Choose the best answer for each multiple-choice question, worth 2 points unless stated otherwise.

D  1. Which is the correct sequence of EM radiation, in the order of increasing wavelength?
   A) visible, X-ray, ultraviolet, gamma ray
   B) radio, gamma ray, ultraviolet, visible
   C) visible, X-ray, radio, infrared
   D) gamma ray, X-ray, ultraviolet, visible, infrared

D  2. A blue star appears blue because
   A) Earth’s atmosphere emits more blue light than other colors, and “colors” the stars.
   B) of the Doppler effect.
   C) all colors coming from the star except blue are absorbed by the Earth’s atmosphere.
   D) it emits more short-wavelength visible radiation than it does long-wavelength visible radiation.

C  3. A hydrogen atom in the ground state (i.e., its electron in the lowest energy level)
   A) can emit a photon.
   B) cannot make any transitions.
   C) can absorb a photon.
   D) has lost its electron.

D  4. An atom in an excited state
   A) can emit a photon
   B) can absorb a photon
   C) cannot make any transitions
   D) can emit and absorb photons
   E) can neither emit nor absorb photons
   F) has lost or gained an electron

5. In the schematic energy diagram of an atom shown, the arrows indicate electronic transitions between energy levels, either emitting or absorbing a photon. The spacing between the levels represent the relative sizes of the energy differences. Thus, for example, the transition between levels 1 and 2 involves a greater energy than that between levels 2 and 3. You may choose any of the arrows multiple times.

- Which transition represents the emission of the smallest-energy photon?  
- Which transition represents the absorption of the longest-wavelength photon?  
- Which transition represents the absorption of the greatest-energy photon?  
- Of all the transition indicated, which involves the highest-frequency photon?
6. In the schematic diagram at right, the intensity vs. wavelength curves of three blackbodies are shown. Which blackbody has: (4 points)

• The highest-temperature? ___________ A

• The reddest color? ___________ C

7. Stars X and Y are similar in every way except that Star X has a temperature of 6000 kelvin and Star Y has that of 3000 kelvin. Assume that stars radiate like blackbodies. Then

A) Star X emits 2 times more energy than Star Y.
B) Star X emits 2 times less energy than Star Y.
C) Star X emits 16 times more energy than Star Y.
D) Star X emits 16 times less energy than Star Y.

8. Astronomers determine the chemical elements in a gas cloud by

A) detecting the black body radiation of the gas cloud.
B) applying the Doppler effect.
C) identifying the wavelengths of light absorbed or emitted by the gas.
D) obtaining the continuous spectrum of the gas cloud.

9. A Spectroscope breaks up light into its constituent colors. In the diagram are three spectrosopes 1, 2, and 3, pointed in the direction indicated by an arrow. Spectroscope 1 is looking directly at the hot light bulb. Spectroscope 2 is looking only at the cool, low-density gas of atoms, which have been excited by the hot light bulb to emit light. Spectroscope 3 is looking through the cool, low-density gas at the hot light bulb. What type of spectrum will each see? Choose one for each spectroscope. (6 points)

Spectroscope 1 _________ D

Spectroscope 2 _________ B

Spectroscope 3 _________ A

A) Absorption spectrum
B) Emission spectrum
C) Transition spectrum
D) Continuous spectrum
10. O- and B-type stars typically have very weak Balmer absorption lines in their spectra. This is because
   A) Hydrogen gas, the major component of O- and B-type stars, does not form any visible lines.
   B) hot stars ionize most of the hydrogen atoms in their atmosphere.
   C) cool stars like these are unable to excite the atoms enough to form spectral lines.
   D) Misleading: They have strong Balmer lines in their spectra.

11. K- and M-type stars typically have very weak Balmer absorption lines in their spectra. This is because
   A) Hydrogen gas, the major component of O- and B-type stars, does not form any visible lines.
   B) hot stars ionize most of the hydrogen atoms in their atmosphere.
   C) cool stars like these are unable to excite the atoms enough to form spectral lines.
   D) Misleading: They have strong Balmer lines in their spectra.

12. You hear higher-pitch sound from a sound source that is moving toward you. This is analogous to observing ________ in the spectrum of a star moving toward Earth.
   A) red-shifted lines.
   B) blue-shifted lines.
   C) strong lines.
   D) weak lines.

13. In a laboratory, the hydrogen Balmer alpha line has a wavelength of 656.30 nm. A star’s spectrum reveals the same line to have a wavelength of 656.50 nm.
   A) The star must be cooler than the hydrogen in the laboratory.
   B) The star is moving away from Earth.
   C) The electrons in the hydrogen atoms in the star have dropped down two energy levels.
   D) The electrons in the hydrogen atoms in the star have jumped up two energy levels.

