Reach for the Stars B

Michigan Region 8
March 11, 2017

Names: _____

Team: _____

Team Number: _____

Directions

1. **There is a separate answer sheet.** Answers written elsewhere (e.g. on the test) will not be considered.
2. You may take the test apart, but please put it back together at the end.
3. **This test is 100 points total.** Questions are worth 1 point each unless otherwise specified.
4. Further tiebreakers are indicated as [T1], [T2], etc. Time is NOT a tiebreaker.
5. Numerical answers should be in MKS units unless otherwise specified.

Useful Constants

$b = 3 * 10^7\ nm * K$
$c = 3.00 * 10^8\ m/s$

$1\ pc = 3.25\ ly = 206{,}000\ AU = 3.1 * 10^{16}\ m$
$1\ ly = 0.3\ pc = 63{,}000\ AU = 9.5 * 10^{15}\ m$

$L_{sun} = 4 * 10^{26}\ W$
$M_{sun} = 2 * 10^{30}\ kg$
$R_{sun} = 7 * 10^8\ m$
$T_{sun} = 6000\ K$

Bonus (+1)
NASA has recently announced the (exciting) discovery of an exoplanetary system with several planets. What is the name of this system?

Part I: Stars, Constellations, and DSOs [50 pts]

1. Which DSO is depicted in Image [1]?
2. Which other DSO was among the few supernovae in the Milky Way visible to the naked eye?

3. Which DSO, location of the famous "Pillars of Creation", is depicted in Image [2]?
4. What will eventually cause the dust and gas in this DSO to dissipate?

5. Which DSO, a very bright radio source, is depicted in Image [3]?
6. Why might this DSO not have been visible in the past?

7. Which DSO, a massive star-forming region, is depicted in Image [4]?
8. [T10] What is the common nickname of this DSO?
9. Which galaxy is this DSO located in?

10. Which DSO is the supermassive black hole at the center of the Milky Way?
11. How was it possible to determine the mass of this black hole?

12. Which DSO is depicted in Image [5]?
13. [T8] What is the name for the cluster of 4 bright stars at the center of this DSO?
14. This is one of several DSOs on this year's list designated by "M". Who is the "M" catalogue named after?

15. Name one of the planetary nebulae on this year's list.
16. During which phase of the star's life was the material in these planetary nebulae ejected?
17. What is one possible cause of planetary nebulae with non-spherical, more complex shapes?

18. Which DSO is depicted in Image [6]?
19. [T4] What are the bright arc-like features in the image?
20. Which portion of the EM spectrum was this image taken in?

21. Which DSO is depicted in Image [7]?
22. What is special about the stars forming here?

23. Which DSO is depicted in Image [8]?
24. Stars like this DSO can undergo sudden outbursts where their brightness varies wildly. What are they called during this outburst phase?

25. Which DSO is depicted in Image [9]?
26. What type of cluster is this DSO?

27. Which two DSOs are depicted in Image [10]?
28. Both of these DSOs are classified to be what shape?
29. What causes the shapes of these DSOs to be warped?

30. Which DSO is depicted in Image [11]?
31. What kind of nebula is this DSO?
32. Which portion of the EM spectrum is shown in blue toward the center of the image?

33. Which DSO is depicted in Image [12]?
34. What is one common nickname for this DSO?
35. What cluster of stars causes this nebula to shine?

36. Which DSO is depicted in Image [13]?
37. What is the cause of the bright yellow feature down the middle of the image?

38. Sirius A (α Canis Majoris) has a white dwarf companion, creatively named Sirius B. What effect does Sirius B have on the path of Sirius A across the sky?
39. Which other star on this year's list also has a white dwarf companion?

40. Which two stars are not a true binary system, but an "optical double" (need both names)?
41. Of these two stars, which one is a quadruple star system?

42. Which star on this year's list was recently discovered to have a planet – named Thestias – orbiting it?

43. [T5] Many stars on this year's list are oblate (flattened at the poles and bulging at the equator). What causes their shape?
44. Name one of these noticeably flattened stars.

45. Which star is known as the "North Star"?
46. What effect will cause this star to eventually lose its status as the North Star?

