Astronomy Answer Key (UChicago 2018) - Do Not Share

1. (6 points total) __M_R_S_N___
give 1 pt for correct position of each pair (so MS before RG is 1 pt, MS before SG is 1 pt, etc.)

2. (1 pt)___AG Carinae_____

3. (1 pt)___Luminous Blue Variable_____

4. (8 pts total)
Y axis - Luminosity or Magnitude (2 pts)
X axis - Color, Temperature, Spectral Class (2 pts)
Main sequence gets the shape approximately correct (2 pts)
Main sequence hits the correct points on the graph (see drawing) (2 pts)

Drawing on back side

5. (4 pts total)
a) Its normal state (0.5 pt per variable)
Log T = 4.4 T = 26000 K C = B1
Log L = 6.2 M = -10.8
b) At its brightest (0.5 pt per variable)
Log T = 3.9 T = 8000 K C = A6
Log L = 6.2 M = -10.8
See drawing
2 points total

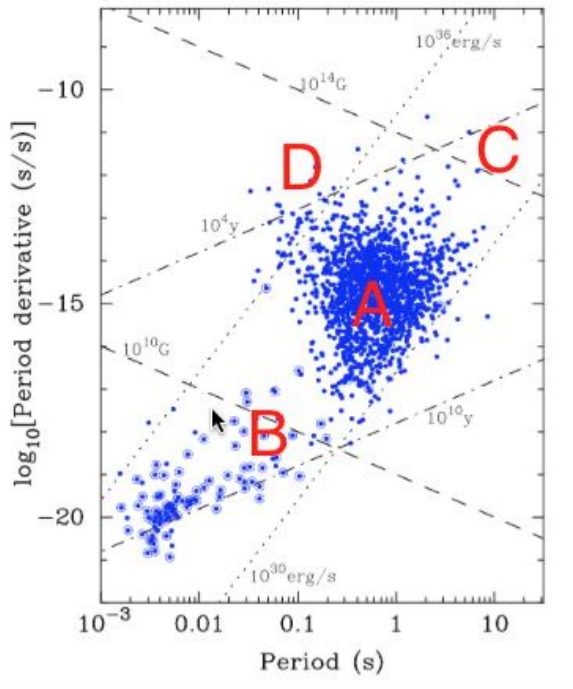
6. (4 pts total) Correct location (2 pts)
T = 3590 K C = M1-2 B-V = +1.85 U-B = +2.06
L = 9-15 x 10^4 Lsun
M = -5.85
It is a supergiant (1 pt)
Likely to go supernova soon (1 pt)

