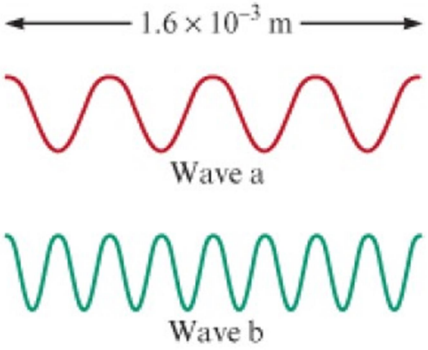
## Suggested end-of-chapter problems for Ch. 7

Question numbers correspond to the 9th edition.

45. Consider the following waves representing electromagnetic radiation:




Which wave has the longer wavelength? Calculate the wavelength. Which wave has the higher frequency and larger photon energy? Calculate these values. Which wave has the greater velocity? What type of electromagnetic radiation does each wave represent?

46. One type of electromagnetic radiation has a frequency of **107.1 MHz**, another type has a wavelength of $\mathbf{2.12 \times 10^{-10}\ m}$, and another type of electromagnetic radiation has photons with energy equal to $\mathbf{3.97 \times 10^{-19}\ J/photon}$. Identify each type of electromagnetic radiation and place them in order of increasing photon energy and increasing frequency.

47. Carbon absorbs energy at a wavelength of **150. nm**. The total amount of energy emitted by a carbon sample is $\mathbf{1.98 \times 10^{5}\ J}$. Calculate the number of carbon atoms present in the sample, assuming that each atom emits one photon.

50. It takes **208.4 kJ** of energy to remove **1 mole** of electrons from an atom on the surface of rubidium metal. How much energy does it take to remove a single electron from an atom on the surface of solid rubidium? What is the maximum wavelength of light capable of doing this?

51. It takes $7.21 \times 10^{-19}$ **J** of energy to remove an electron from an iron atom. What is the maximum wavelength of light that can do this?

52. Ionization energy is the energy required to remove an electron from an atom in the gas phase. The ionization energy of gold is **890.1 kJ/mol**. Is light with a wavelength of **225 nm** capable of ionizing a gold atom (removing an electron) in the gas phase?

53. Calculate the de Broglie wavelength for each of the following.

    a. an electron with a velocity **10.%** of the speed of light

    b. a tennis ball **(55 g)** served at **35 m/s** ($\sim$ **80 mi/h**)

64. An electron is excited from the $n = 1$ ground state to the $n = 3$ state in a hydrogen atom. Which of the following statements are true? Correct the false statements to make them true.

    a. It takes more energy to ionize (completely remove) the electron from $n = 3$ than from the ground state.

    b. The electron is farther from the nucleus on average in the $n = 3$ state than in the $n = 1$ state.

    c. The wavelength of light emitted if the electron drops from $n = 3$ to $n = 2$ will be shorter than the wavelength of light emitted if the electron falls from $n = 3$ to $n = 1$.

    d. The wavelength of light emitted when the electron returns to the ground state from $n = 3$ will be the same as the wavelength of light absorbed to go from $n = 1$ to $n = 3$.

    e. For $n = 3$, the electron is in the first excited state.

69. Using the Heisenberg uncertainty principle, calculate $\Delta x$ for each of the following.

    a. an electron with $\Delta v = 0.100\ \text{m/s}$

    b. a baseball $(\text{mass} = 145\ \text{g})$ with $\Delta v = 0.100\ \text{m/s}$

    c. How does the answer in part a compare with the size of a hydrogen atom?

    d. How does the answer in part b correspond to the size of a baseball?

