Q**	visible light	**R**	**S**	gamma rays
Jodrell Bank			Hubble			Compton

Jodrell Bank is located near Manchester, whereas Hubble and Compton are in space.

Explain why some telescopes are located outside the Earth's atmosphere.

(2)

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*(d) Describe how modern telescopes have contributed to our understanding of the Universe.

(6)

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(Total for Question is 12 marks)

Q12.

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 (☒) 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)

Mark Scheme

Q1.

Question Number	Answer	Mark
(i)	**The only correct answer is C red-shifted** A is not correct because the spectrum is not blue-shifted B is not correct because the spectrum is not green-shifted D is not correct because the spectrum is not violet-shifted	**(1) comp**

Question Number	Answer	Mark
(ii)	**The only correct answer is D Universe** A is not correct because the shift does not provide evidence for the expansion of Earth. B is not correct because the shift does not provide evidence for the expansion of the Milky Way Galaxy C is not correct because the shift does not provide evidence for the expansion of the Solar system	**(1) comp**

Q2.

Question Number	Answer	Acceptable answers	Mark
(i)	**D** ..is expanding … did not have a beginning		**(1)**

Question Number	Answer	Acceptable answers	Mark
(ii)	Cosmic Microwave Background (Radiation)	[order of words unimportant] CMB(R) reject 'CMB and red shift'	**(1)**

Q3.

	Answer	Acceptable answers	Mark
	An explanation linking any three of galaxies moving (1) away from Earth / Sun (1) galaxy 2 (moving away) faster (than galaxy 1) (1) galaxy 2 is (likely to be) most distant galaxy (1)	galaxies are (moving) at different speeds / away from each other / universe is expanding	**(3)**

Q4.

Question Number	Answer	Acceptable answers	Mark
(c)(i)	Correct plotting (1)	+/- ½ a small square if line is drawn exactly through the point accept for the mark even if point is not obvious	**(1)**

Question Number	Answer	Acceptable answers	Mark
(c)(ii)	Line of best fit drawn	straight line to be within lower two printed dots and upper 3 printed dots does not need to pass through origin **ignore** line below the given points	**(1)**

Question Number	Answer	Acceptable answers	Mark
(d)	A description including 1. expansion (of space) (1) and any one of 2. continuing (expansion) (1) 3. from very {hot/dense} start (1) 4. from a {point /small volume} (1) 5. origin of Universe (1)	 **ignore** expansion of Earth, particles and other objects unqualified 'explosion' is insufficient, a reference to expansion is needed (this point only is **dependent** on first) singularity {Universe / Space} still expanding = 2 marks	**(2)**

Q5.

	Answer	Acceptable answers	Mark
(i)	cosmic microwave background (radiation) all three words needed		**(1)**
(ii)	(the) Big Bang (theory)		**(1)**
(iii)	change in the (observed) frequency **or**wavelength of light/radiation (received from a distant galaxy)	light/absorption lines is/are shifted toward red end of spectrum light/radiation has longer wavelength/lower frequency waves are more spread out/stretched Ignore references to sound or colour of light eg galaxies/light appear(s) red(er)	**(1)**
(iv)	An explanation linking the following:- It/the Universe is expanding (1) some galaxies are (moving)faster (than others) (1)	 they/ galaxies are moving further/away (from the Earth/us) the further away the galaxy is the greater the red-shift/the faster the galaxy is moving (some galaxies) are moving away faster (than others) gains 2 marks IGNORE references to planets/stars	**(2)**

Q6.

