Chapter 8 Answers

Practice Examples

1a. 4.34×10^{14} Hz

1b. 3.28 m

2a. 520 kJ/mol

2b. 4.612×10^{14} Hz (orange), 6.662×10^{14} Hz (indigo).

3a. Yes, This is E_9 for n = 9.

3b. n = 7

4a. 486.2 nm

4b. 121.6 nm (1216 angstroms)

5a. 80.13 nm

5b. Be^{3+}

6a. 1.21×10^{-43} m

6b. 3.96×10^{4} m/s

7a. 6.4×10^{-43} m

7b. 1.3 m s^{-1}

8a. 0.167 out of 1, or 16.7%.

8b. 100 and 200 pm.

9a. 0.52 nm

9b. 150. pm

10a. Yes

10b. ℓ=1 and 2

11a. 3*p*

11b. n = 3; l = 0, 1, 2; m_l = -2, -1, 0, 1, 2

12a.	(3,2,-2,1)	m_s = 1 is incorrect. The values of m_s can only be + ½ or – ½.
	(3,1,-2, ½)	m_ℓ= -2 is incorrect. The values of m_ℓ can be +1,0,+1 when ℓ=1
	(3,0,0, ½)	All quantum numbers are allowed.

	(2,3,0, ½)	ℓ= 3 is incorrect. The value for ℓ can not be larger than n.
	(1,0,0,- ½)	All quantum numbers are allowed.
	(2,-1,-1, ½)	ℓ= -1 is incorrect. The value for ℓ can not be negative.
12b.	(2,1,1,0)	m_s = 0 is incorrect. The values of m_s can only be + ½ or – ½.
	(1,1,0, ½)	ℓ= 1 is incorrect. The value for ℓ is 0 when n=1.
	(3,-1,1, ½)	ℓ= -1 is incorrect. The value for ℓ can not be negative.
	(0,0,0, - ½)	n= 0 is incorrect. The value for n can not be zero.
	(2,1,2, ½)	m_ℓ= 2 is incorrect. The values of m_ℓ can be +1,0,+1 when ℓ=1.

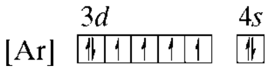
13a. (a) and (c) are equivalent.

13b. excited state of a neutral species

14a. Ti

14b. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^2 5p^5$. Each iodine atom has ten $3d$ electrons and one unpaired $5p$ electron.

15a.



15b.

16a. (a) Tin is in the 5th period, hence, five electronic shells are filled or partially filled; (b) The $3p$ subshell was filled with Ar; there are six $3p$ electrons in an atom of Sn; (c) The electron configuration of Sn is [Kr] $4d^{10}5s^25p^2$. There are no $5d$ electrons; (d) Both of the $5p$ electrons are unpaired, thus there are two unpaired electrons in a Sn atom.

16b. (a) The $3d$ subshell was filled at Zn, thus each Y atom has ten $3d$ electrons; (b) Ge is in the $4p$ row; each germanium atom has two $4p$ electrons; (c) We would expect each Au atom to have ten $5d$ electrons and one $6s$ electron. Thus each Au atom should have one unpaired electron.

Integrative Example

A. (a) 73.14 pm; (b) 17.7 K.

B. The possible combinations are $1s \rightarrow np \rightarrow nd$, for example, $1s \rightarrow 3p \rightarrow 5d$. The frequencies of these transitions are calculated as follows:

$$1\text{s} \rightarrow 3\text{p} : \nu = 2.92 \times 10^{15}\text{ Hz}$$

$$3\text{p} \rightarrow 5\text{d} : \nu = 2.34 \times 10^{14}\text{ Hz}$$

The emission spectrum will have lines representing $5d \rightarrow 4p$, $5d \rightarrow 3p$, $5d \rightarrow 2p$, $4p \rightarrow 3s$, $4p \rightarrow 2s$, $4p \rightarrow 1s$, $3p \rightarrow 2s$, $3p \rightarrow 1s$, and $2p \rightarrow 1s$. The difference between the sodium atoms is that the positions of the lines will be shifted to higher frequencies by 11^2.

