CHAPTER 27

The life cycle of stars

Answers to revision questions

1. The stages are: coalescence (contraction) of the gas and dust cloud releasing gravitational potential energy; the protostar stage, during which further contraction occurs and the ball of gas emits heat and light, although still shrouded in the molecular dust cloud; and the 'birth' of the star, when the density and temperature in the core are sufficient to sustain nuclear fusion, and the radiation pressure and solar wind disperses the remaining molecular gas cloud so that the star becomes visible.
2. The 20 nearest stars are a typical representative sample of the abundance of different star types in our galaxy. There are many more low luminosity 'dwarf' stars, such as our Sun, than there are giant, very luminous stars. The 20 brightest stars sample is biased towards these luminous stars, which is reflected in their positions on the HR diagram.
3. The commencement of sustained fusion of hydrogen in the core of the star.
4. The chances of a collision between four particles occurring with the required velocities are very remote. Additionally, the 'activation energy' necessary for this to result in the production of a helium nucleus is too great for such reactions to account for the production of the observed energy in stars. Other mechanisms must dominate, which have intermediate steps with lower activation energies and greater probabilities of occurring.
5. See Figure 27.9 for this answer.
6. The synthesis of iron by fusion is an endothermic process. That is, energy is absorbed, not released. If iron were produced in the core of a normal star, the core would cool and the fusion would stop. Therefore, iron can only be produced in an explosive phenomenon known as a supernova.
7. When significant quantities of helium have built up around the core of the star and the hydrogen has become depleted, the core begins to collapse and the conditions in the layer of helium become sufficient for helium to begin to fuse into heavier elements such as carbon and nitrogen.
8. The more massive stars in the globular cluster have evolved off the main sequence as they have depleted their supplies of hydrogen. These are now the red giant stars that are visible within the cluster. The smaller stars are consuming their hydrogen more slowly and have yet to reach the red giant stage.
9. See Figure 27.12 and go to the useful websites listed for some background information on this question. The smaller stars will remain on the main sequence fusing hydrogen for much longer (1 solar mass star for about 10 billion years, 10 solar mass stars for approximately 30 million years). The larger stars will end their lives in a supernova explosion, the smaller as a planetary nebula. The final stage for a 1 solar mass star will be a white dwarf; the larger star may collapse into a black hole if its left-over core exceeds approximately 1.4 solar masses. A neutron star results for the intermediate star, which may be detected as a pulsar.
10. White dwarfs are not fusing hydrogen or any other nuclei in their cores. The energy source for the radiation they emit is the residual heat and radioactivity left over from the remnants of the stars they once were.