

Name _____

Do not forget to write your name and fill in the bubbles with your student number, and fill in test form D on the answer sheet. Write your name above as well. You have 40 minutes. For each question, mark the best answer. The formulas you may want are:

$$d = \frac{3.26 \text{ ly}}{p} \quad \frac{L}{L_{\odot}} = \left(\frac{T}{T_{\odot}}\right)^4 \left(\frac{R}{R_{\odot}}\right)^2 \quad L = 4\pi d^2 B$$

- Suppose you went from one solar cycle to the next, so you went from (say) maximum sunspots to minimum sunspots. What would be different the second time?
 - The magnetic field would reverse, so north would become south
 - The Sun's rotation would reverse, so it would spin the opposite way
 - The number of sunspots per cycle alternates between high and low
 - The Sun's temperature would oscillate, colder one cycle and hotter the next
 - The fusion process would be working on one cycle and not on the next (or vice versa)
- The Sun has magnetic fields, which implies that currents are flowing throughout the Sun. What component of the Sun can conduct electric currents?
 - Iron in the Sun
 - Liquid metallic hydrogen
 - Solid metallic hydrogen
 - Salts dissolved in the Sun's atmosphere
 - All of the Sun: it is made of plasma (ionized gas) which is highly conductive
- Which stars will end up as neutron stars?
 - Light stars much lighter than the Sun
 - Light stars, including the Sun
 - Heavy stars, including the Sun
 - Heavy stars much heavier than the Sun, but not extremely heavy ones that become black holes
 - The heaviest stars, much heavier than the Sun, that are too heavy to become black holes
- When helium starts to fuse in heavy stars, which of the following elements is produced?
 - Hydrogen
 - Iron
 - Silicon
 - Beryllium
 - Carbon
- One of the ways of measuring the distance to a star involves measuring its apparent movement compared to background stars over the course of a year. This method is called
 - Radar distancing
 - Parallax
 - Spectroscopic parallax
 - Moving cluster method
 - None of the above

6. Star A and Star B are the same distance away, but star A is brighter. Which star is more luminous?
 - A) Star A
 - B) Star B
 - C) If they are the same distance, they must be the same brightness
 - D) It is impossible to tell without knowing the spectral class of the stars
 - E) It is impossible to tell, even if we knew the spectral class of the stars

7. The reason there are no stars lighter than about 0.08 times the Sun's mass is because
 - A) Objects with this mass almost never occur
 - B) Such small objects never get hot enough to undergo fusion
 - C) These stars would simply be too dim to be observed, so they don't count
 - D) These stars live such a short time that they basically never occur
 - E) These stars always gravitationally attract other stars, making them get more massive

8. What element is responsible for the red emission line that gives the chromosphere its color?
 - A) Hydrogen
 - B) Neon
 - C) Helium
 - D) Oxygen
 - E) Iron

9. Which two objects are believed to be necessary to produce an X-ray burster?
 - A) Giant star and black hole
 - B) Giant star and neutron star
 - C) Giant star and white dwarf
 - D) White dwarf and neutron star
 - E) Neutron star and black hole

10. If a star stayed the same temperature while it was becoming more luminous, how would it move on the Hertzsprung-Russel diagram?
 - A) Up
 - B) Down
 - C) Right
 - D) Left
 - E) No movement

11. The best indication of the surface temperature of a star would be its
 - A) Mass
 - B) Brightness
 - C) Luminosity
 - D) Doppler shift
 - E) Color

12. Which of the following spectral classes has the highest surface temperature?
 - A) A9
 - B) B9
 - C) A2
 - D) B2
 - E) K5

13. From which of the following is it theoretically impossible to escape?
 - A) White dwarf (only)
 - B) Neutron star (only)
 - C) Black hole (only)
 - D) White dwarf and black hole
 - E) Neutron star and black hole

14. The mass of stars can be pretty accurately measured if the star is
 - A) Binary
 - B) A red giant
 - C) A protostar
 - D) A supergiant
 - E) A supernova

