1. In a neutron star, the core is
   A) made of compressed neutrons in contact with each other.
   B) no longer rotating.
   C) primarily iron and silicon. electrons and protons packed so tightly they are in contact.
   D) constantly expanding and contracting.

1. Two important properties of young neutron stars are
   A) extremely slow rotation and a strong magnetic field.
   B) extremely rapid rotation and a weak magnetic field.
   C) no rotation and a weak magnetic field.
   D) no rotation and no magnetic field.
   E) extremely rapid rotation and a strong magnetic field.

2. An object more massive than the Sun, but roughly the size of a city, is a
   A) white dwarf.
   B) brown dwarf.
   C) neutron star.
   D) red dwarf.
   E) supernova remnant.

3. The mass range for neutron stars is
   A) .08 to .4 solar masses.
   B) .4 to 3 solar masses.
   C) 1.4 to 3 solar masses.
   D) 3 to 8 solar masses.
   E) 6 to 11 solar masses.

4. Which of these does not exist?
   A) a million solar mass black hole
   B) a 6 solar mass black hole
   C) a 1.8 solar mass neutron star
   D) a 1.5 solar mass white dwarf
   E) a 0.06 solar mass brown dwarf

5. Most pulsars are observed only as _____ sources.
   A) gamma-ray burster
   B) x-ray
   C) radio
   D) visible lighthouse
   E) ultraviolet repeating

6. Neutron stars have
   A) no relation to pulsars.
   B) weak or non-existent magnetic fields.
   C) monopolar fields that switch polarity every rotation.
   D) very strong bi-polar magnetic fields.
   E) periods of days or weeks.

7. What makes the Crab Nebula pulsar unusual among other pulsars?
   A) Its period is much less regular than other pulsars.
   B) It is the fastest spinning known pulsar.
   C) It is the oldest known pulsar.
   D) It is a magnetar, with far more intense magnetic fields than any other.
   E) It is relatively bright in shorter wavelengths, like visible and X-rays.

8. Who discovered the first four pulsars?
   A) Carl Sagan
   B) Anthony Hewish
   C) Martin Schwartzschild
   D) Stephen Hawking
   E) Jocelyn Bell

9. Pulsars
   A) generally form from 25 solar mass stars.
   B) spin very rapidly when they're young.
   C) emit radio radio in all directions.
   D) are the cause of gamma-ray bursts.
   E) spin very slowly when they're young, and gradually spin faster as they age.

10. In the Lighthouse Model,
    A) the period of pulsation must speed up as the neutron star continues collapsing.
    B) all pulsars must have their poles pointed directly toward us.
    C) the period of pulsation slows down due to the drag of the remnant on its field.
    D) the star literally turns on and off like a lighthouse beacon.
    E) if the beam sweeps across us, we will detect a pulse of radiation.

11. Neutron stars do not have
    A) strong magnetic fields.
    B) rotation periods comparable to the Sun's.
    C) sizes comparable to large cities.
    D) masses greater than 1.4 solar masses.
    E) large surface gravities, compared to the Sun.

12. The supernova of 1054 produced
    A) an optically visible pulsar with a period of 33 milliseconds.
    B) the first known gamma-ray burster.
    C) no remaining trace, like most Type I supernovae.
    D) a supernova remnant still visible to the naked eye.
    E) the most famous black hole, Cygnus X-1.

13. Three terrestrial-sized planets in orbits of a fraction of an AU have been found near
    A) Cygnus X-1.
    B) a magnetar.
    C) a millisecond pulsar.
    D) a white dwarf.
    E) Supernova 1987A.

14. Many of the millisecond pulsars lie in _____, suggesting great stellar density.
    A) globular clusters
    B) giant molecular clouds
    C) planetary nebulae
    D) open clusters
    E) emission nebulae

15. X-ray bursters occur in binary systems, containing a
    A) pair of white dwarfs.
    B) white dwarf and a neutron star.
    C) red giant and a neutron star.
    D) pair of neutron stars.
    E) black hole and a main sequence star.

16. Pulsars have a measured mass of
    A) less than 1.0 solar masses.
    B) about 1.4 solar masses.
    C) greater than 10 solar masses.
    D) 5.2 solar masses.
    E) between 2 and 4 solar masses.

17. You would expect millisecond pulsars to be
    A) part of a binary system.
    B) rotating slowly.
    C) isolated in space.
    D) collapsing rapidly.
    E) most common in open clusters.

18. A proposed explanation for gamma-ray bursters is
    A) hypernova-making black holes and bi-polar jets.
    B) coalescence of a neutron star binary.
    C) collisions between two white dwarfs.
    D) Both A and B are possible.
    E) All three are possible.

19. What would happen if more mass was added to a 1.4 solar mass neutron star?
    A) All of its protons and electrons would turn into quarks.
    B) It could eventually become a black hole, via a hypernova explosion.
    C) It would blow off mass as a gamma ray burster.
    D) It would erupt as a Type I supernova.
    E) It would grow larger, temporarily becoming a red giant again.

