Golden Gate Invitational Astronomy C Key

Team Name/Number: Astronomy

Raw Score: 89.5/89.5

Grading Instructions:

- 1 point per part of question except questions with multiple parts or longer answers (specified below)
- For questions with more than one answer in a single part of a question (1 – 5, 11, 11a, 12a, 13, 14a, 14b, 19, 20)
  - Each part of the answer is 0.5 pts
  - For example, question 4 has the answer B, E, so B and E are each worth 0.5 pts (and as a whole the question is thus worth 1 point)
  - The total point values for these questions are noted in parentheses next to the questions
- Questions with longer answers include 28, 29a
  - The main parts of an answer needed as well as the associated points for that part of the answer are noted by brackets []
  - These questions also have total point values in parentheses next to the questions

Section A

1. 1, 5, 6, 8, 16, 21, 23, 25, 27 (4.5)
2. 6, 16, 23 (1.5)
3. 9, 10, 13, 14 (2)
4. B, E (1)
5. 18, 7, 14, 3, 23 (2.5)
6. HR Diagram or color-magnitude diagram
   a. K
   b. H
   c. D
   d. E
   e. L
7. Asymptotic Giant branch or AGB
   a. First dredge-up
   b. William Herschel
8. 3
   a. Ultraviolet or UV
   b. Precession
9. Hen 2-428
   a. The Chandrasekhar limit
   b. Type Ia SN
   c. AM CVn
10. Post-AGB
    a. Optical/Visible
    b. Third dredge-up
11. 22, differentiated by characteristically long period (1)
    a. Left, Stefan-Boltzmann Law (1)
    b. X-ray
12. 2

Golden Gate Invitational Astronomy C Key

a. _Red Dwarf, White Dwarf_____(1)

b. _GPE / Gravitational Potential Energy_

13. _26, Sirius (or Sirius A and B)_____(1)

a. _1_____

b. _ Only Balmer lines (no He I or metals)_____

14. _ AM CVn _____

a. _Less, more_____(1)

b. _More, more_____(1)

15. _16_____

a. _X-ray_____

b. _Gravitational waves_____

16. _13_____

a. _ Nickel or Ni-56 _____

17. _ SNR 0509-67.5_____

a. _ Fe or Iron _____

b. _ Double-degenerate or two white dwarf binary system _____

18. _ Tycho's SNR _____

a. _ Silicon or Si _____

b. _ Shell-type _____

c. _ Cosmic rays _____

19. _20, Sagittarius _____(1)

a. _ Delayed detonation (a slow wavefront followed by a much faster one) _____

b. _Electrons_____

20. _12, NGC 1846 _____(1)

a. _ Multiple stellar populations _____

b. _ Isochrones _____

21. _ Messier 15 or M15 _____

a. _ PN (Planetary Nebula) _____

b. _ They may require more massive progenitors (or systems) to form, which is rarer OR planetary nebulae are dispersed quickly/have short lifetimes _

Golden Gate Invitational Astronomy C Key

Section B

22. 0.112 kpc

23. 0.886 ly

24. RR Lyrae stars
    a. 1.714 kpc

25. 11,900 Lsun

26. -90.1 km/s
    a. 364 km/s
    b. 375 km/s
    c. 79.1 AU

27. 87.71 yr
    a. 0.976”
    b. 0.191 solar masses
    c. $2.27 * 10^{-9}$ rad/s
    d. $1.45 * 10^{-7}$ rad/s

28. Occurred ~23.2 million years ago [**1 pt**]. We would be unlikely to see a trace (the SN would be dispersed). [**1 pt**] (2)

29. $3.31 * 10^{47}$ ergs
    a. Type Ia SN in general should explode with consistent amounts of energy based on the Chandrasekhar limit [**1 pt**]. Since the kinetic energy was lower, the ejecta may have been relatively heavy [**1 pt**]. This makes sense with a double degenerate progenitor (a Type Ia SN from two white dwarfs) because the companion of a single white dwarf progenitor system would be less evolved/would only fuse up to lighter elements by the time the SN occurred (OR that a system of white dwarfs would be more evolved/made of heavier elements) [2 pt]. (4)

30. 9700 K
    a. The top, green curve
    b. The bottom, blue curve
    c. False
    d. False
    e. True

Tiebreaker list (in order):

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