

- 2.67. (a) Both contain the same; (b)  $\text{N}_2\text{O}_4$ ; (c)  $\text{CO}_2$
- 2.69. (a) 3.00 mol; (b) 4.50 mol; (c) 1.50 mol
- 2.71. a. 64.063 g/mol  
b. 47.997 g/mol  
c. 44.009 g/mol  
d. 108.009 g/mol
- 2.73. a. 152.148 g/mol  
b. 164.203 g/mol  
c. 148.204 g/mol  
d. 132.161 g/mol
- 2.75. 41.63 mol
- 2.77. 0.25 mol; 10 g
- 2.79. (a) NO; (b)  $\text{CO}_2$ ; (c)  $\text{O}_2$
- 2.81. 0.752 mol
- 2.83. Diamond
- 2.85. First formed (d) quark, last formed (a) deuteron
- 2.87. Energy is released in fusion processes when product has  $Z < 26$  (Fe) because binding energy per nucleon is relatively high but drops off after Fe.
- 2.89. Because for fusion of helium, we have to force together two nuclei of higher positive charge and higher temperatures are required to overcome the higher repulsion.
- 2.91. The expanding universe was cooling and expanding and therefore could not support the high temperatures and densities needed for fusion to produce elements heavier than lithium.
- 2.93. The effect of  $\beta$  decay on the neutron-to-proton ratio is to decrease it as a neutron is transformed into a proton plus  $\beta$  particle.
- 2.95. a.  $^{16}_8\text{O}$   
b.  $^{24}_{12}\text{Mg}$   
c.  $^{36}_{18}\text{Ar}$
- 2.97. a.  $^{99}_{43}\text{Tc}$   
b.  $^{121}_{51}\text{Sb}$   
c.  $^{110}_{80}\text{Hg}$
- 2.99. The transformation of  $^{137}\text{I}$  to  $^{137}\text{Xe}$  can be balanced as  $^{137}_{53}\text{I} \rightarrow ^{137}_{54}\text{Xe} + ^0_{-1}\beta$ .  
The transformation of  $^{137}\text{Xe}$  to  $^{137}\text{Cs}$  can be balanced as  $^{137}_{54}\text{Xe} \rightarrow ^{137}_{55}\text{Cs} + ^0_{-1}\beta$ .  
Both of the nuclear reactions involve  $\beta$  emission.
- 2.101.  $^{209}_{83}\text{Bi} + 2\ ^1_0\text{n} \rightarrow ^{211}_{85}\text{At} + 2\ ^0_{-1}\beta$
- 2.103. a.  $^{32}_{15}\text{P}$   
b.  $4\ ^1_0\text{n}$   
c.  $2\ ^1_1\text{H}$   
d.  $^{125}_{54}\text{Xe}, ^0_{-1}\beta$
- 2.105. a.  $^0_{-1}\beta$   
b.  $^{122}_{53}\text{I}$   
c.  $^{10}_5\text{B}$   
d.  $^{67}_{30}\text{Zn}$
- 2.107. a. Electrons  
b. The negatively charged electrons were attracted to the positively charged plate as the electrons passed through the electric field.  
c. If the polarities of the plates were switched, the electron would still be deflected toward the positively charged plate, which would now be at the opposite side of the screen.
- 2.109. 10.00%  $^{25}\text{Mg}$  and 11.01%  $^{26}\text{Mg}$
- 2.111.  $^{11}_5\text{B} + ^1_0\text{n} \rightarrow ^{12}_5\text{B} \rightarrow ^8_3\text{Li} + ^4_2\text{He}$   
 $^{11}_5\text{B} + ^1_0\text{n} \rightarrow ^{12}_5\text{B} \rightarrow ^{12}_6\text{C} + ^0_{-1}\beta$
- 2.113.  $^{208}_{82}\text{Pb} + ^{62}_{28}\text{Ni} \rightarrow ^{269}_{110}\text{Ds} + ^1_0\text{n}$
- 2.115. (a) 0.7580 mol C; (b)  $4.565 \times 10^{23}$  atoms C