15. Which stage comes immediately before the planetary nebula stage?

- A) Double shell burning
 - B) Red giant
 - C) Main sequence
 - D) White dwarf
 - E) Core helium burning
16. What makes sunspots dark compared to the rest of the surface of the Sun?
- A) Carbon compounds concentrated at these places
 - B) Clouds of gas blocking our view of the surface of the Sun
 - C) Places where the Sun has run out of hydrogen and therefore isn't undergoing fusion
 - D) Places on the Sun's surface where the temperature is cooler
 - E) "Holes" that let us see into the cool interior of the Sun
17. Suppose stars X and Y were both spectral class F5. What additional information would allow us to conclude that they are approximately the same luminosity?
- A) If they are both the same distance from the Sun
 - B) If they have the same mass
 - C) If they are both main sequence stars
 - D) If they are both about the same age
 - E) None of these would be sufficient
18. Sometimes when we look at the spectrum of a star, the dark lines come in pairs, slightly shifted compared to each other. What could be causing this?
- A) The star is really two stars at slightly different temperatures
 - B) The star is really two stars moving at different velocities (probably in orbit)
 - C) The star is rotating, with one side coming towards us and the other moving away
 - D) The star is made of two varieties of hydrogen with slightly different wavelengths
 - E) The star is pulsating, sometimes causing one wavelength set and sometimes the other
19. What causes the granulation, the small patterning of relatively cooler and hotter portions of the surface of the Sun?
- A) Distribution of chemical compounds on the Sun's surface
 - B) Changes in the rate of fusion at different points on the Sun's surface
 - C) Gases floating above the surface of the Sun
 - D) Vibrations in the overall structure of the Sun
 - E) Convection as heat flows from the interior to the surface of the Sun
20. If star X has the same temperature as the Sun, but it is four times more luminous, what does this tell us about the radius of star X?
- A) It is half that of the Sun
 - B) It is the same as the Sun
 - C) It is twice that of the Sun
 - D) It is four times that of the Sun
 - E) It is 16 times that of the Sun
21. The following net reaction powers the Sun and most stars. What is wrong with this formula?
- $$3 \text{ hydrogen} + 2 \text{ electrons} \rightarrow 1 \text{ helium} + 2 \text{ neutrinos} + \text{energy}$$

- A) There should be 2 helium on the right
 - B) There should be 4 hydrogen on the left
 - C) The neutrinos should be on the left side
 - D) The electrons should be on the right side
 - E) There is nothing wrong; this formula is correct
22. The star Wolf 359 is one of the nearest stars to the Sun. Which might be its distance from the Sun?
- A) 0.583 AU B) 7.78 AU C) 0.583 ly D) 7.78 ly E) 583 ly
23. Which two elements are the most common in the Sun?
- A) Hydrogen and helium
 - B) Hydrogen and carbon
 - C) Helium and carbon
 - D) Hydrogen and oxygen
 - E) Carbon and oxygen
24. As heat leaks out of a protostar, the star gets
- A) Smaller and cooler
 - B) Larger and cooler
 - C) Smaller and hotter
 - D) Larger and hotter
 - E) Cooler, but they stay the same size
25. Which element cannot undergo nuclear fusion, because it has produced as much energy as it can?
- A) Helium B) Carbon C) Oxygen D) Silicon E) Iron
26. The merger of two of which of the following types of stars have produced gravity waves that have been detected?
- A) Main sequence
 - B) White dwarf
 - C) Black hole
 - D) Protostar
 - E) Massive star supernovae
27. Why does nuclear fusion only take place in the center of the Sun?
- A) This is the only place with enough oxygen for burning to occur
 - B) The hydrogen has completely run out near the surface
 - C) Fusion can only occur in regions where heat is transported by radiation
 - D) Fusion requires high pressure, which only exists in the center
 - E) Fusion requires high temperature, which only exists in the center
28. At some stage, we expect that the Sun will burn helium to heavier elements. What happens when the helium at the core runs out?
- A) It will begin losing mass and become a planetary nebula

- B) It will start burning helium in a thin shell
 - C) It will collapse to a white dwarf
 - D) It will start burning hydrogen instead
 - E) None of the above
29. The typical size of a neutron star is about the same as the size of
- A) The Sun
 - B) The Earth
 - C) A city
 - D) A baseball
 - E) A pinhead
30. What event will trigger the transition of the Sun from a main sequence star to a red giant?
- A) When hydrogen gets hot enough to undergo fusion
 - B) When helium gets hot enough to undergo fusion
 - C) When carbon gets hot enough to undergo fusion
 - D) When all the hydrogen throughout the Sun runs out
 - E) When the hydrogen at the core is used up
31. What determines the path that plasma in solar prominences follow when they are outside the Sun?
- A) Pressure pushes them the direction they go
 - B) They are following ballistic paths, just shooting out of the Sun and falling back due to gravity
 - C) The hot plasma follows magnetic field lines sticking out of the Sun
 - D) Electric currents cause them to flow much as electricity does through wires
 - E) The plasma follows solid tubes that channel them in the direction they are going
32. Where are stars born?
- A) Planetary nebulae
 - B) Hot bubbles
 - C) Atomic hydrogen clouds
 - D) Molecular clouds
 - E) Hollywood
33. How does the mass of the Sun compare to the mass of the planets?
- A) It is lighter than all of the planets, because it is made of hydrogen
 - B) It is lighter than some planets, and heavier than others
 - C) It is heavier than all the planets, but not as heavy as all the planets added together
 - D) It is much heavier than all the planets put together
 - E) It is unknown; we don't know the mass of the Sun