Chapter 2

(Textbook Ch.12-13)

32. $\lambda = \dfrac{h}{mv}$, $v = \dfrac{h}{\lambda m}$; for $\lambda = 1.0 \times 10^2$ nm $= 1.0 \times 10^{-7}$ m:

$$v = \frac{6.63 \times 10^{-34}\ \text{J s}}{9.11 \times 10^{-31}\ \text{kg} \times 1.0 \times 10^{-7}\ \text{m}} = 7.3 \times 10^3\ \text{m/s}$$

For $\lambda = 1.0$ nm $= 1.0 \times 10^{-9}$ m: $v = \dfrac{6.63 \times 10^{-34}\ \text{J s}}{9.11 \times 10^{-31}\ \text{kg} \times 1.0 \times 10^{-9}\ \text{m}} = 7.3 \times 10^5$ m/s

36. a. $\Delta E = -2.178 \times 10^{-18}\text{J}\left(\dfrac{1}{3^2} - \dfrac{1}{4^2}\right) = -1.059 \times 10^{-19}$ J

$$\lambda = \frac{hc}{|\Delta E|} = \frac{6.6261 \times 10^{-34}\ \text{J s} \times 2.9979 \times 10^8\ \text{m/s}}{1.059 \times 10^{-19}\ \text{J}} = 1.876 \times 10^{-6}\ \text{m} = 1876\ \text{nm}$$

From Figure 12.3, this is infrared electromagnetic radiation.

b. $\Delta E = -2.178 \times 10^{-18}\text{J}\left(\dfrac{1}{4^2} - \dfrac{1}{5^2}\right) = -4.901 \times 10^{-20}$ J

$$\lambda = \frac{hc}{|\Delta E|} = \frac{6.6261 \times 10^{-34}\ \text{J s} \times 2.9979 \times 10^8\ \text{m/s}}{4.901 \times 10^{-20}\ \text{J}} = 4.053 \times 10^{-6}\ \text{m}$$

= 4053 nm (infrared)

c. $\Delta E = -2.178 \times 10^{-18}\ \text{J}\left(\dfrac{1}{3^2} - \dfrac{1}{5^2}\right) = -1.549 \times 10^{-19}$ J

$$\lambda = \frac{hc}{|\Delta E|} = \frac{6.6261 \times 10^{-34}\ \text{J s} \times 2.9979 \times 10^8\ \text{m/s}}{1.549 \times 10^{-19}\ \text{J}} = 1.282 \times 10^{-6}\ \text{m}$$

= 1282 nm (infrared)

43. $$|\Delta E| = E_{photon} = \frac{hc}{\lambda} = \frac{6.6261\times 10^{-34}\ \text{J s} \times 2.9979\times 10^{8}\ \text{m/s}}{397.2\times 10^{-9}\ \text{m}} = 5.001\times 10^{-19}\ \text{J}$$

$\Delta E = -5.001\times 10^{-19}$ J because we have an emission.

$$-5.001\times 10^{-19}\ \text{J} = E_2 - E_n = -2.178\times 10^{-18}\ \text{J}\left(\frac{1}{2^2} - \frac{1}{n^2}\right)$$

$$0.2296 = \frac{1}{4} - \frac{1}{n^2},\quad \frac{1}{n^2} = 0.0204,\quad n = 7$$

66. b. For $\ell = 3$, m_ℓ can range from -3 to +3; thus +4 is not allowed.

c. n cannot equal zero.

d. ℓ cannot be a negative number.

The quantum numbers in part a are allowed.

75. a. $n = 4$: ℓ can be 0, 1, 2, or 3. Thus we have s (2 e^-), p (6 e^-), d (10 e^-) and f (14 e^-) orbitals present. Total number of electrons to fill these orbitals is 32.

b. $n = 5$, $m_\ell = +1$: for $n = 5$, $\ell = 0, 1, 2, 3, 4$; for $\ell = 1, 2, 3, 4$, all can have $m_\ell = +1$. Four distinct orbitals which can hold a maximum of 8 electrons.

c. $n = 5$, $m_s = +1/2$: for $n = 5$, $\ell = 0, 1, 2, 3, 4$. Number of orbitals = 1, 3, 5, 7, 9 for each value of ℓ, respectively. There are 25 orbitals with $n = 5$. They can hold 50 electrons, and 25 of these electrons can have $m_s = +1/2$.

