Chapter 23, Introduction

1. What is the physical process that produces the energy that results in the vast majority of light in our universe?

- Thermonuclear fusion.
- Gravitational release by the concentration of matter.
- The Big Bang.

Section 23-1

2. If the supernova discovered by a Chinese astronomer in 1054 AD is 6500 light-years away, when did the explosion actually occur?

- 5446 BC
- 7554 BC
- 1054 AD

Section 23-1

3. What is the force that keeps a neutron star from collapsing to a black hole under its intense self-gravitational field?

- The very high temperature and velocity of the neutrons, which creates a thermal gas pressure to oppose gravity.
- The intense nuclear repulsion between neutrons, only felt when these neutrons are very closely packed because the nuclear force is very short-ranged.
- Neutron degeneracy pressure, the quantum-mechanical effect in which no two neutrons with the same properties can occupy the same space.

Section 23-1

4. When was the existence of neutron stars first predicted?

- 1967
- Never. They were discovered observationally before anyone predicted their existence.
- 1933

Section 23-2

5. Who made the first discovery of a pulsar?

- Fritz Zwicky and Walter Baade
- Jocelyn Bell
- Albert Einstein

Section 23-2

6. What is the single most remarkable fact about the pulses of radio energy discovered by Jocelyn Bell to be coming from various regions of space?

- The very intense energy in each pulse.
- The location from which they were coming, at the centers of nearby galaxies.
- Their extremely regular pulsation period.

Section 23-3

7. What type of force holds a neutron star together?

- Electrical force
- Nuclear force
- Magnetic force

Section 23-3

8. What makes a pulsar pulse?

- A white dwarf in a binary star system is periodically eclipsed by its companion star.
- A rapidly spinning black hole pulsates and sends out regularly spaced pulses of electromagnetic radiation.
- A rapidly spinning, magnetized neutron star emits light and radio waves along its magnetic axis.

Section 23-3

9. What physical mechanism produces the very rapid rotation rate of a neutron

star in the center of a supernova explosion?

Intense radiation pressure on the imploding stellar core from the supernova explosion spins this core up to high rotation speeds as a consequence of the conservation of energy.

Explosive expansion of the supernova has transformed the slow rotation of a massive star into rapid rotation, as a consequence of the conservation of angular momentum.

Rapid implosion of a slowly rotating mass into a much smaller volume, where the conservation of angular momentum results in high rotation speed.

Section 23-3

10. What is the mechanism that produces the continuous series of narrow pulses of electromagnetic radiation at precise rates from neutron stars or pulsars in our universe?

The regular passage across the Earth of a narrow, directed beam of electromagnetic radiation from a very compact and rapidly rotating neutron star.

The regular ringing or oscillation of the solid surface of a very compact neutron star, in the manner of a ringing bell or a vibrating wine glass.

The rapid orbiting of a neutron star around a black hole, the intense gravitational field that periodically focuses emitted electromagnetic radiation from the neutron star toward the Earth.

Section 23-3

11. Neutron stars that appear in our sky as pulsars are known to emit

beams of electromagnetic radiation at all wavelengths.

only visible light, produced by recombination of electrons with atoms and nuclei in the beams of ejected matter from the neutron star.

only beams of radio energy, produced by beams of accelerating electrons.

Section 23-3

12. What produces the rapid rotation rate of a young neutron star, or pulsar?

Mass transfer from a companion star causes the neutron star to spin up.

The core of the dying star spins up because it collapses to a very small radius.

☐ Matter falling onto the neutron star from the debris of the supernova explosion causes the neutron star to spin up.

Section 23-3

13. What is the source of the charged particles that are accelerated along a neutron star's magnetic field to produce two oppositely directed beams of radiation?

☐ Electrons and protons from the neutron star's ionized atmosphere.

☐ Pair production of electrons and positrons.

☐ Matter transferred from a companion star.

Section 23-3

14. What kind of star produces a neutron star?

☐ Only high-mass stars.

☐ All masses of stars.

☐ Only low-mass stars.

Section 23-4

15. Synchrotron radiation is emitted whenever

☐ electrons recombine with atomic nuclei, dropping through energy levels to produce specific, or synchronous, wavelengths of light.

☐ charged particles are ejected in straight lines through a dense gas such as the outer atmosphere of a star.

☐ charged particles, such as electrons, are forced to move along curved paths through a magnetic field.

Section 23-4

16. What is the underlying source of the energy that produces the glow in the gases of the Crab Nebula?

☐ The rotational energy of the central pulsar.

