Electronic Configuration

Name Section

Problem Statements: How are the electrons in an atom arranged? How is the arrangement of electrons in an atom related to the periodic table?

I. Data Collection

A. Go to http://introchem.chem.okstate.edu/DCICLA/aufbau.swf and open the Aufbau Simulation. Your screen should look like the figure below.

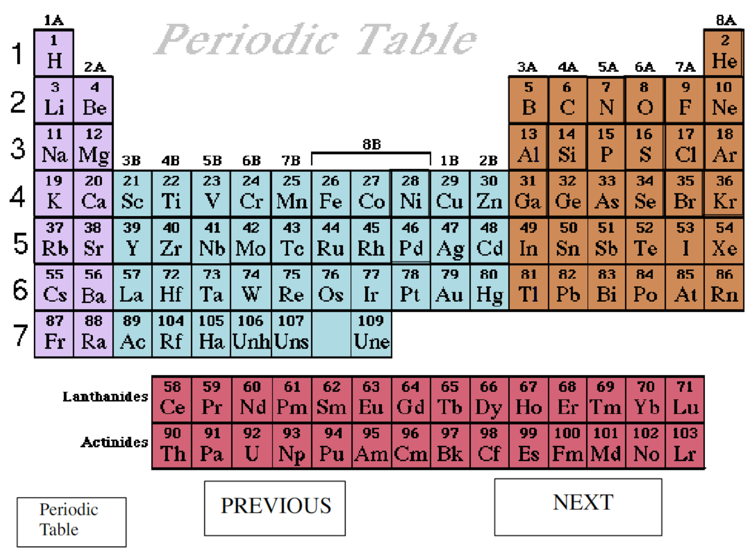


Figure 1.

This window will give you access to the energy level diagrams for many of the elements of the periodic table. Each element square from element 1, H, to element 48, cadmium, will display the locations of each of the electrons in an atom of the element. Click on the box for element 12, magnesium. Your screen should look like the figure below.

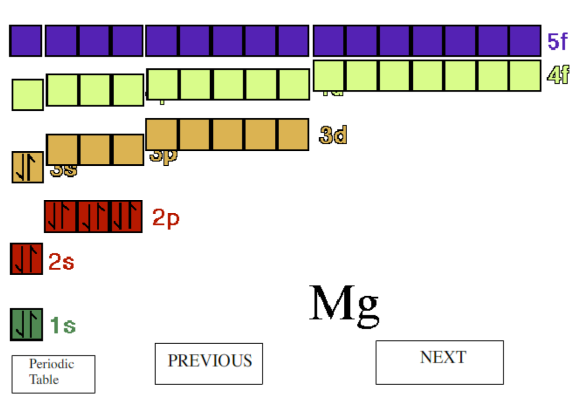


Figure 2.

B. Click on the "Periodic Table" button to return to the periodic table window and click on the "NEXT" button. The diagram represents the energy levels of atoms from the lowest energies to higher energies. Sketch the diagram below.

C. Each box in the diagram is called an orbital and represents the region in space that the electrons in an atom can occupy. The numbers in the diagram label the energy level of the orbital from lowest (1) to higher (5) and the letters identify the type of orbital at each level. Orbital types are grouped together in the diagram and have specified letters. How many s orbitals are there at each energy level? How many p orbitals are at each energy level? How many d orbitals are at each energy level? How many f orbitals are there at each energy level? Fill in the following table with your results.

Energy Level	s orbitals	p orbitals	d orbitals	f orbitals
1				
2				
3				
4				
5				

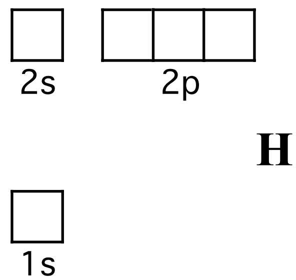
II. Data Analysis, Interpretation, and Conclusions

A. Speculate on why there are more orbitals at higher energy levels. (Consider what happens to the geometry of an atom in three-dimensional space as one get further from the nucleus.)