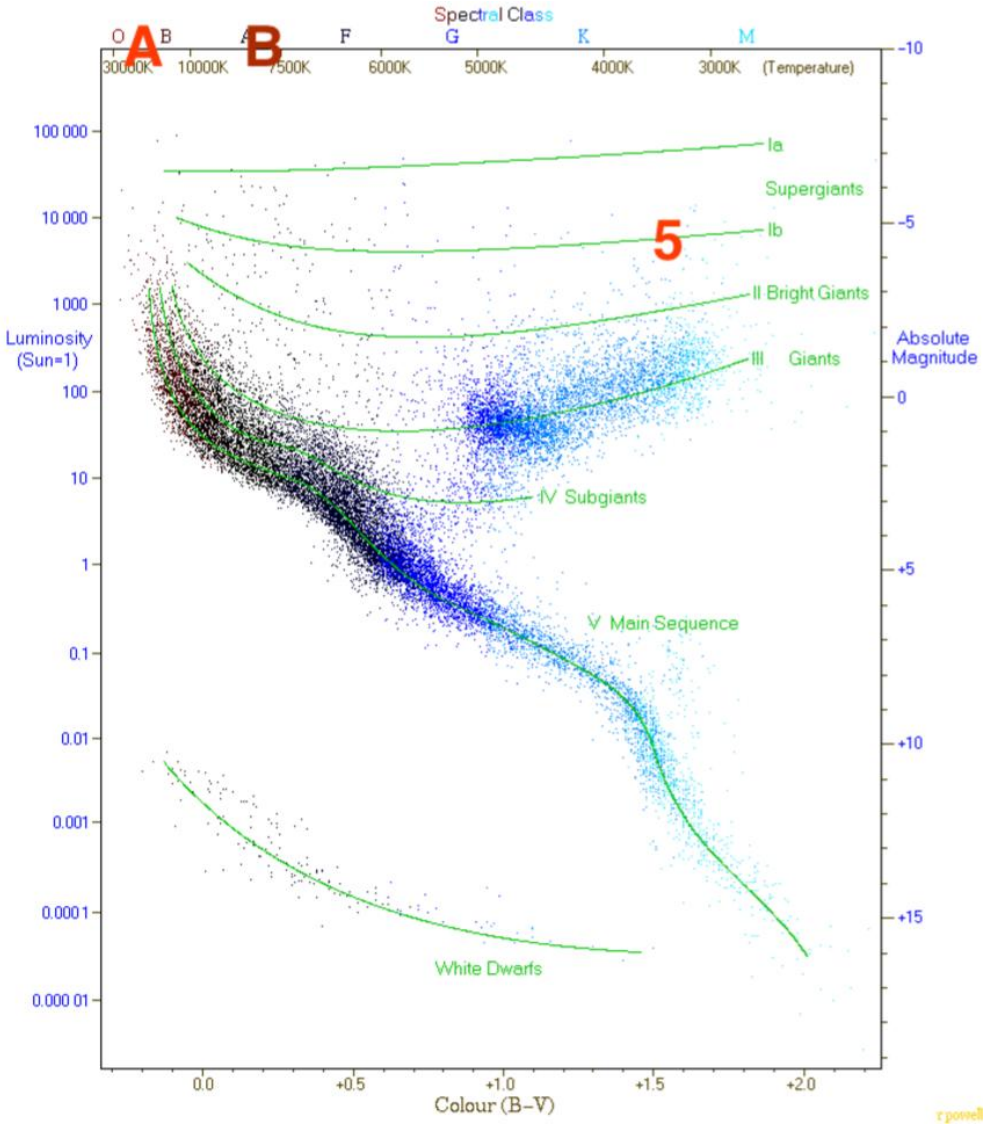
7. (2 pts)
Type II have Hydrogen lines in their spectra, while Type I do not

8. (6 points total)
Type II supernovae are core collapse supernovae (2 pts)
When the core is iron so it can't fuse any more, there is no radiative pressure to support the star and it collapses to a core (1 pt)
The bounce from that collapse results in an explosion (1 pt)
Type Ib, Ic are also core collapse, but have shed their outer envelopes so that their spectra lack Hydrogen lines and are not technically Type II (1 pt for identifying other core collapse, 1 pt for explanation)

9. (3 pts total)
Recent stellar formation (2 pts)
Radiation and supernovae will destroy them, so they don't last to see the end of stellar lifetimes (1 pt)

10. 8 points total - 2 for each letter




Spectral Class
O
A
B
A
B
F
G
K
M
30000K
10000K
7500K
6000K
5000K
4000K
3000K
(Temperature)
-10
100 000
Ia
Supergiants
10 000
Ib
-5
5
1000
II Bright Giants
Luminosity
(Sun=1)
Absolute
Magnitude
III Giants
100
0
10
IV Subgiants
1
+5
V Main Sequence
0.1
0.01
+10
0.001
0.0001
+15
White Dwarfs
0.000 01
0.0
+0.5
+1.0
+1.5
+2.0
Colour (B–V)
r powell

11. (5 points total)
"Death Line" - 2 points
As pulsars age their magnetic field weakens and the spin slows (2 points)
This weakens the radiation so we don't see it (1 point)

12. 8 points total (2 pts each)
A
___DEM L241, ~~supernova remnant~~___
^this should be HII region, I'm so sorry I messed this up!!

