Phys.G12-Atomic physics-Qs.Bank

Multiple Choice
Identify the choice that best completes the statement or answers the question.

_____ 1. What term is used to describe a perfect radiator and absorber of electromagnetic radiation?
a. blackbody
c. quantum
b. atom
d. photon

_____ 2. Classical electromagnetic theory predicted that the energy radiated by a blackbody would become infinite as the wavelength became shorter. What was the contradiction between observation and this result called?
a. the quantum theory
c. the wave-particle duality
b. the photoelectric effect
d. the ultraviolet catastrophe

_____ 3. What were the units of light energy emitted by blackbody radiation originally called?
a. electron volts
c. joules
b. quanta
d. resonators

_____ 4. What is the frequency of a photon with an energy of 1.99×10^{-19} J?
($h = 6.63 \times 10^{-34}$ J•s)
a. 1.00×10^{14} Hz
c. 3.00×10^{14} Hz
b. 2.00×10^{14} Hz
d. 4.00×10^{14} Hz

_____ 5. What is the energy of a photon whose frequency is 6.0×10^{20} Hz?
($h = 6.63 \times 10^{-34}$ J•s; 1 eV = 1.60×10^{-19} J)
a. 1.6 MeV
c. 3.3 MeV
b. 2.5 MeV
d. 4.8 MeV

_____ 6. Light with an energy equal to three times the work function of a given metal causes the metal to eject photoelectrons. What is the ratio of the maximum photoelectron kinetic energy to the work function?
a. 1 : 1
c. 3 : 1
b. 2 : 1
d. 4 : 1

_____ 7. A monochromatic light beam with a quantum energy value of 3.0 eV is incident upon a photocell. The work function of the photocell is 1.6 eV. What is the maximum kinetic energy of the ejected electrons?
a. 4.6 eV
c. 1.4 eV
b. 4.8 eV
d. 2.4 eV

_____ 8. According to the Rutherford model, what makes up most of the volume of an atom?
a. empty space
c. positive charges
b. the nucleus
d. electrons

_____ 9. In Rutherford's experiment, why did the nucleus repel alpha particles?
a. electrostatic repulsion between the negatively charged nucleus and alpha particles
b. electrostatic attraction between the negatively charged nucleus and alpha particles
c. electrostatic repulsion between the positively charged nucleus and alpha particles
d. electrostatic attraction between the positively charged nucleus and alpha particles

_____ 10. Which of the following is *not* a weakness of the Rutherford model of the atom?
a. The atom radiates energy continuously.
b. The atom cannot produce spectral lines.
c. The atom is unstable.
d. The atom is mostly empty space.

_____ 11. What is the concentration of positive charge and mass in Rutherford's atomic model called?
    a. alpha particle   c. proton
    b. neutron   d. nucleus

_____ 12. Which statement about Rutherford's model of the atom is *not* correct?
    a. The model states that positive charge is unevenly distributed.
    b. The model depicts electrons orbiting the nucleus as planets orbit the sun.
    c. The model explains spectral lines.
    d. The model predicts that atoms are unstable.

_____ 13. When a high potential difference is applied to a low-pressure gas, what kind of spectrum will the gas emit?
    a. emission   c. continuous
    b. absorption   d. monochromatic

_____ 14. Which statement about emission spectra is correct?
    a. All of the lines are evenly spaced.
    b. All noble gases have the same spectra.
    c. Each line corresponds to a series of wavelengths.
    d. All of the lines result from discrete energy differences.

_____ 15. What would you observe if light from argon gas were passed through a prism?
    a. a series of discrete bright lines
    b. a continuous spectrum
    c. a series of dark lines imposed on a continuous spectrum
    d. a single bright line

_____ 16. Which of the following statements is true about emission spectra?
    a. Emission spectra form dark lines on a continuous spectrum.
    b. The wavelengths of the spectrum are characteristic of the element emitting the light.
    c. The wavelengths of the spectrum are the same for all atomic gases.
    d. The wavelengths of the spectrum are the same for all elements.

_____ 17. Which of the following is *not* a feature of Bohr's model of the atom?
    a. Electrons move in circular orbits about the nucleus.
    b. Only certain electron orbits are allowed.
    c. Electrons emit radiation continuously while orbiting the nucleus.
    d. Electron jumps between energy levels account for discrete spectral lines.

_____ 18. What is the process in which an electron returns to a lower energy level and emits a photon?
    a. spontaneous emission   c. line absorption
    b. line emission   d. energy transition

_____ 19. What causes the bright lines in the emission spectrum of an element to occur?
    a. Photons are absorbed when electrons jump from a higher-energy to a lower-energy state.
    b. Photons are emitted when electrons jump from a higher-energy to a lower-energy state.
    c. Photons are absorbed when electrons jump from a lower-energy to a higher-energy state.
    d. Photons are emitted when electrons jump from a lower-energy to a higher-energy state.

_____ 20. What causes the dark lines in the absorption spectrum of an element to occur?
    a. Photons are absorbed when electrons jump from a higher-energy to a lower-energy state.
    b. Photons are emitted when electrons jump from a higher-energy to a lower-energy state.
    c. Photons are absorbed when electrons jump from a lower-energy to a higher-energy state.
    d. Photons are emitted when electrons jump from a lower-energy to a higher-energy state.

_____ 21. How will light behave in a single experiment, according to the principle of wave-particle duality?
    a. Light will act both like a wave and like a particle.
    b. Light will act either like a wave or like a particle.
    c. Light will act neither like a wave nor like a particle.
    d. Light always exists as two waves or as two particles.

_____ 22. Which of the following processes is more easily observable for light with a short wavelength?
    a. the photoelectric effect   c. diffraction
    b. radio transmission   d. interference

_____ 23. What happens as the frequency of photons increases?
    a. The diffraction of light becomes easier to observe.
    b. The momentum of light decreases.
    c. The photoelectric effect becomes more difficult to observe.
    d. The wave effects of light become more difficult to observe.

_____ 24. What observation confirmed de Broglie's theory of matter waves?
    a. the photoelectric effect   c. the diffraction of electrons
    b. the scattering of alpha particles   d. the spontaneous emission of photons

_____ 25. According to de Broglie, as the momentum of a moving particle is tripled, the corresponding wavelength changes by what factor?
    a. $\frac{1}{9}$ c. 3
    b. $\frac{1}{3}$ d. 9

_____ 26. What is the speed of a 50 g rock if its de Broglie wavelength is 3.32×10^{-34} m? ($h = 6.63 \times 10^{-34}$ J•s)
    a. 40 m/s   c. 20 m/s
    b. 30 m/s   d. 60 m/s

_____ 27. According to the Heisenberg uncertainty principle, which of the following statements about the simultaneous measurements of position and momentum is true?
    a. Neither quantity can be measured with accuracy.
    b. The more accurately one value is measured, the less accurately the other value is known.
    c. Both quantities can be measured with infinite accuracy.
    d. Accuracy of measurement improves as the object observed becomes less massive.

_____ 28. According to the Heisenberg uncertainty principle, which of the following occurs as soon as the exact location of an electron is known?
    a. The electron's exact energy is known.
    b. The electron's spin becomes uncertain.
    c. The electron's exact momentum becomes uncertain.
    d. The electron's exact momentum is known.

