

Name of the Student: _____

Max. Marks : 21 Marks

Time : 21 Minutes

Mark Schemes

Q1.

Question Number	Acceptable answers	Additional guidance	Mark
	<p>An explanation that makes reference to the following points:</p> <ul style="list-style-type: none"> 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) <p>OR</p> <ul style="list-style-type: none"> $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ 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

Q2.

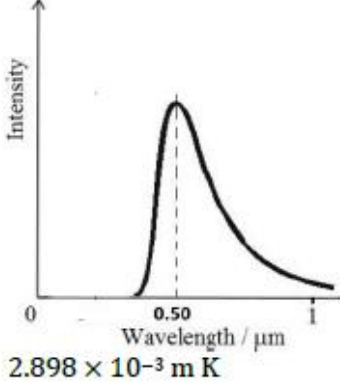
Question Number	Acceptable answers	Additional guidance	Mark
	<p>An explanation that makes reference to the following points:</p> <ul style="list-style-type: none"> Estimate λ_{star} (1) (above 7×10^{-7} m) Use of $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ with (1) 656 nm as denominator $v = 3.8 \times 10^7 \text{ m s}^{-1}$ (1) (range $3.4 \times 10^7 \text{ m s}^{-1}$ to $4.2 \times 10^7 \text{ m s}^{-1}$) (Star is) moving away from the Earth (1) Or (star is) receding 	<p><u>Example of calculation</u></p> $\frac{(7.40 \times 10^{-7} - 6.56 \times 10^{-7})}{6.56 \times 10^{-7} \text{ m}} = \frac{v}{3.00 \times 10^8 \text{ m s}^{-1}}$ $\therefore v = \frac{0.84 \times 10^{-7} \text{ m}}{6.56 \times 10^{-7} \text{ m}} \times 3.00 \times 10^8 \text{ m s}^{-1}$ $\therefore v = 3.84 \times 10^7 \text{ m s}^{-1}$	4

Q3.

Question Number	Acceptable answers	Additional guidance	Mark
(i)	<ul style="list-style-type: none"> Use of $v = H_0 d$ and $v = d/t$ to derive equation (1) 	<p><u>Example of derivation:</u> $v = H_0 d$ $v = d/t$ $d/t = H_0 d$ $1/t = H_0$</p> <p>Need to see $v = d/t$</p>	1
(ii)	<ul style="list-style-type: none"> Expansion (of Universe) has been uniform (1) Or Expansion (of Universe) at a constant rate Or Galaxy moves at constant velocity 	Accept H_0 is constant	1
(iii)	<ul style="list-style-type: none"> Converts to s (1) Use of $H = 1/T$ (1) 75 ($\text{km s}^{-1} \text{Mpc}^{-1}$) and conclusion that it lies within range (1) Or Upper and lower limits of values of the Hubble constant are $2.58 \times 10^{-18} \text{ s}^{-1}$ to $1.94 \times 10^{-18} \text{ s}^{-1}$, so it is in range 	<p><u>Example of calculation:</u> Age of universe = $13 \times 10^9 \times 3.16 \times 10^7 = 4.11 \times 10^{17} \text{ s}$</p> <p>$H = 1 / 4.11 \times 10^{17} \text{ s} = 2.43 \times 10^{-18} \text{ s}^{-1}$</p> <p>$(2.43 \times 10^{-18} \text{ s}^{-1} \div 10^3 \text{ (k)} \times 10^6 \text{ (M)} \times 3.1 \times 10^{16} \text{ (Pc)})$ $= 75.5 \text{ km s}^{-1} \text{Mpc}^{-1}$</p>	3

Q4.

Question Number	Acceptable answers	Additional guidance	Mark
(i)	<p>An explanation that makes reference to the following points:</p> <ul style="list-style-type: none"> Electrons / atoms exist in discrete/fixed/certain energy levels Or there are only a certain number of specific differences in energy levels of electrons / atoms (1) (Absorbing) a <u>photon</u> causes an electron / atom to move to a higher energy level (1) Or (Absorbing) a <u>photon</u> causes an electron / atom become excited (1) Photons are (only) absorbed when the <u>photon</u> energy is equal to the difference between energy levels (1) <u>Photon</u> energy depends on frequency/wavelength, so photons of specific frequencies/wavelengths are absorbed, (producing dark lines) 	May refer to photon energy $E = hf$	4

<p>(ii)</p>	<ul style="list-style-type: none"> • Use of $\lambda_{max}T = 2.898 \times 10^{-3} \text{ m K}$ (1) • $\lambda_{max} = 5.0 \times 10^{-7} \text{ (m)}$ (1) • Curve with a peak at candidate's value of λ_{max} (1) • Black body asymmetric curve with intensity = 0 when wavelength = 0 (1) 	<p><u>Example of calculation:</u></p> $\lambda_{max} = \frac{2.898 \times 10^{-3} \text{ m K}}{5800 \text{ K}}$ $= 5.0 \times 10^{-7} \text{ m}$  <p>Meets x axis on left but not on right, steeper on the left than on the right and narrower on the left at every point than on the right</p>	<p>4</p>
<p>(iii)</p>	<p>An explanation that makes reference to the following points:</p> <ul style="list-style-type: none"> • Fusion takes place (from hydrogen to helium) (1) • This releases energy and leads to an (outward) pressure/force which balances gravitational forces (1) 	<p>Accept high temperature for energy</p>	<p>2</p>