Assignment 9

Multiple Choice
Identify the letter of the choice that best completes the statement or answers the question.

_____ 1. The astrophysicist who first calculated the highest mass that a dying star can have and still be a white dwarf was
   a. H. R. Russell
   b. S. Chandrasekhar
   c. I. Shelton
   d. A. Hewish
   e. D. Generate

_____ 2. Which of the following is a characteristic of degenerate matter in a white dwarf star?
   a. helium is actively fusing into carbon
   b. electrons and protons join together in the nucleus to make neutrons and neutrinos
   c. the degenerate matter region is expanding as time passes, until it covers a region the size of the orbit of Mars
   d. the electrons get as close to each other as possible and resist further compression
   e. the atoms drink, smoke, use bad language, and are attracted to the wrong kinds of particles

_____ 3. When the mass of a star's core becomes greater than 1.4 times the mass of the Sun, degenerate electrons can no longer keep it as a white dwarf. Instead, it becomes:
   a. a neutron star
   b. a planetary nebula
   c. a red giant
   d. a ball of solid iron, with layers of other elements around it
   e. a black dwarf

_____ 4. A neutron star is as dense as
   a. water
   b. the center of the Earth
   c. a white dwarf star
   d. the nucleus of an atom
   e. your astronomy textbook
5. When neutron stars were first predicted theoretically, no scientist expected to be able to detect one of them across interstellar distances. What enabled astronomers to find neutron stars in the late 1960's?
   a. they give off a lot more light than expected, and can be seen glowing with a reddish light from far away
   b. they are so large, their dark outline block a significant amount of starlight from behind them
   c. we found strongly magnetic neutron stars whose whirling beams of energy were seen as pulsars
   d. some neutron stars soon collapse to be white dwarfs, which can be detected further away
   e. astronomers have actually only found one neutron star and that was discovered very close to us and by sheer luck

6. Which of the following statements about the Crab Nebula is FALSE?
   a. it is the remnant of a supernova explosion first seen on Earth in 1054 AD
   b. the nebula still puts out more energy (at all wavelengths) than 100,000 Suns
   c. inside, there are a number of newly formed massive stars (O and B type stars)
   d. the neutron star inside shows clear evidence of slowing down just a little bit in its rotation
   e. we can detect a pulsar inside the nebula using both radio waves and visible light

7. Astronomer have concluded that pulsars are
   a. rotating black holes
   b. rotating neutron stars
   c. rotating red giants
   d. supernovae that are about to explode
   e. protostars that are collapsing and spinning very rapidly

8. What kind of telescope did Jocelyn Bell use to discover pulsars in 1968?
   a. visible light
   b. radio
   c. ultraviolet
   d. x-ray
   e. neutrino

9. Which of the following is one reason we do not detect a pulsar in many remnants of supernova explosions?
   a. most stars (our own Sun, for example) don't rotate at all, so no pulsar can form
   b. because the radiation with which we detect pulsars doesn't get through the Earth's atmosphere
   c. the pulsar beam doesn't happen to point toward us in many cases
   d. many supernova remnants contain white dwarfs or black dwarfs
   e. the little green men inside put shades on their pulsars for privacy
10. Where does the energy come from that allows the Crab Nebula to keep shining almost a 1000 years after the star exploded? (Who ultimately "pays the energy bill"?)
   a. material is still being ejected from the star in the form of a planetary nebula
   b. a massive black hole is "eating" material at the center of the nebula
   c. a neutron star is slowing down (losing rotation energy)
   d. large parts of the nebula are falling inward, releasing gravitational energy
   e. the Crab nebula is a signal station, where some aliens (LGM) are broadcasting rock and roll

11. According to the general theory of relativity, the presence of mass
   a. causes motion at the speed of light squared
   b. is equivalent to the presence of light
   c. causes curved paths to straighten out until they are exactly straight lines
   d. causes a curvature (or warping) of spacetime
   e. will cause a black hole to form, unless there is motion

12. According to Einstein's general theory of relativity, the stronger a star's gravity,
   a. the weaker its pull on another star will be
   b. the slower time runs near it
   c. the weaker the x-rays we see from it
   d. the smaller the event horizon will be of the black hole it makes
   e. the less spacetime around it will be distorted

13. When a light wave leaves a region of strong gravity, compared to the same wave leaving a spaceship in empty space, the wave will have
   a. a longer wavelength
   b. a lower frequency
   c. less energy
   d. a gravitational redshift
   e. all of the above

14. A member of the college football team wants to weigh as much as possible. Assuming he could somehow survive on all of them, at the surface of which object would he weigh the most?
   a. an O-type star in the main sequence stage of its life
   b. an M-type star in the main sequence stage of its life
   c. a white dwarf
   d. a neutron star
   e. you can't fool me, his weight would be the same on all of the above objects

