Chapter 8 The Quantum Mechanical Atom

Multiple Choice

Section 8.1

3. What is the wavelength of electromagnetic radiation which has a frequency of $4.464 \times 10^{14}\ s^{-1}$?

   a. 1.338×10^{23} m
   b. 1.489×10^{-6} m
   c. 6.716×10^{-7} nm
   ! d. 671.6 nm
   e. 7.472×10^{-15} nm

Section 8.1

4. What is the wavelength of electromagnetic radiation which has a frequency of $5.732 \times 10^{14}\ s^{-1}$?

   a. 1.718×10^{23} m
   b. 1.912×10^{6} m
   ! c. 5.230×10^{-7} m
   d. 523.0 m
   e. 5.819×10^{-15} nm

Section 8.1

6. What is the wavelength of electromagnetic radiation which has a frequency of 6.282×10^{14} s^{-1}?

   a. 1.883×10^{23} m
   b. 2.095×10^{6} m
   ! c. 4.772×10^{-7} m
   d. 4.772×10^{-7} nm
   e. 530.9 nm

Section 8.1

7. Calculate the frequency of visible light having a wavelength of 464.1 nm

   a. 139.1 s^{-1}
   b. 1.548×10^{-6} s^{-1}
   c. 1.548×10^{-15} s^{-1}
   ! d. 6.460×10^{14} s^{-1}
   e. 6.460×10^{5} s^{-1}

Section 8.1

9. A police radar unit is operating on a frequency of 9.527 Gigahertz. What is the wavelength of the radiation being employed?

   a. 314.7 nm
   b. 314.7 m
   ! c. 3.147 cm
   d. 314.7 cm
   e. 31.78 m

Section 8.1
11. Which one of the following types of radiation has the lowest frequency?

! a. FM radio waves
b. infrared radiation
c. microwave radiation
d. x-rays
e. ultraviolet rays

Section 8.1
12. Which one of the following types of radiation has the lowest frequency?

a. gamma rays
b. infrared radiation
! c. microwave radiation
d. visible light rays
e. ultraviolet rays

Section 8.1
13. Which one of the following types of radiation has the highest frequency?

! a. blue visible light
b. FM radio
c. infrared radiation
d. microwave radiation
e. short wave radio waves

Section 8.1
14. Which one of the following types of radiation has the highest frequency?

! a. x-rays
b. ultraviolet rays
c. FM radio waves
d. microwave radiation
e. infrared radiation

Section 8.1
15. Which one of the following types of radiation has the shortest wavelength?

a. FM radio waves
b. infrared radiation
c. microwave radiation
d. ultraviolet rays
! e. x-rays

Section 8.1
17. Which one of the following types of radiation has the shortest wavelength?

a. FM radio waves
b. infrared radiation
c. microwave radiation
! d. ultraviolet rays
e. visible light rays

Section 8.1
18. Which one of the following types of radiation has the longest wavelength?

a. gamma rays
b. green colored visible light rays
! c. red colored visible light rays
d. ultraviolet rays
e. x-rays

Section 8.1
19. Which one of the following types of radiation has the longest wavelength?

a. gamma rays
b. infrared radiation
! c. microwave radiation
d. ultraviolet rays
e. red colored visible light rays

Section 8.1

21. What is the energy, in joules, of one photon of microwave radiation with a wavelength of 0.158 m?

! a. 1.26×10^{-24} J
b. 3.14×10^{-26} J
c. 3.19×10^{25} J
d. 3.49×10^{-43} J
e. 7.15×10^{40} J

Section 8.1

22. What is the energy, in joules, of one photon of visible radiation with a wavelength of 464.1 nm?

a. 1.026×10^{-48} J
b. 2.100×10^{35} J
c. 2.341×10^{11} J
! d. 4.280×10^{-19} J
e. 4.280×10^{-12} J

Section 8.1

26. What is the energy, in joules, of one mole of photons associated with radiation which has a frequency of 3.818×10^{15} Hz?

a. 1.045×10^{-25} J
! b. 1.524×10^{6} J
c. 2.530×10^{-18} J
d. 6.564×10^{-7} J
e. 9.568×10^{24} J

