

Reach for the Stars

Division B



- You will have 50 minutes to complete the test
- You are only allowed to use two 8.5 by 11 inch papers and a calculator
- There is no penalty for wrong answers; don't hesitate to guess
- Good luck, and have fun!

Part 1: DSO's and Constellations

Each letter is worth 2 points. Questions labeled "Bonus" are worth 3 points.

1. a) What DSO is shown in image 1 (Give it's Messier or New General Catalogue number)
b) What constellation is it in?
c) What is this object also known as? (there are two names; only one is required)
d) What wavelength was this image taken in?
e) True or false: This object is also an H II region

2. a) Which constellation is shown in image 4?
b) What DSO is found in this constellation?
c) What type of galaxy is this DSO (there are two acceptable answers)?
d) This object contains a large population of what type of stars?

3. a) Which image shows the Baby Boom Galaxy?
b) About how many stars does this galaxy produce in a year? Bonus: This rate is how many times greater than the Milky Way's star formation rate (per year)?
c) This galaxy challenges the traditional model of galactic development. How so?

4. a) Which image shows Altair?
b) What constellation is this star in?
c) Why is this star oblate?
d) Bonus: Altair's brightness changes slightly, so it is a variable star. What type of variable star is it?

5. a) What image shows GN-z11?
b) Why is this object so special?
c) How far and how old is it?
d) What constellation is it in?
e) Bonus: What does the "z11" in the object's name mean?

6. a) Which constellation is shown in image 5?
b) Which star in this year's rule manual is in this constellation?
c) True or false: The star in the preceding question is on the main sequence
d) What other object is found in this constellation?
e) What type of nebula is the object in the preceding question?

7. a) Which constellation is shown in image 6?
b) What galaxy is in this constellation?
c) What type of galaxy is it?
d) Why is there intense star formation in this galaxy?
e) The center of this galaxy contains what that causes relativistic jets?

- f) Bonus: These jets are responsible for emissions in which 2 wavelengths?
8. a) The star shown in image 9 was once the North Star and will be the North Star again in the future. What is the star?
 - b) What constellation is it in?
 - c) This star is the vertex of what asterism?
 - d) After leaving the main sequence, what type of star will it become (spectral class)?
 - e) Bonus: What nuclear fusion process does this star use?
 - f) Bonus: This star acts as 0 for what photometric system?
9. a) What galaxy is shown in Image 7?
 - b) Most galaxies are in clusters, but this one is solitary. What are these types of galaxies called?
 - c) What constellation is this galaxy in?
 - d) What type of galaxy is this (e.g., spiral, elliptical, irregular, etc)?
 - e) What wavelength was this image taken in?
 - f) This galaxy has large amounts of what?
 - g) Bonus: How do astronomers know this (the preceding question)?
10. For each of the following constellations, name the brightest star.
 - a) Orion
 - b) Gemini
 - c) Ursa Minor
 - d) Canis Minor
 - e) Virgo

Part 2: Stars and Galaxies

Each letter is worth 3 points. Questions labeled "Bonus" are worth 4 points.

1. a) List the order of the spectral classes from hottest to coldest
 - b) What spectral class is the Sun (only the letter)?
 - c) Which spectral class has the strongest Balmer lines?
2. a) What is the name of the diagram shown in the bottom left of the image sheet?
 - b) What two values can be used for the y axis?
 - c) What two values can be used for the x axis?
 - d) What type of stars are found in the bottom left of this diagram?
 - e) Bonus: Give an example of one of the stars in the preceding question that can be found in the rules manual.

3. a) Describe the evolution of the Sun (beginning with protostar)
b) Bonus: describe the different types of supernovae (the two basic types)

4. a) What is the name of the diagram shown in the bottom right of the image sheet?
b) True or false: This diagram does not show how galaxies evolve
c) Bonus: What type of galaxy is indicated by S0?

5. a) What type of galaxy has a disk, a bulge and a halo?
b) True or false: This type of galaxy is normally in the center of galaxy clusters
c) Where do most of the stars form in this type of galaxy?
d) Bonus: Clusters of old stars are often found in the halo of these types of galaxies.
What are these clusters called?

6. a) What type of galaxy lacks a distinct shape?
b) Give two examples of this type of galaxy that are in the rules manual
c) True or false: These galaxies are often part of galactic interactions

7. a) What type of galaxy has very little star formation?
b) True or false: This type of galaxy is the most common in the universe
c) Give one example of this type of galaxy that is in the rules manual

8. For each of the following types of stars write the corresponding luminosity class
 - a) Subgiant
 - b) Supergiant
 - c) White dwarf
 - d) Giant
 - e) Main sequence
 - f) Bright giant

Part 3: Multiple Choice

Each question is worth 1 point.

