10 **(a)** State Hubble's law.

.....

.....

..... [2]

(b) A star in a distant galaxy emits radiation that has a maximum intensity of emission at a wavelength of 4.62×10^{-7} m.

Observations of the galaxy made on the Earth detect the maximum intensity of emission from the star at a wavelength of 4.91×10^{-7} m.

(i) Explain why the observed wavelength and the emitted wavelength have different values.

.....

.....

..... [2]

(ii) Calculate the speed of the star relative to the Earth.

speed = ... $m\,s^{-1}$ [2]

(iii) The wavelength of maximum intensity of emission is used to determine a value for the surface temperature of the star.

Explain how the temperature determined using the observed wavelength compares with the true value of temperature determined using the emitted wavelength.

.....

.....

..... [2]

(c) A value for the Hubble constant is $2.3 \times 10^{-18}\,s^{-1}$.

Use your answer in **(b)(ii)** to determine the distance of the star in **(b)** from the Earth.

distance = ... m [2]

[Total: 10]

10 **(a)** Explain how redshift leads to the idea that the Universe is expanding.

.....

.....

.....

.....

..... [3]

(b) Stars in a distant galaxy emit radiation. The total luminosity of the stars in the galaxy is 1.90×10^{36} W.
The emission spectrum of the radiation contains a line X at a wavelength of 658 nm.

Radiation from the galaxy is observed on the Earth. The observed radiation has a radiant flux intensity of 8.42×10^{-16} W m^{-2}. In the observed emission spectrum, line X is at a wavelength of 726 nm.

Determine:

(i) the distance d of the galaxy from the Earth

d = ... m [2]

(ii) the speed v of the galaxy relative to the Earth.

v = ... m s^{-1} [2]

(c) Observations of many galaxies, such as the one in **(b)**, lead to many pairs of values of d and v. Plotting these values reveals a trend.

(i) On Fig. 10.1, sketch the variation of v with d.

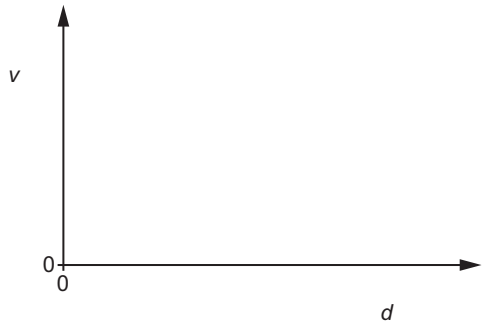

Fig. 10.1

[2]

(ii) State the name of the quantity represented by the gradient of the line in Fig. 10.1.

..... [1]

[Total: 10]