15. To predict whether a star will ultimately become a black hole, what is the key property of the star we should look at?
   a. mass
   b. surface temperature
   c. color
   d. distance
   e. diameter
**16.** The region around a black hole where everything is trapped, and nothing can get out to the rest of the universe, is called
a. the singularity  
b. the neutron star radius  
c. the gravitational redshift zone  
d. the event horizon  
e. day-time television

**17.** Deep inside a black hole (and hidden from our view) is the compressed center, where all the "stuff" of the star goes. Astronomers call this central point
a. an event horizon  
b. a singularity  
c. a time-stopping point  
d. a black dwarf  
e. Bayonne, New Jersey

**18.** The astronomer who first worked out the mathematical description of black hole event horizons was
a. Edwin Hubble  
b. Jocelyn Bell  
c. Karl Schwarzschild  
d. S. Chandrasekhar  
e. Frederik Pohl

**19.** Once a black hole forms, the size of its event horizon is determined only by
a. the size of the star that collapsed into the black hole  
b. the mass inside the event horizon  
c. the time since the black hole formed  
d. the composition of the material that formed the black hole  
e. you can't fool me; every black hole has an event horizon of the same size

**20.** In the far future, a starship becomes trapped inside the event horizon of a black hole. Although the crew discovers that their ship cannot get out, they at least want to send a message to other ships in the area to stay away from the danger zone. If they send out a message in the form of a radio wave, what will be its fate?
 a. the message will emerge from the event horizon with a huge gravitational redshift  
b. although the radio wave will emerge from the event horizon, all the information in the message will be garbled  
c. the radio wave will become a gamma ray by the time it emerges from the event horizon  
d. the radio wave will only emerge from the event horizon if it is moving in the direction of the magnetic north and south pole of the star that formed the black hole  
e. you can't fool me; this message will never emerge from the event horizon
21. Suppose each of the following objects could collapse into a black hole. Each black hole would have a sphere around it that is the limit for escape -- once you are inside this region, you cannot get away. For which object would this region be the largest in diameter?
   a. a star with the mass of our Sun
   b. a planet like Jupiter
   c. a star that was type O when it was on the main sequence
   d. an entire cluster of stars (with about 150 stars in it)
   e. an entire galaxy of stars (with about a billion stars in it)

22. Wearing a very accurate watch, you volunteer to go on a mission to a black hole in a spaceship that has powerful rockets. You are able to orbit the black hole and stay a little distance outside of the event horizon. Compared to watches on Earth, your watch near the black hole will run:
   a. more slowly
   b. more quickly
   c. infinitely slow
   d. infinitely fast
   e. you can't fool me, watches near a black hole don't change the pace at which they run

23. When one member of a binary star system is a black hole, and astronomers detect flickering x-rays coming from the system, where are these x-rays usually coming from?
   a. from inside the black hole event horizon
   b. from the photosphere of the companion star (the star that is not a black hole)
   c. from the singularity
   d. from a disk of material around the black hole (material that has been pulled from the companion star and is falling toward the black hole)
   e. from a distant galaxy that just happens to lie behind the black hole system (the x-rays have nothing to do with the black hole)

24. Which of the following can a black hole not "eat" (swallow)?
   a. a planet
   b. a cloud of gas and dust
   c. a star
   d. another black hole
   e. you can't fool me, black holes can eat anything
25. A handsome, rich, but vain movie star notices that he is starting to age, and consults you as his astronomy expert, to see if you can find an astronomical way to slow down his aging. Putting aside practical considerations (such as the fact that we cannot travel to other stars), which of the following strategies would IN THEORY allow him to age more slowly than the rest of humanity.

a. he should always live at sea level on Earth, and never go to any mountains or high altitudes
b. he should live far away from the gravity of any planet or star (in a deep-space station)
c. he should be in orbit around the Earth, and expose himself to as many cosmic rays as possible
d. he should travel to a black hole, and spend some time in orbit just above the event horizon
e. he should live in a room filled with positive charges

26. Far away from a black hole (at the distance of another star), which of the following is a possible way to detect it?

a. notice what a large amount of star light it blocks from behind it
b. look for the pulsed radio waves it gives off as it rotates like a lighthouse
c. look for the neutrinos that always escape from the event horizon
d. search for flickering x-rays being given off as it "eats" part of a neighbor star
e. you can't fool me, you can never ever detect a black hole!
Assignment 9
Answer Section

MULTIPLE CHOICE

1. ANS: B
3. ANS: A
5. ANS: C
7. ANS: B
9. ANS: C
11. ANS: D
13. ANS: E
15. ANS: A
17. ANS: B
19. ANS: B
21. ANS: E
23. ANS: D
25. ANS: D