Electron Configurations

Information: Energy of Sublevels

Each sublevel has a different amount of energy. For example, orbitals in the 3p sublevel have more energy than orbitals in the 2p sublevel. The following is a list of the sublevels from lowest to highest energy:

1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, 5s, 4d, 5p, 6s, 4f, 5d, 6p, 7s, 5f, 6d…

To help you, here is the above list with the orbitals included. Recall that each blank represents an orbital:

1s-, 2s-, 2p---, 3s-, 3p---, 4s-, 3d-----, 4p---, 5s-, 4d-----, 5p---, 6s-, 4f-------

Note that d and f sublevels appear to be out of place. This is because they have extra high energies. For example, the 3d sublevel has a higher energy than a 4s sublevel and the 4f sublevel has a higher energy than the 6s sublevel.

When electrons occupy orbitals, they try to have the lowest amount of energy possible. (This is called the ***Aufbau Principle***.) An electron will enter a 2s orbital only after the 1s sublevel is filled up and an electron will enter a 3d orbital only after the 4s sublevel is filled. Recall that only two electrons can fit in each orbital. (This is called the ***Pauli Exclusion Principle***.) When two electrons occupy the same orbital they must spin in opposite directions—one clockwise and the other counterclockwise.

Critical Thinking Questions

1. a) How many electrons would an atom need to have before it can begin filling the 3s sublevel?

   - 10 electrons

   b) What is the first element that has enough electrons to have one in the 4p sublevel? (Use your periodic table.)

   - Gallium

2. a) How many electrons would an atom need to have before it can begin filling the 4d sublevel?

   - 38 electrons

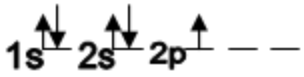
   b) What is the first element that has enough electrons to begin placing electrons in the 4d sublevel?

   - Yttrium

3. How many electrons does the element barium have? (use your periodic table)

   - 81

4. Below are two different ways of depicting the electrons in an atom.

Orbital diagram: 

Electron configuration: $1s^2 2s^2 2p^1$

a) In the orbital diagram, what do the arrows stand for?

- direction the electrons are spinning

b) What do the little superscripts stand for in the electron configuration?

- the electron

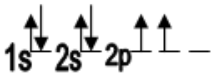
c) Both of the diagrams represent the same element. Name the element.

- Boron

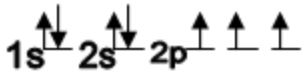
5. For each of the following electron diagrams decide whether it is an "orbital diagram" or an "electron configuration" and name the element.

a) $1s^2 2s^2 2p^6 3s^2 3p^4$

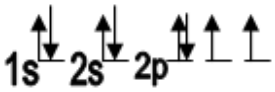
Electron configuration, sulfur

b) 

Orbital diagrams, carbon

c) 

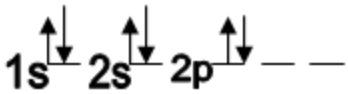
Orbital diagrams, nitrogen

d) 

Orbital diagram, oxygen

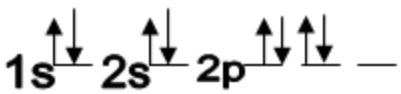
Information: Hund's Rule

Look at the orbital diagram from question 5b. Hopefully you identified the element as carbon. The following diagram has six arrows just like carbon's from 5b:

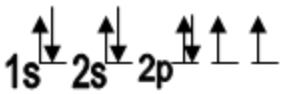


It is technically **wrong** to put the electrons like this. Electrons like to spread out within their sublevel.

Look again at oxygen's orbital diagram from question 5d. The following diagram is a **wrong** way to draw oxygen's orbital diagram:



It is technically **wrong** to put the electrons like this. Electrons like to spread out within their sublevel.



This is **correct**. When electrons have to occupy the same orbital then they will spin in opposite directions.

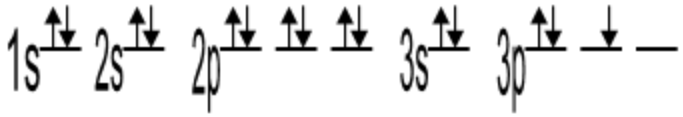
This is **correct**. Electrons like to fill all orbitals within a sublevel before pairing. They will also spin parallel if they are not in the same orbital.