14. Stellar parallax would be easier to measure (i.e., larger parallax) if
   A) the Earth’s orbit were larger.
   B) the stars were farther away.
   C) the Earth moved faster along its orbit.
   D) all of these.

15. If two observations of the stars Sirius and Arcturus are made at 6 month intervals, Sirius reveals a greater parallax because Sirius is
   A) closer to us than Arcturus.
   B) hotter than Arcturus.
   C) more massive than Arcturus.
   D) more distant than Arcturus.

16. Which of the following does a star’s spectrum NOT tell us about that star?
   A) Its apparent visual magnitude.
   B) Its chemical composition.
   C) Its motion relative to Earth.
   D) Its luminosity class.

17. A star’s luminosity is
   A) dependent on the star’s size and distance.
   B) calculated by measuring the star’s parallax angle.
   C) dependent on the star’s temperature and amount of surface area.
   D) expressed as its apparent visual magnitude.

18. Two stars have the same yellow-white color, but one is twice as big as the other. Which of the following is correct?
   A) The larger one is the hotter.
   B) The smaller one is the hotter.
   C) The larger one has the greater luminosity.
   D) The smaller one has the greater luminosity.
   E) The larger one is the hotter and has the greater luminosity.
   F) The smaller one is the hotter and has the greater luminosity.
19. Choose from stars A through G in the H-R diagram shown. (The letters A through G are just labels, and not related to the spectral types O, B, A, F, G, K, M.) You may choose any of the stars multiple times. (20 points)

- Lowest-mass main-sequence star? \text{G}
- Luminosity class III? \text{C}
- White dwarf? \text{F}
- Most likely to be our Sun? \text{D}
- Bluest in color? \text{A}
- Shortest-living main-sequence star? \text{A}
- Red supergiant? \text{B}

Which two have the same color? \text{C & D}

Which two have the greatest size difference? \text{B & F}

Which two have the same luminosity? \text{C & E}

20. A red star and a blue star have the same size.
\text{A) The red star is hotter and more luminous.}
\text{B) The blue star is hotter and more luminous.}
\text{C) The red star is hotter but the blue star is more luminous.}
\text{D) The blue star is hotter but the red star is more luminous.}

21. If two stars have the same luminosity, then
\text{A) the cooler one is the brighter.}
\text{B) the bigger one is the brighter.}
\text{C) the hotter one is the cooler.}
\text{D) the bigger one is the hotter.}
\text{E) the brighter one is the hotter.}
\text{F) the bigger one is the cooler.}

22. When two objects of unequal masses orbit one another, the center of mass is located
\text{A) closer to the more massive object.}
\text{B) at the center of the more massive object.}
\text{C) exactly halfway between the two objects.}
\text{D) closer to the less massive object.}

23. At what point in the light curve of an eclipsing binary system shown is the cooler star \text{in front of} the hotter star?
24. List and briefly describe the three types of binary systems discussed in the textbook. Be sure to include a description of how each type is detected (what shows in their measurements). (24 points)

1. **Visual binary**

Telescopes reveal the system as two distinct stars orbiting each other. Orbital characteristics can be measured and individual masses can be determined.

2. **Spectroscopic binary**

Telescopes cannot resolve the two orbiting stars, but their spectrum reveals periodically doppler-shifting spectral lines; both blueshift and redshift are present as they orbit each other.

3. **Eclipsing binary**

Detected from periodic changes in their brightness (light curve) as one star eclipses (passes in front of) the other because their orbital plane is oriented edge-on toward Earth. It is also a spectroscopic binary and their orbital and physical characteristics, such as size, can be measured.

25. **Bonus Challenge!** In the following table (m indicates apparent magnitude), which star is the brightest (in apparent magnitude)? Most luminous (i.e., brightest in absolute magnitude)? Most likely to be the closest to Earth? Recall that a difference of 5 magnitudes equals a factor of 100 in actual brightness. (6 points)

<table>
<thead>
<tr>
<th>Star</th>
<th>Spectral Type</th>
<th>m</th>
<th>Brightest</th>
<th>Most luminous</th>
<th>Closest</th>
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<tbody>
<tr>
<td>a</td>
<td>B1 V</td>
<td>4</td>
<td>a</td>
<td>e</td>
<td>c</td>
</tr>
<tr>
<td>b</td>
<td>G2 V</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>c</td>
<td>white dwarf</td>
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</tr>
<tr>
<td>d</td>
<td>M5 III</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e</td>
<td>K0 Ib</td>
<td>13</td>
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