A. Key Concepts

1. State the three equations used to calculate different characteristics of a star.
2. Explain how stars are formed with reference to a balancing of gravitational force.
3. Explain the stages in the proton-proton chain in stellar fusion reactions converting hydrogen to helium.
4. Sketch a Hertzsprung-Russel diagram and label on it the position of different classes of stars.
5. Which classification of stars have the fusion of hydrogen occurring in the core?
6. Explain how a main sequence star could become a giant or super giant star.
7. Explain how the mass of a star determines its lifetime and eventual fate.

B. Past Paper Questions

1. Hertzsprung-Russell (H-R) diagrams are widely used by physicists and astronomers to categorise stars. Figure 5A shows a simplified H-R diagram.

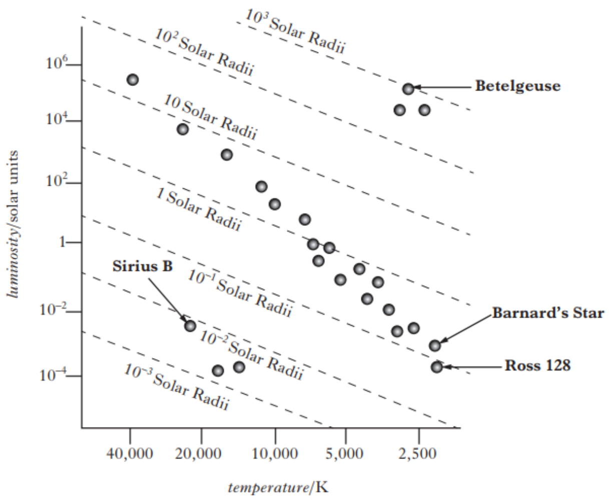

Figure 5A

a) What class of star is Sirius B?

b) Estimate the radius in metres of Betelgeuse. **1**

c) Ross 128 and Barnard's Star have a similar temperature but Barnard's Star has a slightly greater luminosity. What other information does this tell you about the two stars? **2**

1

d) During the life cycle of the Sun its position in the H-R diagram is expected to change as shown by the arrowed line in Figure 5B.

Describe the changes that occur to the Sun during its expected life cycle. **3**

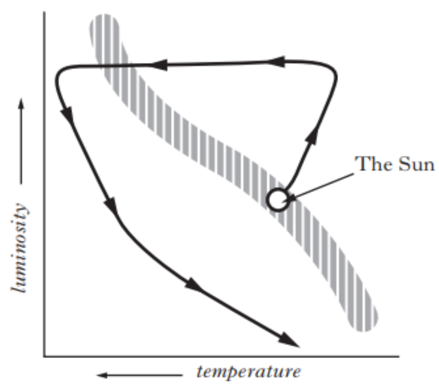

Figure 5B

e) Hydrogen fusion in a star is a result of a proton-proton chain. The process eventually results in the production of a helium-4 nucleus.

i. Show that the percentage loss of mass from four protons to one helium-4 nucleus is 0·7%. **2**

ii. The luminosity of the Sun is 3·8 × 1026W. Using Einstein's energy equation, show that the mass of hydrogen lost per second in the Sun is 4·2 × 109 kg. **1**

iii. Estimate the lifetime of the Sun in seconds. Assume the mass of hydrogen in the Sun to be the same as the mass of the Sun.

1

f) The “no greenhouse” temperature of a planet is the average surface temperature of a planet in the absence of any greenhouse effect. The “no greenhouse” temperature of a planet in kelvin in given by

$$T = 280\left(\frac{(1 - reflectivity)}{d^2}\right)^{\frac{1}{4}}$$

where d is the distance from the Sun in astronomical units (AU).

The reflectivity is a measure of the percentage of energy reflected from the surface, 1 represents 100% reflectivity and 0 represents no reflectivity.

Mercury has a reflectivity of 0·12 and is $5{\cdot}8 \times 10^{10}$ m from the Sun.

Calculate its “no greenhouse” temperature.

2