

# Astronomy C

## KEY

Part I (DSOs)	Part II (Stellar Evo)	TOTAL
50	50	100

Team Number \_\_\_\_\_

Team Name \_\_\_\_\_

Type (select one) \_\_\_\_\_ Varsity

\_\_\_\_\_ Junior Varsity

**Bonus (+1)** Merger of 2 neutron stars (kilonova) – the event was GW170817

## Part I: Deep Sky Objects (50 points)

1. X-ray
2. Torus
3. Pulsar Wind Nebula (PWN)
4. NGC 6357 (Lobster Nebula)
5. Open cluster
6. Emission
7. NGC 7822 (Sharpless 171)
8. "Elephant trunks" (or cold molecular pillars, if you're no fun)
9. [T<sub>2</sub>] Can see through dust in infrared
10. S Doradus
11. P Cygni profiles
12. Cold material surrounding the star (which was possibly ejected by it) is moving towards us
13. Large Magellanic Cloud (LMC)
14. HR 5171 A (V766 Centauri)
15. Upper center
16. [T<sub>4</sub>] Too massive (will collapse directly into a compact object)
17. X-ray
18. Radio emission is from jet (pointed at us), gamma rays are from torus (perpendicular)
19. W<sub>49B</sub>
20. Gamma-ray bursts (long GRBs)
21. Black hole
22. Most SNRs are spherical, but this one is not
23. AG Carinae
24. It was ejected by stellar wind or outburst
25. Wolf-Rayet star
26. DEM L241
27. X-ray
28. We see (periodic) changes in its velocity indicating that it is orbiting something
29. Neutron star
30. Accretion
31. The material has angular momentum
32. SN 1987A

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|---|---|
| 33. Blue supergiants weren't thought to go supernova, according to evolution models           | 42. Eddington Limit   |
| 34. Neutrinos   | 43. NuSTAR  |
| 35. D   | 44. IC 443 (Sharpless 248)  |
| 36. [T9] Absorption   | 45. Neutron star  |
| 37. Betelgeuse  | 46. The material they are interacting with has different properties (density, temperature, etc) |
| 38. Supernova (Type II, core-collapse)  | 47. RCW 103 (technically the pulsar itself is called 1E 161348-5055, or 1E 1613)                |
| 39. ASASSN-15lh   | 48. X-ray   |
| 40. It was a hypernova (overluminous Type I SN)<br>-OR- it was a tidal disruption event (TDE) | 49. Rotational energy (of the pulsar)   |
| 41. The purple one (has some extended emission)   | 50. Magnetar  |

## Part II: Stellar Evolution (50 points)

- |  |   |
|--|---|
| 51. [T10] A  | 57. Wolf-Rayet stars  |
| 52. All H is ionized, so it can't form spectral lines            | 58. Fe (iron)   |
| 53. TiO (titanium oxide)   | 59. r-process (rapid) -OR- s-process (slow)   |
| 54. Magnitude difference or flux ratio in different filter bands | 60. Neutron degeneracy pressure   |
| 55. [T6] Presence of H (Type I doesn't have it)                  | 61. [T8] Beam of radiation sweeps across Earth (rotation and radiation axes are misaligned) |
| 56. He   | 62. Orbits or radial pulsations can't happen fast enough to match fastest pulsar periods    |

63. Their gravity still affects other objects
64. [T7] Only see eclipses when the system is edge-on (but it could have other inclinations)
65. Instability strip
66. [T3] Opacity changes with temperature (kappa mechanism)
67. Semi-regular variables pulsate in overtones, instead of the fundamental mode like Miras
68. Supernovae
69. o -OR- Ia-o -OR- Ia<sup>+</sup>
70. Blue loops
71. a. 107 pc (accept 105 to 110)
72. a. 4300 K (accept 4200 to 4400)
- b.  $2.0 * 10^7 W/m^2$  (accept 1.8E7 to 2.1E7)
- c. [T1] 0.20  $L_{\odot}$  (accept 0.18 to 0.22)
73. a. 0.36 AU (accept 0.34 to 0.38)
- b. [T5] 1.4 (accept 1.3 to 1.5)
- c. 34  $M_{\odot}$  (accept 30 to 40)
- d. 14  $M_{\odot}$  (accept 12 to 17)
74. a. -5.65 (accept -5.55 to -5.75)
- b. 11.7 kpc (accept 11.2 to 12.3)
- c. -4.05 (accept -3.95 to -4.15)  
5.6 kpc (accept 5.3 to 5.9)
75. a. 3  $L_{\odot}$  (accept 2 to 4)
- b. 1.3  $M_{\odot}$  (accept 1.2 to 1.4)
- c. 5 Gyr (accept 4.0 to 6.5)
- d. Open cluster (a very old open cluster, but still too young to be a globular cluster)