

1 (a) State Hubble's Law.

.....
..... [1]

(b) The dark lines of the spectrum observed from a distant galaxy are red-shifted by 15% of their normal wavelengths.

The Hubble constant is estimated to be $65 \text{ km s}^{-1} \text{ Mpc}^{-1}$. One parsec = $3.1 \times 10^{16} \text{ m}$.

(i) Show that the speed of the galaxy is $4.5 \times 10^7 \text{ m s}^{-1}$.

[1]

(ii) Estimate the distance of the galaxy from the Earth.

distance = m [2]

(iii) Estimate the age of the universe in years.

1 year = $3.2 \times 10^7 \text{ s}$

age = y [2]

(c) The age of the universe is calculated from the time of the big bang. Describe **two** observations that directly support the idea of the big bang.

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.....
.....
.....
.....
..... [2]

2 (a) Define the *parsec*. Draw a diagram to illustrate your answer.

.....
..... [2]

(b) The star Tau Ceti has a parallax of 0.275 seconds of arc.

Calculate the distance of Tau Ceti from Earth

(i) in parsec (pc)

distance = pc [1]

(ii) in light year (ly).

$$1 \text{ pc} = 3.1 \times 10^{16} \text{ m}$$

distance = ly [2]

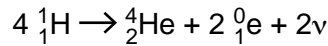
[Total: 5]

- (b) The present mass of the Sun is 2.0×10^{30} kg. The Sun emits radiation at an average rate of $3.8 \times 10^{26} \text{ J s}^{-1}$. Calculate the time in years for the mass of the Sun to decrease by one millionth of its present mass.

$$1 \text{ y} = 3.2 \times 10^7 \text{ s}$$

time = y [3]

- (c) The following nuclear equation summarises a typical fusion reaction cycle that occurs in the Sun.



- (i) Explain the process of nuclear fusion in the core of the Sun. In your explanation refer to the conditions necessary for fusion to occur.

.....

 [4]

- (ii) Name two forms of energy produced in thermonuclear reactions.

1.

2.

[2]

- (iii) The binding energy per nucleon of ^1_1H and ^4_2He are 0 and 7.2 MeV respectively. Calculate the energy produced in joules for the fusion reaction above.

energy = J [2]