_____ 29. What picture of the electron is suggested by the quantum-mechanical model of the hydrogen atom?
    a. a raisin in pudding   c. a planetary orbiting body
    b. a probability cloud   d. a light quantum

_____ 30. What does the peak of a probability curve for an electron in an atom indicate?
    a. the location where there is zero probability of finding the electron
    b. that the electron's location can be precisely determined
    c. that Heisenberg's uncertainty principle is violated
    d. the distance from the nucleus at which the electron is most likely to be found

____ 31. Why is a probability wave required to describe an electron's location?
    a.   The electron's location can be precisely determined.
    b.   Electrons violate Heisenberg's uncertainty principle.
    c.   The electron may be found at various distances from the nucleus.
    d.   The electron has less probability of being at the first Bohr orbit than at any other distance.

Choose the best answer from the options that follow each question.

____ 32. Which of the following phrases correctly describes a blackbody?
    a.   object from which neither light nor matter escapes
    b.   absorbs all radiation and emits no radiation
    c.   emits all radiation and absorbs no radiation
    d.   perfectly absorbs and emits all radiation

____ 33. Classical electromagnetic theory predicted that the energy radiated by a blackbody would become infinite as the wavelength of the radiation became shorter. What was the contradiction between observation and this result called?
    a.   the Compton shift
    b.   the ultraviolet catastrophe
    c.   the photoelectric effect
    d.   the quantum theory

____ 34. Which of the following statements is true about the energy of a quantum of radiation?
    a.   Energy increases with wavelength.
    b.   Energy increases with frequency.
    c.   Energy increases with intensity.
    d.   Energy increases with speed.

____ 35. What is the energy of a photon with a frequency of 5.45×10^{14} Hz?
($h = 6.63 \times 10^{-34}$ J•s)
    a. 3.61×10^{-19} J
    b. 3.61×10^{-34} J
    c. 3.65×10^{-40} J
    d. 1.22×10^{-48} J

____ 36. What is the frequency of a photon with an energy of 1.3×10^{-19} J?
($h = 6.63 \times 10^{-34}$ J•s)
    a. 8.6×10^{-20} Hz
    b. 1.5×10^{-6} Hz
    c. 2.0×10^{14} Hz
    d. 1.2×10^{52} Hz

____ 37. For a photoelectron to be emitted by a metal that is exposed to photons, the energy of the photons must be greater than what property of the metal?
    a.   its threshold frequency
    b.   its ionization energy
    c.   its electronegativity
    d.   its work function

____ 38. A metal with a work function of 3.5 eV is exposed to photons with an energy of 3.7 eV. What is the maximum kinetic energy of the emitted photoelectrons?
   a. 7.2 eV
   b. 3.7 eV
   c. 3.5 eV
   d. 0.2 eV

____ 39. Which of the following statements correctly describes the Compton shift that occurs when photons scatter from electrons?
   a. Electron momentum decreases as electrons scatter from photons.
   b. Photon wavelengths shorten as they gain energy from electrons.
   c. Photon wavelengths lengthen as they lose energy to electrons.
   d. Scattered photons interfere with each other at different angles.

Choose the best answer from the options that follow each question.

____ 40. What did Rutherford's experiment demonstrate?
   a. The atomic nucleus was a large spherical volume of positive charge.
   b. The atomic nucleus was a small, compact region of positive charge.
   c. The electrons were imbedded in the sphere of positive charge.
   d. The electrons moved around the nucleus like planets orbiting the sun.

____ 41. Which of the following statements is true about an emission spectrum?
   a. The wavelengths of the spectrum are the same for all elements.
   b. The lines of the spectrum are equally separated.
   c. It consists of dark lines in an otherwise continuous spectrum.
   d. It consists of narrow bright lines.

____ 42. What type of spectrum is observed in the light from the sun and other stars?
   a. a continuous spectrum
   b. an emission spectrum
   c. an absorption spectrum
   d. an atomic spectrum

____ 43. By what process does an electron in the Bohr model of the atom drop from a higher-energy level to a lower-energy level and emit a photon?
   a. line emission
   b. line absorption
   c. spontaneous emission
   d. spontaneous absorption

____ 44. Which of the following is a feature of the Bohr model of the atom?
   a. Only specific electron orbits with given energies are stable.
   b. Electrons emit radiation continuously while orbiting the nucleus.
   c. Orbits of all possible energies are allowed for the atom's electrons.
   d. Electrons are located within a spherical region of positive charge.

____ 45. Which of the following statements correctly describes an atom's energy levels as they are depicted in an energy-level diagram?
   a. The energy levels are separated by equal amounts.
   b. The higher energy levels are separated by smaller amounts.
   c. The higher energy levels are separated by greater amounts.
   d. The energy levels are the same for all elements.

_____ 46. A photon with an energy of 2.86 eV is absorbed by a hydrogen atom. Afterwards, three photons are spontaneously emitted. Which statement correctly describes the emitted photons?
   a. The emitted photons each have the same wavelengths.
   b. The photons are produced by a single electron energy-level transition.
   c. The sum of the emitted photon energies equals 2.86 eV.
   d. Three photons are always emitted when a 2.86 eV photon is absorbed.

Choose the best answer from the options that follow each question.

_____ 47. At what point do photons behave less like waves and more like particles?
   a. as the frequency of the photons increases
   b. as the wavelength of the photons increases
   c. as the intensity of the photons increases
   d. as the speed of the photons increases

_____ 48. Which of the following phenomena is the result of light's wave properties?
   a. the Compton shift
   b. two-slit interference
   c. the photoelectric effect
   d. momentum transfer

_____ 49. Which of the following experiments indicated that matter waves exist?
   a. the emission of electrons by a metal exposed to photons
   b. the diffraction of electrons by a single crystal
   c. the change in photon wavelength during scattering by electrons
   d. the spontaneous emission of photons by electron transitions in an atom

_____ 50. What is the momentum of a proton with a de Broglie wavelength of 6.63×10^{-9} m? ($h = 6.63 \times 10^{-34}$ J•s)
   a. 4.40×10^{-44} kg•m/s
   b. 3.33×10^{-34} kg•m/s
   c. 1.00×10^{-25} kg•m/s
   d. 3.00×10^{-17} kg•m/s

_____ 51. According to the matter-wave modification to the Bohr model of the atom, what do the orbits of electrons in an atom resemble?
   a. longitudinal waves
   b. probability waves
   c. traveling waves
   d. standing waves

_____ 52. Which of the following statements correctly describes the results of simultaneous measurement of momentum and location for a particle?
   a. Accuracy of measurement decreases as the particle mass increases.
   b. Neither quantity can be measured with accuracy.
   c. The more accurately one quantity is measured, the less accurately the other quantity is known.
   d. Both quantities can be measured with infinite accuracy.

_____ 53. Which of the following indicates the greatest probability for an electron's position in the ground state of a hydrogen atom?
   a.   the origin of the probability curve
   b.   the middle of the rising part of the probability curve
   c.   the middle of the peak of the probability curve
   d.   the middle of the descending part of the probability curve

_____ 54. Which of the following does *not* describe the electron cloud for an electron in the ground state of a hydrogen atom?
   a.   The electron cloud is spherically symmetrical.
   b.   The electron cloud's density is close to zero near the nucleus.
   c.   The electron cloud's density is greatest at the Bohr radius.
   d.   The electron cloud's density is uniformly constant throughout.

Choose the best answer from the options that follow each question.

