

# Science Olympiad Astronomy

February 15, 2019  
Hosted at University of California, Irvine

## **Instructions**

Answer all questions on the supplied answer sheet in the appropriate location as indicated on the answer sheet. Answers not given on the answer sheet will not be scored and points will be forfeited.

Each question's total point value is the same. The highest score wins. Questions which require a written explanation will be scored as full credit or no credit as determined by the scorer's given guidelines. Failure to keep written answers to the indicated length will be penalized as if the answer were incorrect. Tiebreaker questions are as indicated on the test.

Teams may consist of no more than two (2) students. Teams may have no more than two (2) calculators. **etc etc**. You may remove pages from the packet but you must turn in all pages at the end.

This test is composed of three (3) sections: General questions, Calculation questions, and Identification questions. Each section is marked at its beginning.

**Team Name:**

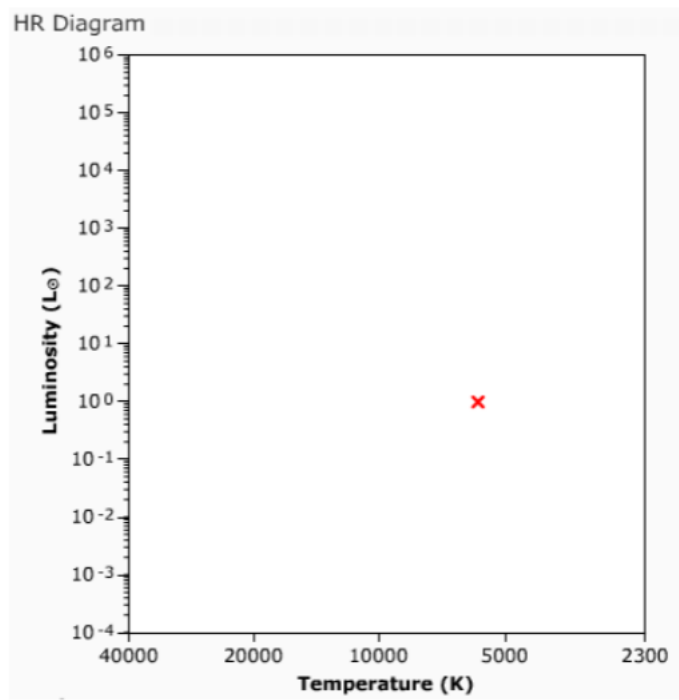
**Student Names:**

## 1 Section A - General Questions

1. On a Color-Magnitude diagram, a galaxy in the Red Sequence is:
  - A) Older than one in the Blue Cloud
  - B) Still forming young, hot stars
  - C) Lensing red light from a background galaxy
  - D) Redshifted beyond  $Z = 5$
2. Spiral Galaxies are:
  - A) The oldest galaxies in the Universe
  - B) Have already merged with another galaxy
  - C) Have not merged with another galaxy
  - D) something else
3. Dark Energy is responsible for the deceleration of the expansion of the Universe.
  - A) True
  - B) False
4. A Blackbody:
  - A) Emits equal amounts of all wavelength light
  - B) Emits unequal amounts of different wavelength light centered around a peak
  - C) Absorbs equal amounts of all wavelength light
  - D) Absorbs unequal amounts of different wavelength light centered around a peak
5. A star with a B-V value of -0.33 is \_\_\_\_\_ and \_\_\_\_\_ than a star with a B-V value of +0.33.
  - A) Hotter, Redder
  - B) Hotter, Bluer
  - C) Cooler, Redder
  - D) Cooler, Bluer
  - E) None of the Above
6. All stars in the main sequence of the HR diagram achieved:
  - A) Enlightenment
  - B) Hydrostatic equilibrium
  - C) Nuclear fission
  - D) Gravitational collapse

