Question Number	Answer		Mark
1(a)	**C** Herschel discovered infrared radiation		**(1)**

Question Number	Answer	Acceptable answers	Mark
1(b)(i)	384 440 (km)	385 000 – 560 (even if calculated value from this is incorrect) accept 384 000	**(1)**

Question Number	Answer	Acceptable answers	Mark
1(b)(ii)	An explanation linking any two of 1. change of relative positions in orbits (1) 2. different radii orbits (1) 3. different (orbital) {speeds / times} (1)	 on same side and opposite sides of Earth – may be shown by calculation or diagram different distances (from Earth) moon is further away (moon/Hubble) moves faster than other mention of {not perfect circle / elliptical / different orbital planes} on its own is insufficient – needs qualifying one moves faster than the other and overtakes it = 2 marks	**(2)**

Question Number	Answer	Acceptable answers	Mark
1(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
1(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
1(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)**

Total for Question 2 = 8 marks

Question Number	Answer	Acceptable answers	Mark
2(a)(i)	**X** amplitude (1) **Y** wavelength (1)		**(2)**

Question Number	Answer	Acceptable answers	Mark
2(a)(ii)	**A**  (1)		**(1)**

Question Number	Answer	Acceptable answers	Mark
2(b)(i)	mirror (1) linked to: (which is) converging / concave / parabolic (1)	reflector (reflection / reflects is insufficient) curved **ignore** any reference to lenses, converging lenses and eyepieces	**(2)**

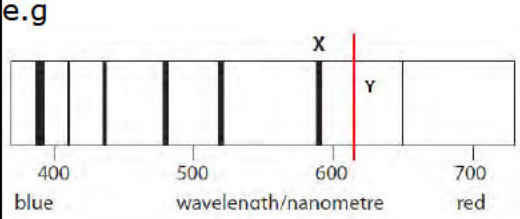
Question Number	Answer	Acceptable answers	Mark
2(b)(ii)	magnifies	makes it (look) bigger **ignore** closeness, clearness, more detail etc. **ignore** focus the image **ignore** zoomed in	**(1)**

Question Number		Indicative Content	Mark
QWC	***2 (c)**	A description including some of the following points evidence for • idea of Sun, Moon, stars or planets moving across the sky (not just orbiting) • in the same direction • pattern is repeated • appear to be going around the Earth • same every day evidence against • moons of {Jupiter/ other planet (with moons)} • appear to {orbit/ go around} {Jupiter/ other planet} • movement of Sun etc. not quite the same each day • planets do not move in a simple path • retrograde (west-east) motion of planets If no other marks scored • heliocentric model = Level 1	**(6)**
Level	**0**	No rewardable content	
1	**1 - 2**	• a limited description stating one fact for or against e.g. for – the Sun / stars move across the sky OR against - Jupiter has moons OR against - (Galileo) produced the {heliocentric / sun-centred} model • the answer communicates ideas using simple language and uses limited scientific terminology e.g. some correct names for the moving objects • spelling, punctuation and grammar are used with limited accuracy	
2	**3 - 4**	• a simple description involving (linked) facts e.g. the Sun and stars move across the sky **AND** do the same thing each day OR moons orbit Jupiter OR one fact for **AND** one against e.g. the sun moves across the sky but changes from day to day • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately e.g. correct names for the moving objects • spelling, punctuation and grammar are used with some accuracy	
3	**5 - 6**	• a detailed description of arguments for **AND** against, including at least one link. e.g. the Sun and stars move across the sky. Galileo observed moons, which orbit Jupiter. • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors	

Total for Question 5 = 12 marks

Question Number	Answer	Acceptable answers	Mark
3(a)(i)	Description including any two of: • gravity (1) • (causes the) nebula to collapse/contract (1) • (causes the) temperature to increase (1)	Pulls {particles/gas} together Forms protostar ke transferred to thermal energy KE/GPE ->thermal GPE -> KE until it was hot enough to start the reaction until fusion starts	**(2)**

Question Number	Answer	Acceptable answers	Mark
3(a)(ii)	**D** white dwarf		**(1)**

Question Number	Answer	Acceptable answers	Mark
3(b)(i)	Y drawn anywhere to the right of X e.g  	Accept any clear indication of where line should be line doesn't have to be labelled Reject lines both sides of X	**(1)**

Question Number	Answer	Acceptable answers	Mark
3(b)(ii)	explanation linking: • (distant) galaxy <u>moving away</u> (1) • (so) line shifted to longer λ (1)	shifted to red/redshift/lower frequency λ (appears to be) increasing Do not allow: galaxy appears red λ and f contradictions	**(2)**

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

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

Total for Question 2 = 8 marks

Question Number	Answer	Acceptable answers	Mark
4(a)(i)	B red giant (1)		**(1)**

Question Number	Answer	Acceptable answers	Mark
4(a)(ii)	C the Milky Way (1)		**(1)**

Question Number	Answer	Acceptable answers	Mark
4(a)(iii)	D Proxima Centauri (1)		**(1)**

Question Number	Answer	Acceptable answers	Mark
4(b)	description to include: • method (1) • relevant detail (1)	Telescope (inc. radio telescopes) Lander (e.g. robots/drones) Orbiter / Satellite has camera / takes photos / collecting samples (e.g rocks) / analyse atmosphere / climate / signs of water / gases that will support life / can test for water/nutrients ignore repeat of stem	**(2)**

Question Number	Answer	Acceptable answers	Mark
4(c)(i)	explanation linking two from: • (on Earth) image is distorted / image not bright enough (ORA) (1) • planets very small / far away (1) • atmosphere (in way) / light pollution (1) • can detect different parts of em spectrum (that are not detectable on Earth) (1) • can keep it pointed at the same spot more easily (1)	Reverse arguments apply throughout (above atmosphere gives) more defined / clearer / better image obscured by clouds waves can be detected (that are not detectable on Earth) not affected by Earth's rotation	**(2)**

Question Number	Answer	Acceptable answers	Mark
4(c)(ii)	Suggestion: • planet takes 150 days to orbit the star (1)	has 150 days in a year	**(1)**

(Total for Question 2 = 8 marks)

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

Question Number	Answer	Acceptable answers	Mark
5 (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
5 (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	***5( )**	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		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

(Total for Question 6 = 12 marks)