

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

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

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

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

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

From Figure 12.3, this is infrared electromagnetic radiation.

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

$$\lambda = \frac{hc}{|\Delta E|} = \frac{6.6261 \times 10^{-34} \text{ J s} \times 2.9979 \times 10^8 \text{ m/s}}{4.901 \times 10^{-20} \text{ J}} = 4.053 \times 10^{-6} \text{ m} \\ = 4053 \text{ nm (infrared)}$$

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

$$\lambda = \frac{hc}{|\Delta E|} = \frac{6.6261 \times 10^{-34} \text{ J s} \times 2.9979 \times 10^8 \text{ m/s}}{1.549 \times 10^{-19} \text{ J}} = 1.282 \times 10^{-6} \text{ m} \\ = 1282 \text{ nm (infrared)}$$

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

$\Delta E = -5.001 \times 10^{-19} \text{ J}$ 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: $1s^2 2s^2 2p^6 3s^2 3p^2$ or $[\text{Ne}]3s^2 3p^2$; Ga: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^1$ or $[\text{Ar}]4s^2 3d^{10} 4p^1$
 As: $[\text{Ar}]4s^2 3d^{10} 4p^3$; Ge: $[\text{Ar}]4s^2 3d^{10} 4p^2$; Al: $[\text{Ne}]3s^2 3p^1$; Cd: $[\text{Kr}]5s^2 4d^{10}$
 S: $[\text{Ne}]3s^2 3p^4$; Se: $[\text{Ar}]4s^2 3d^{10} 4p^4$

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

O: $[\text{He}]2s^2 2p^4$	2p ⁴ : $\uparrow\downarrow \uparrow \uparrow$	Two unpaired e ⁻
O ⁺ : $[\text{He}]2s^2 2p^3$	2p ³ : $\uparrow \uparrow \uparrow$	Three unpaired e ⁻
O ⁻ : $[\text{He}]2s^2 2p^5$	2p ⁵ : $\uparrow\downarrow \uparrow\downarrow \uparrow$	One unpaired e ⁻
Os: $[\text{Xe}]6s^2 4f^{14} 5d^6$	5d ⁶ : $\uparrow\downarrow \uparrow \uparrow \uparrow \uparrow$	Four unpaired e ⁻
Zr: $[\text{Kr}]5s^2 4d^2$	4d ² : $\uparrow \uparrow _ _ _ _$	Two unpaired e ⁻
S: $[\text{Ne}]3s^2 3p^4$	3p ⁴ : $\uparrow\downarrow \uparrow \uparrow$	Two unpaired e ⁻
F: $[\text{He}]2s^2 2p^5$	2p ⁵ : $\uparrow\downarrow \uparrow\downarrow \uparrow$	One unpaired e ⁻
Ar: $[\text{Ne}]3s^2 3p^6$	3p ⁶ : $\uparrow\downarrow \uparrow\downarrow \uparrow\downarrow$	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. $\text{Cu} > \text{Cu}^+ > \text{Cu}^{2+}$ b. $\text{Pt}^{2+} > \text{Pd}^{2+} > \text{Ni}^{2+}$ c. $\text{O}^{2-} > \text{O}^- > \text{O}$
d. $\text{La}^{3+} > \text{Eu}^{3+} > \text{Gd}^{3+} > \text{Yb}^{3+}$ e. $\text{Te}^{2-} > \text{I}^- > \text{Cs}^+ > \text{Ba}^{2+} > \text{La}^{3+}$

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.