		Indicative Content	
		A description including some of the following points • improved QUALITY eg higher or better magnifi detail/resolution or clearer/brighter image **OR**MORE INFORMATION (than with naked eye) image/data eg new planets/stars/nebulae/puls could be extra detail for greater magnification only)	

		• detection of (non-visible) electromagnetic WA UV / IR/ radio • TECHNOLOGY that enable collection of more d reflecting telescope/arrays ***and/or***additions eg computer-aided /photographic connections or (objective) lens/mirror • POSITION of telescopes – eg orbital/outside at top of mountains/away from atmosphere/rays absorbed/obscured/scattered by atmosphere. 'Hubble' or 'Compton'.	
Level	**0**	No rewardable content	
1	**1 - 2**	• a limited description e.g. mention of any one example such as "magnifies stars/planets" OR "discovering new planets/stars" • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy	
2	**3 - 4**	• a simple description e.g. mention of either two of the improvements **OR**extra detail about one of the improvements eg improvement **plus**example (ie Magnifies planets *so that craters/mountains may be seen)* • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy	
3	**5 - 6**	• a detailed description e.g. mention of three (or more) improvements **OR**two improvements **plus extra detail about one of them (ie Telescopes in space can detect XRays *that would be absorbed by the atmosphere*)** • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors	

(Suitable extra detail shown in italics in examples above)

Q7.

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	

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** 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.
	0	No rewardable material.	
Level 1	1–2	Additional guidance some element of physics about the expansion / single point origin	Possible candidate responses red shift shows expansion or CMBR connected with beginning
Level 2	3–4	Additional guidance more detail about one piece of evidence or basic detail about two pieces of evidence	Possible candidate responses red shift connected with galaxies moving away (from earth observer) CMBR to do with release of radiation at the beginning
Level 3	5–6	Additional guidance 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)	Possible candidate responses 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

Q8.

	Answer	**Acceptable answers**	**Mark**
(a)(i)	cosmic microwave background (radiation) all three words needed		**(1)**
(a)(ii)	(the) Big Bang (theory)		**(1)**
(a)(iii)	change in the (observed)	light/absorption lines is/are shifted	

	frequency **or**wavelength of light/radiation (received from a distant galaxy)	toward red end of spectrum light/radiation has longer wavelength/lower frequency waves are more spread out/stretched Ignore references to sound or colour of light eg galaxies/light appear(s) red(er)	**(1)**
(a)(iv)	An explanation linking the following:- It/the Universe is expanding (1) some galaxies are (moving)faster (than others) (1)	 they/ galaxies are moving further/away (from the Earth/us) the further away the galaxy is the greater the red-shift/the faster the galaxy is moving (some galaxies) are moving away faster (than others) gains 2 marks IGNORE references to planets/stars	**(2)**
(b)(i)	D red giant then white dwarf		**(1)**
(b)(ii)	an explanation linking **two** of the following: • Different/more wave(length)s/frequencies (now) detected/collected (1) • because telescopes positioned above Earth's atmosphere or by radio telescopes (1) OR • weaker signal(s) (now) detected/collected (1) • because modern telescopes are more powerful/have greater magnification **or** positioned above Earth's atmosphere/ on top of mountains (1) If no other marks awarded allow 1 mark for idea that: Electronic(s)/computers can process/improve the data/signal information/waves/radiation	 named type of em radiation accept CMB for microwave space telescope or named space telescope (because) less or no light/radiation is absorbed by Earth's atmosphere Accept named space telescope eg Hubble/Planck/Compton etc Ignore references to clearer images/more detail/can see further/photographs	**(2)**

Q9.

Question Number	Answer	Additional guidance	Mark
(i)	a description to include: wavelength (of e.m. radiation) increased / frequency decreased (1) as the (star) moves away (from us) (1)	don't penalise planet instead of object stretched/moves to(wards) red end of spectrum spectral lines move towards the red end of the spectrum	**(2)** AO 1 1

Question Number	Answer	Additional guidance	Mark
(ii)	• an explanation linking: • • big bang has expanding universe (1) • with galaxies moving away (from each other) (1)	 from (original) explosion started at a point accept stars moving away (not objects or planets here) the further away they are the greater is their (recessional) speed idea	**(2)** AO 1 1

Question Number	Answer	Additional guidance	Mark
(iii)	microwave		**(1)** AO 1 1

Question Number	Answer	Additional guidance	Mark
(iv)	(radiation) that comes from all over the sky / space / the universe	from the big bang / explosion	**(1)** AO 1 1

Question Number	Answer	Additional guidance	Mark
(v)	an explanation linking: • the Big Bang theory has a beginning / initial explosion (1) • that releases / gives out radiation (1)	 explosion from a point radiation still present	**(2)** AO 1 1

Q10.