Section 8.1

27. What is the wavelength, in nm, of radiation which has an energy of 3.371×10^{-19} joules per photon?

a. 655.9 nm
b. 152.5 nm
c. 170.0 nm
! d. 589.3 nm
e. 745.1 nm

Section 8.1

30. What is the frequency, in sec^{-1}, of radiation which has an energy of 219.1 kJ per mole (of these photons)?

a. $615.9 \times 10^{14}\ sec^{-1}$
b. $1.624 \times 10^{14}\ sec^{-1}$
c. $1.058 \times 10^{-10}\ sec^{-1}$
! d. $5.491 \times 10^{14}\ sec^{-1}$
e. $3.588 \times 10^{-19}\ sec^{-1}$

Section 8.2

35. Which statement below is true with regard to Bohr's model of the atom?

a. The model accounted for the absorption spectra of atoms but not for the emission spectra.
! b. The model could account for the emission spectrum of hydrogen and for the Rydberg equation.
c. The model was based on the wave properties of the electron.
d. The model accounted for the emission spectra of atoms, but not for the absorption spectra.
e. The model was generally successful for all atoms to which it was applied.

Section 8.2

37. The definite energies associated with specific wavelengths in the emission spectrum of atomic hydrogen suggest that

a. electrons have a smaller rest mass than photons
b. photons have a smaller rest mass than electrons
! c. energy states in the hydrogen atom are quantized
d. atomic hydrogen is more stable and has a lower potential energy than molecular hydrogen
e. the potential energy of electrons in the atom can have any arbitrary value over a period of time, but the kinetic energy may only have certain specific values

Section 8.2

38. Calculate the energy required to excite a hydrogen atom by causing an electronic transition from the energy level with n = 1 to the level with n = 4. Recall that the quantized energies of the levels in the hydrogen atom are given by:

$$E_n = -\frac{21.79 \text{ x } 10^{-19}}{n^2} \text{ joule}$$

a. $2.017 \text{ x } 10^{-29}$ J
! b. $2.043 \text{ x } 10^{-18}$ J
c. $2.192 \text{ x } 10^{5}$ J
d. $2.254 \text{ x } 10^{-18}$ J
e. $3.275 \text{ x } 10^{-17}$J

Section 8.2

41. Calculate the frequency of the light emitted by a hydrogen atom during a transition of its electron from the energy level with n = 6 to the level with n = 3. Recall that the quantized energies of the levels in the hydrogen atom are given by:

$$E_n = -\frac{21.79 \text{ x } 10^{-19}}{n^2} \text{ joule}$$

a. $1.665 \text{ x } 10^{-26}$ s^{-1}
b. $1.824 \text{ x } 10^{-15}$ s^{-1}
! c. $2.740 \text{ x } 10^{14}$ s^{-1}
d. $3.649 \text{ x } 10^{-15}$ s^{-1}
e. $9.132 \text{ x } 10^{13}$ s^{-1}

Section 8.3

48. The letter designation for the subshell is based on

! a. the value of the secondary quantum number
b. the value of the principal quantum number
c. the value of the magnetic quantum number, m_l
d. the value of the spin quantum number, m_s
e. the transverse polarization of the optical emission from the H atom

Section 8.3

49. The three quantum numbers which characterize the solutions to the wave equation describing the behavior of the electron in the H atom are usually designated as

a. *1s 2s 2p*
b. n l m_s
c. m_l m_s m_p
! d. n l m_l
e. l m_l m_s

Section 8.4

56. The wave functions which are solutions to the wave equation which describes the behavior of the electron in the hydrogen atom are described by how many quantum numbers?

a. 1
b. 2
! c. 3
d. 4
e. 5

Section 8.4

57. "No two electrons in the same atom can have all its quantum numbers the same." This statement is based on the work of

a. Louis de Broglie
b. Werner von Heisenberg
c. Albert Einstein
! d. Wolfgang Pauli
e. Erwin Schrödinger