B
____IC 443, supernova remnant_____

C
_____PSR B0355+54, pulsar_____

D
___NGC 6357, diffuse nebula and star formation region_____

13. 3 points total
__Charge, rotation, mass - 1 pt for each_

14.
____D (Delta Cephei) - 1 pt_____

15.
_____E (RV Tauri) -1 pt_____

16. 3 points total
(1 pt) Acknowledge that this has something to do with a gap between the main sequence and giant stars on an HR diagram
(1 pt) Massive stars go from main sequence to red giant region quickly
(1 pt) Explanation - something about how if it were a slow process we'd see more stars in this range

17. Circle: After - 1 pt
_____Phase lag - 1 pt_____2 points total

18. 2 points total
_A, C Yes___B, D No____0.5 pts each___

19. 5 points total
Time on main sequence for a given star varies with mass/temp/radius etc. (1 pt)
Turnoff point says that stars with M > Mturnoff have completed their main sequence lifetime (2 pts)
The cluster age is approximately the age of the shortest lived star still on the MS (2 pts)

<u>Math Section</u>
20) (6 points)
(a) (2 pts; half with eqn) 1.83 pc
(b) (2 pts; half with eqn but 5.2 AU instead of 1) 2.84 arcsec

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

(c) (1 pt) 2 times
(d) (1 pt) 2 times

21) (6 points)
(a) (2 pts; half if eqn) 2.22

$$m - M = -5\log_{10}(d) - 5$$

(b) (2 pts; half if eqn) 4.21 x 10^{27} W = 10.9 Solar Luminosities

$$L_{\text{star}} \text{ in } L_\odot = \frac{L_{\text{star}}}{L_\odot} = 10^{-\frac{M_{\text{star}} - M_\odot}{2.512}}$$

$$L_\odot = 3.83E26 \text{ W}, M_\odot = 4.83$$

(c) (2 pts; half if eqn) 1.34 x 10^{-8} W m^{-2}

$$F = \frac{L}{4\pi d^2}$$

or $m_1 - m_\odot = -2.512 \log_{10}\left(\frac{f_1}{f_\odot}\right)$ with $f_\odot \approx 1380 \frac{\text{W}}{\text{m}^2}$

22) (6 points)

(a) (2 pts; half if eqn) 6.05 x 10^{29} W = 1570 Solar Luminosities

(b) (2 pts; half if eqn) 9992 K

$$T = \frac{2.897 \times 10^{-3} \text{ m K}}{\lambda \text{ (in m)}}$$

(c) (2 pts; half if eqn) 9.23 x 10^{9} m = 13.26 Solar Radii

$$L = 4\pi r^2 \sigma T^4$$

$$\sigma = 5.67 \times 10^{-8} \text{W m}^{-2}\text{K}^{-4}$$

23) (6 points)

(a) (2 pts; half if eqn) -4.24

$$M_v = -2.43 \log_{10} P_d - 1.62$$

(b) (2 pts; half if eqn) 1116.9 pc or

$$d = 10^{-\frac{m-M}{5}+1}$$

(c) (2 pts; half if eqn) 4089 Solar luminosities (4080 is okay - uses intermediary rounding)

or $L_{\text{star}} \text{ in } L_\odot = \frac{L_{\text{star}}}{L_\odot} = 10^{-\frac{M_{\text{star}} - M_\odot}{2.512}}$ with

$$M_\odot = 4.83$$

24) (4 points)

(a) (2 pts; half if eqn) 5.6 Solar Masses

$$\frac{a^3}{P^3} = M_1 + M_2$$

(b) (2 pts; half if eqn) 1.64 x 10^{4} m

$$R_{\text{Schwarzschild}} = \frac{2GM}{c^2}$$

25) (6 points)

(a) (2 pts; half with eqn) 1.44 x 10^{8} m/s

v = H_0d

(b) (2 pts; half with eqn) 42 Gpc

(c) (2 pts; half with eqn) 1428 Mpc (accept 1165 Mpc - takes relativistic effects into account)

v = cz

Tiebreakers

1.It is the third version of the software, the second being called “The Next Generation”

DS9 stands for Deep Space 9 like the Star Trek TV Series

2.

The apparent color is the average, not the peak, and the Planck function is not symmetric.

3.

Wilhelm Carl Werner Otto Fritz Franz Wien

4.

a. Edwin Hubble
b. Subrahmanyan Chandrasekhar
c. Carl Sagan
d. George Hale - discovered magnetic fields in sunspots and built large telescopes
e. William Morgan - co-developed Yerkes Spectral Classification
f. John Grunsfeld - astronaut