SCIOLY SUMMER STUDY SESSION 2014 – ASTRONOMY KEY

This test assumes the 2014-2015 topic is Variable Stars and Stellar Evolution.

SCORING

1. Likely alternate answers are designated with "OR". Use your best judgment when deciding whether or not other answers are acceptable.
2. Answers for each part of a multi-answer question are provided on separate lines.
3. Each correct answer is worth 1 point, unless otherwise specified.
4. Individual section scores should be used as tiebreakers in this order – math, topics, DSOs.
5. This test is worth a total of 75 points.

MATH

1. Use the constants provided below.
2. All answers should have proper sig figs.
3. Full credit will be awarded for answers within 10% of the key.
4. All math questions are worth double points when scored (2 points for each correct answer).

BONUS (+1) — +1 PTS

Thorne-Żytkow Object (link to abstract and full paper – www.arxiv.org/abs/1406.0001)

SECTION I – DSOs 30 PTS

1. Delta Scuti

   AH Leo

   ZZ Ceti

2. HeII and HeIII [must have both]

3. Radiation from massive star HD 217086

4. Hydrogen deficient

   Carbon rich

5. Pair-instability

   Gamma rays interact with heavy nuclei to produce electron/positron pairs, dropping the core's radiation pressure and causing the star to collapse (and then rebound and explode as an extremely bright supernova)

6. BY Draconis

7. A dusty disk surrounding an orbiting pair of stars, OR a dusty disk surrounding a single star, OR a thick dusty disk seen edge-on (with a hole in the middle), OR a cool and "semitransparent" companion star

8. Beta Lyrae

9. UV Ceti

10. VIII

11. A range of metallicities and ages of the stars within the cluster suggest prolonged formation over ~4 GYr, atypical of globular clusters.

    May be the core remnant of a dwarf galaxy.

12. Gravity waves, OR g-mode pulsation

13. Delta Scuti

14. Double-degenerate, OR collision/merger of two white dwarfs to form one object with a mass above the Chandrasekhar limit

15. UV Ceti

    R Coronae Borealis

16. Blazhko effect

    About 20 days

17. Combination of a low-temperature spectrum with the emission lines of a high-temperature object

18. Compression of ISM due to movement through space (ram pressure)

19. DQ Herculis OR Intermediate Polar

20. The shell was observed within months afterwards (ejecta from novae typically takes many years to appear), OR the shell was apparently moving faster than the speed of light

21. UGZ, OR dwarf novae with subtype Z Cam

22. VY Sculptoris

    Because of quiescent standstills in its light curve

Section II – Topics 25 pts

23. Vogt-Russell Theorem, OR Russell-Vogt Theorem

24. Gravitational potential energy

25. CNO cycle has a stronger temperature dependence ($E \sim T^{20}$), and so produces relatively more energy as the core temperature increases

26. Increased fusion rate produces more radiation pressure, pushing outer layers outwards

27. Blue loops

28. Star's outer layer of H (and potentially He as well) have been blown away by strong stellar winds, OR mass transfer to a binary partner

29. About 8 solar masses

    Below this mass, the star cannot produce sufficiently high temperatures/pressures in its core to continue fusion beyond C/O/Ne

30. Collapsar does not have enough energy to expel layers, so no visible SN outburst

31. r- and s-processes [must have both]

32. HR Diagram will show the "turnoff" point where stars are evolving off the Main Sequence; cluster's age is the same as this main sequence lifetime.