d. $n = 3$, $\ell = 2$: these quantum numbers define a set of 3d orbitals. There are 5 degenerate 3d orbitals that can hold a total of 10 electrons.

e. $n = 2$, $\ell = 1$: these define a set of 2p orbitals. There are 3 degenerate 2p orbitals that can hold a total of 6 electrons.

f. It is impossible for $n = 0$. Thus no electrons can have this set of quantum numbers.

g. The four quantum numbers completely specify a single electron.

h. $n = 3$: 3s, 3p, and 3d orbitals all have $n = 3$. These orbitals can hold 18 electrons, and 9 of these electrons can have $m_s = +1/2$.

i. $n = 2$, $\ell = 2$: this combination is not possible ($\ell \neq 2$ for $n = 2$). Zero electrons in an atom can have these quantum numbers.

j. $n = 1$, $\ell = 0$, $m_\ell = 0$: these define a 1s orbital that can hold 2 electrons.

78. Si: $1s^22s^22p^63s^23p^2$ or $[Ne]3s^23p^2$; Ga: $1s^22s^22p^63s^23p^64s^23d^{10}4p^1$ or $[Ar]4s^23d^{10}4p^1$

As: $[Ar]4s^23d^{10}4p^3$; Ge: $[Ar]4s^23d^{10}4p^2$; Al: $[Ne]3s^23p^1$; Cd: $[Kr]5s^24d^{10}$

S: $[Ne]3s^23p^4$; Se: $[Ar]4s^23d^{10}4p^4$

87. We get the number of unpaired electrons by examining the incompletely filled subshells.

O: $[He]2s^22p^4$	$2p^4$: $\underline{\uparrow\downarrow}\ \underline{\uparrow}\ \underline{\uparrow}$	Two unpaired e^-
O^+: $[He]2s^22p^3$	$2p^3$: $\underline{\uparrow}\ \underline{\uparrow}\ \underline{\uparrow}$	Three unpaired e^-
O^-: $[He]2s^22p^5$	$2p^5$: $\underline{\uparrow\downarrow}\ \underline{\uparrow\downarrow}\ \underline{\uparrow}$	One unpaired e^-
Os: $[Xe]6s^24f^{14}5d^6$	$5d^6$: $\underline{\uparrow\downarrow}\ \underline{\uparrow}\ \underline{\uparrow}\ \underline{\uparrow}\ \underline{\uparrow}$	Four unpaired e^-
Zr: $[Kr]5s^24d^2$	$4d^2$: $\underline{\uparrow}\ \underline{\uparrow}\ \underline{\ }\ \underline{\ }\ \underline{\ }$	Two unpaired e^-
S: $[Ne]3s^23p^4$	$3p^4$: $\underline{\uparrow\downarrow}\ \underline{\uparrow}\ \underline{\uparrow}$	Two unpaired e^-
F: $[He]2s^22p^5$	$2p^5$: $\underline{\uparrow\downarrow}\ \underline{\uparrow\downarrow}\ \underline{\uparrow}$	One unpaired e^-
Ar: $[Ne]3s^23p^6$	$3p^6$: $\underline{\uparrow\downarrow}\ \underline{\uparrow\downarrow}\ \underline{\uparrow\downarrow}$	Zero unpaired e^-

97. Size (radius) decreases left to right across the periodic table, and size increases from top to bottom of the periodic table.

a. S < Se < Te b. Br < Ni < K c. F < Si < Ba

d. Be < Na < Rb e. Ne < Se < Sr f. O < P < Fe

All follow the general radius trend.

98. The ionization energy trend is the opposite of the radius trend; ionization energy (IE), in general, increases left to right across the periodic table and decreases from top to bottom of the periodic table.

a. Te < Se < S b. K < Ni < Br c. Ba < Si < F

d. Rb < Na < Be e. Sr < Se < Ne f. Fe < P < O

All follow the general ionization energy (IE) trend.

29. a. $Cu > Cu^{+} > Cu^{2+}$ b. $Pt^{2+} > Pd^{2+} > Ni^{2+}$ c. $O^{2-} > O^{-} > O$

d. $La^{3+} > Eu^{3+} > Gd^{3+} > Yb^{3+}$ e. $Te^{2-} > I^{-} > Cs^{+} > Ba^{2+} > La^{3+}$

For answer a, as electrons are removed from an atom, size decreases. Answers b and d follow the radius trend. For answer c, as electrons are added to an atom, size increases. Answer e follows the trend for an isoelectronic series, i.e., the smallest ion has the most protons.