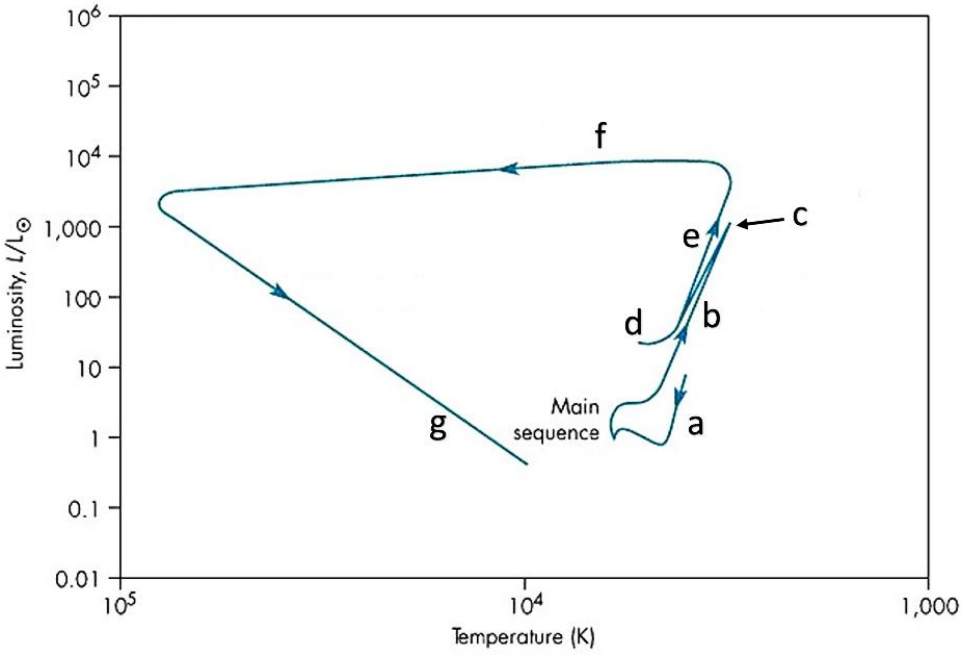
47. Spica (α Virginis) is a "spectroscopic binary". What does this mean?
48. Spica also varies in brightness as it pulsates. What kind of variable star is it?

49. Algol (ß Persei) is the namesake of a paradox where the less-massive star in a binary system is further along in its evolution. How can this paradox be resolved?

50. Often, the brightest star in a constellation is designated as α (alpha), the second brightest as ß (beta), and so on. Who came up with this naming system?

Part II: Topics and Calculations [50 pts]

51. By what process do low-mass stars turn hydrogen into helium?
52. Why do lower-mass stars have longer lifetimes than higher-mass stars?
53. [T6] Based on the diagram below, complete the life cycle of a 1 $M_\odot$ star. [7 pts]



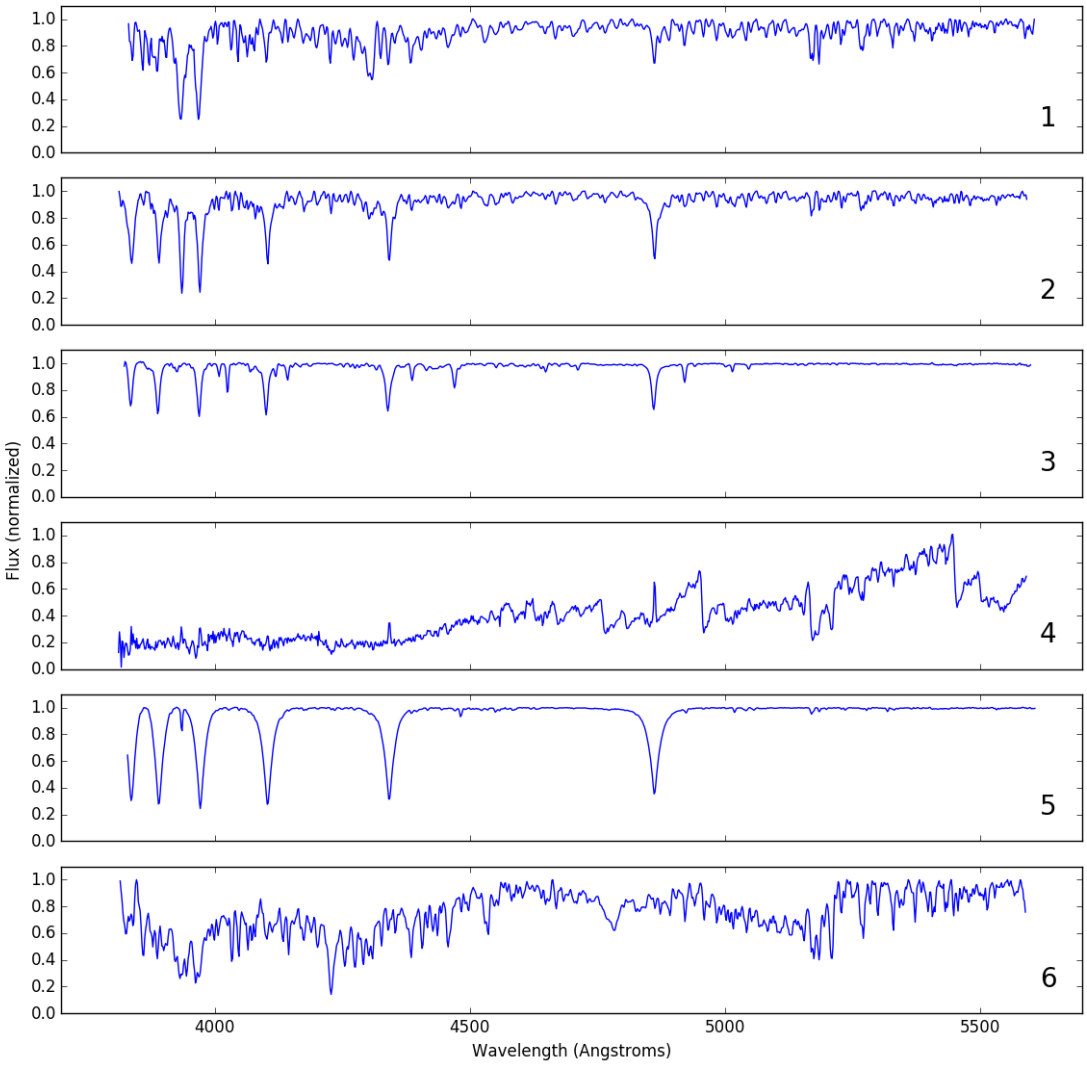
54. What elements make up the remnants left behind by low-mass stars?
55. What type of supernovae may result from these low-mass remnants?

