1. (2 points) Light is given off by a sodium- or mercury-containing streetlight when the atoms are excited in some way. The light you see arises for which one of the following reasons:

   (a) Electrons moving from a given energy level to one of higher *n*

   (b) Electrons being removed from the atom, thereby creating a metal cation

   (c) Electrons moving from a given energy level to one of lower *n*

   (d) Electrons whizzing about the nucleus in an absolute frenzy

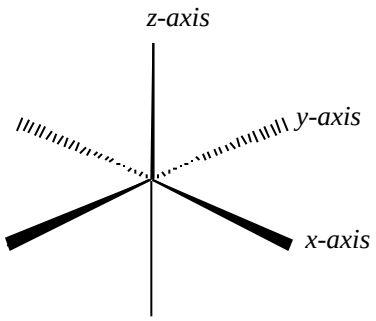
2. (2 points) What is incorrect about the Bohr model of the atom? How is this "corrected" in the more modern view of the atom's structure?

3. (4 points) Match the values of ℓ shown in the table with orbital type (*s*, *p*, *d*, or *f*).

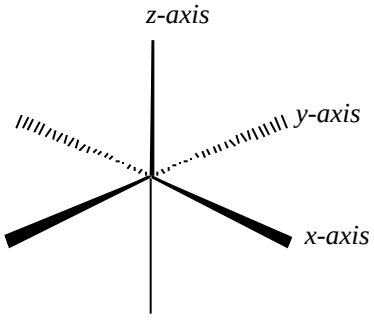
ℓ Value	Orbital Type
3	_____
0	_____
1	_____
2	_____

4. (4 points) Sketch *carefully* a picture of the 90% boundary surface of an *s* orbital and the p_x orbital. Be sure the latter drawing shows why the *p* orbital is labeled p_x and not p_y, for example.

Draw 90% surface for s orbital



Draw 90% surface for p_x orbital



Electromagnetic Radiation

5. (5 points) Visible spectrum.

   (a) Which color of light has photons of greater energy, yellow or blue? _____

   (b) Which color of light has the higher frequency, blue or green? _____

   (c) Which type of radiation involves less energy, x-rays or microwaves? _____

   (d) Which radiation has the longer wavelength, ultraviolet or infrared light? _____

   (e) Which types of radiation has the greater energy, red light or radar? _____

6. (5 points) Consider only the following energy levels for the hydrogen atom.

   ---------- $n = 4$

   ---------- $n = 3$

   ---------- $n = 2$

   ---------- $n = 1$

   Assume the emission spectrum of an excited H atom consists of transitions between only the levels given above.

   (a) How many emission lines are possible, considering only the four quantum levels? _____

   (b) Photons of the highest energy are emitted in a transition from the level with n = _____ to level with the n = _____.

   (c) The emission line having the longest wavelength corresponds to a transition from the level with n = _____ to the level with n = _____.

7. (6 points) The most prominent line in the line spectrum of aluminum is found at 396.15 nm. What is the frequency of this line?

   (a) $3.96 \times 10^{-7}\ s^{-1}$

   (b) $3.00 \times 10^{8}\ s^{-1}$

   (c) $7.57 \times 10^{5}\ s^{-1}$

   (d) $7.57 \times 10^{14}\ s^{-1}$

   What is the energy of 1.00 mol of these photons?

   (a) 3.0×10^{5} J/mol

   (b) 0.00030 J/mol

   (c) 0.129 J/mol

   (d) 1.58×10^{-16} J/mol

8. (9 points) Answer the following questions:

   (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 3*p* orbital, what are the possible values of n, ℓ, and m_ℓ?

   n = _____ ℓ = _____ m_ℓ = _____

   (d) When $n = 4$, $\ell = 2$ and $m_\ell = -1$, to what orbital type does this refer? (Give the orbital label, such as 1*s*.) _____

   (e) In the $n = 3$ shell, there are _____ subshells and _____ orbitals.

   (f) If a subshell is labeled *f*, how many orbitals occur in the subshell? _____

9. (4 points) What is the maximum number of electrons that can be identified by each of the following sets of quantum numbers? When "none" is the correct answer, explain your reasoning.

Quantum Number Set	***Maximum Number of Electrons***
(a) $n = 4$, $\ell = 3$	_____
(b) $n = 5$	_____
(c) $n = 2$, $\ell = 2$	_____
(d) $n = 3$, $\ell = 1$, $m_\ell = -1$	_____

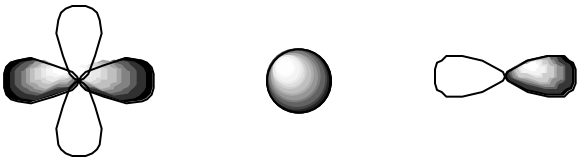
10. (4 points) When Sojouner landed on Mars in 1997, the planet was approximately 7.8×10^7 km from the earth. How long did it take, in minutes, for the television picture signal to reach Earth from Mars?. ***Show your work!***

11. (15 points) Answer the following questions.

