CH 221 Practice Problem Set #6

*This is a **practice problem set** and not the actual graded problem set that you will turn in for credit. Answers to each problem can be found at the end of this assignment.*

Covering: **Chapter Six** *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**, the **Electromagnetic Spectrum** *and* **Subshell Filling Order diagrams** *on page 5 of Problem Set #6.* ***Memorize c and h!***

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1. Traffic signals are often now made of LEDs (light-emitting diodes). The light from an amber signal has a wavelength of 595 nm, and that from a green signal has wavelength of 500 nm. Which has the higher frequency? Which has the highest energy per photon? Calculate the frequency of amber light.
2. Place the following types of radiation in order of increasing energy per photon:
   a. yellow light from a sodium lamp
   b. x-rays from an instrument in a dentist's office
   c. microwaves in a microwave oven
   d. your favorite FM music station at 91.7 MHz
3. The most prominent line in the spectrum of aluminum is at 396.15 nm. What is the frequency of this line? What is the energy of one photon with this wavelength? Of 1.00 mol of these photons?
4. The energy emitted when an electron moves from a higher energy state to a lower energy state in any atom can be observed as electromagnetic radiation.
   a. Which involves the emission of less energy in the H atom, an electron moving from $n = 4$ to $n = 2$ or an electron moving from $n = 3$ to $n = 2$?
   b. Which involves the emission of more energy in the H atom, an electron moving from $n = 4$ to $n = 1$ or an electron moving from $n = 5$ to $n = 2$? Explain fully.
5. A rifle bullet (mass = 1.50 g) has a velocity of 7.00 x 10^{2} miles per hour. What is the wavelength associated with this bullet? (0.6214 miles = 1 km)
6. a. When $n = 4$, what are the possible values of ℓ?
   b. When ℓ is 2, what are the possible values of m_ℓ?
   c. For a 4*s* orbital, what are the possible values of n, ℓ, and m_ℓ?
   d. For a 4*f* orbital, what are the possible values of n, ℓ, and m_ℓ?
7. Which of the following represent valid sets of quantum numbers? For a set that is invalid, explain briefly why it is not correct.
   a. $n = 3$, $\ell = 3$, $m_\ell = 0$, $m_s = 0$
   b. $n = 2$, $\ell = 1$, $m_\ell = 0$, $m_s = +1/2$
   c. $n = 6$, $\ell = 5$, $m_\ell = -1$, $m_s = -1/2$
   d. $n = 4$, $\ell = 3$, $m_\ell = -4$, $m_s = -1/2$

8. What is the maximum number of orbitals that can be identified by each of the following sets of quantum numbers? When "none" is the correct answer, explain your reasoning.
   a. $n = 3$, $\ell = 0$, $m_\ell = -1$
   b. $n = 5$, $\ell = 1$
   c. $n = 7$, $\ell = 5$
   d. $n = 4$, $\ell = 2$, $m_\ell = -2$, $m_s = -1/2$
9. How many nodal surfaces (planar *and* spherical) are associated with each of the following atomic orbitals?
   a. 5*f*
   b. 1*p*
   c. 4*s*
10. Answer the following questions:
   a. The quantum number *n* describes the _____ of an atomic orbital.
   b. The shape of an atomic orbital is given by the quantum number _____.
   c. A photon of green light has _____ (less or more) energy than a photon of orange light.
   d. The maximum number of orbitals that may be associated with the set of quantum numbers $n = 4$ and $\ell = 3$ is _____.
   e. The maximum number of orbitals that may be associated with the quantum number set $n = 3$, $\ell = 2$, and $m_\ell = -2$ is _____.
   f. Sketch a *d*, *s* and *p* orbital.
   g. When $n = 5$, the possible values of ℓ are _____.
   h. The number of orbitals in the $n = 4$ shell is _____.
   i. The maximum number of orbitals that may be associated with the quantum number set $n = 3$, $\ell = 3$, $m_\ell = -2$ and $m_s = -1/2$ is _____.
   j. The maximum number of orbitals that may be associated with the quantum number set $n = 6$, $\ell = 0$, $m_\ell = 0$ and $m_s = +1/2$ is _____.
11. Write the electron configurations for P and Mg using *spdf* notation and orbital box diagrams.
12. Depict the electron configuration for each of the following atoms using *spdf* and/or noble gas notations.
   a. Arsenic, As. A deficiency of As can impair growth in animals even though larger amounts are poisonous.
   b. Krypton, Kr. It ranks seventh in abundance of the gases in the earth's atmosphere.
   c. Vanadium, V, an element found in some brown and red algae and some toadstools
13. Using orbital box diagrams and noble gas notation, depict the electron configurations of the following: (a) V, (b) V^{2+}, and (c) V^{5+}. Are any of the ions paramagnetic?
14. Arrange the following elements in order of increasing size: Al, B, C, K, and Na.
15. Name the element corresponding to each characteristic below.
   a. the element with the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^3$
   b. the alkaline earth element with the smallest atomic radius
   c. the element with the largest ionization energy in Group 5A
   d. the element whose 2+ ion has the configuration [Kr]$4d^5$
   e. the element with the most negative electron affinity in Group 7A
   f. the element whose electron configuration is [Ar]$3d^{10}4s^2$

Answers to the Practice Problem Set:

1. Green, green, 5.04×10^{14} Hz
2. FM radio (d) < microwaves (c) < yellow light (a) < X-rays (b)
3. 7.5676×10^{14} s^{-1}, 5.0144×10^{-19} J/photon, 3.02×10^{5} J/mol photons
4. a. $n = 3$ to $n = 2$ b. $n = 4$ to $n = 1$
5. 1.41×10^{-33} m
6. *Answers:*
   a. ℓ can be 0, 1, 2, 3
   b. m_ℓ can be 0, ±1, ±2
   c. $n = 4$, $\ell = 0$, $m_\ell = 0$
   d. $n = 4$, $\ell = 3$, $m_\ell = 0, \pm1, \pm2, \pm3$
7. *Answers:*
   b. and c. are valid sets of quantum numbers
   a. incorrect; when $n = 3$, the maximum value of ℓ is 2; also, m_s = *must* be $+1/2$ or $-1/2$
   d. incorrect; when $\ell = 3$, m_ℓ can only have values of 0, ±1, ±2, or ±3
8. a. none b. 3 c. 11 d. 1
9. a. 3 planar, 1 spherical b. zero planar, zero spherical c. zero planar, three spherical
10. a. size, energy b. ℓ c. more d. 7 e. 1 f. "cloverleaf", "spherical", "figure eight/dumbbell" g. 0, 1, 2, 3, 4 h. 16 i. 0 j. 1
11. P: $1s^2 2s^2 2p^6 3s^2 3p^3$ Mg: $1s^2 2s^2 2p^6 3s^2$
12. a. [Ar]$3d^{10} 4s^2 4p^3$ b. [Ar]$3d^{10} 4s^2 4p^6$ c. [Ar]$3d^3 4s^2$
13. a. [Ar]$3d^3 4s^2$ b. [Ar]$3d^3$ c. [Ar]
14. C < B < Al < Na < K
15. a. P b. Be c. N d. Tc e. Cl f. Zn