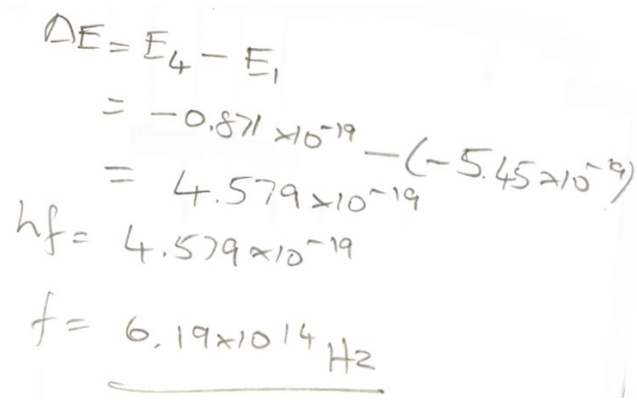
Question			Expected response	Max mark	Additional guidance
6.	(a)	(i)	$E_2 - E_1 = hf$ **(1)** $(-0{\cdot}871\times10^{-19} - (-5{\cdot}45\times10^{-19}) =$ $6{\cdot}63\times10^{-34}\times f$ **(1)** $f = 6{\cdot}91\times10^{14}$ Hz **(1)**	**3**	Accept: 6·9, 6·906, 6·9065 Accept: $E_1 - E_4 = -hf$ $E_4 - E_1 = hf$ $(\Delta)E = hf$ for relationship mark anywhere Accept: $(5{\cdot}45\times10^{-19} - 0{\cdot}871\times10^{-19}) =$ $6{\cdot}63\times10^{-34}\times f$ If $(0{\cdot}871\times10^{-19} - 5{\cdot}45\times10^{-19})$ shown for substitution, maximum 1 mark for relationship
		(ii)	$v = f\lambda$ **(1)** $3{\cdot}00\times10^{8} = 6{\cdot}91\times10^{14}\times\lambda$ **(1)** $\lambda = 4{\cdot}34\times10^{-7}$ m **(1)**	**3**	Or consistent with (a)(i) Accept: 4·3, 4·342, 4·3415
		(iii)	Blue-violet	**1**	Or consistent with (a)(ii)
	(b)		$z = \frac{v}{c}$ **(1)** $z = \frac{4{\cdot}51\times10^{6}}{3{\cdot}00\times10^{8}}$ **(1)** $z = 0{\cdot}0150$ **(1)**	**3**	Accept: 0·015, 0·01503, 0·015033
	(c)		Redshift is evidence that the Universe is expanding **(1)** <u>Expanding Universe</u> is evidence supporting the Big Bang theory **(1)**	**2**	Accept: Redshift is evidence that the galaxies are moving away from each other.

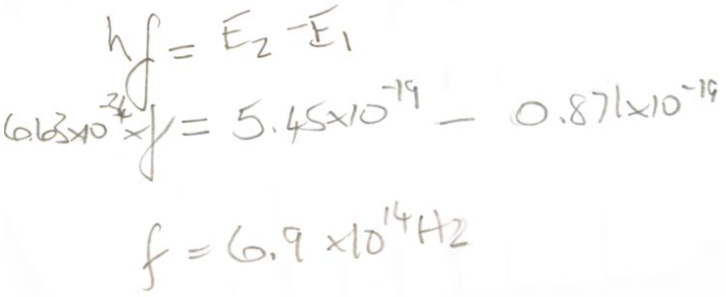
Q6(a)(i) Maximum mark: 3

Response A

Marks



Response B



Q6(b) **Maximum mark: 3**

Response 1

Marks

$$Z = \frac{V}{C} = \frac{4.51 \times 10^{6}}{3 \times 10^{8}} = 0.01500$$

Q6(c) **Maximum mark: 2**

Response A **Marks**

the vast majority of objects are redshifted away from us, this suggests that everything started as one singularity, supporting the Big Bang theory.

Response B

if everything is redshifted that means it is all moving away showing that it was all at one singularity hence the big bang

Response C

As it shows the majority of galaxies are redshifting away from Earth showing the Universe started with a singularity.

6(a)(i)	A	3	1	The candidate has implied the selection of an appropriate relationship ($\Delta E = hf$). However, as the candidate has not shown all substituted values (no value for h) and given an incorrect final answer, correct substitution into $\Delta E = hf$ cannot be implied by the incorrect final answer.
	B	3	3	The candidate has selected an appropriate relationship, correctly substituted values (it is assumed that the two negative signs applied to 5.45×10^{-19} have been 'cancelled') and given an acceptable final answer.
6(b)	A	3	2	The candidate has selected an appropriate relationship and has correctly substituted values. The final answer, however, is incorrect (0.01503 rather than 0.01500).
6(c)	A	2	1	The candidate has implied, but not specifically used the term 'Expanding Universe' and so is awarded the first mark referenced in the marking instructions but not the second.
	B	2	1	Again, this candidate has implied, but not specifically used the term 'Expanding Universe' and so is awarded the first mark referenced in the marking instructions but not the second.
	C	2	0	The candidate has not sufficiently explained that redshift implies galaxies moving away from each other.