(a) The quantum number n describes the _____ of an atomic orbital and the quantum number ℓ describes its _____.

(b) For a 4*d* orbital, the value of n is _____, the value of ℓ is _____, and a possible value of m_ℓ is _____.

(c) Each drawing represents a type of atomic orbital. Give the letter designation for the orbital and its value of ℓ.



letter = _____ _____ _____

ℓ value = _____ _____ _____

(d) An atomic orbital with 3 nodal planes is _____

(e) Which of the following orbitals cannot exist according to modern quantum theory: 2*s*, 3*p*, 2*d*, 3*f*, 5*p*, 6*p*? _____

(f) Which one of the following is *not* a valid set of quantum numbers?

n	ℓ	m_ℓ
3	2	1
2	1	2
4	3	0

ELECTRON CONFIGURATIONS AND PROPERTIES OF THE ELEMENTS

1. (8 points) Name the element or give the symbol of the element, that corresponds to each characteristic below or otherwise answer the question.

a) The element with the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^4$. _____

b) The element whose 2+ ion has the configuration [Xe]. _____

c) The element whose 3+ ion configuration is $[Ar]3d^6$. _____

c) The element with the configuration $[Rn]7s^2 5f^3$. _____

d) The element whose 2- ion has the configuration $1s^2 2s^2 2p^6$. _____

e) The element at which the n = 3 shell is completed _____

f) The group in the periodic table whose elements all have the configuration [noble gas]ns^2 is called _____

g) The elements in the periodic table that utilize *5f* orbitals for valence electrons. _____

2. (9 points) Electron Configurations

(a) Use the *orbital box notation* to give the electron configuration for *phosphorus*. Show all the orbitals in your diagram. (That is, do *not* use the noble gas abbreviation.)

(b) Using the *spectroscopic notation*, give the electron configuration for the phosphorus(III) ion, P^{3+}.

(c) Use the *orbital box notation* (and the *noble gas abbreviation*) to show the electron configuration for the manganese(II) ion.

Is the Mn^{2+} ion paramagnetic or diamagnetic? _____

(d) Element 106 was recently named seaborgium, Sg, in honor of Glenn Seaborg, the recipient of the Nobel Prize in Chemistry in 1951 for discovering a number of new elements. He is still an active scientist even though he is 85 years old. (See *Chemistry & Chemical Reactivity*, page 1106.) Depict the likely electron configuration for Sg using the *spectroscopic notation* and *noble gas abbrevia - tion*.

3. (6 points) Answer the questions below about the elements A and B, which have the electron configurations shown.

A = $[Kr]5s^1$ B = $[Ar]3d^{10}4s^24p^4$

(a) Is element A a metal, nonmetal, or metalloid? _____

(b) Which element has the greater ionization energy? _____

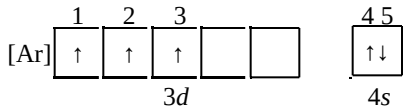
(c) Which element has the greater (more negative) electron affinity? _____

(d) Which element has larger atoms? _____

(e) Which is more likely to form a cation? _____

(e) What is a likely formula for a compound formed between A and B (e.g, AB, AB_2) _____

4. (9 points) The configuration of an element is given here.



(a) What is the identity of the element? _____

(b) In what group and period is the element found? _____

(c) Is the element a nonmetal, a main group element, a transition element, a lanthanide element, or an actinide element? _____

(d) Is the element diamagnetic or paramagnetic? If paramagnetic, how many unpaired electrons are there? _____

(e) Write a complete set of quantum numbers (n, ℓ, m_ℓ, m_s) for electrons 1, 2, and 5.

Electron	**n**	ℓ	$\mathbf{m_\ell}$	$\mathbf{m_s}$
1	____	____	____	____
2	____	____	____	____
4	____	____	____	____

(f) If two electrons are removed to form the 2+ ion, what two electrons are removed? _____ Is the ion diamagnetic or paramagnetic? _____

5. (4 points) Compare the elements Na, B, Al, and C with regard to the following properties.

(a) Which has the largest atomic radius? _____

(b) Which has the largest electron affinity? _____

(c) Place the elements in order of increasing ionization energy.

_____ _____ _____
lowest IE highest IE

6. (2 points) Explain why the first ionization energy of Ca is greater than that of K, whereas the second ionization energy of Ca is lower than the second ionization energy of K.

7. (2 points) Explain why the reaction of calcium and fluorine does not have the balanced equation

$2\ Ca(s) + 3\ F_2(g) \rightarrow 2\ CaF_3(s)$