20. In a hypernova, a very energetic supernova creates a
    A) set of planets to orbit their neutron star host.
    B) black hole.
    C) white dwarf and its planetary nebula.
    D) very visible supernova remnant.
    E) millisecond pulsar.

21. A hypernova creates
    A) short-duration gamma-ray bursts.
    B) a pulsar.
    C) a neutron star..
    D) a black hole.
    E) Both B and C are correct.

22. Which statement about gamma ray bursters is not correct?
    A) In seconds, they radiate hundreds of times more energy than even supernovae do.
    B) They seem to be coming from far beyond our own Milky Way.
    C) They are scaled up X-ray bursters, with more massive objects involved.
    D) Millisecond flickering implies they are tiny in size.
    E) The beams may be bi-polar ejections from the hypernova formation of black holes.

23. Which are the two most popular candidates for gamma-ray bursters?
    A) formation of uranium in the core of a supergiant, and collisions of white dwarfs
    B) mergers of two black holes, and merger of a neutron star and a white dwarf
    C) hypernova making a black hole, and merger of two neutron stars
    D) collisions between a white dwarf and a giant, and merger of two neutron stars
    E) hypernova making pulsars, and mergers of two white dwarfs

24. Which statement about black holes is true?
    A) Their event horizon is a physical surface boundary.
    B) Their escape velocity is greater than the speed of light.
    C) Their main sequence mass was 5-10 solar masses.
    D) They form an event horizon at twice the Schwartzschild radius.
    E) They form from 1.4 solar mass stars.

25. The densely packed neutrons of a neutron star cannot balance the inward pull of gravity if the total mass is
    A) Chandrasekhar's limit of 1.4 solar masses.
    B) greater than Schwartzschild's limit of 3 solar masses.
    C) less than 1.0 solar masses.
    D) not at least 25 solar masses.
    E) between 1.4 and 2.0 solar masses.

26. The Schwartzschild radius for a 12 solar mass star is
    A) 4 km
    B) 15 km
    C) 36 km
    D) 100 km
    E) 3000 km

27. What explanation does general relativity provide for gravity?
    A) Gravity is the opposite of the electromagnetic force.
    B) Gravity is the result of curved spacetime.
    C) Gravity is directly proportional to the mass of the attracting body.
    D) Gravity is inversely proportion to the radius of the body.
    E) Gravity can affect only massive particles, not massless photons.

28. An observer on a planet sees a spaceship approaching at 0.5c. A beam of light projected by the ship would be measured by this observer to travel at
    A) 0.25c
    B) 0.5c
    C) c
    D) 1.5c
    E) 2.5c

29. As a spaceship's velocity gets closer to the speed of light
    A) its length will decrease and its clock will run more slowly.
    B) its length will decrease and its clock will run faster.
    C) its length will increase and its clock will run more slowly.
    D) its length will increase and its clock will run faster.
    E) None of these will happen.

30. If light from a distant star passes close to a massive body, the light beam will
    A) bend towards the star due to gravity.
    B) continue moving in a straight line.
    C) accelerate due to gravity.
    D) slow down.
    E) change color to a shorter wavelength.

31. What can we detect from matter that has crossed an event horizon?
    A) Gamma bursts.
    B) Visible light.
    C) Radio waves if the matter was traveling fast enough.
    D) X-rays if the matter was dense.
    E) Nothing.

32. As a spaceship nears an event horizon, a clock on the spaceship will be observed
    A) to run slowly.
    B) to run faster.
    C) to run backwards.
    D) to run the same as one on Earth.
    E) to stop.

33. If the Sun were replaced by a one solar mass black hole
    A) life here would be unchanged.
    B) our clocks would all stop.
    C) we would still orbit it in a period of one year.
    D) we would immediately escape into deep space, driven out by its radiation.
    E) all terrestrial planets would fall in immediately.

34. What is Cygnus X-1?
    A) a millisecond pulsar with three Earth-like planets around it
    B) The brightest star in the constellation Cygnus.
    C) the leading candidate for an observable black hole binary system
    D) the strongest x-ray eclipsing binary system in the sky
    E) the first gamma-ray burster to be spotted in other wavelengths as well

35. A method for identifying a black hole is to
    A) search for their pulsar signal.
    B) look for their effects on nearby companions.
    C) look for voids in the star fields.
    D) search for radio waves from the accretion disk.
    E) locate a visible star that disappears when the black hole passes in front of it.

36. The largest known black holes
    A) can be no more than 1.4 solar masses, according to Chandrasekhar.
    B) can be no bigger than the earth, like white dwarfs.
    C) lie in the cores of the most massive galaxies.
    D) can be no bigger than a small city, just like neutron stars.
    E) create the dark nebulae in the plane of the Milky Way.

37. Which of these is not an argument for Cygnus X-1 being a black hole?
    A) It is the third strongest source of X-rays in the sky.
    B) Spectroscopic data suggests hot gas is flowing toward the X-ray source.
    C) The X-rays from the compact source vary in as little as a millisecond.
    D) The mass of the visible star is greater than that of the X-ray source.
    E) The mass of the X-ray source is about 10 solar masses.