

Science Olympiad  
Astronomy C Division Event

National Cathedral School Invitational  
Washington, DC  
December 3<sup>rd</sup>, 2016



Name: \_\_\_\_\_

Start Time: \_\_\_\_\_

Directions:

- 1) Please turn in all materials at the end of the event.
- 2) Write all answers on the answer pages. Any marks elsewhere will not be scored.
- 3) Please do not access the internet during the event.
- 4) Don't worry about significant figures. Use 3 or more in your answers, regardless of how many are in the question. Answers within twelve percent of the key will typically be counted as correct
- 5) This test spans fifty minutes. Move quickly through problems and use all of the time. Time is not a tie-breaker
- 6) This test was written by Troy Nguyen. If you have any questions, email [troynguyen8@gmail.com](mailto:troynguyen8@gmail.com)
- 7) Good luck!

**Section A: Identification of Deep Space Objects. Use Image Set A to answer the following questions**

1.
  - (a) What is the number of the image that shows Tycho's SNR?
  - (b) What was the mass, in solar masses, of the object that evolved into this remnant before it went supernova?
  - (c) Given that Tycho's SNR is located 2.75 kpc away, what was the peak apparent magnitude of the super nova that led to the creation of the remnant?
2.
  - (a) What image shows a visible image of a binary system that will evolve into an AM CVn system?
  - (b) How are angular momentum and energy being lost in this system?
3. Place Images 5,6,10,11 in evolutionary sequence of star formation.
4. Image 1 shows Omicron Ceti
  - (a) Omicron Ceti is the prototype to what class of variable stars? Does this class display intrinsic or extrinsic variability?
  - (b) What stage of stellar evolution is Omicron Ceti in?
5.
  - (a) What is the image number and name of the youngest observed planetary nebula?
  - (b) What is the dot in the middle of the nebula?
6. Refer to the H-R diagram on page two of image set A
  - (a) Which letter (A-E) shows the location of White Dwarfs?
  - (b) Which letter (A-E) shows the location of the Sun?
  - (c) Which letter (A-E) shows the location of Red Supergiants?
7. Image 21 shows a color-magnitude diagram of M15.
  - (a) What type of star cluster is M15?
  - (b) Why is there a lack of stars in the top-left region of the color-magnitude diagram?
8.
  - (a) What is the name of the object and number of the image that shows a dwarf nova binary system?
  - (b) Which image shows the behavior of this system?
  - (c) What causes this behavior?

9. Refer to Image 8 on Image set A
  - (a) What galaxy does this image show?
  - (b) What is the name of the boxed object in the image?
  - (c) When was this picture taken?
  - (d) If this object were located 10 pc away from Earth, what would have been its apparent magnitude on the date in part (c), assuming the picture captured its maximum luminosity?
10. Image 19 shows a globular cluster
  - (a) What is this object's New General Catalogue designation?
  - (b) What type of object is shown in the zoomed-in image?
  - (c) Why is it strange to see this type of object in this globular cluster?
11.
  - (a) What image shows observational data of HM Cancri?
  - (b) What portion of the electromagnetic spectrum was this observation made in?
  - (c) What objects compose the HM Cancri system?
  - (d) Based on the observational data, what is HM Cancri's orbital period?
12.
  - (a) Which image shows SNR 0509-67.5?
  - (b) Does this remnant have heavier elements, lighter elements, or the same mass elements as the star that went supernova to create this remnant?
13.
  - (a) What will be the Sun's next step in stellar evolution? When will this change occur?
  - (b) In  $10^{25}$  years, what will be the only evidence of the Sun's existence?
14. What is the name and picture number of the most recent supernova event in the Milky Way Galaxy?
15.
  - (a) Which image shows Hen 2-428?
  - (b) What could have been the progenitor of Hen 2-428?
16. Stars have many properties, but some are more important than others.
  - (a) What property of a star is the main factor in determining how it will evolve?
  - (b) What is the next most influential factor?
17. There are two main types of star clusters
  - (a) Which type of star cluster is primarily found in a halo around the core of the Milky Way?
  - (b) Name both types of star clusters and describe three differences in their characteristics.