_____ 55. What term is used to describe a perfect radiator and absorber of electromagnetic radiation?
   a.   blackbody
   b.   atom
   c.   quantum
   d.   photon

_____ 56. Classical electromagnetic theory predicted that the energy radiated by a blackbody would become infinite as the wavelength became shorter. What was the contradiction between observation and this result called?
   a.   the quantum theory
   b.   the photoelectric effect
   c.   the wave-particle duality
   d.   the ultraviolet catastrophe

_____ 57. What were the units of light energy emitted by blackbody radiation originally called?
   a.   electron volts
   b.   quanta
   c.   joules
   d.   resonators

_____ 58. According to the Rutherford model, what makes up most of the volume of an atom?
   a.   empty space
   b.   the nucleus
   c.   positive charges
   d.   electrons

_____ 59. In Rutherford's experiment, why did the nucleus repel alpha particles?
   a.   electrostatic repulsion between the negatively charged nucleus and alpha particles
   b.   electrostatic attraction between the negatively charged nucleus and alpha particles
   c.   electrostatic repulsion between the positively charged nucleus and alpha particles
   d.   electrostatic attraction between the positively charged nucleus and alpha particles

_____ 60. What is the concentration of positive charge and mass in Rutherford's atomic model called?
   a.   alpha particle
   b.   neutron
   c.   proton
   d.   nucleus

_____ 61. Which statement about Rutherford's model of the atom is not correct?
    a.   The model states that positive charge is unevenly distributed.
    b.   The model depicts electrons orbiting the nucleus as planets orbit the sun.
    c.   The model explains spectral lines.
    d.   The model states that atoms are unstable.

_____ 62. When a high potential difference is applied to a low-pressure gas, what kind of spectrum will the gas emit?
    a.   emission
    b.   absorption
    c.   continuous
    d.   monochromatic

_____ 63. Which statement about emission spectra is correct?
    a.   All of the lines are evenly spaced.
    b.   All noble gases have the same spectra.
    c.   Each line corresponds to a series of wavelengths.
    d.   All of the lines result from discrete energy differences.

_____ 64. What would you observe if light from argon gas were passed through a prism?
    a.   a series of discrete bright lines
    b.   a continuous spectrum
    c.   a series of dark lines imposed on a continuous spectrum
    d.   a single bright line

_____ 65. Which of the following is not a feature of Bohr's model of the atom?
    a.   Electrons move in circular orbits about the nucleus.
    b.   Only certain electron orbits are allowed.
    c.   Electrons emit radiation continuously while orbiting the nucleus.
    d.   Electron jumps between energy levels account for discrete spectral lines.

_____ 66. What is the process in which an electron returns to a lower energy level and emits a photon?
    a.   spontaneous emission
    b.   line emission
    c.   line absorption
    d.   energy transition

_____ 67. How will light behave in a single experiment, according to the principle of wave-particle duality?
    a.   Light will act both like a wave and like a particle.
    b.   Light will act either like a wave or like a particle.
    c.   Light will act neither like a wave nor like a particle.
    d.   Light always exists as two waves or as two particles.

_____ 68. Which of the following processes is more easily observable for light with a short wavelength?
    a.   the photoelectric effect
    b.   radio transmission
    c.   diffraction
    d.   interference

_____ 69. According to the Heisenberg uncertainty principle, which of the following statements about the simultaneous measurements of position and momentum is true?
    a.   Neither quantity can be measured with accuracy.
    b.   The more accurately one value is measured, the less accurately the other value is known.
    c.   Both quantities can be measured with infinite accuracy.
    d.   Accuracy of measurement improves as the object observed becomes less massive.

_____ 70. What happens as the frequency of photons increases?
    a.   The diffraction of light becomes easier to observe.
    b.   The momentum of light decreases.
    c.   The wave effects of light become easier to observe.
    d.   The wave effects of light become more difficult to observe.

_____ 71. What picture of the electron is suggested by the quantum-mechanical model of the hydrogen atom?
    a.   a raisin in pudding
    b.   a probability cloud
    c.   a planetary orbiting body
    d.   a light quantum

_____ 72. What does the peak of a probability curve for an electron in an atom indicate?
    a.   the location where there is zero probability of finding the electron
    b.   that the electron's location can be precisely determined
    c.   that Heisenberg's uncertainty principle is violated
    d.   the distance from the nucleus at which the electron is most likely to be found

Choose the best answer from the options that follow each question.

_____ 73. What is the frequency of a photon with an energy of 1.99×10^{-19} J?
($h = 6.63 \times 10^{-34}$ J•s)
    a. 1.00×10^{14} Hz
    b. 2.00×10^{14} Hz
    c. 3.00×10^{14} Hz
    d. 4.00×10^{14} Hz

_____ 74. Light with an energy equal to three times the work function of a given metal causes the metal to eject photoelectrons. What is the ratio of the maximum photoelectron kinetic energy to the work function?
    a.   1 : 1
    b.   2 : 1
    c.   3 : 1
    d.   4 : 1

_____ 75. A monochromatic light beam with a quantum energy value of 3.0 eV is incident upon a photocell. The work function of the photocell is 1.6 eV. What is the maximum kinetic energy of the ejected electrons?
    a.   4.6 eV
    b.   4.8 eV
    c.   1.4 eV
    d.   2.4 eV

_____ 76. What causes the bright lines in the emission spectrum of an element to occur?
    a.   Photons are absorbed when electrons jump from a higher-energy to a lower-energy state.
    b.   Photons are emitted when electrons jump from a higher-energy to a lower-energy state.
    c.   Photons are absorbed when electrons jump from a lower-energy to a higher-energy state.
    d.   Photons are emitted when electrons jump from a lower-energy to a higher-energy state.

_____ 77. What causes the dark lines in the absorption spectrum of an element to occur?
    a.   Photons are absorbed when electrons jump from a higher-energy to a lower-energy state.
    b.   Photons are emitted when electrons jump from a higher-energy to a lower-energy state.
    c.   Photons are absorbed when electrons jump from a lower-energy to a higher-energy state.
    d.   Photons are emitted when electrons jump from a lower-energy to a higher-energy state.

_____ 78. What observation confirmed de Broglie's theory of matter waves?
    a.   the photoelectric effect
    b.   the scattering of alpha particles
    c.   the diffraction of electrons
    d.   the spontaneous emission of photons

_____ 79. According to de Broglie, as the momentum of a moving particle is tripled, the corresponding wavelength changes by what factor?
    a. $\dfrac{1}{9}$
    b. $\dfrac{1}{3}$
    c.   3
    d.   9

_____ 80. Why is a probability wave required to describe an electron's location?
    a.   The electron's location can be precisely determined.
    b.   Electrons violate Heisenberg's uncertainty principle.
    c.   The electron may be found at various distances from the nucleus.
    d.   The electron has less probability of being at the first Bohr orbit than at any other distance.