1. In about 5 billion years, the Sun will become a:
 - a) White dwarf
 - b) Red supergiant
 - c) Red giant
 - d) Blue supergiant
2. What property of a star determines its stellar evolution?
 - a) Luminosity
 - b) Mass
 - c) Temperature
 - d) Size
3. While on the main sequence, a star does not collapse because
 - a) Gravity is too weak
 - b) The pressure due to fusion combats the force of gravity
 - c) Stars near pull at it, stopping it from going inward
 - d) All of the above
4. A white dwarf does not collapse because of
 - a) Weak gravity
 - b) Electron degeneracy pressure
 - c) Pressure from nuclear fusion
 - d) Stars near it pull at it, stopping it from going inward
5. What is hypothesized to be the strongest material in the universe?
 - a) Supernova remnants
 - b) Stellar Cores
 - c) Dark matter
 - d) Nuclear Pasta
6. Where is the material in the previous questions found?
 - a) In a black hole
 - b) In a white dwarf
 - c) In a neutron star
 - d) In the center of a galaxy
7. What is the name for a "failed" star?
 - a) Red dwarf
 - b) Brown dwarf

- c) Yellow dwarf
 - d) Black dwarf
8. What type of star can live for trillions and trillions of years?
- a) Red dwarf
 - b) Brown dwarf
 - c) Yellow dwarf
 - d) Black dwarf
9. Stars that are similar in size to the Sun generate energy through which process?
- a) Nuclear fission
 - b) Proton-proton chain
 - c) CNO cycle
 - d) Nucleosynthesis
10. Stars that are very massive generate energy through which process?
- a) Nuclear fission
 - b) Proton-proton chain
 - c) CNO cycle
 - d) Nucleosynthesis
11. Population I stars are . . .
- a) Old
 - b) Metal-rich
 - c) Both A and B
 - d) None of the above
12. Population II stars are . . .
- a) Old
 - b) Metal-rich
 - c) Both A and B
 - d) None of the above
13. A white dwarf goes supernova when it exceeds the . . .
- a) Chandrasekhar limit
 - b) Bekenstein bound
 - c) TOV limit
 - d) Eddington limit
14. A neutron star collapses into some denser form when it exceeds the . . .
- a) Bekenstein bound
 - b) Chandrasekhar limit
 - c) TOV limit
 - d) Eddington limit

15. One example of an object that is best viewed in the radio wavelength is a . . .
- a) Star-forming region
 - b) Pulsar
 - c) Supernova
 - d) Galactic center
16. One example of an object that is best viewed in the infrared wavelength is a . . .
- a) Star-forming region
 - b) Pulsar
 - c) Supernova
 - d) Galactic center
17. One example of an object that is best viewed in the x-ray wavelength is a . . .
- a) Star-forming region
 - b) Pulsar
 - c) Supernova
 - d) Galactic center
18. One example of an object that is best viewed in the gamma ray wavelength is a . . .
- a) Star-forming region
 - b) Pulsar
 - c) Supernova
 - d) Galactic center
19. Which of the following stars consists of a triple-star system
- a) Vega
 - b) Polaris
 - c) Deneb
 - d) Rigel
20. True or false: Triple-star systems are rarer than binary star systems
- a) True
 - b) False

Part 4: Free Response

There is a star in this year's rules manual that is the prototype for its namesake type of variable stars. What is it (1 point)? What phase of stellar evolution are these stars in (2 points)? What track of the HR Diagram are these types of variable stars in (1 point)? What spectral classes can these stars be (2 points)? Are these stars more or less luminous than main sequence stars? Why (4 points)? These types of stars are not hot enough to generate fusion. How do they emit radiation (6 points)? Why are these types of stars useful (5 points)?

Part 5: Math

Points are labeled on the questions. If needed, use 5.67×10^{-8} for the Stefan Boltzmann constant, 3×10^6 for Wien's displacement constant, and 3×10^{28} for the zero-point luminosity.

- Suppose Star A has twice the temperature of Star B. Which star is more luminous? By a factor of what? (4 points)
 - Now suppose Star B has twice the radius of Star A, but still the same temperature. Which star is more luminous? By a factor of what? (4 points)
- A star has a peak emission of 200 nanometers. Based on this, what is its spectral class? (3 points)
 - What color is this star? (2 points)
 - How strong are its Balmer lines (choose from very weak, weak, medium, or strong) (3 points)
- Star A has an absolute magnitude of 1, Star B has an absolute magnitude of -4, and Star C has an absolute magnitude of 6. Which star is the brightest? (4 points)
 - Out of Star A and Star C, which one is brighter? By a factor of what? (4 points)
 - Out of Star B and Star C, which one is brighter? By a factor of what? (4 points)
- Suppose a star is 100 parsecs away from Earth and has an apparent magnitude of 6. Find the absolute magnitude. (4 points)
 - Is this star brighter than the Sun? (2 points)
- A star has a parallax angle of 0.04 arcseconds. What is its distance, in parsecs? (2 points)
- Challenge Question
A star's luminosity is 3×10^{30} . Find the absolute magnitude. (9 points)