Sections 8.3 and 8.4

59. Given the following sets of quantum numbers for n l m_l m_s, which one of these sets is not a possible set for an electron in an atom?

		n	l	m_l	m_s
	a.	3	2	2	-½
	b.	3	1	-1	½
	c.	4	3	2	½
	d.	4	3	-2	-½
!	e.	5	2	3	½

Sections 8.3 and 8.4

62. Given the following sets of quantum numbers for n l m_l m_s, which one of these sets is not a possible set for an electron in an atom?

		n	l	m_l	m_s
!	a.	3	1	-1	0
	b.	3	2	2	-½
	c.	4	3	2	½
	d.	4	3	-2	-½
	e.	5	3	2	½

Section 8.5

64. The statement that the ground state configuration of an atom is generated by filling in levels from the lowest (energy-wise) to the highest with electrons observing the maximum for each of these levels is

! a. the Aufbau principle
b. Bustamente's principle
c. Hund's Rule
d. Murphy's rule
e. the Pauli Principle

Section 8.6

81. Based on the Aufbau principle and other applicable guiding principles, what ground state electronic configuration would one reasonably expect to find for technetium (Z = 43)?

a. [Kr] $4s^2$ $3d^5$
b. [Kr] $4s^2$ $4d^5$
c. [Kr] $4d^7$
! d. [Kr] $5s^2$ $4d^5$
e. [Kr] $5s^2$ $5d^5$

Section 8.6

83. Which one of the following configurations represents an alkaline earth element?

a. [Ar] $4s^1$ $3d^5$
b. [Ar] $4s^2$ $3d^4$
c. [Xe] $5s^2$ $5p^1$
d. [Xe] $6s^2$ $4f^7$
! e. [Rn] $7s^2$

Section 8.6

86. A possible set of quantum numbers for an electron in the partially filled subshell in the gallium atom in its ground state configuration would be

		n	l	m_l	m_s
	a.	3	1	0	-½
	b.	3	1	1	½
	c.	4	0	0	-½
!	d.	4	1	0	½
	e.	4	2	1	½

Section 8.6

87. A possible set of quantum numbers for an electron in the partially filled subshell in the vanadium atom in its ground state configuration would be

		n	l	m_l	m_s
	a.	3	1	0	-½
!	b.	3	2	1	½
	c.	4	0	0	-½
	d.	4	1	0	½
	e.	4	2	1	½

Section 8.8

94. Which one of the species below should have the smallest radius?

a. Ca
b. Ba
c. K
d. Mg
! e. C

Section 8.8

95. Which one of the species below should have the largest radius?

a. Ca
! b. Ba
c. Al
d. Mg
e. C

Section 8.8

98. Which one of the species below should have the smallest radius?

! a. Ar
b. Ca
c. K
d. Mg
e. Na

Section 8.8

99. Which one of the atoms listed below has the largest value for its first ionization energy?

! a. Al
b. Sr
c. Ga
d. Cr
e. Fr

Section 8.8

100. Which one of the species below should have the smallest value for its first ionization energy?

! a. Rb
b. Na
c. Al
d. Ne
e. O

Section 8.8

101. Which one of the species below should have the smallest value for its first ionization energy?

a. Ba
b. C
! c. Cs
d. K
e. Mg

Section 8.8

103. Which one of the atoms represented by its symbol below has the largest value for its electron affinity?

a. Al
b. Sr
c. Ga
! d. Cl
e. F

Section 8.8

105. For which one of the processes below is ΔH largest in magnitude?

a. $Be^{+}(g) \rightarrow Be^{2+}(g) + e^{-}$
! b. $Be^{2+}(g) \rightarrow Be^{3+}(g) + e^{-}$
c. $B^{2+}(g) \rightarrow B^{3+}(g) + e^{-}$
d. $C(g) \rightarrow C^{+}(g) + e^{-}$
e. $C^{2+}(g) \rightarrow C^{3+}(g) + e^{-}$

Fill In The Blanks

Section 8.3

108. The number of orbitals in a shell with $n = 3$ is ______ (! 9)

Section 8.3

109. The number of orbitals in a subshell with $l = 3$ is ______ (! 7)