1. What is the Sun's photosphere?
   A) envelope of convective mass motion in the outer interior of the Sun
   B) lowest layer of the Sun's atmosphere
   C) middle layer of the Sun's atmosphere
   D) upper layer of the Sun's atmosphere

2. The temperature of the Sun's photosphere is
   A) close to 1 million K.
   B) about 10,000 K.
   C) 5800 K.
   D) 4300 K.

3. The granular appearance of the surface of the Sun is evidence of what phenomenon occurring in or on the Sun?
   A) cells of thermonuclear fusion just under the visible surface
   B) rapid rotation of the surface layers producing swirls of gas
   C) concentration and heating of ionized gas by regions of high magnetic fields
   D) convective motion under the solar surface

4. A typical granule on the surface of the Sun is
   A) about 1000 km across and lasts for a few minutes.
   B) a few thousand kilometers across and lasts for about two solar rotations.
   C) about 30,000 km across and lasts for several hours.
   D) only about 50 km across and cannot be seen from Earth without special equipment.

5. Spectral lines observed in the granules seen at the center of the Sun's disk are
   A) split by the Zeeman effect due to the strong magnetic fields in the granule.
   B) always redshifted because granules are caused by gas descending into the Sun from higher layers.
   C) redshifted near the center of the granule and blueshifted near the edge of the granule.
   D) blueshifted near the center of the granule and redshifted near the edge of the granule.

6. What is the name of the layer of the Sun's atmosphere that appears as a pinkish ring just outside the visible disk of the Sun during a total solar eclipse?
   A) chromosphere
   B) photosphere
   C) convective zone
   D) corona
7. What are the names of the three layers in the Sun's atmosphere, in order from lowest to highest?
   A) corona, chromosphere, photosphere
   B) photosphere, chromosphere, corona
   C) photosphere, corona, chromosphere
   D) chromosphere, photosphere, corona

8. What is the temperature of the solar corona?
   A) 50,000 to 100,000 K
   B) 2000 to 3000 K
   C) 5800 K
   D) 1 to 2 million K

9. What is the rotation period of the Sun?
   A) about two rotations per year
   B) about one rotation per day
   C) about four rotations per month
   D) about one rotation per month

10. The sunspot cycle on the Sun is a(n)
    A) regular movement of a relatively constant number of sunspots from the poles to the equator of the Sun over an 11-year period.
    B) somewhat irregular but always present cycle of buildup and decay of sunspot numbers.
    C) irregular buildup and decay in the number of sunspots averaging about 11 years, which occasionally fails for a time when no spots appear.
    D) extremely regular buildup and decay in the number of sunspots, with a precise period of 11.3 years.

11. What is the Zeeman effect?
    A) When a light source is moving relative to an observer, the wavelengths of its spectral lines are shifted to longer or shorter wavelengths.
    B) When the temperature of a light source is increased, the wavelength of maximum emission decreases.
    C) When a light source is located in a magnetic field, the emitted spectral lines are split into two or more components.
    D) When light is focused on a metal surface, electrons are ejected from the metal only if the wavelength of the light is shorter than some critical wavelength.
12. From which fusion reaction does the Sun derive its power?
   A) $^4\text{He} \Rightarrow \text{O}$
   B) $^2\text{H} \Rightarrow \text{He}$
   C) $^3\text{He} \Rightarrow \text{C}$
   D) $^4\text{H} \Rightarrow \text{He}$

13. A hydrogen nucleus (a proton) has a charge of +1 and a helium nucleus has a charge of +2. Why, then, does it require four protons to form helium in the core of the Sun?
   A) Two of the protons are converted into neutrinos.
   B) Two of the protons become neutrons.
   C) Two of the protons are ejected back into the solar material.
   D) Two helium nuclei are formed from the four protons.

14. When four protons collide to form helium, what fraction of the original mass of the protons is converted into energy?
   A) $3/4$ of $1\%$
   B) $100\%$
   C) $1/20$ of $1\%$
   D) $4\%$

15. What is the dominant mechanism by which energy is transported through the inner regions of the Sun?
   A) hotter gas rising and cooler gas falling—convective transport of energy
   B) photons transferring between nuclei and atoms—radiative transport of energy
   C) neutrinos streaming outward through the Sun's material—particle transport of energy
   D) collisions of faster-moving particles with slower-moving particles—conductive transport of energy

16. What is the dominant mechanism by which energy is transported through the outer regions of the solar interior?
   A) highly penetrating neutrinos streaming outward through the Sun's material—particle transport of energy
   B) photons transferring between nuclei and atoms—radiative transport of energy
   C) collisions of faster-moving particles with slower-moving particles—conductive transport of energy
   D) hotter gas rising and cooler gas falling—convective transport of energy

17. The order of the layers or parts of the Sun, as radius increases, is
   A) radiative zone, convection zone, chromosphere, photosphere, corona.
   B) radiative zone, convection zone, photosphere, chromosphere, corona.
   C) corona, chromosphere, convection zone, photosphere, radiative zone.
   D) radiative zone, convection zone, corona, chromosphere, photosphere.
18. Just outside the radiation zone lies the
   A) convection zone.
   B) conduction zone.
   C) photosphere.
   D) corona.

19. The temperature at the center of the Sun, where thermonuclear processes take place, is approximately
   A) 6000 K.
   B) 1.5 million K.
   C) $1.5 \times 10^7$ K.
   D) 4500 K, as shown by sunspots.

20. In a modern neutrino detector, neutrinos
   A) are detected directly by photomultipliers that emit an electrical signal when struck by a neutrino.
   B) strike water molecules, converting them into molecules of heavy water that then sink to the bottom of the tank.
   C) cause reactions that emit Cerenkov radiation that is then detected with photomultipliers.
   D) which have electric charge, are focused by a series of magnets to produce an intense beam that can be more easily detected by conventional detectors.
Answer Key

1. B
2. C
3. D
4. A
5. D
6. A
7. B
8. D
9. D
10. C
11. C
12. D
13. B
14. A
15. B
16. D
17. B
18. A
19. C
20. C