33. O-C diagram

34. Roche lobe

35. κ (kappa) mechanism, OR Eddington valve

    Iron

36. TiO

37. GW Vir, OR DOV and PNNV

38. Shape of light curve, OR components' physical characteristics, OR degree of filling of Roche lobes

39. Eruptive [½]

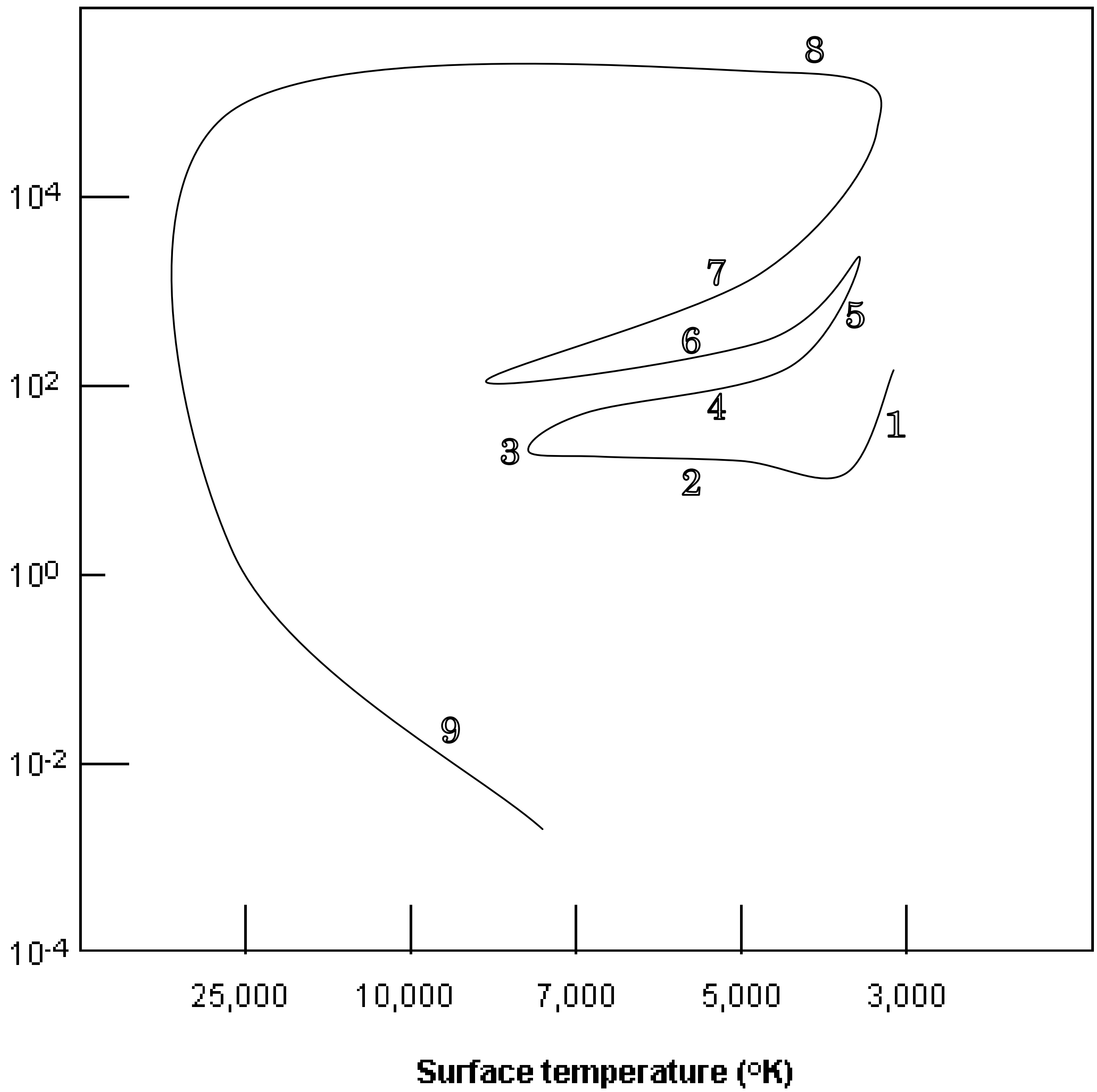
    Pulsating [½]

    Rotating [½]

    Cataclysmic [½]

    Eclipsing [½]

40.



1 – Hayashi Track [½]

2 – Henyey Track [½]

3 – Main Sequence [½]

4 – Subgiant Branch (SGB) [½]

5 – Red Giant Branch (RGB) [½]

6 – Horizontal Branch (HB) [½]

7 – Asymptotic Giant Branch (AGB) [½]

8 – Planetary Nebula [½]

9 – White Dwarf [½]

SECTION III – MATH 20 PTS

41. Star X and Star Y form a binary system with the plane of orbit nearly edge-on as we observe the system from Earth.

a. The Hα spectral line is normally found at 656.28 nm. In the spectrum of Star X, Hα has a maximum wavelength of 656.40 nm, and in the spectrum of Star Y, it has a maximum wavelength of 656.58 nm. What are the orbital velocities of Star X and Star Y, <u>in km/s</u>? (Assume the recessional velocity of the binary system as a whole is negligible.)

$$z = \frac{v}{c} = \frac{\Delta\lambda}{\lambda_0}$$

$$v = \frac{\Delta\lambda}{\lambda_0} * c$$

Star X: 55 km/s Star Y: 140 km/s

b. The cyclic shifts in the wavelength of Hα have a period of 68.1 days. If the average separation of the binary components has been determined by other means to be $7.45 * 10^{10}$ m, what is the combined mass of Star X and Star Y, <u>in kg</u>?

$$p^2 = \frac{4\pi^2}{G(M_1 + M_2)} a^3$$

$$M_1 + M_2 = \frac{4\pi^2}{G} * \frac{a^3}{p^2}$$

Star X + Star Y = $7.07 * 10^{30}$ kg

c. What are the individual masses of Star X and Star Y, <u>in solar masses</u>?

$$m_1 v_1 = m_2 v_2$$

$$m_1 = \frac{v_2}{v_1 + v_2} m_{total}$$

Star X = 2.5 solar masses Star Y = 1.0 solar masses

42. The following information is known about Star Z.

Parallax angle	196.7 mas
Apparent magnitude (V)	+4.03
Temperature	5300 K

a. What is its absolute visual magnitude?

$$d = \frac{1}{p} = 5.084\ pc$$

$$M = m - 5\log\left(\frac{d}{10}\right)$$

M = +5.50

b. What is its wavelength of maximum radiation, in nm?

$$\lambda_{max} = \frac{b}{T}$$

λ_{max} = 550 nm

c. What is its radius, in m?

$$\frac{L}{L_{sun}} = 100^{\frac{M_{sun}-M}{5}} = 0.54\ L_{sun}$$

$$\left(\frac{L}{L_{sun}}\right) = \left(\frac{R}{R_{sun}}\right)^2 * \left(\frac{T}{T_{sun}}\right)^4$$

$$\frac{R}{R_{sun}} = \sqrt{\frac{\frac{L}{L_{sun}}}{\left(\frac{T}{T_{sun}}\right)^4}}$$

R = 0.88 Rsun = 6.1 $*$ 10^8 m

d. By what factor would Star Z's luminosity change if it evolved into a red giant with a radius of 50. times its current radius and a temperature of 3500 K?

$$\left(\frac{L}{L_0}\right) = \left(\frac{R}{R_0}\right)^2 * \left(\frac{T}{T_0}\right)^4$$

480 times

e. What is the maximum intensity (irradiance) of the visible light from Star Z on Earth, in W/m^2?

$$I = \frac{L}{4\pi d^2} = \frac{4\pi r^2 \sigma T^4}{4\pi d^2}$$

I = 6.7 $*$ 10^{-10} W/m^2