Problem

1. What is the energy, in eV, of a photon whose frequency is 5.6×10^{14} Hz? ($h = 6.63 \times 10^{-34}$ J•s; 1 eV = 1.60×10^{-19} J)

2. What is the energy, in eV, of a photon whose frequency is 7.9×10^{14} Hz? ($h = 6.63 \times 10^{-34}$ J•s; 1 eV = 1.60×10^{-19} J)

3. How much energy does a photon of red light that has a wavelength of 645 nm contain? ($h = 6.63 \times 10^{-34}$ J•s; $c = 3.00 \times 10^{8}$ m/s; 1 eV = 1.6×10^{-19} J)

4. Light shining on a selenium surface causes photoelectrons with maximum kinetic energies of 0.23 eV to be emitted. If the work function of selenium is 5.11 eV, what is the frequency of the light? ($h = 6.63 \times 10^{-34}$ J•s; 1 eV = 1.60×10^{-19} J)

5. Light with a wavelength of 269.3 nm is incident on a piece of tin. The work function of tin is 4.42 eV. What is the maximum kinetic energy of the ejected photoelectrons? ($h = 6.63 \times 10^{-34}$ J•s; $c = 3.00 \times 10^{8}$ m/s; 1 eV = 1.60×10^{-19} J)

6. A metal surface is illuminated first with light that has a wavelength of 4.86×10^{-7} m, then with light that has a wavelength of 4.38×10^{-7} m. The photoelectrons emitted by the metal under the 4.25×10^{-7} m light have twice the maximum kinetic energy of the photoelectrons emitted under the 4.50×10^{-7} m light. What is the work function of metal? ($h = 6.63 \times 10^{-34}$ J•s; $c = 3.00 \times 10^{8}$ m/s; 1 eV = 1.60×10^{-19} J)

7. A metal surface is illuminated first with light that has a wavelength of 2.15×10^{-7} m, then with light that has a wavelength of 1.46×10^{-7} m. The photoelectrons emitted by the metal under the 1.46×10^{-7} m light have three times the maximum kinetic energy of the photoelectrons emitted under the 2.15×10^{-7} m light. What is the work function of the metal? ($h = 6.63 \times 10^{-34}$ J•s; $c = 3.00 \times 10^{8}$ m/s; 1 eV $= 1.60 \times 10^{-19}$ J)

E_6 ————————————————————————— $E = -0.378$ eV
E_5 ————————————————————————— $E = -0.544$ eV
E_4 ————————————————————————— $E = -0.850$ eV

E_3 ————————————————————————— $E = -1.51$ eV

E_2 ————————————————————————— $E = -3.40$ eV

8. The figure shown above shows the energy levels for a hydrogen atom. What is the energy of the photon emitted when the electron in a hydrogen atom drops from energy level E_5 to energy level E_2?

9. In the figure above, what is the energy of the photon emitted when the electron in a hydrogen atom drops from energy level E_6 to energy level E_3?

10. Using the figure above, calculate the frequency of the photon emitted when the electron in a hydrogen atom drops from energy level E_6 to energy level E_3. ($h = 6.63 \times 10^{-34}$ J•s; 1 eV $= 1.60 \times 10^{-19}$ J)

11. A hydrogen atom absorbs a photon, which causes the electron to go into a higher energy level. The electron returns to the initial energy level by two separate transitions, each involving the emission of a photon. If the two photons have wavelengths of 7489 nm and 1287 nm, respectively, what were the initial and final energy levels of the original excited electron? ($h = 6.63 \times 10^{-34}$ J•s; $c = 3.00 \times 10^{8}$ m/s; 1 eV $= 1.60 \times 10^{-19}$ J)

12. A hydrogen atom absorbs a photon, which causes the electron to go into a higher energy level. The electron returns to the initial energy level by two separate transitions, each involving the emission of a photon. If the two photons have wavelengths of 4062.5 nm and 487.5 nm, respectively, what were the initial and final energy levels of the original excited electron? ($h = 6.63 \times 10^{-34}$ J•s; $c = 3.00 \times 10^{8}$ m/s; 1 eV $= 1.60 \times 10^{-19}$ J)

13. What is the de Broglie wavelength of a proton that has a mass of 1.67×10^{-27} kg and is moving at a speed of 2.9×10^{5} m/s? ($h = 6.63 \times 10^{-34}$ J•s)

14. What is the de Broglie wavelength of an electron that has a mass of 9.11×10^{-31} kg and travels a distance of 16 km in 0.029 s? ($h = 6.63 \times 10^{-34}$ J•s)

15. What is the de Broglie wavelength of a 45.9 g golf ball that has a kinetic energy of 26.3 J? ($h = 6.63 \times 10^{-34}$ J•s)

16. What is the energy, in eV, of a photon whose frequency is 3.0×10^{14} Hz?
    ($h = 6.63 \times 10^{-34}$ J•s; 1 eV $= 1.60 \times 10^{-19}$ J)

17.
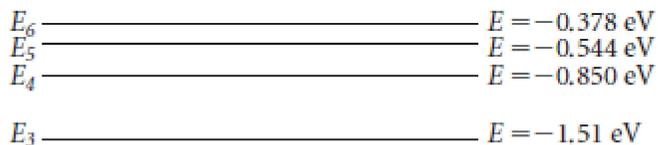
E_6 ————————————	$E = -0.378$ eV
E_5 ————————————	$E = -0.544$ eV
E_4 ————————————	$E = -0.850$ eV
E_3 ————————————	$E = -1.51$ eV
E_2 ————————————	$E = -3.40$ eV

What is the energy of the photon emitted when the electron in a hydrogen atom drops from energy level E_6 to energy level E_3 in the figure above?

18. What is the de Broglie wavelength for a proton that has a mass of 1.67×10^{-27} kg and is moving at a speed of 1.3×10^{-3} m/s? ($h = 6.63 \times 10^{-34}$ J•s)

19. What is the energy of a photon whose frequency is 312nm?
    ($h = 6.63 \times 10^{-34}$ J•s; $c = 3.00 \times 10^{8}$ m/s;1 eV $= 1.60 \times 10^{-19}$ J)

20. What is the de Broglie wavelength of a proton that has a mass of 1.67×10^{-27} kg and is moving at a speed of 2.7×10^{5} m/s? ($h = 6.63 \times 10^{-34}$ J•s)

Phys.G12-Atomic physics-Qs.Bank
Answer Section

MULTIPLE CHOICE

1. ANS: A   PTS: 1   DIF: I   OBJ: 21-1.1
2. ANS: D   PTS: 1   DIF: I   OBJ: 21-1.1
3. ANS: B   PTS: 1   DIF: I   OBJ: 21-1.1
4. ANS: C
   Given

   $E = 1.99 \times 10^{-19}$ J

   $h = 6.63 \times 10^{-34}$ J•s

   Solution
   $E = hf$

   $f = \dfrac{E}{h} = \dfrac{1.99 \times 10^{-19} \text{ J}}{6.63 \times 10^{-34} \text{ Js}}$

   $f = 3.00 \times 10^{14}$ Hz

   PTS: 1   DIF: IIIA   OBJ: 21-1.2
5. ANS: B
   Given

   $f = 6.0 \times 10^{20}$ Hz

   $h = 6.63 \times 10^{-34}$ J•s

   Solution
   $E = hf$

   $E = (6.63 \times 10^{-34} \text{ Js})(6.0 \times 10^{20} \text{ Hz}) \times \left(\dfrac{1 \text{ eV}}{1.60 \times 10^{-19} \text{ J}} \right)$

   $E = 2.5 \times 10^{6}$ eV $= 2.5$ MeV

   PTS: 1   DIF: IIIA   OBJ: 21-1.2
6. ANS: B   PTS: 1   DIF: II   OBJ: 21-1.3

7. ANS: C
Given
$hf = 3.0$ eV
$hf_t = 1.6$ eV

Solution
$KE_{max} = hf - hf_t$
$KE_{max} = 3.0\,\text{eV} - 1.6\,\text{eV} = 1.4\,\text{eV}$

