NAME______________________________ **Quantum Mechanics/Trends Lab**

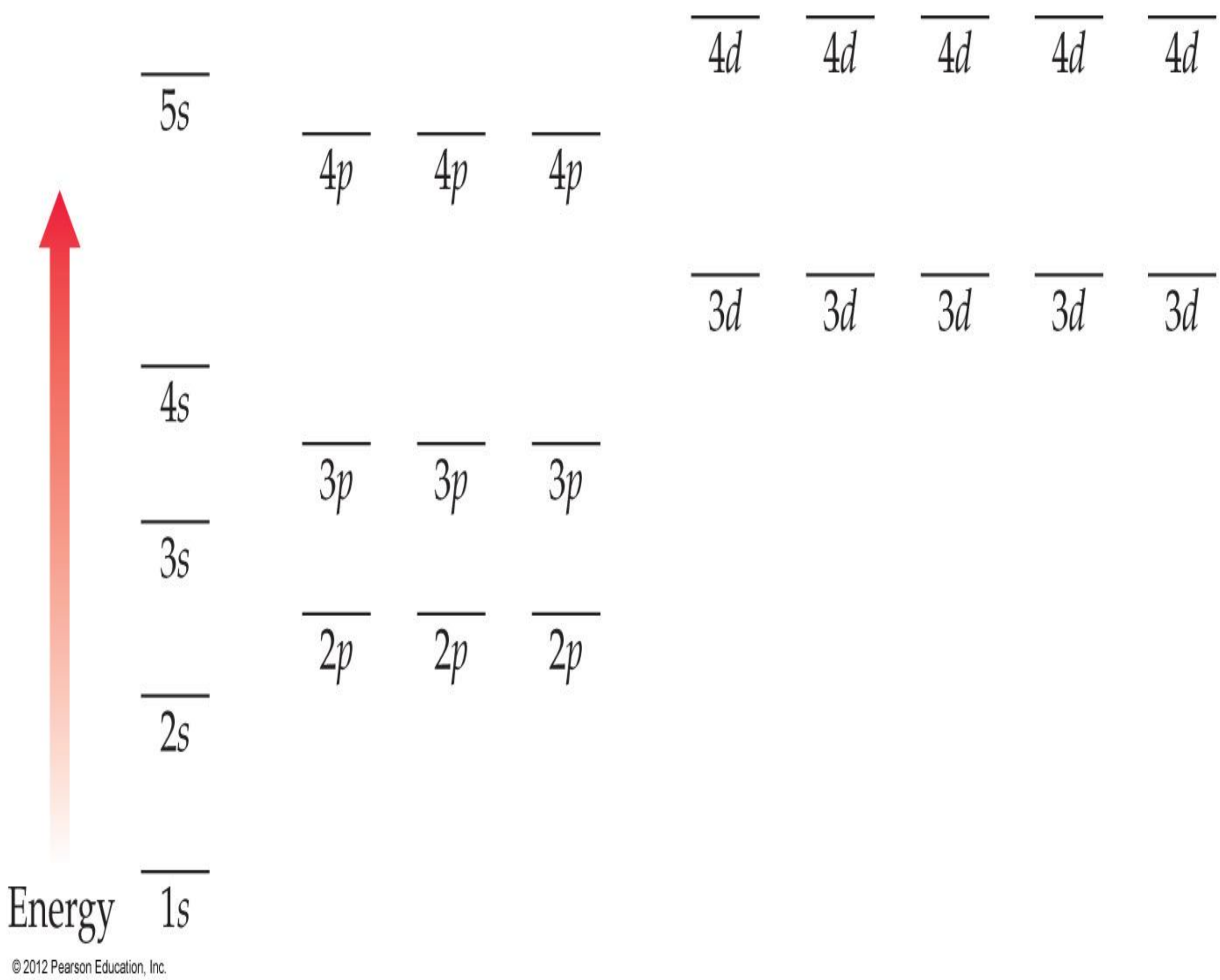
Quantum mechanics:

- The electron orbit model (Bohr Model) that was proposed for hydrogen, does not work for any other atom. This model does give us the idea of quantization: that there are only specific energies avaliable for the electron. (Remember the ladder)
- A better model is used to describe where the electrons can be found in an atom. This is Quantum mechanics. It is based on the idea that electrons behave both as waves and as particles, but keeps the quantized idea from before.
- The "orbitals" are 3D volumes where you have a 90% chance of finding a particular electron. Each electron in an atom has a set of 4 quantum numbers which are like a serial number. <u>Each electron muse have its own unique set of quantum numbers.</u> The first three designate which orbital you can find the electron, and the last designates the spin on the electron.
- These quantum numbers are:
  - n This tells you the "shell number" and tells you the SIZE of the orbital. It also is a large factor in the energy of the orbital. Larger n, means larger size and energy.
    - n=1,2,3,4,5,6,…
  - l This tells you the shape of the orbital, and is often called the "subshell". We use letters to name the shape. There is some energy associated with this number as well. So, in energy terms:

