ASTR1102-002

Practice Questions for Exam #2

1. Why do sunspots appear to be darker than most of the Sun's photosphere?

    ANS: Because sunspots are cooler (have a lower temperature) than the surrounding photosphere.

2. Sometimes the Sun's surface displays virtually no sunspots, while at other times its surface displays a relatively large number of sunspots. What is the typical length of time between sunspot minimums and sunspot maximum; that is, what is the typical length of the "sunspot cycle"?

    ANS: The length of the sunspot cycle is 11 years.

3. Sunspots appear to be associated with regions of the Sun's surface where the magnetic field is especially _____ (weak or strong).

    ANS: Strong

4. The north and south magnetic poles of the Earth reverse every 11 years. (True or False?)

    ANS: False

5. Heat can be transported from the center to the surface of a star either by radiative diffusion, or by convection. Which one of these two processes is principally responsible for transporting heat in the surface layers of the Sun?

    ANS: Convection

6. By tracking the changing position of sunspots across the surface of the Sun over many hours and days, astronomers have determined that the Sun rotates once every 24 hours. (True or False?)

    ANS: False

7. Which of the following properties of the Sun can best be studied during a total solar eclipse?

   a. Sunspots.
   b. The Solar Corona.
   c. Photospheric granulation.
   d. Nuclear fusion in the Sun's core.

   ANS: "b"

8. The central temperature of the Sun is _____. (Fill in the blank.)

   a. approximately 5800 K.
   b. approximately 16 million K.
   c. orange.
   d. not known.

   ANS: "b"

9. If the Sun was not in **hydrostatic equilibrium**, how long would it take for the Sun's structure to noticeably change?

   a. A few hours.
   b. Tens of thousands of years.
   c. Approximately 10 million years.
   d. Approximately 10 billion years.

   ANS: "a"

10. If the Sun was undergoing **Kelvin-Helmholtz contraction**, how long would it take for the Sun's structure to noticeably change?

    a. A few hours.
    b. Tens of thousands of years.
    c. Approximately 10 million years.
    d. Approximately 10 billion years.

    ANS: "c"

11. Because heat generated through **nuclear fusion reactions** in the central core of the Sun is replenishing the heat that the Sun is steadily losing at its surface, how long can the Sun "live" without experiencing a noticeable change in its structure?

    a. A few hours.
    b. Tens of thousands of years.
    c. Approximately 10 million years.
    d. Approximately 10 billion years.

    ANS: "d"

12. What is the **average density** of material in the Sun? State your answer in units of kilograms per cubic meter and compare it to the density of water (1000 kg/m^3).

    HINT: You can calculate the average density by dividing the Sun's total mass ($M_\odot = 2 \times 10^{30}$ kg) by the Sun's volume. Given the Sun's radius ($R_\odot = 7 \times 10^8$ meters), what is the Sun's volume?

    ANS: 1392 kg/m^3; so the Sun's average density is approximately the same as the density of water.

13. According to the mathematical (theoretical) model of the Sun that has been developed by astronomers, what is the **central density** of the Sun? (See, for example, Table 16-2 or Figure 16-3.)

    ANS: 160,000 kg/m^3

14. According to the mathematical (theoretical) model of the Sun that has been developed by astronomers, what is the **central temperature** of the Sun? (See, for example, Table 16-2 or Figure 16-3.)

    ANS: 16 million K

15. How many neutrons are in the nucleus of the most common isotope of hydrogen (^{1}H)?

    ANS: 0 neutrons

16. How many protons are in the nucleus of a ^{1}H atom?

    ANS: 1 proton

17. How many protons are in the nucleus of a deuterium (^{2}H) atom?

    ANS: 1 proton

18. How many neutrons are in the nucleus of a deuterium (^{2}H) atom?

    ANS: 1 neutron

19. How many protons are in the nucleus of a tritium (^{3}H) atom?

    ANS: 1 proton

20. How many neutrons are in the nucleus of a tritium (^{3}H) atom?

    ANS: 2 neutrons

21. How many protons are in the nucleus of a ^{3}He atom?

    ANS: 2 protons

22. How many neutrons are in the nucleus of a ^{3}He atom?

    ANS: 1 neutron

23. How many protons are in the nucleus of a ^{4}He atom?

    ANS: 2 protons

24. How many neutrons are in the nucleus of a ^{4}He atom?

    ANS: 2 neutrons

25. How many protons are in the nucleus of a ^{12}C atom?

    ANS: 6 protons

26. How many neutrons are in the nucleus of a ^{12}C atom?

    ANS: 6 neutrons

27. How many neutrinos are created when four ^{1}H nuclei combine (via the proton-proton chain, nuclear fusion reaction) to form one ^{4}He nucleus?