	PTS: 1		DIF: IIIA		OBJ: 21-1.3
8. ANS: A	PTS: 1	DIF: I		OBJ: 21-2.1	
9. ANS: C	PTS: 1	DIF: I		OBJ: 21-2.1	
10. ANS: D	PTS: 1	DIF: I		OBJ: 21-2.1	
11. ANS: D	PTS: 1	DIF: I		OBJ: 21-2.1	
12. ANS: C	PTS: 1	DIF: I		OBJ: 21-2.1	
13. ANS: A	PTS: 1	DIF: I		OBJ: 21-2.2	
14. ANS: D	PTS: 1	DIF: I		OBJ: 21-2.2	
15. ANS: A	PTS: 1	DIF: I		OBJ: 21-2.2	
16. ANS: B	PTS: 1	DIF: I		OBJ: 21-2.2	
17. ANS: C	PTS: 1	DIF: I		OBJ: 21-2.3	
18. ANS: A	PTS: 1	DIF: I		OBJ: 21-2.3	
19. ANS: B	PTS: 1	DIF: II		OBJ: 21-2.3	
20. ANS: C	PTS: 1	DIF: II		OBJ: 21-2.3	
21. ANS: B	PTS: 1	DIF: I		OBJ: 21-3.1	
22. ANS: A	PTS: 1	DIF: I		OBJ: 21-3.1	
23. ANS: D	PTS: 1	DIF: I		OBJ: 21-3.1	
24. ANS: C	PTS: 1	DIF: II		OBJ: 21-3.2	
25. ANS: B	PTS: 1	DIF: II		OBJ: 21-3.2	

26. ANS: A
Given
$m = 50$ g

$\lambda = 3.32 \times 10^{-34}$ m

$h = 6.63 \times 10^{-34}$ J•s

Solution

$\lambda = \dfrac{h}{mv}$

$v = \dfrac{h}{m\lambda} = \dfrac{6.63 \times 10^{-34}\,\text{Js}}{(50\,\text{g})(3.32 \times 10^{-34}\,\text{m})} \times \left(\dfrac{1000\,\text{g}}{1\,\text{kg}} \right)$

$v = 40$ m/s

	PTS: 1		DIF: IIIA		OBJ: 21-3.2
27. ANS: B	PTS: 1	DIF: I		OBJ: 21-3.3	

28. ANS: C   PTS: 1   DIF: I   OBJ: 21-3.3
29. ANS: B   PTS: 1   DIF: I   OBJ: 21-3.4
30. ANS: D   PTS: 1   DIF: I   OBJ: 21-3.4
31. ANS: C   PTS: 1   DIF: II   OBJ: 21-3.4
32. ANS: D   PTS: 1   TOP: Chapter 21 Section Quiz 1
33. ANS: B   PTS: 1   TOP: Chapter 21 Section Quiz 1
34. ANS: B   PTS: 1   TOP: Chapter 21 Section Quiz 1
35. ANS: A

Given
$f = 5.45 \times 10^{14}$ Hz
$h = 6.63 \times 10^{-34}$ J•s
Solution
$E = hf = (6.63 \times 10^{-34}$ J•s$)(5.45 \times 10^{14}$ Hz$) = 3.61 \times 10^{-19}$ J

PTS: 1   TOP: Chapter 21 Section Quiz 1
36. ANS: C

Given
$E = 1.3 \times 10^{-19}$ J
$h = 6.63 \times 10^{-34}$ J? •s
Solution
$$f = \frac{E}{h} = \frac{1.3 \times 10^{-19} \text{ J}}{6.63 \times 10^{-34} \text{ J} \bullet \text{s}} = 2.0 \times 10^{14} \text{ Hz}$$

PTS: 1   TOP: Chapter 21 Section Quiz 1
37. ANS: D   PTS: 1   TOP: Chapter 21 Section Quiz 1
38. ANS: D

Given
$hf = 3.7$ eV
$hf_t = 3.5$ eV
Solution
$KE_{max} = hf - hf_t = 3.7$ eV - 3.5 eV = 0.2 eV

PTS: 1   TOP: Chapter 21 Section Quiz 1
39. ANS: C   PTS: 1   TOP: Chapter 21 Section Quiz 1
40. ANS: B   PTS: 1   TOP: Chapter 21 Section Quiz 2
41. ANS: D   PTS: 1   TOP: Chapter 21 Section Quiz 2
42. ANS: C   PTS: 1   TOP: Chapter 21 Section Quiz 2
43. ANS: C   PTS: 1   TOP: Chapter 21 Section Quiz 2
44. ANS: A   PTS: 1   TOP: Chapter 21 Section Quiz 2
45. ANS: B   PTS: 1   TOP: Chapter 21 Section Quiz 2
46. ANS: C   PTS: 1   TOP: Chapter 21 Section Quiz 2
47. ANS: A   PTS: 1   TOP: Chapter 21 Section Quiz 3
48. ANS: B   PTS: 1   TOP: Chapter 21 Section Quiz 3
49. ANS: B   PTS: 1   TOP: Chapter 21 Section Quiz 3

50. ANS: C
Given
$\lambda = 6.63 \times 10^{-9}$ m
h = 6.63×10^{-34} J•s
Solution

$$p = \frac{h}{\lambda} = \frac{6.63 \times 10^{-34} \text{J} \bullet \text{s}}{6.63 \times 10^{-9} \text{m}} = 1.00 \times 10^{-25} \text{ kg•m/s}$$

     PTS: 1   TOP: Chapter 21 Section Quiz 3

51. ANS: D   PTS: 1   TOP: Chapter 21 Section Quiz 3
52. ANS: C   PTS: 1   TOP: Chapter 21 Section Quiz 3
53. ANS: C   PTS: 1   TOP: Chapter 21 Section Quiz 3
54. ANS: D   PTS: 1   TOP: Chapter 21 Section Quiz 3
55. ANS: A   PTS: 1   TOP: Chapter 21 Test A
56. ANS: D   PTS: 1   TOP: Chapter 21 Test A
57. ANS: B   PTS: 1   TOP: Chapter 21 Test A
58. ANS: A   PTS: 1   TOP: Chapter 21 Test A
59. ANS: C   PTS: 1   TOP: Chapter 21 Test A
60. ANS: D   PTS: 1   TOP: Chapter 21 Test A
61. ANS: C   PTS: 1   TOP: Chapter 21 Test A
62. ANS: A   PTS: 1   TOP: Chapter 21 Test A
63. ANS: D   PTS: 1   TOP: Chapter 21 Test A
64. ANS: A   PTS: 1   TOP: Chapter 21 Test A
65. ANS: C   PTS: 1   TOP: Chapter 21 Test A
66. ANS: A   PTS: 1   TOP: Chapter 21 Test A
67. ANS: B   PTS: 1   TOP: Chapter 21 Test A
68. ANS: A   PTS: 1   TOP: Chapter 21 Test A
69. ANS: B   PTS: 1   TOP: Chapter 21 Test A
70. ANS: D   PTS: 1   TOP: Chapter 21 Test A
71. ANS: B   PTS: 1   TOP: Chapter 21 Test A
72. ANS: D   PTS: 1   TOP: Chapter 21 Test A
73. ANS: C
Solution
E = hf

$$f = \frac{E}{h} = \frac{1.99 \times 10^{-19} J}{6.63 \times 10^{-34} J \bullet s}$$