    $$s<p<d<f$$

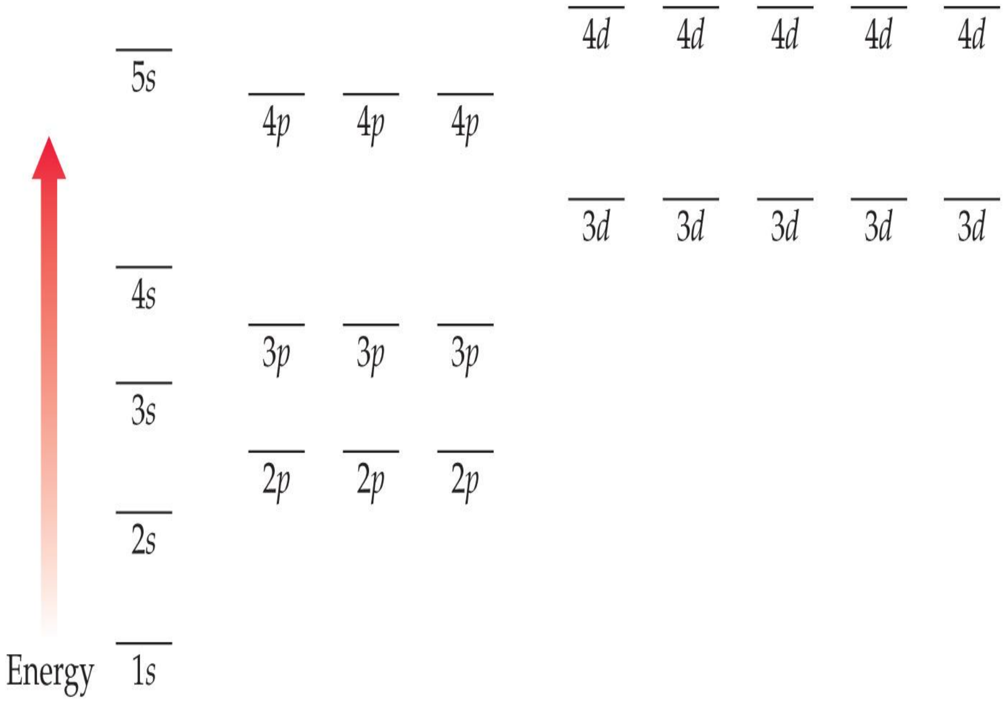
    The shell number (n) dictates how many types of orbitals you can have. For example if n=1, you can only have s-shaped orbitals, but for n=2, you can have s and p-shaped orbitals
  - The third quantum number tells you how many orbitals of each type there are. This is where we find that the number of each type follows odd numbers:
    - there is only one s-shaped orbital per shell
    - there are 3 p-shaped orbitals per shell
    - there are 5 d-orbitals per shell
    - and so on…
  - The last quantum number tells you the spin of the electron. Because there are 2 types of spin for an electron (up or down) there can only be two electrons per orbital.

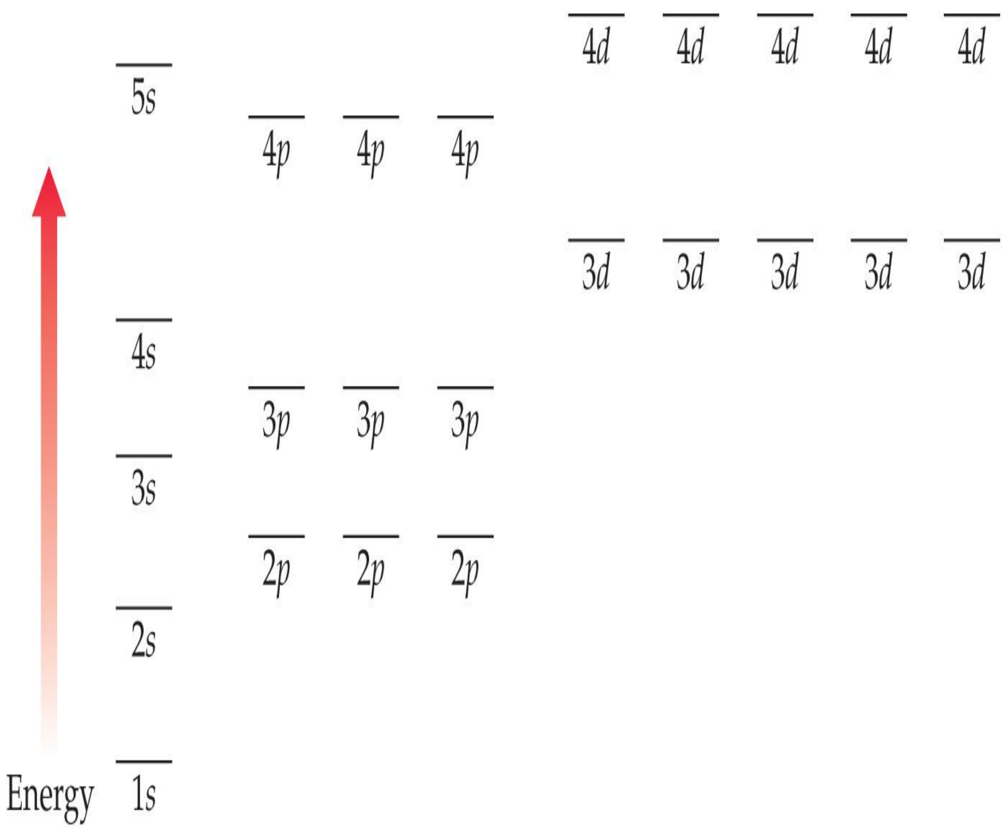
Shell	Number of subshells	Letters specifying subshells			
$n = 4$	4	s	p	d	f
$n = 3$	3	s	p	d	
$n = 2$	2	s	p		
$n = 1$	1	s			