Exercises

1. 4.68 nm

3a. True

3b. False

3c. False

3d. True

5. Choice (c).

7. 8.3 min

9a. $6.9050 \times 10^{14} \text{s}^{-1}$

9b. 397.11 nm

9c. $\text{n} = 10$

11a. $4.90 \times 10^{-18} \text{ J/photon}$

11b. 78.6 kJ/mol

13. -1.816×10^{-19} J, 2.740×10^{14} s^{-1}

15. $n = 7.9 \approx 8$

17. 656.46 nm, 486.26 nm, 434.16 nm, 410.28 nm.

19a. 3.46×10^{-19} J/photon

19b. 2.08×10^{5} J/mol

21. 2.1×10^{-5} nm radiation, has the greatest energy per photon. 4.1×10^{3} nm has the least amount of energy per photon.

23. UV radiation

25a. 6.60×10^{-19} J/photon

25b. Indium will display the photoelectric effect when exposed to ultraviolet light. It will not display the photoelectric effect when exposed to infrared light.

27a. 1.9 nm

27b. -6.053×10^{-20} J

29a. 1.384×10^{14} s^{-1}

29b. 2166 nm

29c. Infrared radiation.

31a. 8.5×10^{-10} m

31b. The electron in the hydrogen atom does not orbit at a radius of 4.00 Å.

31c. -3.405×10^{-20} J

31d. No

33. $n = 2$

35a. Line A is for the transition n = 3 → n = 1, while Line B is for the transition n = 4 → n = 1.

35b. Hydrogen atom

37a. Line A is for the transition n = 5 → n = 2, while Line B is for the transition n = 6 → n = 2.

37b. Be^{3+} cation

39. Electrons

41. 9.79×10^{-35} m. The diameter of a nucleus approximates 10^{-15} m, which is far larger than the baseball's wavelength.

43. The Bohr model implies that the position of the electron is exactly known at any time in the future, once its position is known at the present. The distance of the electron from the nucleus, its energy, and the velocity of the electron in its orbit are also exactly known. All of these exactly known quantities can't, according to the Heisenberg uncertainty principle, be known with great precision simultaneously.

45. ~1×10^{-13} m

47. 1.4×10^{7} m s^{-1}

49. $\lambda \simeq 17$ cm

51. 0.55 nm

53. $n = 4.0$

55. Bohr orbits, as originally proposed, are circular, while orbitals can be spherical, or shaped like two tear drops or two squashed spheres, or shaped like four tear drops meeting at their

points. Bohr orbits are planar pathways, while orbitals are three-dimensional regions of space in which there is a high probability of finding electrons. The electron in a Bohr orbit has a definite trajectory. Its position and velocity are known at all times. The electron in an orbital, however, does not have a well-known position or velocity. Orbits and orbitals are similar in that the radius of a Bohr orbit is comparable to the average distance of the electron from the nucleus in the corresponding wave mechanical orbital.

57. Answer (c) is the only one that is correct.

59a. 5*p*

59b. 4*d*

59c. 2*s*

61a. 1 electron

61b. 2 electrons

61c. 10 electrons

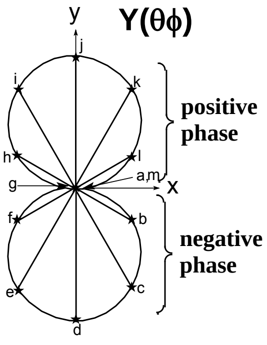
61d. 32 electrons

61e. 5 electrons

63. 106 pm

65. The angular part of the $2p_y$ wave function is $Y(\theta\phi)_{py} = \sqrt{\frac{3}{4\pi}}\sin\theta\sin\phi$. For all points in the xz plane ϕ□= 0, and since the sine of 0º is zero, this means that the entire x z plane is a node. Thus, the probability of finding a $2p_y$ electron in the xz plane is zero.

67.