E = 3.00×10^{14} Hz

     PTS: 1   TOP: Chapter 21 Test B

74. ANS: B   PTS: 1   TOP: Chapter 21 Test B

75. ANS: C
    Solution
    $KE_{max} = hf - hf_t$
    $KE_{max} = 3.0 \text{ eV} - 1.6 \text{ eV} = 1.4 \text{ eV}$

      PTS: 1   TOP: Chapter 21 Test B
76. ANS: B   PTS: 1   TOP: Chapter 21 Test B
77. ANS: C   PTS: 1   TOP: Chapter 21 Test B
78. ANS: C   PTS: 1   TOP: Chapter 21 Test B
79. ANS: B   PTS: 1   TOP: Chapter 21 Test B
80. ANS: C   PTS: 1   TOP: Chapter 21 Test B

PROBLEM

1. ANS:
   2.3 eV

   Given

   $f = 5.6 \times 10^{14}$ Hz

   $h = 6.63 \times 10^{-34}$ J•s

   Solution
   $E = hf$

   $E = (6.63 \times 10^{-34} \text{ J} \bullet \text{s})(5.6 \times 10^{14} \text{ Hz})\left(\dfrac{1 \text{ eV}}{1.60 \times 10^{-19} \text{ J}}\right)$

   $E = 2.3 \text{ eV}$

   PTS: 1   DIF: IIIA   OBJ: 21-1.2
2. ANS:
   3.3 eV

   Given

   $f = 7.9 \times 10^{14}$ Hz

   $h = 6.63 \times 10^{-34}$ J•s

   Solution
   $E = hf$

   $E = (6.63 \times 10^{-34} \text{ J} \bullet \text{s})(7.9 \times 10^{14} \text{ Hz})\left(\dfrac{1 \text{ eV}}{1.60 \times 10^{-19} \text{ J}}\right)$

   $E = 3.3 \text{ eV}$

   PTS: 1   DIF: IIIA   OBJ: 21-1.2

3. ANS:
   1.93 eV

   Given
   $\lambda = 645$ nm

   $h = 6.63 \times 10^{-34}$ J•s

   $c = 3.00 \times 10^8$ m/s

   Solution
   $E = hf$

   $c = f\lambda$

   $$E = \frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34}\text{ J}\bullet\text{s})(3.00 \times 10^8\text{ m/s})}{645\text{ nm}} \left(\frac{10^9\text{ nm}}{1\text{ m}} \right) \left(\frac{1\text{ eV}}{1.60 \times 10^{-19}\text{ J}} \right)$$

   $E = 1.93$ eV

   PTS: 1   DIF: IIIB   OBJ: 21-1.2
4. ANS:

   1.29×10^{15} Hz

   Given
   $KE_{max} = 0.23$ eV

   $hf_t = 5.11$ eV

   $h = 6.63 \times 10^{-34}$ J•s

   Solution
   $KE_{max} = hf - hf_t$

   $$f = \frac{KE_{max} + hf_t}{h} = \left(\frac{0.23\text{ eV} + 5.11\text{ eV}}{6.63 \times 10^{-34}\text{ J}\bullet\text{s}} \right) \left(\frac{1.60 \times 10^{-19}\text{ J}}{1\text{ eV}} \right) = \left(\frac{5.34\text{ eV}}{6.63 \times 10^{-34}\text{ J}\bullet\text{s}} \right) \left(\frac{1.60 \times 10^{-19}\text{ J}}{1\text{ eV}} \right)$$

   $f = 1.29 \times 10^{15}$ Hz

   PTS: 1   DIF: IIIA   OBJ: 21-1.3

5. ANS:
    0.20 eV

    Given
    $\lambda = 269.3$ nm
    $hf_t = 4.42$ eV

    $h = 6.63 \times 10^{-34}$ J•s
    $c = 3.00 \times 10^{8}$ m/s

    Solution
    $KE_{max} = hf - hf_t$

    $c = f\lambda$

    $KE_{max} = \dfrac{hc}{\lambda} - hf_t$

    $KE_{max} = \left(\dfrac{(6.63 \times 10^{-34} \text{ J} \bullet \text{s})(3.00 \times 10^{8} \text{ m/s})}{269.3 \text{ nm}} \right)\left(\dfrac{10^{9} \text{ nm}}{1 \text{ m}} \right)\left(\dfrac{1 \text{ eV}}{1.60 \times 10^{-19} \text{ J}} \right) - 4.42 \text{ eV}$

    $KE_{max} = 4.62 \text{ eV} - 4.42 \text{ eV} = 0.20 \text{ eV}$

    PTS: 1   DIF: IIIB   OBJ: 21-1.3

6. ANS:
    2.29 eV

    Given

    $\lambda_1 = 4.86 \times 10^{-7}$ m

    $\lambda_2 = 4.38 \times 10^{-7}$ m

    $KE_{max,2} = 2KE_{max,1}$

    $h = 6.63 \times 10^{-34}$ J•s

    $c = 3.00 \times 10^8$ m/s

    Solution
    $KE_{max} = hf - hf_t$

    $c = f\lambda$

    $KE_{max,1} = hf_1 - hf_t = \dfrac{hc}{\lambda_1} - hf_t$

    $KE_{max,2} = 2KE_{max,1} = hf_2 - hf_t = \dfrac{hc}{\lambda_2} - hf_t$

    $KE_{max,2} - KE_{max,1} = 2KE_{max,1} - KE_{max,1} = KE_{max,1}$

    $KE_{max,2} - KE_{max,1} = \dfrac{hc}{\lambda_2} - hf_t - \dfrac{hc}{\lambda_1} + hf_t = hc\left(\dfrac{1}{\lambda_2} - \dfrac{1}{\lambda_1}\right)$

    $KE_{max,1} = hc\left(\dfrac{1}{\lambda_2} - \dfrac{1}{\lambda_1}\right)$

    $KE_{max,1} = (6.63 \times 10^{-34}\ \text{J}\bullet\text{s})(3.00 \times 10^8\ \text{m/s})\left(\dfrac{1}{4.38 \times 10^{-7}\ \text{m}} - \dfrac{1}{4.86 \times 10^{-7}\ \text{m}}\right)\left(\dfrac{1\ \text{eV}}{1.60 \times 10^{-19}\ \text{J}}\right)$

    $KE_{max,1} = (6.63 \times 10^{-34}\ \text{J}\bullet\text{s})(3.00 \times 10^8\ \text{m/s})\left(2.28 \times 10^6\ \text{m}^{-1} - 2.06 \times 10^6\ \text{m}^{-1}\right)\left(\dfrac{1\ \text{eV}}{1.60 \times 10^{-19}\ \text{J}}\right)$

    $KE_{max,1} = (6.63 \times 10^{-34}\ \text{J}\bullet\text{s})(3.00 \times 10^8\ \text{m/s})\left(2.2 \times 10^5\ \text{m}^{-1}\right)\left(\dfrac{1\ \text{eV}}{1.60 \times 10^{-19}\ \text{J}}\right)$

    $KE_{max,1} = 0.27$ eV

    $hf_t = \dfrac{hc}{\lambda_1} - KE_{max,1} = \left(\dfrac{(6.63 \times 10^{-34}\ \text{J}\bullet\text{s})(3.00 \times 10^8\ \text{m/s})}{4.86 \times 10^{-7}\ \text{m}}\right)\left(\dfrac{1\ \text{eV}}{1.60 \times 10^{-19}\ \text{J}}\right) - 0.27$ eV