70. The Heisenberg uncertainty principle can be expressed in the form

$$\Delta E \cdot \Delta t \geq \frac{h}{4\pi}$$

where $E$ represents energy and $t$ represents time. Show that the units for this form are the same as the units for the form used in this chapter:

$$\Delta x \cdot \Delta(mv) \geq \frac{h}{4\pi}$$

73. Which of the following sets of quantum numbers are not allowed in the hydrogen atom? For the sets of quantum numbers that are incorrect, state what is wrong in each set.

a. $n = 3, \ell = 2, m_\ell = 2$

b. $n = 4, \ell = 3, m_\ell = 4$

c. $n = 0, \ell = 0, m_\ell = 0$

d. $n = 2, \ell = -1, m_\ell = 1$

74. Which of the following sets of quantum numbers are not allowed? For each incorrect set, state why it is incorrect.

a. $n = 3, \ell = 3, m_\ell = 0, m_s = -\frac{1}{2}$

b. $n = 4\ \ell = 3, m_\ell = 2, m_s = -\frac{1}{2}$

c. $n = 4, \ell = 1, m_\ell = 1, m_s = +\frac{1}{2}$

d. $n = 2, \ell = 1, m_\ell = -1, m_s = -1$

e. $n = 5\ \ell = -4, m_\ell = 2, m_s = +\frac{1}{2}$

f. $n = 3, \ell = 1, m_\ell = 2, m_s = -\frac{1}{2}$

84. For elements **1–36**, there are two exceptions to the filling order as predicted from the periodic table. Draw the atomic orbital diagrams for the two exceptions and indicate how many unpaired electrons are present.

85. The elements **Si**, **Ga**, **As**, **Ge**, **Al**, **Cd**, **S**, and **Se** are all used in the manufacture of various semiconductor devices. Write the expected electron configuration for these atoms.

90. Using only the periodic table inside the front cover of the text, write the expected ground-state electron configurations for

a. the third element in Group 5A.

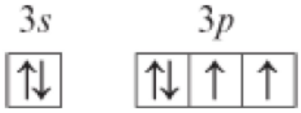
b. element number **116**.

c. an element with three unpaired **5*d*** electrons.

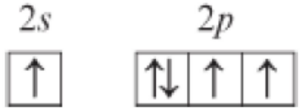
d. the halogen with electrons in the **6*p*** atomic orbitals.

91. Given the valence electron orbital level diagram and the description, identify the element or ion.

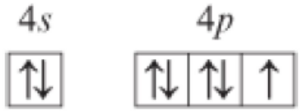
a. a ground-state atom




b. an atom in an excited state (assume two electrons occupy the **1*s*** orbital)




c. a ground-state ion with a charge of **−1**



92. Identify the following elements.

a. An excited state of this element has the electron configuration $1s^2 2s^2 2p^5 3s^1$.

b. The ground-state electron configuration is $[\mathrm{Ne}] 3s^2 3p^4$.

c. An excited state of this element has the electron configuration $[\mathrm{Kr}] 5s^2 4d^6 5p^2 6s^1$.

d. The ground-state electron configuration contains three unpaired $6p$ electrons.

93. In the ground state of mercury, **Hg**,

a. how many electrons occupy atomic orbitals with $n = 3$?

b. how many electrons occupy $d$ atomic orbitals?

c. how many electrons occupy $p_z$ atomic orbitals?

d. how many electrons have spin "up" $\left(m_s = +\frac{1}{2}\right)$?

100. Which of the following electron configurations correspond to an excited state? Identify the atoms and write the ground-state electron configuration where appropriate.

a. $1s^2 2s^2 3p^1$

b. $1s^2 2s^2 2p^6$

c. $1s^2 2s^2 2p^4 3s^1$

d. $[\mathrm{Ar}] 4s^2 3d^5 4p^1$

How many unpaired electrons are present in each of these species?

104. How many unpaired electrons are present in each of the following in the ground state: **O**, $\mathbf{O^+}$, $\mathbf{O^-}$, **Os**, **Zr**, **S**, **F**, **Ar**?