- E) None of the above
7. **blank** galaxies are formed by merger event:
- A) Spiral
  - B) Disc
  - C) Elliptical
  - D) Circular
  - E) Dwarf
8. On the Hertzsprung-Russell (HR) Diagram:
- a) What is measured on the x-axis?
  - b) What is measured on the y-axis?
  - c) Diagonal lines from the top left to bottom right indicate stars with the same:
    - A) Mass
    - B) Radius
    - C)  $\log g$
    - D) Luminosity
    - E) Nothing
  - d) Diagonal lines from the bottom left to top right indicate stars with the same:
    - A) Mass
    - B) Radius
    - C)  $\log g$
    - D) Luminosity
    - E) Nothing
9. Assuming all stars are perfect blackbodies, calculate the peak wavelengths for the following stars (give answer in nanometers):
- a) An O type star with effective Temperature 31,000 K
  - b) A G type star with effective Temperature of 6500 K
  - c) An M Dwarf with effective Temperature of 3000 K
  - d) A Red Giant with effective Temperature of 3000 K

10. A star born today will have, on average, a \_\_\_\_\_ metallicity than one born one billion years after the Big Bang.
  - A) lower
  - B) higher
  - C) the sameIn one sentence explain why.
11. In one sentence, describe the determining mechanism behind why a star will evolve into either a white dwarf or a neutron star.
12. Stars generate energy via nuclear fusion. What is the heaviest element that can be created via nuclear fusion? In one sentence, how are the heavier elements produced?
13. In no more than two sentences, why is the Cosmic Microwave Background (CMB) detected in the microwave region of electromagnetic radiation?
14. The mass limit for which a star will evolve into a white dwarf is named after an astrophysicist. What is that person's name and what is the mathematical limit in solar mass units?
15. In one sentence, describe the significance of a black hole's event horizon.
16. In one sentence, describe the primary difference between Weak and Strong lensing.
17. List two (2) phenomena that are direct evidence for the existence of Dark Matter.
18. What are brown dwarfs, and what element is used to distinguish them from low-mass stars?
19. **"We are all stardust."** You've probably heard of this phrase and understand the reasoning behind it. However, someone tells you that this can't be true because we aren't exclusively made of hydrogen and helium. In under two sentences, explain how stars form heavier elements.
20. The Ancient Greeks noted that the star Algol seemed to periodically dim every 2.1 days by the same amount each time. In one sentence, what could have caused this?
21. Let's follow a typical G type star through its life cycle. Draw and label each stage of its evolution on the supplied blank HR Diagram.



## 2 Calculation Questions

1. Given that it takes Jupiter 11.86 years to complete one orbit, what is the magnitude of the force on Earth created Jupiter when it is at opposition?
2. You observe a Type 1a Supernova at apparent magnitude +6 and you know the absolute magnitude for these events is -19.3. How far away is the host galaxy?
3. The H-alpha spectral line is at 656.3 nm. Star A has that line at 656.8 nm, star B has that line at 656.0 nm, and star C has that line at 656.3 nm.
  - a) Which star is moving the fastest along our line of sight?
  - b) What are the three stars' directions of motion (toward or away from us)?
4. Leo 1 is a Dwarf Galaxy orbiting the Milky Way at a distance of 1 Mpc (megaparsec). If it's circular velocity is measured at  $5 \times 10^4$  m/s, what is the mass of the Milky Way?
5. Answer the following questions about a supernova that is observed in a distant galaxy.
  - a) Astronomers measure the Si II line in the remnant shell and find it red shifted to 6551.34 angstroms. The rest wavelength is known to be 6347.103 angstroms. How fast is the shell expanding in km/s?
  - b) Assuming the astronomers don't observe strong hydrogen lines, what type of supernova would this be?
  - c) What is the diameter of the remnant 100 days after the explosion in meters, assuming a constant rate of expansion?
6. Suppose the nearby dwarf galaxy has a star formation rate of 0.3 Solar Masses per year.
  - a) How many Rigel-mass stars could be created in one million years?
  - b) If we did form these many Rigel's, and if the dwarf galaxy was made up of only these stars, what is the galaxy's luminosity? (Rigel's Luminosity is 10,000 times that of the Sun)
  - c) If we observe this dwarf galaxy at an apparent magnitude of 22.4, how far away is it?