	Answer	Acceptable answers	Mark
(a)	D		**(1)**
(b)	An explanation linking any two of (presence of Earth's) atmosphere (1) causes light to be absorbed/reduced in intensity (1) causes distortion of the image(1) (more) **light**pollution (1) (bigger) variations in temperature (1)	Accept reverse argument (more) air/ clouds/ pollution/ dust blocked / (more) difficult to see through blurs the image / refracts the light	**(2)**
(c)	An explanation linking any three of galaxies moving (1) away from Earth / Sun (1) galaxy 2 (moving away) faster (than galaxy 1) (1) galaxy 2 is (likely to be) most distant galaxy (1)	galaxies are (moving) at different speeds / away from each other / universe is expanding	**(3)**
(d)	A description including the following stages (up to 3 marks) Protostar (1) Main sequence star (1) (super) red giant (1) supernova (1)		**(4)**

	neutron star (1) (even more massive star can become) black hole (1) more massive stars have shorter life (1) Three stages in the correct sequence (1)		

Q11.

	Answer	Acceptable answers	Mark
(a)	D the Universe (1)		**(1)**
(b)	(nebula) main sequence (star) (1) AND red giant white dwarf (1) All three in correct order for 2 marks	Red Giant White Dwarf (Main sequence) (1)	**(2)**
(c)i	infrared (radiation)/(rays) (1)		**(1)**
(c)ii	An explanation linking any two from • above the clouds / no clouds/ no weather (1) • image is clearer/more detailed/ not distorted/not blurred (1) • no light pollution (1) • (some) telescopes use gamma/ X-rays/ultraviolet /infrared/microwaves (1) • no absorption (by atmosphere) of gamma/ Xrays/ ultraviolet /infrared/ microwaves (1)	Credit to be given for stating that all telescopes would be better in space, but size and weight may exclude e.g. Jodrell Bank from space. no {air/dust/pollution} wider field of view/ can use anytime IGNORE 'see further' IGNORE 'it is closer (to the stars/planets)'	**(2)**

		IGNORE: references to improving understanding / knowledge of space	

		Indicative Content	
QWC	***(d)**	A description including some of the following points • improved QUALITY eg higher or better magnifi detail/resolution or clearer/brighter image **OR**MORE INFORMATION (than with naked eye) image/data eg new planets/stars/nebulae/puls could be extra detail for greater magnification only) • detection of (non-visible) electromagnetic WA UV / IR/ radio • TECHNOLOGY that enable collection of more d reflecting telescope/arrays ***and/or***additions eg computer-aided /photographic connections or (objective) lens/mirror • POSITION of telescopes – eg orbital/outside atr top of mountains/away from atmosphere/rays absorbed/obscured/scattered by atmosphere. 'Hubble' or 'Compton'.	

Level	**0**	No rewardable content	
1	**1 - 2**	• a limited description e.g. mention of any one example such as "magnifies stars/planets" OR "discovering new planets/stars" • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy	
2	**3 - 4**	• a simple description e.g. mention of either two of the improvements **OR**extra detail about one of the improvements eg improvement **plus**example (ie Magnifies planets *so that craters/mountains may be seen)* • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy	
3	**5 - 6**	• a detailed description e.g. mention of three (or more) improvements **OR**two improvements **plus extra detail about one of them (ie Telescopes in space can detect XRays *that would be absorbed by the atmosphere*)** • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors	

(Suitable extra detail shown in italics in examples above)

Total for Question = 12 marks

Q12.

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