Critical Thinking Questions

6. *Hund's Rule* is the name of the rule that summarizes the above information section about electrons. Highlight the best statement of *Hund's Rule* below.

   A) Electrons prefer to pair up to occupy the same orbital whenever possible.
   B) Whenever possible, electrons will be unpaired (in separate orbitals) with parallel spins.

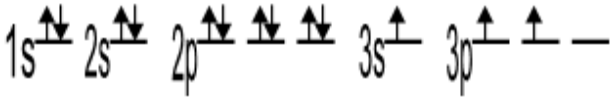
7. The following orbital diagram is drawn incorrectly. Redraw it correctly.



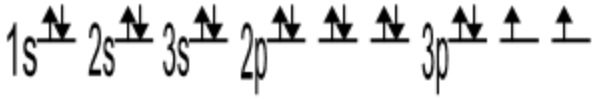
redraw:

1s ↑↓ 2s ↑↓ 2p ↑↓ ↑↓ ↑↓ 3s↑↓ 3p ↑ ↑ ↑

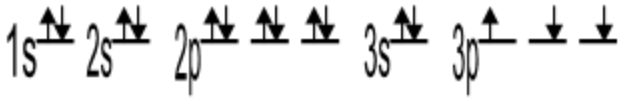
8. Each of the following orbital diagrams is incorrect. Redraw them correctly or explain how the correct drawing would look like.



- the 3s is supposed to have a down arrow
- 3p should only have one upwards arrow.



- the orbitals should be arranged as 1s, 2s, 2p, 3s, 3p



- the 3p last 2 arrows would be facing up

9. Translate the following "electron configurations" and "orbital diagrams" (use arrows).

Electron Configuration	Orbital Diagram (use arrows)
a) $1s^2 2s^2\ 2p^6\ 3s^2 3p^6 4s^2$	**1s ↑↓ 2s ↑↓ 2p ↑↓ ↑↓ ↑↓ 3s ↑↓ 3p ↑↓ ↑↓ ↑↓ 4s ↑↓**
b) $1s^2\ 2s^2\ 2p^6\ 3s^1$	**1s ↑↓ 2s ↑↓ 2p ↑↓ ↑↓ ↑↓ 3s ↑**

c) $1s^2\,2s^2\,2p^5$

1s ↑↓ 2s ↑↓ 2p ↑↓ ↑↓ ↑

10. Look at the electron configurations from question 9. Write the name of each element.

a) The element from question 9a is Potassium

b) The element from question 9b is Sodium

c) The element from question 9c is Fluorine

11. Write electron configurations for the following elements. The first one is done for you.

a) Phosphorus $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$ (phosphorus has 15 electrons)

b) Neon $1s^2\ 2s^2\ 2p^6$ (Neon has 10 electrons)

c) Aluminum $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$ (Aluminum has 13 electrons)

d) Sodium $1s^2\ 2s^2\ 2p^6\ 3s^1$ (Sodium has 11 electrons)

12. The following electron configurations are incorrect. Fix them. (The first is done for you)

Wrong Electron Configuration	Correct Electron Configuration
a) $1s^2 2s^2 3s^2 3p^2$ (First, add up the electrons. There are 8 here.)	$1s^2\ 2s^2\ 2p^4$ (this is the correct way to do 8 electrons)

b) $1s^2\,2s^2\,2p^5\,3s^2$ $1s^2\ 2s^2\ 2p^6\ 3s^1$

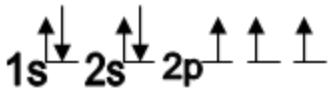
- 2p should have 6 electrons
- 3s should have 1 electrons

c) $1s^2\,2s^4\,2p^8$ $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$

- 2s should have 2 electrons
- 2p should only have 6
- add 3s with 2 electrons
- add 3p with 2 electrons

d) $1s^2\ 2s^2\ 3s^2\ 3p^6$ $1s^2\ 2s^2\ 2p^6\ 3s^2$

- add a 2p with 6 electrons
- take away the 3p with 6 electrons

13. Nitrogen's orbital diagram is: 

Nitrogen as 3 "unpaired electrons" . Define the term unpaired electron:

Unpaired electrons are electrons in separate orbitals with parallel spins.

14. How many unpaired electrons does oxygen have?

- 2 unpaired electrons

15. How many unpaired electrons does chlorine have?

- no unpaired electrons