

Question 2

part a, 4%

part b, 4%

part c, 4%

An observed binary star system consists of a main sequence star of mass $M_{ms} = 0.80M_{\odot}$ and a white dwarf of mass $M_{wd} = 1.06M_{\odot}$.

(a) Briefly describe the dominant mechanism that prevents the main sequence star from collapsing under its own gravity. Name the physical mechanism that supports a white dwarf star against gravitational collapse. Contrast these two mechanisms in terms of the length of time that they can act to support a star.

(b) The orbit of either star with respect to the other star is circular, and the stars have a separation $a = 1.50 \times 10^9$ m. Calculate the orbital period of the binary. Express your answer in hours.

(c) The main sequence star has a radius (measured to its photosphere) of $R = 7 \times 10^8$ m. Consider a blob of gas of mass m in the photosphere of the main sequence star, on the line between the centres of the two stars.

(i) If F_{wd} is the gravitational force of the white dwarf on the blob, and F_{ms} is the force of the main sequence star on the blob, show that

$$\frac{F_{wd}}{F_{ms}} = \frac{M_{wd}R^2}{M_{ms}(a-R)^2}$$

(Assume that the force due to gravity from either star is the same as from point masses located at the centres of the respective stars.)

(ii) Hence show that the main sequence star will lose mass to the white dwarf.

Question 3

part a, 4%

part b, 8%

(a) Consider a main sequence star of $8M_{\odot}$ that formed in the early history of the Universe from material with primordial abundances (i.e. no significant abundance of any element heavier than helium).

(i) State why you would expect the dominant hydrogen-burning nuclear reaction to have been *different* from that in a star of the same mass that formed more recently.

(ii) State which hydrogen-burning nuclear reaction *would* have been dominant in that primordial star.

(b) Describe the main nuclear processes that occur during the evolution of a star that formed later with a mass of $8M_{\odot}$, and that had the same composition as the Sun at its formation. Start from the point when it joins the main sequence, and proceed up to and including the time when the star is disrupted in a supernova explosion. Your account should concentrate on the synthesis of the chemical elements, including elements heavier than iron. There is no need to write nuclear reaction equations in your description, but you should describe the different types of reaction, and the physical conditions that make them possible.