Short Answer

21.1 Planck and Quantum Nature of Light 46.

Describe the form of a blackbody radiation curve if all frequencies of light were emitted with equal probability.

a. The curve would appear as a Gaussian probability distribution with a large peak in the middle.
b. The curve would appear as a vertical line.
c. The curve would appear as a horizontal line.
d. The curve would appear as a diagonal line correlating intensity to frequency at a 1:1 ratio.

47.

Because there are more gradations to high frequency radiation than low frequency radiation, scientists also thought it possible that a curve titled the *ultraviolet catastrophe* would occur. Explain what the blackbody radiation curve would look like if this were the case.

a. The curve would steadily increase in intensity with increasing frequency.
b. The curve would steadily decrease in intensity with increasing frequency.
c. The curve would be much steeper than in the blackbody radiation graph.
d. The curve would be much flatter than in the blackbody radiation graph.

48.

Energy provided by a light exists in the following quantities: 150 J, 225 J, 300 J. Define one possible quantum of energy and provide an energy state that cannot exist with this quantum.

a. 65 J; 450 J cannot exist
b. 70 J; 450 J cannot exist
c. 75 J; 375 J cannot exist
d. 75 J; 100 J cannot exist

49.

How did Planck's work come to be regarded as a major dividing line between classical and modern physics?

a. Planck's constant is smaller than any previous discovered constant.
b. Planck hypothesized that energy is quantized rather than continuous.
c. Planck's theories meant that classical physics was no longer useful for any system.
d. Plank discovered the blackbody radiation spectrum.

50.

How many 500-mm microwave photons are needed to supply the 8 kJ of energy necessary to heat a cup of water by 10 degrees Celsius?

a. 8.05×10^{28} photons
b. 8.05×10^{26} photons
c. 2.01×10^{26} photons
d. 2.01×10^{28} photons

51.

What is the efficiency of a 100-W, 550-nm lightbulb if a photometer finds that 1×10^{20} photons are emitted each second?

a. 101 percent
b. 72 percent
c. 18 percent
d. 36 percent

52.

Which form of electromagnetic radiation would deliver the most photons per unit time from a distant galaxy to an observer on Earth?

a. Gamma rays
b. Radio waves
c. Ultraviolet light
d. X-rays

53.

Why are photons of gamma rays and X-rays able to penetrate objects more successfully than ultraviolet radiation?

a. Photons of gamma rays and X-rays carry with them less energy.
b. Photons of gamma rays and X-rays have longer wavelengths.
c. Photons of gamma rays and X-rays have lower frequencies.
d. Photons of gamma rays and X-rays carry with them more energy.

21.2 Einstein and the Photoelectric Effect 54.

According to wave theory, what is necessary to eject electrons from a surface?

a. Enough energy to overcome the binding energy of the electrons at the surface
b. A frequency that is higher than that of the electrons at the surface
c. Energy that is lower than the binding energy of the electrons at the surface
d. A very small number of photons

55.

What is the wavelength of EM radiation that ejects 2.00-eV electrons from calcium metal, given that the binding energy is 2.71 eV?

a. 16.1×10^{5} m
b. 6.21×10^{-5} m

c. 9.94×10^{-26} m
d. 2.63×10^{-7} m

56.

Find the wavelength of photons that eject 0.100\text{-eV} electrons from potassium, given that the binding energy is 2.24\,\text{eV}.

a. 6.22 \times 10^{-7}\,\text{m}
b. 5.92 \times 10^{-5}\,\text{m}
c. 1.24 \times 10^{-5}\,\text{m}
d. 5.31 \times 10^{-7}\,\text{m}

57.

An extremely efficient solar panel is designed with an energy gap of 1.4 eV. If shining a light on the panel causes a current to flow and the temperature of the panel to increase slightly, what can you say about the wavelength of the light?

a. The light's wavelength was about 837 nm.
b. The light's wavelength was about 886 nm.
c. The light's wavelength was about 908 nm.
d. The light's wavelength was about 950 nm.

58.

How do solar panels work?

a. Solar panels take advantage of the photoelectric effect to store potential energy as heat.
b. Solar panels take advantage of the photoelectric effect to convert heat energy into power.
c. Solar panels take advantage of the photoelectric effect to generate power from incoming radiation.
d. Solar panels take advantage of the photoelectric effect to create light from incoming heat energy.

21.3 The Dual Nature of Light 59.

Predict the effect on a photon's wavelength of a collision with an electron.

a. The photon's wavelength will drop to zero.
b. The photon's wavelength will decrease.
c. The photon's wavelength will increase.
d. The photon's wavelength will be inverted.

60.

Compare the momentums of a proton and an electron with the same energy and explain any difference.

a. Their momentums are the same because they have the same energy.

b. The electron has a greater momentum than the photon; photon momentum arises from Planck's constant which is many orders of magnitude smaller than the mass of an electron.
c. The photon has a greater momentum than the electron; photon momentum arises from the speed of light which is much faster than an electron can move.
d. The photon must have a momentum of zero because its rest mass is zero.

61.

A 500-nm photon strikes an electron and loses 20 percent of its energy. What is the new momentum of the photon?

a. 4.24×10^{-27} kg m/s
b. 3.18×10^{-27} kg m/s
c. 2.12×10^{-27} kg m/s
d. 1.06×10^{-27} kg m/s

62.

A 500-nm photon strikes an electron and loses 20 percent of its energy. What is the speed of the recoiling electron?

a. 7.18×10^5 m/s
b. 6.18×10^5 m/s
c. 5.18×10^5 m/s
d. 4.18×10^5 m/s

63.

When a photon strikes a solar sail, what is the direction of impulse on the photon?

a. parallel to the sail
b. perpendicular to the sail
c. tangential to the sail
d. opposite to the sail

64.

What is a fundamental difference between solar sails and sails that are used on sailboats?

a. Solar sails rely on disorganized strikes from light particles, while sailboats rely on disorganized strikes from air particles.
b. Solar sails rely on disorganized strikes from air particles, while sailboats rely on disorganized strikes from light particles.
c. Solar sails rely on organized strikes from air particles, while sailboats rely on organized strikes from light particles.
d. Solar sails rely on organized strikes from light particles, while sailboats rely on organized strikes from air particles.

65.

The wavelength of a particle is called the de Broglie wavelength, and it can be found with the equation $p = \frac{h}{\lambda}$.
Yes or no—Can the wavelength of an electron match that of a proton?

a. Yes, a slow-moving electron can achieve the same momentum as a slow-moving proton.
b. No, a fast-moving electron cannot achieve the same momentum, and hence the same wavelength, as a proton.
c. No, an electron can achieve the same momentum, and hence not the same wavelength, as a proton.
d. Yes, a fast-moving electron can achieve the same momentum, and hence have the same wavelength, as a slow-moving proton.

66.

Why do we not observe the wave-like nature of an object such as quickly rolling bowling ball?

a. The length of the wave is the same as the diameter of the ball, so they are indistinguishable.
b. The length of the wave is longer than the diameter of the ball, making the wave difficult to observe.
c. The length of the wave is much shorter than the diameter of the ball, making the wave difficult to observe.
d. The ball is not rolling quickly enough to have wave-like qualities.