25. Astronomy and Cosmology

25.3 Hubble's law and the Big Bang theory

Paper 4

Marking Scheme

Q1.

(a)(i)	movement of star causes change in (observed) frequency **or** movement of star causes redshift	**B1**
	observed frequency is lower (than emitted frequency)	**B1**
(a)(ii)	all three lines shown to left of corresponding printed lines	**B1**
	distance between drawn line and corresponding printed line approximately the same for all three lines	**B1**
(b)(iii)	$\Delta\lambda = \lambda \times (v / c)$ $= (488 \times 6.2 \times 10^{6}) / (3.00 \times 10^{8})$ $(= 10\ \text{nm})$	**C1**
	observed wavelength $= 488 + \Delta\lambda = 488 + 10$ $= 498\ \text{nm}$	**A1**
(c)	$v = H_0 d$	**C1**
	$d = (6.2 \times 10^{6}) / (2.3 \times 10^{-18})$ $= 2.7 \times 10^{24}\ \text{m}$	**A1**

Q2.

(a)	• redshift is the increase in observed wavelength / decrease in observed frequency (caused by Doppler effect) • radiation from distant galaxies is observed to be redshifted • redshift provides evidence that galaxies are moving apart • galaxies moving apart means Universe must be expanding *Any three points, 1 mark each*	**B3**
(b)(ii)	$\Delta\lambda / \lambda = v / c$ $(726 - 658) / 658 = v / (3.00 \times 10^{8})$	**C1**
	$v = 3.1 \times 10^{7}\ \text{m s}^{-1}$	**A1**
(c)(i)	line with positive gradient passing through the origin	**B1**
	straight line with positive gradient	**B1**
(c)(ii)	Hubble constant	**B1**

Q3.

(a)	speed is (directly) proportional to distance	**M1**
	speed is speed of recession of galaxy from an observer, and distance is the distance of the galaxy from the observer	**A1**
(c)(i)	galaxy is moving away (from the Earth)	**B1**
	wavelength (of light from the galaxy) increased by the Doppler effect / due to redshift	**B1**
(c)(ii)	$\Delta\lambda / \lambda = v / c$ $v = [(492 - 486) \times 3.00 \times 10^{8}] / 486$ $(v = 3.7 \times 10^{6}\ \text{m s}^{-1})$	**C1**
	$H_0 = v / d$	**C1**
	$= (3.7 \times 10^{6}) / (1.8 \times 10^{24})$ $= 2.1 \times 10^{-18}\ \text{s}^{-1}$	**A1**

Q4.

(b)(ii)	star / galaxy is moving away from the student	**B1**

Q5.

(c)(i)	apparent wavelength is greater **or** wavelength is greater than known value	**B1**
	(due to) movement of star away (from observer)	**B1**
(c)(ii)	by examining the (lines in the) spectrum (of light from the star)	**B1**
	and comparing with known spectrum	**B1**

Q6.

(a)(i)	speed is (directly) proportional to distance	**M1**
	where speed is speed of recession of galaxy (from observer) and distance is distance of galaxy away from observer	**A1**
(a)(ii)	wavelengths (of spectral lines) are greater (than their known values)	**B1**
	redshift shows stars (in distant galaxies) moving away from Earth	**B1**
(b)	(all) parts of Universe moving away from each other	**B1**
	more distant objects are moving away faster	**B1**
	matter must have been close together / very dense in the past	**B1**

Q7.

(b)(i)	redshift	**B1**
(b)(ii)	moving away (from observer)	**B1**
(b)(iii)	$\Delta\lambda / \lambda = v / c$ e.g. for 658 nm line: $\Delta\lambda$ = 686 – 658 (= 28 nm) (*other lines may be used*)	**C1**
	$28 / 658 = v / (3.00 \times 10^8)$ (*other lines may be used*)	**C1**
	$v = 1.3 \times 10^7$ m s^{-1}	**A1**
(c)	$v = H_0 d$	**C1**
	$H_0 = (1.3 \times 10^7) / (5.7 \times 10^{24})$ $= 2.3 \times 10^{-18}$ s^{-1}	**A1**