    $hf_t = 2.56\ \text{eV} - 0.27\ \text{eV} = 2.29$ eV

    PTS: 1   DIF: IIIC   OBJ: 21-1.3

7. ANS:
   4.41 eV

   Given

   $\lambda_1 = 2.15 \times 10^{-7}$ m

   $\lambda_2 = 1.46 \times 10^{-7}$ m

   $KE_{max,2} = 3KE_{max,1}$

   $h = 6.63 \times 10^{-34}$ J•s

   $c = 3.00 \times 10^8$ m/s

   Solution
   $KE_{max} = hf - hf_t$

   $c = f\lambda$

   $KE_{max,1} = hf_1 - hf_t = \dfrac{hc}{\lambda_1} - hf_t$

   $KE_{max,2} = 3KE_{max,1} = hf_2 - hf_t = \dfrac{hc}{\lambda_2} - hf_t$

   $KE_{max,2} - KE_{max,1} = 3KE_{max,1} - KE_{max,1} = 2KE_{max,1}$

   $KE_{max,2} - KE_{max,1} = \dfrac{hc}{\lambda_2} - hf_t - \dfrac{hc}{\lambda_1} + hf_t = hc\left(\dfrac{1}{\lambda_2} - \dfrac{1}{\lambda_1}\right)$

   $2KE_{max,1} = hc\left(\dfrac{1}{\lambda_2} - \dfrac{1}{\lambda_1}\right)$

   $KE_{max,1} = \dfrac{hc}{2}\left(\dfrac{1}{\lambda_2} - \dfrac{1}{\lambda_1}\right)$

$$KE_{max,1} = \frac{(6.63 \times 10^{-34} \text{ J} \bullet \text{s})(3.00 \times 10^{8} \text{ m/s})}{2} \left(\frac{1}{1.46 \times 10^{-7} \text{ m}} - \frac{1}{2.15 \times 10^{-7} \text{ m}} \right) \left(\frac{1 \text{ eV}}{1.60 \times 10^{-19} \text{ J}} \right)$$

$$KE_{max,1} = \frac{(6.63 \times 10^{-34} \text{ J} \bullet \text{s})(3.00 \times 10^{8} \text{ m/s})}{2} \left(6.85 \times 10^{6} \text{m}^{-1} - 4.65 \times 10^{6} \text{m}^{-1} \right) \left(\frac{1 \text{ eV}}{1.60 \times 10^{-19} \text{ J}} \right)$$

$$KE_{max,1} = \frac{(6.63 \times 10^{-34} \text{ J} \bullet \text{s})(3.00 \times 10^{8} \text{ m/s})}{2} \left(2.20 \times 10^{6} \text{m}^{-1} \right) \left(\frac{1 \text{ eV}}{1.60 \times 10^{-19} \text{ J}} \right)$$

$$KE_{max,1} = 1.37 \text{ eV}$$

$$hf_t = \frac{hc}{\lambda_1} - KE_{max,1} = \left(\frac{(6.63 \times 10^{-34} \text{ J} \bullet \text{s})(3.00 \times 10^{8} \text{ m/s})}{2.15 \times 10^{-7} \text{ m}} \right) \left(\frac{1 \text{ eV}}{1.60 \times 10^{-19} \text{ J}} \right) - 1.37 \text{ eV}$$

$$hf_t = 5.78 \text{ eV} - 1.37 \text{ eV} = 4.41 \text{ eV}$$

PTS: 1   DIF: IIIC   OBJ: 21-1.3

8. ANS:
2.86 eV

Given
$E_{initial} = E_5 = -0.544$ eV

$E_{final} = E_2 = -3.40$ eV

Solution
$E = E_{initial} - E_{final} = E_5 - E_2$

$E = -0.544 \text{ eV} - (-3.40 \text{ eV}) = 2.86 \text{ eV}$

PTS: 1   DIF: IIIA   OBJ: 21-2.4

9. ANS:
1.13 eV

Given
$E_{initial} = E_6 = -0.378$ eV

$E_{final} = E_3 = -1.51$ eV

Solution
$E = E_{initial} - E_{final} = E_6 - E_3$

$E = -0.378 \text{ eV} - (-1.51 \text{ eV}) = 1.13 \text{ eV}$

PTS: 1   DIF: IIIA   OBJ: 21-2.4

10. ANS:

2.73×10^{14} Hz

Given
$E_{initial} = E_6 = -0.378$ eV
$E_{final} = E_3 = -1.51$ eV
$h = 6.63 \times 10^{-34}$ J•s

Solution
$E = hf$
$E = E_{initial} - E_{final} = E_6 - E_3$

$$f = \frac{E_6 - E_3}{h} = \frac{(-0.378 \text{ eV} - (-1.51 \text{ eV}))}{6.63 \times 10^{-34} \text{ Js}} \left(\frac{1.60 \times 10^{-19} \text{ J}}{1 \text{ eV}} \right) = \left(\frac{1.13 \text{ eV}}{6.63 \times 10^{-34} \text{ Js}} \right) \left(\frac{1.60 \times 10^{-19} \text{ J}}{1 \text{ eV}} \right)$$

$f = 2.73 \times 10^{14}$ Hz

PTS: 1   DIF: IIIB   OBJ: 21-2.4

11. ANS:
The initial energy level for the excited electron was E_3 ($E = -1.51$ eV), and the final energy level was E_6 ($E = -0.378$ eV).

Given
$\lambda_1 = 7489$ nm

$\lambda_2 = 1287$ nm

$h = 6.63 \times 10^{-34}$ J•s

$c = 3.00 \times 10^8$ m/s

Solution
$E = hf$

$c = f\lambda$

$E_{photon,1} = \dfrac{hc}{\lambda_1}$

$E_{photon,1} = \dfrac{(6.63 \times 10^{-34} \text{ Js})(3.00 \times 10^8 \text{ m/s})}{7489 \text{ nm}} \left(\dfrac{10^9 \text{ nm}}{1 \text{ m}} \right) \left(\dfrac{1 \text{ eV}}{1.60 \times 10^{-19} \text{ J}} \right) = 0.166 \text{ eV}$

$E_{photon,2} = \dfrac{hc}{\lambda_2}$

$E_{photon,2} = \dfrac{(6.63 \times 10^{-34} \text{ Js})(3.00 \times 10^8 \text{ m/s})}{1287 \text{ nm}} \left(\dfrac{10^9 \text{ nm}}{1 \text{ m}} \right) \left(\dfrac{1 \text{ eV}}{1.60 \times 10^{-19} \text{ J}} \right) = 0.966 \text{ eV}$

$E_{tot} = E_{photon,1} + E_{photon,2} = 0.166 \text{ eV} + 0.966 \text{ eV} = 1.132 \text{ eV}$

Using the energy level diagram, the energy transition between levels E_6 and E_3 is

$E_{tot} = E_6 - E_3 = -0.378 \text{ eV} - (-1.51 \text{ eV}) = 1.13 \text{ eV}$.

The initial energy level for the excited electron was E_3 ($E = -1.51$ eV).

The final energy level for the excited electron was E_6 ($E = -0.378$ eV).

