Answer Key

Section A

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

For official use only:

Section:	A	B	C	Total
Points:	35	28	38	101
Score:				

Section B

36. (a) Lyra
    (b) Vega
37. (a) Sgr A*
    (b) A supermassive black hole
38. (a) Image 8
    (b) Young
39. (a) Image 17
    (b) Messier 104 (also accept just 104)
40. (a) Chandra
    (b) Image 14
    (c) A collision with another galaxy
41. (a) Betelgeuse
    (b) Image 3
    (c) Supergiant
42. (a) Sirius B
    (b) Diffraction spikes
    (c) B, it emits more x-rays since it is hotter
43. (a) Image 10
    (b) Infrared
    (c) Spitzer
    (d) Interstellar dust will absorb and redden the light, so it is not possible.
44. (a) Image 15
    (b) Curves on an illuminated surface that connect points of equal brightness
    (c) Elliptical
45. (a) T Tauri
    (b) Hayashi Track
    (c) Herbig Ae/Be
    (d) Image 16

Section C

46. (a) Accept between 1.5×10^{26} and 2.3×10^{26} Watts
    (b) Accept between 9×10^{2} and 1.1×10^{3} Watts per square meter
    (c) Accept between 2.40×10^{2} and 2.55×10^{2} Kelvin
47. (a) Accept between -1.4 and -1.6
    (b) Your friend is incorrect. Stars in the same cluster are formed at approximately the same time, so they are the same age. However, the clumps of gas that they individually form from may be of different sizes, so their masses are not necessarily the same.
    (c) Possible answers include: use parallax to find the distance to one of the stars, and then use the Distance Modulus to estimate its absolute magnitude.
48. (a) Hydrogen atoms can only emit visible light if they are first excited to high energy levels, is quite unlikely to occur in the cold depths of interstellar space. Furthermore, even if there are some hydrogen atoms that glow strongly at visible wavelengths, interstellar extinction due to dust would make it impossible to see this glow.
    (b) Radio waves' wavelengths are much longer than anything in the interstellar medium that could block their way (e.g. dust, gas, etc).
    (c) Neutral hydrogen in the context of an H I region has 1 proton, 0 neutrons, and 1 electron.
    (d) The energy of a hydrogen atom is slightly different depending on whether the spins of the proton and electron are in the same direction or opposite directions. (According to the laws of quantum mechanics, these are the only two possibilities; the spins cannot be at random angles.) If the spin of the electron changes its orientation from the higher-energy configuration to the lower-energy one—called a **spin-flip transition** - a photon is emitted. The energy difference between the two spin configurations is very small, so the photon emitted in a spin-flip transition between these configurations has only a small energy, and thus its wavelength is a relatively long 21 cm—a radio wavelength.
49. (a) high, high, large
    (b) low, thin, radiation
    (c) high, decreasing, radiation
    (d) Their interior temperature is never high enough to fully ionize the interior. The interior remains too opaque for radiation to flow efficiently, so energy is transported by convection throughout the volume of the star.
50. (a) Constant temperature
    (b) The optical depth increases
    (c) Increase in temperature. The increased optical depth prevents heat from escaping, essentially making the process adiabatic.
    (d) Since the cloud will be heating up as it contracts, it will take more work to compress it.
    (e) The entropy will stay constant since no heat is exchanged with its surroundings! This is essentially describing a reversible adiabatic compression.