    ANS: 2 neutrinos

28. What happens to the positron (e^+) shortly after it is created during the first step of a "proton-proton chain" nuclear reaction?

    ANS: The positron collides with an electron and the two particles annihilate each other; the energy released as a result of this annihilation is $E = mc^2$, where in

this case "m" is the total mass (electron + positron) that was present before the annihilation.

29. What is the chemical composition of the Sun? What two atomic elements are most abundant in the Sun?

   ANS: Hydrogen and helium are, by far, the two most abundant elements in the Sun. By mass, the Sun's composition is 74% H and 25% He; the remaining 1% is a mixture of all the other heavier elements found in a chemist's periodic table of elements.

30. What is the end product of a nuclear reaction when two ^{3}He atoms fuse together?

   ANS: One ^{4}He nucleus plus two free protons (that is, two ^{1}H nuclei).

31. Discuss how measurements of the flux of neutrinos from the Sun have helped us (a) check the accuracy of our mathematical models of the Sun, and (b) establish a more fundamental understanding of the properties of neutrino particles.

   ANS: Read the textbook's discussion of "solar neutrinos".

32. Explain how measurements of solar oscillations have helped us check the accuracy of our mathematical models of the Sun.

   ANS: Read the textbook's discussion of "solar oscillations".

33. Stars on the main sequence that are 15 times more massive than the Sun should live 15 times longer than the Sun because they have more fuel to burn. (True or False?)

   ANS: False

34. Stars on the main sequence that are 3 times more massive than the Sun have luminosities that are 60 times brighter than the Sun. What should the lifetime of these stars be on the main sequence (relative to the Sun's lifetime)?

   ANS: The lifetime of these stars is approximately $3/60 = 1/20^{th}$ the Sun's expected lifetime, that is, approximately 500 million years.

35. What is the significance of Einstein's famous equation, $E = mc^2$, to our study of stars?

   ANS: Read class notes and textbook's discussion of the energy that is produced in nuclear reactions, such as the proton-proton chain reaction.

36. When hydrogen nuclei combine through a thermonuclear reaction to form the nucleus of a helium atom, the process is called "nuclear fusion." (True or False?)

    ANS: True

37. When a heavy atomic nucleus, such as the nucleus of a uranium atom, spontaneously splits apart into two or more smaller atomic nuclei, the process is called "nuclear fusion." (True or False?)

    ANS: False

38. What is special about the "iron-nickel group" of chemical elements in the context of our discussion of nuclear fusion and nuclear fission reactions?

    ANS: Chemical elements that are lighter than the "iron-nickel group" of elements will usually release energy when they participate in a fusion reaction, whereas chemical elements that are heavier than the "iron-nickel group" will usually only release energy when they undergo fission.

39. The River Bend Nuclear Power plant (in St. Fancisville, LA) derives its energy from the fusion of hydrogen into helium. (True or False?)

    ANS: False

40. The atomic bombs that were developed and used during World War II derived their explosive energies from the fusion of hydrogen into helium. (True or False?)

    ANS: False

41. In one or two sentences, explain why normal stars spend a much larger fraction of their "lives" on the main sequence than they spend as red giant stars.

    ANS: When any individual star becomes a red giant, its luminosity will be greater than it was when the star was on the main sequence; hence as a red giant the star must burn up its fuel at a faster rate than when it was on the main sequence (hence, it can't live as long as a red giant). Also, as a red giant a star is fusing Helium nuclei to form Carbon, and less energy is produced for each one of these fusion reactions than was released during the fusion of Hydrogen to form Helium (while the star was on the main sequence); hence, a star has a smaller reservoir of energy available during its phase as a red giant than it had available during its phase as a main sequence star.

42. How many neutrinos are created each time three ^{4}He nuclei fuse to form one ^{12}C nucleus? (Consider only the simplest possible way of combining 3 ^{4}He nuclei to make ^{12}C.)

   ANS: None

43. Make up (and answer) at least six questions about stellar evolution, based on the three schematic H-R diagrams depicted below.

H-R Diagram #1

H-R Diagram #2

H-R Diagram #3