## Chapter 3

- 3.1. a. Purple (Na), red (Cr), and orange (Au)  
b. Blue (Ne)  
c. Orange (Au)  
d. Red (Cr)  
e. Blue (Ne) and green (Cl)
- 3.3. a. Green (Cl)  
b. Purple (Na)
- 3.5. Blue (Rb), green (Sr), and orange (Y)
- 3.7. c
- 3.9. a
- 3.11. All these forms of light have perpendicular, oscillating electric and magnetic fields that travel together through space.
- 3.13. The lead shield must protect the parts of your body that might be exposed to X-rays but are not being imaged. Lead is a very high density metal with many electrons, which interact with X-rays and absorb nearly all the X-rays before they can reach your body.
- 3.15. It still emits infrared radiation.
- 3.17.  $4.87 \times 10^{14} \text{ s}^{-1}$
- 3.19. (a) 3.32 m; (b) 3.14 m; (c) 3.04 m; (d) 2.79 m
- 3.21. The radio station has the lower frequency.
- 3.23. 8.317 min
- 3.25. The absorption spectrum consists of dark lines at wavelengths specific to that element. The emission spectrum has bright lines on a dark background with the lines appearing at the exact same wavelengths as the dark lines in the absorption spectrum.
- 3.27. Because each element shows distinctive and unique absorption and emission lines, the bright emission lines observed for the pure elements could be matched to the many dark absorption lines in the spectrum of sunlight. This approach can be used to deduce the sun's elemental composition.
- 3.29. The quantum is the smallest indivisible amount of radiant energy that an atom can absorb or emit.
- 3.31. From Figure 3.11 we see that tungsten as a blackbody metal will emit in the visible range at 1000 K and that it will glow red-orange.
- 3.33.  $6.62 \times 10^{-19} \text{ J}$
- 3.35. b
- 3.37.  $6.93 \times 10^{-19} \text{ J}$
- 3.39. No
- 3.41. Potassium;  $8.04 \times 10^5 \text{ m/s}$
- 3.43.  $3.17 \times 10^{18}$  photons/s
- 3.45. The Rydberg equation is more general than the Balmer equation; the Balmer equation is equivalent to the Rydberg when  $n_1 = 2$ .
- 3.47. It is the difference between  $n$  levels that determines emission energy.
- 3.49. a
- 3.51. No
- 3.53. At  $n = 7$ , the wavelength of the electron's transition ( $n = 7$  to  $n = 2$ ) has moved out of the visible region.
- 3.55. 1875 nm; infrared
- 3.57. No, because for hydrogen the transition is in the ultraviolet region and as  $Z$  increases the wavelength will shorten further.
- 3.59. 72.9 nm
- 3.61. In the de Broglie equation,  $\lambda$  is the wavelength the particle of mass  $m$  exhibits as it travels at speed  $u$ , where  $h$  is Planck's constant. This equation states that (1) any moving particle has wavelike properties because a wavelength can be calculated

