Chem 115 POGIL Worksheet - Week #9 - Solutions
Quantum Mechanical Model of Electronic Structure

Key Questions

1. The wave functions, which describe orbitals, are cast in terms of three quantum numbers. Fill in the table below with the name and allowed values for each quantum number.

Number	Name	Allowed values
n	principal	1, 2, 3, ...
l	azimuthal	0, ..., $n - 1$
m_l	magnetic	$-l$, $(-l + 1)$, ..., 0, ..., $(l - 1)$, l

2. The table below shows various combinations of the three quantum numbers. Indicate which combinations are allowed and which are disallowed. For those that are allowed, give the subshell notation (e.g., 2*p*).

n	l	m_l	Allowed?	Notation
3	2	–1	yes	3*d*
4	0	0	yes	4*s*
2	2	1	no	
5	1	1	yes	5*p*
4	3	–2	yes	4*f*
4	–3	0	no	

3. Describe the characteristic shapes of *s*, *p*, and *d* orbitals that distinguish them from each other?

   All *s* orbitals are spheres. The *p* orbitals have opposite lobes along an axis ("dumbbell" shape"). Four of the five *d* orbitals are clover-leaf shaped, and one (d_{z^2}) has a dumbbell and doughnut shape.

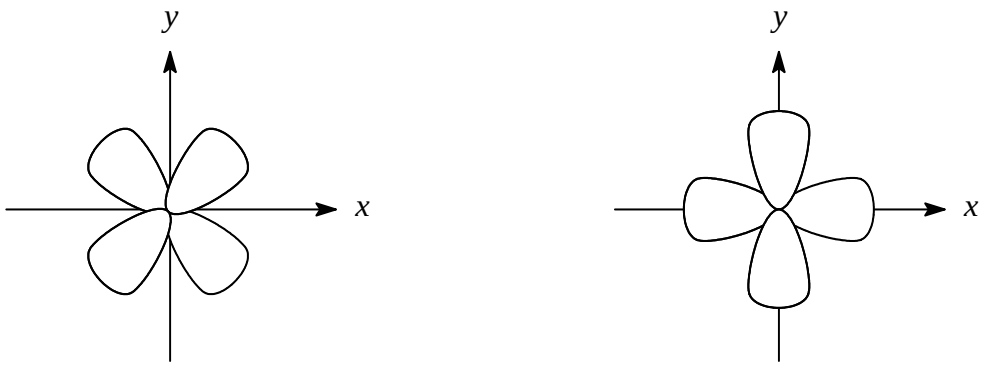
4. Which quantum number identifies the shape of an orbital?

   l, the azimuthal

5. What happens to the size and number of nodes of a particular type of orbital (e.g., *ns* orbitals) as the principal quantum number increases.

   As *n* increases, each orbital type gets larger and acquires an additional spherical node for every integer increase of *n*.

6. On the axes below, sketch a $3d_{xy}$ orbital on the left and a $3d_{x^2-y^2}$ orbital on the right.



   Note that the lobes of the cloverleaf shape lie *between* the axes for a $3d_{xy}$ orbital and *on* the axes for a $3d_{x^2-y^2}$ orbital.

7. In light of the Pauli Exclusion Principle, indicate the electron capacities of the following subshells:

3*s*	2*p*	5*f*	3*d*
2	6	14	10

8. In a one-electron atom the energy depends solely on *n* (e.g., 3*s* = 3*p* = 3*d*). In multielectron atoms, the energy depends on both *n* and *l*. List the following orbitals in order of increasing energy (i.e., most stable first): 4*f*, 3*s*, 4*p*, 2*p*, 3*d*.

   $2p < 3s < 3d < 4p < 4f$

9. Write the complete electronic configuration for each of the following atoms in their ground states.

   $_{6}C$ $1s^2 2s^2 2p^2$
   $_{17}Cl$ $1s^2 2s^2 2p^6 3s^2 3p^5$
   $_{23}V$ $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$
   $_{20}Ca$ $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
   $_{53}I$ $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^5$
   $_{81}Tl$ $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^{10} 6p^1$

10. Write the complete electronic configurations of these two elements.

    $_{24}Cr$ $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$ *not* $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^4$
    $_{29}Cu$ $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$ *not* $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^9$

11. Looking at a periodic table, write down the valence configuration for each of the following

elements. (Practice this on your own so that you can do this without hesitation.)
$_{33}As$ $4s^2 4p^3$ $_{28}Ni$ $3d^8 4s^2$ $_{55}Cs$ $6s^1$ $_{48}Cd$ $4d^{10} 5s^2$ $_{38}Sr$ $5s^2$

12. Consider gold, $_{79}Au$, whose valence configuration is irregular in the same way as $_{29}Cu$ and $_{47}Ag$.
    a. Write the valence configuration of $_{79}Au$ in shell order.
    $5d^{10} 6s^1$ (The fully-fill *d* subshell favors this over the aufbau expected $5d^9 6s^2$.)
    b. Write the complete electronic configuration of $_{79}Au$ in shell order.
    $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 4f^{14} 5s^2 5p^6 5d^{10} 6s^1$
    c. Write the valence configuration of Au^+ by removing one electron from the highest energy occupied subshell in the configuration of neutral Au.
    $5d^{10} 6s^0$, or just $5d^{10}$ (Note that the first electron removed is from the 6*s* subshell.)
    d. Write the valence configuration of Au^{3+} by removing two electrons from the highest energy occupied subshell in the configuration of Au^+.
    $5d^8$

13. Write the condensed electronic configurations for the elements whose valence configurations you wrote in Key Question 11, above.
    $_{33}As$ $[Ar]3d^{10} 4s^2 4p^3$ $_{28}Ni$ $[Ar]3d^8 4s^2$ $_{55}Cs$ $[Xe]6s^1$
    $_{48}Cd$ $[Kr]4d^{10} 5s^2$ $_{38}Sr$ $[Kr]5s^2$

14. Write the condensed electronic configurations for the following ions.
    $_{34}Se^{2-}$ $[Ar]3d^{10} 4s^2 4p^6 = [Kr]$ $_{38}Sr^{2+}$ $[Kr]$
    $_{48}Cd^{2+}$ $[Kr]4d^{10}$ $_{26}Fe^{2+}$ $[Ar]3d^6$
    $_{26}Fe^{3+}$ $[Ar]3d^5$ $_{81}Tl^+$ $[Xe]4f^{14} 5d^{10} 6s^2$

15. Draw box-and-arrow diagrams for the valence configurations of Fe, Fe^{2+}, and Fe^{3+}.