Answer Key

Section A

1. C
2. D
3. E
4. A
5. B
6. B
7. B
8. B
9. A
10. B
11. D
12. A
13. A
14. A
15. A
16. D
17. D
18. B
19. C
20. D
21. D
22. B
23. A
24. A
25. E
26. C
27. D
28. C
29. C
30. B

For official use only:

Section:	A	B	C	Total
Points:	60	144	72	276
Score:				

Section B

31. (a) Andromeda
    (b) True
    (c) M31
    (d) Elliptical (give half credit for irregular)
    (e) Increase. The collision leads to more interactions between clouds of gas and increases the probability that the density in any given cloud gets high enough to collapse and form a star.
32. (a) Centaurus A
    (b) Centaurus
    (c) Merger of two smaller galaxies
33. (a) Image 8
    (b) Starburst galaxy
    (c) Spitzer
    (d) Sextans
34. (a) Betelgeuse
    (b) Image 11
    (c) Red supergiant
    (d) Supernova (also accept neutron star)
    (e) Image 6
35. (a) T Tauri
    (b) Protostar
    (c) Herbig Ae/Be stars
36. (a) Image 10
    (b) Infrared
    (c) Spitzer
    (d) Interstellar dust absorbs and reddens its light, making it hard to see
37. (a) Cygnus
    (b) Northern Cross (give half credit for the Summer Triangle; Deneb is a part of it, but the other two starts come from other constellations)
    (c) Deneb
    (d) Alpha Cygni
38. (a) Image 9
    (b) Castor is given the α designation, even though Pollux is brighter
39. (a) Image 4
    (b) NGC 1333
    (c) Brown dwarf
40. (a) Polaris
    (b) Ursa Minor
    (c) Precession
41. (a) Sgr A
    (b) A supermassive black hole
42. (a) Image 16
    (b) Ursa Major
    (c) GN-z11 and M101
43. (a) LMC
    (b) Dorado (also accept Mensa)
44. (a) Altair
    (b) Capella
    (c) Arcturus
    (d) Procyon
    (e) Vega

Section C

45. (a) Accept between 1300 and 1400 W/m^2
    (b) Decrease by a factor of 4 (other equivalent wordings accepted). If they mention the Inverse Square Law but do not get the correct answer, award half credit.
46. (a) Accept between 4100 and 4200 Kelvin
    (b) No - main sequence stars at this temperature are very dim (think: M class red dwarfs). In order to be bright, this star must have evolved off the main sequence to be a red giant or supergiant, which are very luminous because of their giant size.
47. (a) 2.9×10^7 parsecs
    (b) Closer than expected
48. (a) Triple-alpha process
    (b) Electron degeneracy pressure! White dwarfs also rely on electron degeneracy pressure. If they correctly identify electron degeneracy pressure bu mention neutron stars, give them 2/3 credit.
    (c) Much of the energy released during the helium flash goes into heating the core and terminating the degenerate state of the electrons. Second, the energy that does escape the core is largely absorbed by the star's outer layers, which are quite opaque.
    (d) Yes - in a shell around the helium-fusing core.
    (e) After the onset of core helium fusion, a star's superheated core expands like an ideal gas. Temperatures drop around the expanding core, so the hydrogen-fusing shell reduces its energy output and the star's luminosity decreases. This allows the star's outer layers to contract and heat up. Consequently, a post− helium-flash star is less luminous, hotter at the surface, and smaller than a red giant.
    (f) The horizontal branch!