105. Arrange the following groups of atoms in order of increasing size.

    a. **Te**, **S**, **Se**

    b. **K**, **Br**, **Ni**

    c. **Ba**, **Si**, **F**

106. Arrange the following groups of atoms in order of increasing size.

    a. **Rb**, **Na**, **Be**

    b. **Sr**, **Se**, **Ne**

    c. **Fe**, **P**, **O**

107. Arrange the atoms in Exercise 105 in order of increasing first ionization energy.

108. Arrange the atoms in Exercise 106 in order of increasing first ionization energy.

109. In each of the following sets, which atom or ion has the smallest radius?

    a. **H**, **He**

    b. **Cl**, **In**, **Se**

    c. element **120**, element **119**, element **116**

    d. **Nb**, **Zn**, **Si**

    e. $\mathbf{Na^-}$, **Na**, $\mathbf{Na^+}$

110. In each of the following sets, which atom or ion has the smallest ionization energy?

a. **Ca, Sr, Ba**

b. **K, Mn, Ga**

c. **N, O, F**

d. $\mathbf{S^{2-}}$**, S,** $\mathbf{S^{2+}}$

e. **Cs, Ge, Ar**

115. Consider the following ionization energies for aluminum:

$$\begin{aligned} \mathrm{Al}(g) &\rightarrow \mathrm{Al}^{+}(g) + \mathrm{e}^{-} \quad I_1 = 580\ \mathrm{kJ/mol} \\ \mathrm{Al}^{+}(g) &\rightarrow \mathrm{Al}^{2+}(g) + \mathrm{e}^{-} \quad I_2 = 1815\ \mathrm{kJ/mol} \\ \mathrm{Al}^{2+}(g) &\rightarrow \mathrm{Al}^{3+}(g) + \mathrm{e}^{-} \quad I_3 = 2740\ \mathrm{kJ/mol} \\ \mathrm{Al}^{3+}(g) &\rightarrow \mathrm{Al}^{4+}(g) + \mathrm{e}^{-} \quad I_4 = 11,600\ \mathrm{kJ/mol} \end{aligned}$$

a. Account for the trend in the values of the ionization energies.

b. Explain the large increase between $I_3$ and $I_4$.

118. For each of the following pairs of elements

**(Mg and K)** **(F and Cl)**

pick the atom with

a. more favorable (exothermic) electron affinity.

b. higher ionization energy.

c. larger size.

121. Order the atoms in each of the following sets from the least exothermic electron affinity to the most.

a. **S**, **Se**

b. **F**, **Cl**, **Br**, **I**

122. Order the atoms in each of the following sets from the least exothermic electron affinity to the most.

a. **N**, **O**, **F**

b. **Al**, **Si**, **P**

127. An ionic compound of potassium and oxygen has the empirical formula **KO**. Would you expect this compound to be potassium(II) oxide or potassium peroxide? Explain.

133. Complete and balance the equations for the following reactions.

a. $\mathbf{Li}(s) + \mathbf{N_2}(g) \rightarrow$

b. $\mathbf{Rb}(s) + \mathbf{S}(s) \rightarrow$

138. A certain microwave oven delivers **750. watts** $(\mathbf{J/s})$ of power to a coffee cup containing **50.0 g** water at $\mathbf{25.0^\circ C}$. If the wavelength of microwaves in the oven is **9.75 cm**, how long does it take, and how many photons must be absorbed, to make the water boil? The specific heat capacity of water is $\mathbf{4.18\ J/^\circ C \cdot g}$, and assume only the water absorbs the energy of the microwaves.

143. Are the following statements true for the hydrogen atom only, true for all atoms, or not true for any atoms?

a. The principal quantum number completely determines the energy of a given electron.

b. The angular momentum quantum number, $\ell$, determines the shapes of the atomic orbitals.

c. The magnetic quantum number, $m_\ell$, determines the direction that the atomic orbitals point in space.

145. Which of the following orbital designations are incorrect: $1s$, $1p$, $7d$, $9s$, $3f$, $4f$, $2d$?

148. An ion having a $4+$ charge and a mass of $49.9$ amu has $2$ electrons with principal quantum number $n = 1$, $8$ electrons with $n = 2$, and $10$ electrons with $n = 3$. Supply as many of the properties for the ion as possible from the information given. (*Hint:* In forming ions for this species, the $4s$ electrons are lost before the $3d$ electrons.)

a. the atomic number

b. total number of $s$ electrons

c. total number of $p$ electrons

d. total number of $d$ electrons

e. the number of neutrons in the nucleus

f. the ground-state electron configuration of the neutral atom

149. The successive ionization energies for an unknown element are

$I_1 = 896\ \text{kJ/mol}$

$I_2 = 1752\ \text{kJ/mol}$

$I_3 = 14,807\ \text{kJ/mol}$

$I_4 = 17,948\ \text{kJ/mol}$

To which family in the periodic table does the unknown element most likely belong?