

Mark Scheme

Q1.

Question Number	Answer	Mark
	D	1

Q2.

Question Number	Acceptable Answer	Additional Guidance	Mark
	The speed of the pulsar is negligible compared with the speed of light	Attempt at calculation may result in this conclusion and so should gain mark Accept idea of speed being much smaller Accept comment that red shift is negligible/very small, if based on a calculation	1

Q3.

Question Number	Answer	Mark
	The only correct answer is D because there is relative motion of the objects away from each other so the wavelength is increased by the Doppler effect so the observed frequency is decreased A there is relative motion of the objects towards each other so the wavelength is decreased by the Doppler effect so the observed frequency is increased B there is no relative motion for the objects so there is no observed change in wavelength or frequency C there is relative motion of the objects towards each other so the wavelength is decreased by the Doppler effect so the observed frequency is increased	1

Q4.

Question Number	Answer	Mark
	A	1

Q5.

Question Number	Acceptable answer	Additional guidance	Mark
	C	The only correct answer is C because the correct method for a nearby star is parallax, for a nearby galaxy is standard candle and for a very distant galaxy is red shift A is not correct because only the nearby star method is correct B is not correct because only the nearby galaxy method is correct D is not correct because none of the methods are correct	1

Q6.

Question Number	Answer	Mark
	D – $\frac{(656.3 - 654.9)}{654.9} \times 3 \times 10^8 \text{ m s}^{-1}$	1
	Incorrect Answers: correct method: $\frac{\text{change in wavelength}}{\text{wavelength in laboratory}} \times \text{speed of light}$ A – uses $\frac{\text{wavelength from star}}{\text{wavelength in laboratory}} \times \text{speed of light}$ B – uses $\frac{\text{wavelength in laboratory}}{\text{change in wavelength}} \times \text{speed of light}$ C – uses $\frac{\text{wavelength in laboratory}}{\text{wavelength from star}} \times \text{speed of light}$	

Q7.

Question Number	Acceptable answers	Additional guidance	Mark
	An explanation that makes reference to the following points: - The fractional change in wavelength is proportional to the relative velocity of the source (1) - Hence the change in wavelength is proportional to the wavelength (1) OR $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ and v and c are the same for all wavelengths Or $\frac{\Delta\lambda}{\lambda} = z$ and z is constant (1) - change in wavelength is proportional to the wavelength Or rearranges, e.g. $\Delta\lambda = x\lambda$ to demonstrate $\Delta\lambda$ is proportional to λ (1)		2

Q8.

Question Number	Acceptable Answer	Additional Guidance	Mark
	- use of $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ with $\lambda = 656.2 \text{ nm}$ (1) $v = 9 \times 10^4 \text{ m s}^{-1}$ (1) - the star is moving towards the Earth (1)	<u>Example of calculation:</u> $v = \left(\frac{(656.2 - 656.0) \times 10^{-9} \text{ m}}{656.2 \times 10^{-9} \text{ m}} \right) \times 3.00 \times 10^8 \text{ m s}^{-1}$ $= 9.14 \times 10^4 \text{ m s}^{-1}$	3

Q9.

Question Number	Acceptable Answer	Additional Guidance	Mark
	- Use of $\frac{\Delta\lambda}{\lambda} \approx \frac{v}{c}$ (1) $v = (-) 1.8 \times 10^5 \text{ m s}^{-1}$ (1) - Towards the Earth (dependent upon correct numerator in Doppler equation) (1)	<u>Example of calculation</u> $\frac{(655.88 - 656.28) \text{ nm}}{656.28 \text{ nm}} \approx \frac{v}{3.0 \times 10^8 \text{ m s}^{-1}}$ $v = \frac{(-)0.4 \text{ nm}}{656.28 \text{ nm}} \times 3.0 \times 10^8 \text{ m s}^{-1} =$ $-1.83 \times 10^5 \text{ m s}^{-1}$	3

Q10.

Question Number	Answer	Mark
	(Observed frequency is less, so) source is receding (from Earth) (1) Use of $\frac{\Delta f}{f} = \frac{v}{c}$ Or $z = \frac{\Delta f}{f}$ (1) $v = 1.5 \times 10^6 \text{ m s}^{-1}$ Or $z = 5.0 \times 10^{-3}$ (1) (min 2 sf answer required) <u>Example of calculation:</u> $\Delta f = (4.547 \times 10^{14} - 4.570 \times 10^{14}) \text{ Hz} = (-)2.3 \times 10^{12} \text{ Hz}$ $v = \frac{c \Delta f}{f} = \frac{3.0 \times 10^8 \text{ m s}^{-1} \times 2.3 \times 10^{12} \text{ Hz}}{4.57 \times 10^{14} \text{ Hz}} = 1.51 \times 10^6 \text{ m s}^{-1}$	3
	Total for question	3

Q11.

Question Number	Answer	Mark
	There is a red shift [accept Doppler shift] (1)	
	The galaxy is receding Or the galaxy is moving away from us (1)	2
	[Do not accept "the universe is expanding"]	
	Total for question	2

Q12.

Question Number	Acceptable answers	Additional guidance	Mark
(i)	- Use of $z = \frac{\Delta\lambda}{\lambda}$ (1) - Uses $\Delta\lambda = 4.0 \times 10^{-6} \text{ m} - \lambda$ and λ as the denominator (1) - Wavelength emitted = $2.7 \times 10^{-7} \text{ m}$ (1)	<u>Example of calculation:</u> $z = 14 = \frac{4.0 \times 10^{-6} \text{ m} - \lambda}{\lambda}$ Wavelength emitted = $2.67 \times 10^{-7} \text{ m}$	3
(ii)	An explanation that makes reference to the following points: - Wavelength of light has increased (1) One from: - Visible / UV light which was initially emitted might arrive as IR / radio (1) - Due to expanding universe/space (1)		2