

**PART I**

**Q1** A main sequence star has a spectral class that puts it on the main sequence at a point corresponding to stars with a mass of  $0.8M_{\odot}$ . A previously undetected fainter companion is discovered, and careful analyses reveal that the orbital period of the binary system is 48 years, and that the semimajor axis of the orbit of one star around the other is 14 AU. Calculate the mass of the fainter companion. Select from the key the value closest to yours, and pencil across *one* cell in row 1.

KEY for Q1

- A  $0.4M_{\odot}$
- B  $0.5M_{\odot}$
- C  $0.6M_{\odot}$
- D  $0.8M_{\odot}$
- E  $1.0M_{\odot}$
- F  $1.2M_{\odot}$

**Q2** Here are some nuclear reactions:

- (i) CNO cycles
- (ii) carbon burning
- (iii) pp cycles
- (iv)  $3\alpha$  process

Consider a star that starts on the upper main sequence, and evolves to become a supergiant. What is the time sequence in which each of these reactions in turn is the *dominant* reaction in the core? The key lists possibilities, starting with the earliest reaction, and ending with the latest. Which is the correct time sequence? Pencil across *one* cell in row 2.

KEY for Q2

- A (i) then (ii) then (iii) then (iv)
- B (iii) then (i) then (iv) then (ii)
- C (iii) then (ii) then (i) then (iv)
- D (iii) then (ii) then (iv) then (i)
- E (i) then (iv) then (ii)
- F (i) then (ii) then (iv)
- G (iii) then (iv) then (ii)
- H (iii) then (ii) then (iv)

**Q3** The key contains various statements about the late stages of stellar evolution. Which two of these statements are FALSE? Pencil across *two* cells in row 3.

KEY for Q3

- A White dwarfs are supported by electron degeneracy pressure.
- B Neutron stars are supported by neutron degeneracy pressure.
- C In a neutron star, the neutrons are almost entirely those that were earlier contained in iron nuclei.
- D If neutron degeneracy pressure is insufficient to support a neutron star, it collapses to a black hole.
- E An important factor leading to supernova explosions is that iron nuclei have the least rest energy per nucleon.
- F Some of the heaviest elements are created predominantly by r-process reactions in a supernova explosion.
- G Pulsars with pulses spaced by more than a few seconds have not been observed because the radio beams from all such pulsars within observing range are missing the Earth.
- H A shell helium flash is one possible cause of a star shedding a planetary nebula.

**Q4** Select from the key three statements about impact craters that are FALSE. Pencil across *three* cells in row 4.

KEY for Q4

- A They are produced by impacts at speeds of approximately 10–70 km per hour.
- B They are excavated by the action of shock waves.
- C The largest impact craters are multi-ringed basins.
- D For a given mass of impactor and a given impact velocity, a crater on Mars would be smaller than on Venus.
- E There are fewer impact craters per unit area in the lunar maria than in the lunar highlands.
- F A crater on the Moon less than 10 km in diameter would be unlikely to have a central peak.
- G The 'flap' of continuous ejecta immediately surrounding a crater is inverted (with originally deeper material overlying originally shallower material).
- H Craters resembling lunar craters cannot be formed on the icy satellites of the outer planets.