

Question			Answer	Max mark	Additional guidance
5.	(a)		Cosmic Microwave Background Radiation OR Olber's Paradox OR Abundance of Hydrogen and Helium in the Universe	1	Present temperature of the universe 2.7K (Blackbody radiation graph) Accept: Abundance of Light elements in the Universe Do not accept: the abbreviation "CMBR" on its own. Do not accept any further evidence based on redshift alone.
	(b)	(i)	$\left(\text{Age} = \frac{1}{H_0} \right)$ $\text{Age} = \frac{1}{2.0 \times 10^{-17}}$ (1) $(\text{Age} = 5.0 \times 10^{16} \text{ (s)})$ $\text{Age} = 1.6 \times 10^9 \text{ (years)}$ (1)	2	Accept: 2, 1.58, 1.584 Accept: 2, 1.59, 1.585 (365 days has been used - this does not need to be shown explicitly.) Years in brackets as question asks for age "in years".

Question			Answer	Max mark	Additional guidance
5.	(ii)	(A)	(Student's) value for H_0 is incorrect/too large/not accurate (enough). OR Incorrect line (of best fit) drawn. OR The (student's) gradient (which is H_0) is too large. OR New/more data is available/more accurate. OR Not enough data at large distances.	1	Accept: H_0 varies/decreases as age of the universe increases Do not accept: H_0 is different
		(B)	The student could draw the (correct) line of best fit. OR Student could use a larger sample/all of the 1929 Hubble data.	1	Accept: The student could use current data. Do not accept "<u>different</u> line of best fit" alone.
	(c)		Dark energy	1	

Q5(a)

Maximum Mark: 1

RESPONSE 1

red shift

RESPONSE 2

(a) State one other piece of evidence that supports the Big Bang theory.

Cosmic microwave background radiation.
^ Cosmic background microwave radiation - Also
redshift of light from planets.

RESPONSE 3

- (a) State one other piece of evidence that supports the Big Bang theory.

if something is moving away fast. To the observer it shifts to the red end of the spectrum. (red shift). This is what is observed looking at distant galaxies.

Q5(b)(i) Maximum Mark: 2

RESPONSE 1

$$\begin{aligned} \text{age of universe} &= \frac{1}{H_0} \\ &= \frac{1}{2 \times 10^{-17}} \\ &= 5 \times 10^{16} \text{ s} \\ &= \underline{1.6 \times 10^9 \text{ years}} \end{aligned}$$

RESPONSE 2

$$\begin{aligned} \text{age} &= \frac{1}{H_0} \\ &= 5 \times 10^{16} \text{ years} \end{aligned}$$

Q5(b)(ii)

A

Maximum Mark: 1

RESPONSE 1

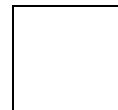
~~This~~ This is because the student's calculation of hubble's constant is not as accurate as the universally used version.

RESPONSE 2

More advanced ~~technology~~ ^{technology} ~~has~~ been invented so the value for H_0 is more accurate now than in 1929.

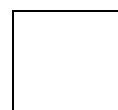
RESPONSE 3

The recessionary velocity can be more accurately measured and time has passed since 1929.
 The recessionary velocity can be measured at greater distances so the gradient has changed.



RESPONSE 4

Because Hubble's Constant changes a lot

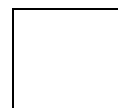


RESPONSE 5

Using Value from data sheet

$$\text{age} = \frac{1}{2.3 \times 10^{-18}} = 4.35 \times 10^{17} \text{ years}$$

Student has not finished calculating, they need to take into consideration the days, hours, minutes and seconds



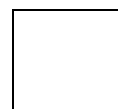
Q5(b)(ii)
B

Maximum Mark: 1

RESPONSE 1

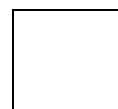
the universe.

~~Plot~~ Gather more information to plot more points to give a more accurate value for H_0 .



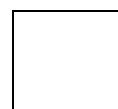
RESPONSE 2

Draw a more accurate line of best fit.



RESPONSE 3

Include more recessionary velocities at greater distances to get a more accurate gradient.



RESPONSE 4

Value in I) = 5×10^{16}
 $\therefore 5 \times 10^{16} / 365 \rightarrow \text{ans} / 24 \rightarrow \text{ans} / 60$
 $\rightarrow \text{ans} / 60 = 15.9 \times 10^8 \text{ years.}$
The student should follow this process.

Q5(c)

Maximum Mark: 1

RESPONSE 1

Dark matter.

RESPONSE 2

~~Dark matter~~

Dark energy

RESPONSE 3

The big bang.

Q5(a)	1	
Response 1	0	The candidate's response 'red shift' alone is not a sufficient piece of evidence for the Big Bang theory.
Response 2	0	The candidate's first answer (<i>Cosmic microwave background radiation</i>) is acceptable, but their second answer (<i>redshift of light from planets</i>) is not acceptable. The second answer negates the first. This is commonly known as the '+/- rule' and is explained in the <i>Physics: general marking principles</i> , issue 21.
Response 3	0	In their attempt to explain redshift, the candidate does not mention <i>light</i> , or relate redshift to the movement of stars, and so their response is not acceptable.
Q5(b)(i)	2	
Response 1	2	The candidate has correctly substituted data into the given relationship and calculated the correct final answer.
Response 2	0	The candidate has not shown the substitution of data into the given relationship, and has given an incorrect final answer. The correct substitution cannot be implied from an incorrect final answer, and so the marks are not awarded.
Q5(b)(ii) A	1	
Response 1	0	The candidate's calculation of the Hubble constant is correct for the line of best fit that has been drawn, and so the candidate's statement 'Hubble's constant is not as accurate' is both ambiguous and insufficient to fully answer the question.
Response 2	1	The candidate's statement is taken as equivalent to the first of the possible acceptable answers given in the marking instructions.
Response 3	1	The candidate's statement is taken as the equivalent to the fourth of the possible answers in the marking instructions.
Response 4	0	The candidate's statement is not acceptable.
Response 5	0	The candidate's statement is not acceptable.
Q5(b)(ii) B	1	
Response 1	1	The candidate's suggestion is acceptable, being similar to the second possible acceptable answer given in the marking instructions.
Response 2	1	The candidate's suggestion is acceptable.
Response 3	1	Again, the candidate's suggestion is acceptable, being similar to the second possible acceptable answer given in the marking instructions.
Response 4	0	The candidate's response is not acceptable.

Question /Response	Mark	Commentary
Q5(c)	1	
Response 1	0	The candidate's response is incorrect.
Response 2	1	The candidate's response is correct.
Response 3	0	Again, the candidate's response is incorrect.
Q6(a)(i)	2	
Response 1	0	The candidate has not explicitly stated an appropriate relationship, and so cannot access the mark for substitution of data. A correct relationship cannot be implied by 'correct' substitution of data in a 'show' type question. In addition, the candidate has not included the unit in the final answer.
Response 2	2	The candidate has explicitly stated an appropriate relationship and substituted data correctly, stating the given final answer.