PTS: 1   DIF: IIIC   OBJ: 21-2.4

12. ANS:
The initial energy level for the excited electron was E_2 ($E = -3.40$ eV), and the final energy level was E_5 ($E = -0.544$ eV).

Given
$\lambda_1 = 4062.5$ nm

$\lambda_2 = 487.5$ nm

$h = 6.63 \times 10^{-34}$ J•s

$c = 3.00 \times 10^8$ m/s

Solution
$E = hf$

$c = f\lambda$

$E_{photon,1} = \dfrac{hc}{\lambda_1}$

$E_{photon,1} = \dfrac{(6.63 \times 10^{-34} \text{ Js})(3.00 \times 10^8 \text{ m/s})}{4062.5 \text{ nm}} \left(\dfrac{10^9 \text{ nm}}{1 \text{ m}} \right) \left(\dfrac{1 \text{ eV}}{1.60 \times 10^{-19} \text{ J}} \right) = 0.306 \text{ eV}$

$E_{photon,2} = \dfrac{hc}{\lambda_2}$

$E_{photon,2} = \dfrac{(6.63 \times 10^{-34} \text{ Js})(3.00 \times 10^8 \text{ m/s})}{487.5 \text{ nm}} \left(\dfrac{10^9 \text{ nm}}{1 \text{ m}} \right) \left(\dfrac{1 \text{ eV}}{1.60 \times 10^{-19} \text{ J}} \right) = 2.55 \text{ eV}$

$E_{tot} = E_{photon,1} + E_{photon,2} = 0.306 \text{ eV} + 2.55 \text{ eV} = 2.86 \text{ eV}$

Using the energy level diagram, the energy transition between levels E_5 and E_2 is

$E_{tot} = E_5 - E_2 = -0.544 \text{ eV} - (-3.40 \text{ eV}) = 2.86 \text{ eV}.$

The initial energy level for the excited electron was E_2 ($E = -3.40$ eV).

The final energy level for the excited electron was E_5 ($E = -0.544$ eV).

PTS: 1   DIF: IIIC   OBJ: 21-2.4

13. ANS:

    1.4×10^{-12} m, or 1.4 pm

    Given

    $m = 1.67 \times 10^{-27}$ kg

    $v = 2.9 \times 10^{5}$ m/s

    $h = 6.63 \times 10^{-34}$ J•s

    Solution

    $$\lambda = \frac{h}{p} = \frac{h}{mv}$$

    $$\lambda = \frac{(6.63 \times 10^{-34} \text{ J} \bullet \text{s})}{(1.67 \times 10^{-27} \text{ kg})(2.9 \times 10^{5} \text{ m/s})} = 1.4 \times 10^{-12} \text{ m} = 1.4 \text{ pm}$$

    PTS: 1   DIF: IIIA   OBJ: 21-3.2

14. ANS:

    1.3×10^{-9} m, or 1.3 nm

    Given

    $m = 9.11 \times 10^{-31}$ kg

    $\Delta x = 16$ km $= 1.6 \times 10^{4}$ m
    $\Delta t = 0.029$ s

    $h = 6.63 \times 10^{-34}$ J•s

    Solution

    $$\lambda = \frac{h}{p} = \frac{h}{mv}$$

    $$v = \frac{\Delta x}{\Delta t}$$

    $$\lambda = \frac{h\Delta t}{m\Delta x} = \frac{(6.63 \times 10^{-34} \text{ J} \bullet \text{s})(0.029 \text{ s})}{(9.11 \times 10^{-31} \text{ kg})(1.6 \times 10^{4} \text{ m})}$$

    $$\lambda = 1.3 \times 10^{-9} \text{ m} = 1.3 \text{ nm}$$

    PTS: 1   DIF: IIIB   OBJ: 21-3.2

15. ANS:

    4.27×10^{-34} m

    Given

    $m = 45.9$ g $= 4.59 \times 10^{-2}$ kg
    $KE = 26.3$ J
    $h = 6.63 \times 10^{-34}$ J•s

    Solution

    $KE = \frac{1}{2}mv^2$

    $v = \sqrt{\dfrac{2KE}{m}}$

    $p = mv = m\sqrt{\dfrac{2KE}{m}} = \sqrt{\dfrac{2KEm^2}{m}} = \sqrt{2KEm}$

    $\lambda = \dfrac{h}{p} = \dfrac{h}{\sqrt{2KEm}} = \dfrac{6.63 \times 10^{-34} \text{ J} \bullet \text{s}}{\sqrt{(2)(26.3 \text{ J})(4.59 \times 10^{-2} \text{ kg})}} = 4.27 \times 10^{-34}$ m

    PTS: 1   DIF: IIIC   OBJ: 21-3.2

16. ANS:
    1.2 eV
    Given
    $f = 3.0 \times 10^{14}$ Hz
    $h = 6.63 \times 10^{-34}$ J•s
    Solution
    $E = hf$
    $E = (6.63 \times 10^{-34}$ J•s$)(3.0 \times 10^{14}$ Hz$)$
    $\left(\dfrac{1eV}{1.60 \times 10^{-19} J}\right)$
    $E = 1.2eV$

    PTS: 1   TOP: Chapter 21 Test A

17. ANS:
    1.13 eV
    Given
    $E_6 = -0.378$ eV
    $E_3 = -1.51$ eV
    Solution
    $E = E_{initial} - E_{final} = E_6 - E_3$
    $E = -0.378$ eV $- (-1.51$ eV$) = 1.13$ eV

    PTS: 1   TOP: Chapter 21 Test A

18. ANS:
    3.1×10^{-10} m, or 0.31 nm
    Given
    $m = 1.67 \times 10^{-27}$ kg
    $v = 1.3 \times 10^3$ m/s
    $h = 6.63 \times 10^{-34}$ J•s
    Solution

    $$\lambda = \frac{h}{p} = \frac{h}{mv}$$

    $$\lambda = \frac{(6.63 \times 10^{-34} \text{J} \bullet s)}{(1.67 \times 10^{-27} kg)(1.3 \times 10^3 m/s)} = 3.1 \times 10^{-10} \text{ m} = 0.31 \text{ nm}$$

    PTS: 1   TOP: Chapter 21 Test A

19. ANS:
    3.98 eV
    Given
    $\lambda = 312$nm
    $h = 6.63 \times 10^{-34}$ J•s
    $c = 3.00 \times 10^8$ m/s
    Solution
    $E = hf$
    $c = f\lambda$

    $$E = \frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34} J \bullet s)(3.00 \times 10^8 m/s)}{312nm}$$

    $$\left(\frac{10^9 nm}{1m} \right) \left(\frac{1eV}{1.60 \times 10^{-19} J} \right)$$

    $E = $ 3.98 eV

    PTS: 1   TOP: Chapter 21 Test B

20. ANS:
    1.5×10^{-12} m, or 1.5 pm
    Given
    $m - 1.67 \times 10^{-27}$ kg
    $v = 2.7 \times 10^5$ m/s
    $h = 6.63 \times 10^{-34}$ J•s
    Solution

    $$\lambda = \frac{h}{p} = \frac{h}{mw}$$

    $$\lambda = \frac{(6.63 \times 10^{-34} J \bullet s)}{(1.67 \times 10^{-27} kg)(2.7 \times 10^5 m/s)} = 1.5 \times 10^{-12} \text{ m} = 1.5 \text{ pm}$$

    PTS: 1   TOP: Chapter 21 Test B