Filling rules:

1. **Fill from low to higher energy.**
2. **Fill orbitals of the same energy halfway before filling any completely**
3. **Only two electrons per orbital, and must have opposite spin.**


Energy
1s
2s
3s
4s
5s
2p 2p 2p
3p 3p 3p
4p 4p 4p
3d 3d 3d 3d 3d
4d 4d 4d 4d 4d


Energy
1s
2s
3s
4s
5s
2p 2p 2p
3p 3p 3p
4p 4p 4p
3d 3d 3d 3d 3d
4d 4d 4d 4d 4d

Write the complete electron configuration and the orbital diagram for each of the following atoms or ions:

1. C:
2. Br:
3. Ar:
4. P^{3-}:
5. Mg^{2+}:

Write the Shorthand electron configuration for the following atoms or ions:

1. Ni:
2. I:
3. I^{-}:
4. Ca:
5. In:
6. In^{3+}:
7. W:
8. W^{2+}:
9. W^{6+}:
10. Bi:

ATOMIC/IONIC RADII

1. Draw the trend on a blank periodic table.
2. When an electron is added to ANY neutral atom, the radius gets ______________________.
    a. Explain what happens to the Z when this happens.
    b. Explain what happens to the shielding when this happens.
    c. The overall effect on Z_{eff} is:
    d. How does your answer in (c) correspond to the radius being larger or smaller?
3. When an electron is remover from ANY neutral atom, the radius gets ______________________.
    a. Explain what happens to the Z when this happens.
    b. Explain what happens to the shielding when this happens.
    c. The overall effect on Z_{eff} is:
    d. How does your answer in (c) correspond to the radius being larger or smaller?
    e. What about if you are an alkali metal and lose an electron, or an alkali earth metal and lose 2 electrons… The answers to (a-d) apply here, too, but there is more. The radius of an ion becomes significantly _____________________ when enough electrons are removed to remove an entire electronic______________ from the configuration.

IONIZATION ENERGY

1. Write the reactions (use E_i for the energy) that corresponds to losing the first 3 electrons.

2. Draw the trend for the first ionization energy on a blank periodic table.

3. How does this trend relate to the size trend for atoms?

    a. (The smallest atom corresponds to the _________________ ionization energy.

    b. The same explanations work for this trend as works for the size trend. Relate the size trend to the ionization trend. If the size is smaller, the electrons are held ___________________, meaning the ionization energy will ______________________.

4. Mark the two columns that are often exceptions to this trend (higher E_{i1} than predicted). Explain why these are exceptions using the electron configurations of a representative element from each of the two columns.

5. Each element has an ionization energy (1st, 2nd, 3rd,…) that is a huge jump in value from the previous one. Why does this happen?

6. Write electron configurations that correspond to Mg, Mg^{+}, Mg^{2+}, and Mg^{3+}. Mark the ionization that corresponds to the huge jump for Mg. What has happened in order to remove this electron?

ELECTRON AFFINITY

1. Write the reaction associated with the electron affinity for an atom.

2. Draw the trend (toward the most favored) for the first ionization energy on a blank periodic table.

3. The MOST favored electron affinity corresponds to the element that ________________the most energy when an electron is added.

4. Black out the columns that have a positive electron affinity.

    a. Explain why these columns have a positive electron affinity.

5. Explain the trend from left to right (ignore the exceptions) of the electron affinity using Z_{eff}.

6. Explain the observed trend from bottom to top of the Periodic Table using Z_{eff} and shell number.

1. In each of the following pairs, circle the species with the *higher* first ionization energy:

(a) Li or Cs (b) Cl or Ar (c) Ca or Br (d) Na or Ne (e) B or Be

Now, go back and underline the atom with the smaller radius.

---

2. In each of the following pairs, circle the species with the *larger* atomic radius:

(a) Mg or Ba (b) S or S^{2-} (c) Cu^{+2} or Cu (d) He or H^{-} (e) Na or Cl

Now, go back and underline the atom with the larger first ionization energy

---

3. *Circle* the best choice in each list:

(a) highest *first* ionization energy: C, N, Si

(b) largest radius: S^{2-}, Cl^{-}, Cl

(c) smallest atom: Na, Li, Be

(d) lowest *first* ionization energy: K, Na, Ca

(e) highest *second* ionization energy: Na, Mg, Al

(f) lowest *second* ionization energy: Ar, K, Ca