- through the equation, and (2) the wavelength of the particle is inversely related to its momentum (mass multiplied by velocity).
- 3.63. No
- 3.65. b and c
- 3.67. a. 10.8 nm  
b. 0.180 nm  
c.  $8.2 \times 10^{-37}$  nm  
d.  $3.7 \times 10^{-54}$  nm
- 3.69.  $\Delta x \geq 1.3 \times 10^{-13}$  m
- 3.71. The Bohr model orbit showed the quantized nature of the electron in the atom as a particle moving around the nucleus in concentric orbits. In quantum theory, an orbital is a region of space where the probability of finding the electron is high. The electron is not viewed as a particle, but as a wave, and it is not confined to a clearly defined orbit; rather, we refer to the probability of the electron being at various locations around the nucleus.
- 3.73. Three:  $n$ ,  $\ell$ , and  $m_\ell$ .
- 3.75. (a) 1; (b) 4; (c) 9; (d) 16; (e) 25
- 3.77. 3, 2, 1, 0
- 3.79. (a)  $2s$ ; (b)  $3p$ ; (c)  $4d$ ; (d)  $1s$
- 3.81. (a) 2; (b) 2; (c) 10; (d) 2
- 3.83. b
- 3.85. Degenerate orbitals have the same energy and are indistinguishable from each other.
- 3.87. As we start from an argon core of electrons, we move to potassium and calcium, which are located in the  $s$  block on the periodic table. It is not until Sc, Ti, V, etc., that we begin to fill electrons into the  $3d$  shell.
- 3.89. (c)  $3s < (a) 3d < (d) 4p < (b) 7f$
- 3.91.  $\text{Li}^+$ :  $1s^2$  or  $[\text{He}]$   
Ca:  $[\text{Ar}]4s^2$   
F $^-$ :  $[\text{He}]2s^22p^6$  or  $[\text{Ne}]$   
 $\text{Mg}^{2+}$ :  $[\text{He}]2s^22p^6$  or  $[\text{Ne}]$   
 $\text{Al}^{3+}$ :  $[\text{He}]2s^22p^6$  or  $[\text{Ne}]$
- 3.93. K:  $[\text{Ar}]4s^1$   
 $\text{K}^+$ :  $[\text{Ar}]$   
Ba:  $[\text{Xe}]6s^2$   
 $\text{Ti}^{4+}$ :  $[\text{Ne}]3s^23p^6$  or  $[\text{Ar}]$   
Ni:  $[\text{Ar}]4s^23d^8$
- 3.95. Ra:  $[\text{Rn}]7s^2$   
I:  $[\text{Kr}] 5s^24d^{10}5p^5$   
In:  $[\text{Kr}] 5s^24d^{10}5p^1$   
Mn:  $[\text{Ar}] 4s^23d^5$   
 $\text{Mn}^{2+}$ :  $[\text{Ar}]3d^5$
- 3.97. (a) 3; (b) 2; (c) 0; (d) 0
- 3.99. Ti, two unpaired electrons.
- 3.101.  $\text{Cl}^-$ , no unpaired electrons
- 3.103. a and d
- 3.105.  $5p$ , yes
- 3.107. If electrons do not repel each other as much in  $\text{Na}^+$  as they do in Na, they will have lower energy and be, on average, closer to the nucleus, resulting in a smaller size. When electrons are added to an atom (Cl), the  $e^-e^-$  repulsion increases, so the electrons have higher energy and they will be, on average, farther from the nucleus, thereby creating a larger size species ( $\text{Cl}^-$ ).
- 3.109. Rb. The size of atoms increases down a group because electrons have been added to higher  $n$  levels.
- 3.111. a. As the atomic number increases down a group, electrons are added to higher  $n$  levels, leading to a decrease in ionization energy.  
b. As the atomic number increases across a period, the effective nuclear charge increases. This means that the ionization energy increases across a period of elements.
- 3.113. Fluorine, with a higher nuclear charge, exerts a higher  $Z_{\text{eff}}$  on the  $2p$  electrons than boron, resulting in higher ionization energy.
- 3.115. Sr
- 3.117. No, sodium has a negative (favorable) electron affinity but is never found as an anion in nature. It is always a cation in salts such as  $\text{NaCl}$  and  $\text{Na}_2\text{CO}_3$ .
- 3.119. The electron is added farther away from the nucleus as we descend the halogens because the atoms get larger. This means that the electron affinities become more positive (less negative).
- 3.121. a.  $-1.11 \times 10^{-26}$  J  
b. 17.9 m  
c. A radio telescope
- 3.123. a, c, and d
- 3.125. Yes. It is generally observed that as  $Z$  increases so does the  $\text{IE}_2$ . However, Ge's second  $\text{IE}_2$  is lower than Ga's because to ionize the second electron in Ga, we need to remove an electron from a lower energy  $4s$  orbital. Also, Br's  $\text{IE}_2$  is lower than Se's because the electron pairing ( $4p^4$ ) in one of the  $p$  orbitals for the  $\text{Br}^+$  ion lowers its  $\text{IE}_2$  slightly.
- 3.127. a.  $\text{Sn}^{2+}$ :  $[\text{Kr}]4d^{10}5s^2$   
 $\text{Sn}^{4+}$ :  $[\text{Kr}]4d^{10}$   
 $\text{Mg}^{2+}$ :  $[\text{He}]2s^22p^6$  or  $[\text{Ne}]$   
b. Cadmium has the same electron configuration as  $\text{Sn}^{2+}$  and neon has the same electron configuration as  $\text{Mg}^{2+}$ .  
c.  $\text{Cd}^{2+}$
- 3.129. a. Ne, 5.76; Ar, 6.76  
b. The outermost electron in argon is a  $3p$  electron that is mostly shielded by the electrons in the  $n = 2$  level (10 electrons) and the  $n = 1$  level (2 electrons), whereas the outermost electron in neon is a  $2p$  electron that is shielded only by the electrons in the  $n = 1$  level (2 electrons).
- 3.131. When we think of the electron as a wave, we can envision the node between the two lobes as a wave of zero amplitude and the  $p$  orbital as a standing wave.

## Chapter 4

- 4.1. a. Group 1 (red)  
b. Group 14 (blue)  
c. Group 16 (purple)
- 4.3.  $\text{Mg}^{2+}$
- 4.5. Group 14 (blue, carbon)
- 4.7. Lithium (red) and fluorine (lilac)
- 4.9. b
- 4.11. The arrangement of the atoms in two of the structures is  $\text{S}=\text{O}=\text{S}$  and in the other two structures it is  $\text{S}-\text{S}=\text{O}$ . Because the arrangement of atoms differs, they are not resonance structures. Also, for each arrangement, the structures do not show a different arrangement of electrons on the atoms; only the bonds are drawn bent, not straight. The "bent form" and "linear form" are not resonance forms of each other if the numbers of lone pairs and bonding pairs of electrons on each atom are the same.
- 4.13. a