☐ Ionization produced by the intense blackbody radiation from the central neutron star.

- The slow gravitational condensation of gases within the nebula.

Section 23-4

17. The blue glow surrounding the central rotating neutron star in the Crab Nebula is caused by

- synchrotron radiation from electrons spiraling in intense magnetic fields.
- blackbody radiation from this very hot gas.
- intensely blueshifted light from atoms being ejected violently from the neutron star.

Section 23-4

18. What is thought to be the source of the energy that makes the Crab Nebula such a luminous object?

- The radiant heat energy from the very compact and very hot neutron star at the center of the nebula.
- The energy from the heating of the material of the nebula by the original supernova explosion.
- The tremendous energy output of the central pulsar, in the form of beams of electrons, which illuminate the nebula with synchrotron radiation.

Section 23-4

19. Pulsars, or rotating neutron stars, emit a series of pulses whose pulsation rate is

- speeding up as the neutron star is slowly being compressed into a smaller volume by its intense gravitational field.
- slowing down with time, as a consequence of the loss of energy as radiation and the conservation of energy.
- absolutely constant, as expected for an isolated spinning object with a superconducting shell around a superfluid core.

Section 23-4

20. A single pulsar (not a member of a binary system) is observed to be rotating at the rapid rate of 20 times per second. What does this tell us about the pulsar?

- It will soon collapse to form a black hole.
- It is an old pulsar.
- It is a young pulsar.

Section 23-5

21. What is the composition of a pulsar?

- Equal numbers of closely packed neutrons and protons, similar to a giant nucleus.
- Entirely protons except for a neutron-rich crust, the mutual electrostatic forces of the protons opposing the gravitational attraction.
- Almost entirely neutrons.

Section 23-5

22. What would be the escape velocity for an object on the surface of the neutron star depicted in Figure 23-8 of Freedman & Kaufmann,*Universe*, 7th Ed.? (Caution: Be careful with units.)

- About 19.7 times the velocity of light.
- About 0.44 the velocity of light.
- About 0.62 of the velocity of light.

Section 23-6

23.The mechanism that results in very high rotation rates for certain pulsars is probably

- mass exchange with a binary companion.
- mass loss from the neutron star, the remainder spinning faster as a result.
- collapse of the neutron star, similar to the way that a skater increases rotation in a spin.

Section 23-6

24. The "spin-up" mechanism that has resulted in millisecond pulsars with abnormally high rotation rates is thought to be

- the ejection of matter along the two opposing beams of the neutron star, the conservation of angular momentum resulting in more rapid rotation of the remaining mass.
- mass transfer and directional streaming of matter from a companion star in a close binary system
- the abrupt collapse of the neutron star to a much smaller volume when mass transfer from a companion star increases the neutron star mass beyond the 3 solar mass limit for stability.

Section 23-7

25. Pulsating X-ray sources in space are thought to be binary star systems containing an ordinary star and

- a spinning neutron star.
- a spinning white dwarf star.
- a black hole.

Section 23-7

26. Pulsating X-ray sources, first detected in 1971, are caused by

- mass transfer from a companion star onto the magnetic poles of a rotating neutron star, producing hot spots of very intense X-ray emission.
- periodic buildup of matter from a companion star onto the surface of a neutron star until the threshold for thermonuclear reactions is reached, whereupon copious amounts of X rays are produced.
- periodic passage of a neutron star through the dense atmosphere of a companion star as it follows an elliptical orbit, producing intense bursts of X rays as it does so.

Section 23-7

27. A pulsating X-ray source is thought to be

- an isolated high-temperature rotating neutron star
- a rotating neutron star in a close binary system with another object.
- a rotating white dwarf with a hot spot upon its surface, in a close binary

system.

Section 23-7

28. What mechanism is believed to produce the regularly spaced pulses of X-ray radiation that we observe from some parts of the sky?

- Charged particles moving along the lines of magnetic force near the poles of a rotating neutron star emit X-ray beams that sweep around the universe.
- Matter falling onto a rotating neutron star from a companion star creates hot spots which emit X rays.
- Matter being accelerated toward a neutron star from a companion star emits a beam of X rays as it falls inward. This beam sweeps around the universe as the two stars revolve around each other.

Section 23-8

29. The energy in a nova arises from

- the sudden stopping of the rapid rotation of a neutron star by the collision with another star.
- the explosive destruction of a massive star at the end of its evolutionary life.
- thermonuclear fusion of matter accreted onto the surface of a white dwarf star from its companion star in a binary system.