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# Astronomy Test - UChicago 2018 Invitational

1) Put the following objects in the correct order for the life of a single star. (6 pts)

m. Main Sequence Star
n. Neutron Star
r. Red Giant
s. Supergiant

2) What object does Figure 1 correspond to? (1pt)

3) What type of star is this? (1 pt)

4) Draw an HR diagram, labeling axes and where the main sequence is. (8 pts)

5) On the HR diagram you drew above, please label where the object in Figure 1 would be found

a) In its normal state (2 pts)
b) At its brightest (2 pts)

6) On the same diagram, please label where Alpha Orionis is. What does its location tell you about the future life of this object? (4 pts)

7) What are the defining spectral characteristics of a Type II Supernova as compared to Type I Supernovae? (2 pts)

8) Describe the process by which a Type II Supernova occurs (what is the stellar material doing before and during the explosion). Are Type II Supernovae the only events that follow this general description? (6 pts)

9) In what phase of stellar evolution do HII regions form (protostars, main sequence, giant phase, etc.)? Explain why they are only found around such objects. (3 pts)

10) Here is a P-Pdot graph of a sample of pulsars.
Please indicate where you would find the following: (8 pts)

a) Normal pulsars
b) Binary pulsars
c) Magnetars
d) Supernova remnants

11) Why do we find almost no pulsars in the region below the red line? (5 pts)

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12) Please label the photos labeled a,b,c, and d in Figure 3 with the name of the DSO and what type of object it is. (8 pts)

13) What three quantities does the “No-hair theorem” say are sufficient to describe a black hole (other than position)? (3 pts)

14) Which of the following is a prototype of Type I (Classical) Cepheids? (1 pt)

a. W Virginis
b. Beta Cephei
c. BL Herculis
d. Delta Cephei
e. RV Tauri

15) Which of the options for the previous question is a prototype star of neither Type I Cepheids nor some subclass of Type II Cepheids? (1 pt)

a. W Virginis
b. Beta Cephei
c. BL Herculis
d. Delta Cephei
e. RV Tauri

16) What does the Hertzsprung Gap suggest about late stellar evolution? (3 pts)

17) A Cepheid’s maximum brightness occurs (before/at/after) it reaches minimum radius. What’s this effect called? (2 pts)

18) Cepheids pulsate in the fundamental mode or first overtone. What is true of this pulsation? (Select all the correct answers) (2 pts)

a. It’s radial
b. There’s a traveling wave on the surface
c. It’s a standing wave
d. Period changes over time in a regular manner

19) How can we use the turnoff point on an HR diagram to tell us about the age of a cluster? (5 pts)

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Math Section

Note: this math section is designed to be a bit long. Don't worry if you can't finish right now -- it may come in handy for studying later.

Show work on provided scratch paper for partial credit! (label each question clearly!)

20) Parallax. Barnard's Star has a parallax angle of 546 milliarcseconds as observed on Earth. (6 pts)

(a) How far is Barnard's Star from the Sun? (give in pc)
(b) If we were on Jupiter, what parallax angle would we observe?
(c) (1 pt) If an object has half the parallax angle (as observed on Earth) as Barnard's Star, how does the distance to that object compare to the distance to Barnard's Star? Options: ¼, ½, 1, 2, 4 times (no need to show work)
(d) (1 pt) What if an object has half the parallax angle as Barnard's Star as observed on Jupiter? Compare the distance to this new object with the distance to Barnard's Star. Same options: ¼, ½, 1, 2, 4 times (again, no need to show work)

21) (6 pts) Distance Modulus and Magnitude/Luminosity/Flux. Altair has an apparent magnitude of 0.77 and is 5.13 parsecs away.

(a) Find the Absolute Magnitude of Altair
(b) Find the luminosity (give in both SI and Solar Luminosities)
(c) What is the flux as observed on Earth assuming there is no interstellar extinction? (give in SI)

22) (6 pts) A star has absolute magnitude -3.2 and a peak wavelength of 290 nm. Please determine some of its other properties.

(a) Find the star's luminosity in SI and Solar Luminosities.
(b) Find the star's temperature in SI.
(c) Find the star's radius in SI and Solar Radii.

23) Star A is a classical Cepheid with a period of 12 days and apparent magnitude 6.0 (as observed on Earth). (6 pts)

(a) Find the absolute magnitude of Star A using the Period-Luminosity relation.
(b) Find the distance to Star A (from the Earth) (in pc if you got part a, symbols otherwise).
(c) Find the luminosity of Star A (in Solar Luminosities if you got parts a and b, symbols otherwise).

24) Suppose an X-ray binary star system has a star and a black hole. The star's orbit has a semimajor axis of 0.310 AU, a period of 12 days, and 22 Solar Masses. (4 pts)

(a) What's the mass of the black hole? (give your answer in Solar Masses) (hint: don't try to convert into SI!)
(b) What's the Schwarzschild radius of this black hole? (now convert into SI)

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25) Let's consider Hubble's Constant. Since there are many values out there, just use $H_0$=70. km/s/Mpc for this problem to simplify grading. (assume all motion in this question is caused by the expansion of the universe; also, ignore any special relativistic effects) (6 pts)

(a) How fast is a star 2 Gpc away from the Earth moving and in what direction?
(b) How far away is something that would seem to be moving at the speed of light? (this puts an upper bound to how far we can see)
(c) If we observe an object with a redshift of z=⅓, how far away is it?

**TIEBREAKERS**:

1. Why does the sun appear yellow if its peak wavelength occurs at 502 nm, which corresponds to green?
2. Where does DS9 imaging Software get its name?
3. What is the full name of the man after whom "Wien's law" is named?
4. List three famous astrophysicists/astronomers affiliated with UChicago (the test writers do not count (...yet))