69. A plot of radial probability distribution versus r/a_o for a H_{1s} orbital shows a maximum at 1.0 (that is, $r = a_o$ or r = 53 pm).

71a. 3*p*

71b. 3*d*

71c. $6f$

73. $5d_{xyz}$

75a. three

75b. two

75c. zero

75d. fourteen

75e. two

75f. five

75g. 32

77. Configuration (b) is correct for phosphorus.

79a. 3

79b. ten

79c. two

79d. two

79e. fourteen

81a. Pb: $[\mathrm{Xe}]\ 4\mathrm{f}^{14}5\mathrm{d}^{10}6\mathrm{s}^{2}6\mathrm{p}^{2}$

81b. 114: $[\mathrm{Rn}]\ 5f^{14}6d^{10}7s^{2}7p^{2}$

83a. Excited state

83b. Excited state

83c. Ground state

83d. Excited state

85a. $[\mathrm{Xe}]6s^{2}4f^{14}5d^{10}$

85b. $[\mathrm{Ar}]4s^{2}$

85c. $[\mathrm{Xe}]6s^{2}4f^{14}5d^{10}6p^{4}$

85d. $[\mathrm{Kr}]5s^{2}4d^{10}5p^{2}$

85e. $[\mathrm{Xe}]6s^{2}4f^{14}5d^{3}$

85f. $[\mathrm{Kr}]5s^{2}4d^{10}5p^{5}$

87a. rutherfordium

87b. carbon

87c. vanadium

87d. tellurium

87e. Not an element.

Integrative and Advanced Exercises

91a. Because the shortest wavelength of visible light is 390 nm, the photoelectric effect for mercury cannot be obtained with visible light.

91b. 2.02×10^{-19} J

91c. 6.66×10^{5} m s^{-1}

92. $1.0 \times 10^{20} \dfrac{\text{photons}}{\text{sec}}$

93. Green

96. $m = 3$ and $n = 4$.

101. 4.8×10^{-3} J

102. 7×10^{2}photons/s

105. 66.2 m/s

Feature Problems

114. Plot ν on the vertical axis and $1/n^2$ on the horizontal axis. The slope is $b = -3.2881 \times 10^{15}$ Hz and the intercept is 8.2203×10^{14} Hz.

116a. 121.5 nm and 102.6 nm.

116b. 97.2 nm, 486.1 nm, 1875 nm, 102.5 nm, 656.3 nm, 121.5 nm.

116c. The number of lines observed in the two spectra is not the same.

Self-Assessment Exercises

122. Atomic orbitals of multi-electron atoms resemble those of the H atom in having both angular and radial nodes. They differ in that subshell energy levels are not degenerate and their radial wave functions no longer conform to the expressions in Table 8.1.

123. Effective nuclear charge is the amount of positive charge from the nucleus that the valence shell of the electrons actually experiences. This amount is less than the actual nuclear charge, because electrons in other shells shield the full effect.

124. The p_x, p_y and p_z orbitals are triply degenerate (the are the same energy), and they have the same shape. Their difference lies in their orientation with respect to the arbitrarily assigned x, y, and z axes of the atom.

125. The difference between the 2p and 3p orbitals is that the 2p orbital has only one node (n = 2-1) which is angular, whereas the 3p orbital has two nodes, angular and radial

126. The answer is (a).

127a. Velocity of the electromagnetic radiation is fixed at the speed of light in a vacuum.

127b. Wavelength is inversely proportional to frequency.

127c. Energy is directly proportional to frequency.

128. Sir James Jeans's obtuse metaphor for the photoelectric effect points to the fact that it is a quantum-mechanical phenomenon. The photoelectric effect is a single photon-to-electron phenomenon; that is, a single photon that meets the minimum energy requirement can cause the ejection of an electron from the atom. If the photon is particularly energetic, the excess energy will not eject a second electron. Hence, you can't kill two birds with one stone. Furthermore, the atom cannot accumulate the energy from multiple photon hits to eject an electron: only one hit of sufficient energy equals one and only one ejection. Therefore, you can't kill a bird with multiple stones.