**Late one night you are observing a far off galaxy and you notice a bright spot suddenly appear. Questions 7 through 14 all go together in one "storyline".**

7. In no more than 2 sentences, how can you determine whether or not this is a Type 1A supernova?

8. If you were able to determine it to be a Type 1A SN, what is the velocity at which you will measure the incoming photons?
- A) 450,000 km/s
  - B) 300,000 km/s
  - C) 60,500 km/s
  - D) 14,600 km/s
  - E) 5,280 km/s
9. If you were able to determine it to be a Type 2 SN, what is the velocity at which you will measure the incoming photons?
- A) 450,000 km/s
  - B) 300,000 km/s
  - C) 60,500 km/s
  - D) 14,600 km/s
  - E) 5,280 km/s
10. If you were able to determine it to be a Type 1A SN, how massive was the star before it exploded?
- A) 2.3 Solar Masses
  - B) 2.6 Solar Masses
  - C) 1.3 Solar Masses
  - D) 1.6 Solar Masses
  - E) Impossible to know without more info.
11. If you were able to determine it to be a Type 2 SN, how massive was the star before it exploded?
- A) 2.3 Solar Masses
  - B) 2.6 Solar Masses
  - C) 1.3 Solar Masses
  - D) 1.6 Solar Masses
  - E) Impossible to know without more info.

**Let's say you successfully determined this to be a Type 1A supernova and you estimate the brightness to be 250 times fainter than the star Vega.**

12. How far away is the galaxy?

13. You fire up your spectrometer and measure the recessional velocity of the galaxy at  $XX$  m/s.  
Calculate the Hubble Constant.
14. Using this information, calculate the age of the Universe.



### 3 Identification Questions

*Use the image sheet to answer the following questions and their respective sub-questions about this year's DSO's.*

1. The apparent visual magnitude of NGC 2623 is 13.36. What is its absolute magnitude if it's 250 mly away?
  - a) This DSO is an example of galactic merging. 4 billion years from now, galactic merging will likely occur with the Milky Way and what other neighboring galaxy?
  - b) Which image depicts NGC 2623?
2. Image H is a picture of a galaxy cluster. What is the name of the galaxy cluster it depicts?
  - a) Another image on the image sheet depicts another galaxy cluster in the Massive Cluster Survey. Which image is it, and what is the cluster's name?
  - b) In image H, one of the galaxy cluster's subclusters undergoes distortion of cosmic microwave background (CMB) radiation. What is this phenomenon called?
3. What DSO is image C a composite picture of?
  - a) What two wavelengths was this image taken in?
4. GW151226 is a gravitational wave event, as indicated by the prefix GW. What do the numbers following GW mean?
  - a) What caused the GW151226 signal to occur?
  - b) Which image corresponds to GW151226 data obtained by LIGO Hanford and Livingston detectors?
  - c) What does the x-axis represent, and what does the y-axis represent for the graphs on the third row?
5. The Bullet Cluster is a galaxy cluster 3.4 billion lightyears away. How far is this distance in parsecs?
  - a) Which image on the image sheet displays 1E 0657-56?
  - b) Because of gravitational lensing studies, the Bullet Cluster provides the best evidence to date for the existence of what phenomenon?
6. Which image on the image sheet depicts SN UDS10Wil?
  - a) This extremely distant supernova has a redshift value of 1.914. What does a positive redshift value indicate, and how does it differ from a negative value?

7. What makes JKCS 041 distinct from other galaxy groups?
  - a) In which constellation is JKCS 041 located?
8. Refer to image E. The inset in this graphic represents some X-ray data from a quasar. What is the plot a spectrum of?
  - a) What is the name of the specific quasar this data was collected from?
9. Refer to image P on the image sheet. What is the name of this object, and what wavelength was it taken in?
  - a) This object was the first of its kind to be identified. What kind of object is it?
10. Refer to image G. What is the name of this specific event?
  - a) What kind of phenomenon is this?
  - b) This event is analogous to GW 170817A. What could be the cause of these phenomena?
11. Messier 87 is a supergiant elliptical galaxy in Virgo. What are some other names for this DSO?
  - a) Which image from the image sheet corresponds to this object?
  - b) In 2019, the very first image of a type of object was taken within this galaxy. What is the object?
  - c) What is at the center of this object?