56. If this were instead a high-mass star, what would be the two possible end results? [2 pts]
57. By what process do high-mass stars turn hydrogen into helium?
58. What is/are the heaviest element(s) that can be produced in the core of high-mass stars?
59. What causes high-mass stars to stop fusion?
60. What kind of supernovae result from the deaths of high-mass stars?

61. Who is the HR diagram named after (need both names)?
62. What is the term for the strip of the HR diagram that contains many pulsating variable stars?
63. How do stars move across the HR diagram during their main sequence lifetimes?
64. What is the term for a difference in magnitude between two wavelength bands, which also corresponds to a star's temperature?

65. [T7] What property of stars was the original spectral classification (A through O) based on?
66. Who reorganized these spectral classes into the order we know today?
67. What spectral classes contain the hottest and coolest stars, respectively? [2 pts]
68. What color do K-type stars generally appear to be?

69. [T1] Put the visible spectra below in order from hottest to coolest. [6 pts]



70. NASA's four "Great Observatories" are Hubble (visible), Compton (gamma rays), Chandra (x-rays), and Spitzer (infrared). Which of these telescopes operates at the longest wavelengths?
71. Which of these telescopes would detect the most energetic photons?

72. [T9] Why are infrared observations particularly useful for studying star-forming regions?
73. What is one portion of the EM spectrum (other than visible light) where ground-based observations are not blocked by Earth's atmosphere?
74. What molecule is often used to "trace" the distribution of H_2, molecular hydrogen?
75. How is HI, neutral hydrogen, often detected?
76. What portion of the EM spectrum is this detection done in?

77. At the end of the Sun's main sequence lifetime, its temperature will drop to approximately 3000 K and its radius will increase by roughly 100 times. How many times more luminous will it be then?

78. [T3] The dimmest objects detectable by human eyes have a magnitude of +6, while the Hubble Space Telescope can detect objects with magnitude of +31. How many times more sensitive is HST than a pair of human eyeballs?

79. Parallax depends on measuring angles on the sky. How much smaller is the parallax angle for an object 400 light years away, as compared to one that is 100 light years away?

80. How many times brighter/dimmer would the Sun appear from a colony on Mars (which orbits at 1.5 AU) than it does from Earth?
81. How many times brighter/dimmer would it be from a space station orbiting Venus (0.75 AU)?

Suppose aliens are observing our solar system from their homeworld 100 pc away. Their star has a temperature of 4500 K and a radius of 0.8 solar radii, and their planet orbits at 0.5 AU. The (visible) absolute magnitude of the Sun is +4.83.

82. What is the apparent magnitude of the Sun, as observed by these aliens?
83. What is the absolute magnitude of the Sun, as observed by these aliens?

84. How luminous is their star, compared to the Sun?
85. What would we observe the apparent magnitude of their star to be?
86. [T2] How many times brighter/dimmer is the aliens' star, viewed from their homeworld, as compared to the Sun viewed from Earth?