CH 221 Problem Set #6

Covering: **Chapter Six, Chapter Seven** *and* **Chapter Guide Six**
Important Tables and/or Constants: **c = 2.998 x 10^{8} m/s, h = 6.626 x 10^{-34} J s**, **Figure 6.25 pg. 233** *(subshell filling order)*

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1. Consider the colors of the visible spectrum.
    a. What color of light has photons of greater energy, yellow or blue?
    b. Which color of light has the greater frequency, blue or green?
    c. Place the following types of radiation in order of increasing energy per photon.
        i. radar signals (RADAR = RAdio Detection And Recognition)
        ii. radiation within a microwave oven
        iii. gamma rays from a nuclear reaction
        iv. red light from a neon sign
        v. ultraviolet radiation from a sun lamp
2. The most prominent line in the spectrum of magnesium is 285.2 nm. Other lines are found at 383.8 and 518.4 nm. In which region of the electromagnetic spectrum are these lines found? Which is the most energetic line? What is the frequency and energy (in both Joules per atom and kJ per mol) of the wavelength of the most energetic line?
3. Consider only transitions involving the n = 1 through n = 4 energy levels for the hydrogen atom:
    a. How many emission lines are possible?
    b. Photons of the lowest energy are emitted in a transition from the level with n = ___ to a level with n = ___.
    c. The emission line having the shortest wavelength corresponds to a transition from the level with n = ___ to the level with n = ___.
4. A beam of electrons (m = 9.11 x 10^{-31} kg/electron) has an average speed of 1.3 x 10^{8} m s^{-1}. What is the wavelength of electrons having this average speed?
5. Answer the following questions:
    a. When n = 4, ℓ = 2 and m_l = -1, to what orbital type does this refer? (Use the orbital label, such as 1*s*.)
    b. How many orbitals occur in the n = 5 electron shell? How many subshells? What are the letter labels of the subshells?
    c. If a subshell is labeled *f*, how many orbitals occur in the subshell? What are the values of m_l?
6. Explain briefly why each of the following is not a possible set of quantum numbers for an electron in an atom. In each case, change the incorrect value(s) to make the set valid.
    a. $n = 2, \ell = 2, m_l = 0, m_s = +{}^1/_2$
    b. $n = 2, \ell = 1, m_l = -1, m_s = 0$
    c. $n = 3, \ell = 1, m_l = +2, m_s = +{}^1/_2$

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7. What is the maximum number of orbitals that can be identified by each of the following sets of quantum numbers?
    a. $n = 4$, $\ell = 3$
    b. $n = 5$
    c. $n = 2$, $\ell = 2$
    d. $n = 3$, $\ell = 1$, $m_l = -1$
8. State which of the following are incorrect designations for orbitals according to the quantum theory: 3*p*, 4*s*, 2*f*, and 1*p*. Briefly explain your answers.
9. How many nodal surfaces (planar *and* spherical) are associated with each of the following atomic orbitals?
    a. 4*f*
    b. 2*p*
    c. 6*s*
10. Answer the following questions:
    a. The quantum number *n* describes the _____ of an atomic orbital and the quantum number ℓ describes its _____.
    b. When $n = 3$, the possible values of ℓ are _____.
    c. What type of orbital corresponds to $l = 3$?
    d. For a 4*d* orbital, the value of *n* is ___, the value of ℓ is ___, and a possible value of m_l is ___.
    e. For each of the orbitals shown in *Figure 12*, give the letter designation for the orbital, the value of ℓ, and the number of nodal surfaces.

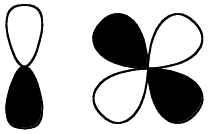

Figure 12

    f. An atomic orbital with three planar nodal surfaces is _____.
    g. Which of the following orbitals cannot exist according to modern quantum theory? 2*s*, 3*p*, 2*d*, 3*f*, 5*p*, 6*p*
    h. Which of the following is *not* a valid set of quantum numbers?
        i. $n = 3$, $\ell = 2$, $m_l = 1$
        ii. $n = 2$, $\ell = 1$, $m_l = 2$
        iii. $n = 4$, $\ell = 3$, $m_l = 0$
    i. What is the maximum number of orbitals that can be associated with each of the following sets of quantum numbers?
        i. $n = 2$ and $\ell = 1$
        ii. $n = 3$
        iii. $n = 3$ and $\ell = 3$
        iv. $n = 2$, $\ell = 1$, $m_l = 0$

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11. In principle, which of the following can be determined?
    a. The energy of a high-speed electron in the H atom with high precision and accuracy
    b. The position of a high-speed electron with high precision and accuracy
    c. At the same time, both the position and the energy of a high-speed electron with high precision and accuracy.
12. Write the electron configuration for Mg and Ar using both *spdf* notation and orbital box diagrams.
13. Using *spdf* and noble gas notations, write electron configurations for atoms of the following elements:
    a. Strontium, Sr. This element is named for a town in Scotland.
    b. Zirconium, Zr. The metal is exceptionally resistant to corrosion and so has important industrial applications. Moon rocks show a surprisingly high zirconium content compared with rocks on earth.
    c. Rhodium, Rh. This metal is used in jewelry and in catalysts in industry.
    d. Tin, Sn. The metal was used in the ancient world. Alloys of tin (solder, bronze, pewter) and important.
14. Using orbital box diagrams, depict an electron configuration for each of the following ions:
    a. Na^{+}
    b. Al^{3+}
    c. Ge^{2+}
    d. F^{-}
15. Explain each answer briefly:
    a. Arrange the following elements in order of increasing size: Ca, Rb, P, Ge, Sr
    b. Which has the largest first ionization energy: O, S, or Se?
    c. Which has the most negative electron affinity: Se, Cl or Br?
    d. Which has the largest radius: O^{2-}, F^{-} or F?
    e. Which is most paramagnetic: Fe^{3+} or Cr^{3+}? Explain.
16. The diagrams in Figure 20, *right*, represent a small section of a solid. Each circle represents an atom and an arrow represents an electron.
    a. Which represents a diamagnetic solid, which is a paramagnetic solid, and which is a ferromagnetic solid?
    b. Which is most strongly attracted to a magnetic field? Which is least attracted?

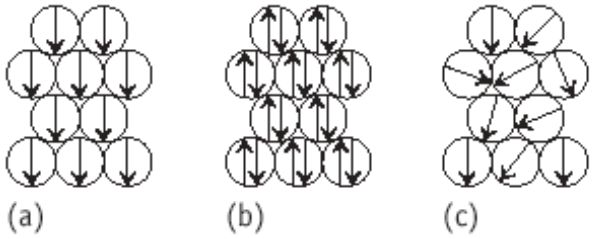

Figure 20

17. Answer the following questions about the elements with the electron configurations given here: **A** = [Ar]$4s^2$ **B** = [Ar]$4s^2 3d^{10} 4p^5$
    a. Is element **A** a metal, metalloid or nonmetal?
    b. Is element **B** a metal, metalloid or nonmetal?
    c. Which element is expected to have the larger ionization energy?
    d. Which element has the smaller atomic radius?