

Question			Marking details	Marks Available
6	(a)		Red shift (accept Doppler) shifts of starlight / galaxies [measured] but not for planets	1
			The further the galaxy the greater the red-shift / velocity (or red-shift is proportional to galaxy distance)	1
			Consistent with initial explosion e.g. expansion is consistent with the Big Bang (or consistent with matter starting from a point)	1
	(b)		Speeds near the speed of light <u>not</u> greater than the speed of light accept velocities are large fractions of the speed of light Don't accept at or greater than the speed of light	1
	(c)		Current content of universe explained clearly i.e. baryons (& leptons) not antibaryons (and anti-leptons)	1
			Argument for symmetry breaking (Violation of Cons of Baryon not enough) - e.g. must have slight excess of baryons etc.	1
	(d)		Smaller mass linked to less energy	1
			Less energy or lower temperature linked to the later time Smaller masses produced at lower temperatures – 1 mark	1
	(e)		Fusion [of nuclei] stated	1
			Due to high T (or velocity or energies) [around 10^{-6} (to 3 min) after Big Bang]	1
	(f)		Universe was cooler or electrons or protons have lower energy	1
			Electrons combined with protons (accept nuclei)	1
			Photon energy too low for atoms/electrons to absorb Accept em radiation was no longer absorbed [by electrons/ions] or em radiation is no longer being scattered	1

Question			Marking details	Marks Available
	(g)		Substitution of $v_{\text{esc}} = H_0 R$ (or equivalent algebraic step)	1
			$M = \frac{4}{3}\pi R^3 \rho$ (or equivalent)	1
			Clear algebra leading to $\rho_c = \frac{3H_0^2}{8\pi G}$	1
	(h)		Correct substitution of H_0 and G	1
			$\frac{9.21 \times 10^{-27}}{1.66 \times 10^{-27}}$ seen or 5.55 seen	1
				1
	(i)		$\lambda_{\text{max}} = 0.105 \text{ cm}$	1
			$T = \frac{2.90 \times 10^{-3}}{0.00105} = 2.76 [\text{K}]$	1
	Question 6 Total			[20]