18. (a) A rapidly rotating neutron star that emits a beam of electromagnetic radiation is known as what?  
(b) What causes these objects to slow down their rotation rate over time?
19. Image 7 shows an image of NGC 2392  
What portion(s) of the electromagnetic spectrum is this image taken in?
20. Image 15 shows a binary system  
(a) What are the two objects that make up this system?  
(b) What is the name of the object in the middle of the image that appears as a larger dot?  
(c) What is the spectral type of the object in (b)?

**Section B: Use Image Set B to answer Questions 21-23**

21. Image 37 shows the light curve of a Type Ia supernova
- (a) How far away did this supernova occur, in parsecs?
  - (b) At its peak, what was the supernova's luminosity in Watts?
  - (c) In order for a blackbody to have the same luminosity as part (b), what temperature in Kelvin would the blackbody need to have if it had the same radius as the sun?
  - (d) In order for a blackbody to have the same luminosity as part (b), what radius in Solar Radii would the blackbody need to have if it had the same temperature as the sun?
  - (e) The orbital system that existed right before this supernova likely consisted of what objects?
22. Image 38 shows an absorption spectrum of type Ia supernova SN UDS10Wil, focusing on the bands created by the absorption of Fe II, Fe III, Si II, and S II. Use Image 38 to answer the following questions
- (a) What is the redshift of this supernova?
  - (b) What is the recessional velocity (caused by the expansion of the universe) of this supernova in km/s?
  - (c) How far away did this supernova occur in Mpc?
  - (d) If we had extremely sensitive equipment, what would the measured parallax of this supernova be in arcseconds?
  - (e) What was this supernova's apparent magnitude at peak luminosity?
23. Star A is a main sequence star 150 parsecs away from Earth with an absolute magnitude of +1.2. A blackbody curve from the star is shown in image 39.
- (a) What is the surface temperature in Kelvin of the star?
  - (b) What is the luminosity of this star in Watts?
  - (c) What is the radius of this star in solar radii?
  - (d) What is the apparent magnitude of this star?

**Section C: Use Image Set C to answer Questions 24-25**

24. Image 40 shows a Mira variable star: Chi Cygni.
- (a) What is the pulsation period of Chi Cygni in days?
  - (b) The first cycle shows the apparent magnitude change from  $\sim 3.0$  to  $\sim 14.0$ . How many times brighter is Chi Cygni at the top of the cycle than the bottom of the cycle?
  - (c) During Chi Cygni's pulsations, the temperature, radius, and luminosity all change. An incomplete graph is given on the answer sheet with high points and low points for each of these characteristics. Complete the graph for the first two phases of Chi Cygni.
25. Image 41 shows the Radial Velocity Curve for a binary star system comprised of Star A (blue curve) and Star B (red curve). Star A has a mass of 1.3 solar masses.
- (a) What is the mass of star B in solar masses?
  - (b) What is the orbital separation of the system in AU?
  - (c) What is the distance in kilometers between each star and the barycenter?
  - (d) Through new measurements, we discover that the binary system has an inclination of 60 degrees. What are the true peak velocities of Star A and B?
26. A star had an orbital period of 28 days, a radius of 1.2 solar radii, a mass of 1.3 solar masses, and a surface temperature of 6,540 K when it was on the main-sequence. Now that the star has evolved into a giant, it has a radius of 14 solar radii and a surface temperature of 4,460 K.
- (a) What was the star's moment of inertia, in  $\text{Kg} * \text{m}^2$ , when it was on main-sequence?
  - (b) As a giant, what is the star's new moment of inertia, in  $\text{Kg} * \text{m}^2$ , assuming the mass did not change?
  - (c) What is the star's new rotational period, in days, due to the conservation of angular momentum?
  - (d) What is the star's new luminosity, in solar luminosities?