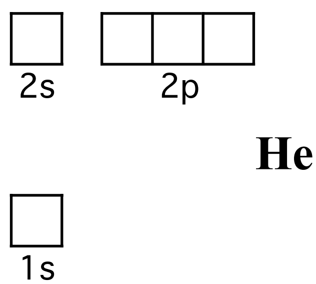
B. Speculate why some orbital types have more orbitals at each energy level. How might s and p orbitals be different so as to account for different numbers? (The three p orbitals are named p_x, p_y, and p_z.)

III. Data Collection

A. Click on the “NEXT” button to display the hydrogen atom. Sketch what you see in the diagram.



B. Click on the “NEXT” button to display the helium atom. Sketch what you see in the diagram.



IV. Data Analysis and Interpretation

A. What do the arrows in the orbitals represent?

B. Why are the arrows pointed in opposite directions? What does the direction of the arrows represent? (Electrons can be thought of as particles that rotate on an axis.)

C. Electrons have common negative charges and consequently repel each other. Why would the second electron in helium go into the same orbital as the first electron instead of a different orbital?

D. The next element is lithium. Where would the next arrow go? Why?

V. Conclusions

A. What are the maximum numbers of electrons that can be put into an orbital? What must be true of these electrons to be able to occupy the same orbital? How is it possible for two electrons to occupy the same space?

B. Why do the electrons for helium fill into the 1s orbital? Why don't they fill into the second or third level? What would be necessary for these electrons to fill into the second level?

C. Locate helium on the periodic table. How many atoms are in the first period (row) of the periodic table? How many atoms are accommodated by the available orbitals in the first energy level? How are the energy levels of the orbitals related to the periodic table?

VI. Data Collection

A. Click on the "NEXT" button to display the lithium atom. Sketch what you see for the first and second energy levels.

B. Predict into which orbital the next electron (representing the beryllium atom) will go. Click on the "NEXT" button to display the Be atom. Sketch what you see for the first and second energy levels.

VII. Data Analysis and Interpretation

A. Why does the third electron representing lithium go into the 2s orbital? Why doesn't it go into one of the 2p orbitals?

B. Why does the fourth electron representing beryllium go into the 2s orbital? Why doesn't it go into one of the 2p orbitals?

C. The next element is boron. Where would the next electron go? Why?

VII. Conclusions

A. Speculate why there are three p orbital but only one s orbital. How are the shapes of s and p orbitals different? Why do the three p orbitals remain at equal energies?

B. Speculate why there are p orbitals at the second energy level, but not at the first energy level.

VIII. Data Collection

A. Click on the “NEXT” button to display the boron atom. Sketch what you see for the first and second energy levels.

B. Predict into which orbital the next electron (representing the carbon atom) will go. Click on the “NEXT” button to display the C atom. Sketch what you see for the first and second energy levels.

IX. Data Analysis and Interpretation

A. Speculate why the 2s and 2p orbitals have different energies in Boron?

B. Why does the sixth electron, representing the element carbon, go into an empty p orbital instead of doubling up as the electrons did in the s orbitals?

C. Consider the relative energies that the 2s and 2p orbitals have. How are they different for B and C? How would you account for any difference? (Using the "PREVIOUS" and "NEXT" buttons, toggle between B and C to see the difference.)

D. Why is the electron for boron placed in the left p orbital? Is there any reason to believe that that orbital has less energy than the other p orbitals?

X. Conclusions

A. The next atom is nitrogen. Predict where the electron will be placed and what will happen to the relative energies of the 2s and 2p orbitals.

B. Predict where the next three electrons for atoms oxygen, fluorine, and neon will be placed. Sketch what you would see for the first and second energy levels for Ne. Confirm your predictions.

C. Locate Ne on the periodic table. How many atoms are accommodated by the available orbitals in the second energy level? How are the energy levels of the orbitals related to the periodic table?

D. Predict where the 11th electron representing the element sodium will be placed. Sketch how the orbitals at the third energy level will look when you view the diagram for Na.

XI. Data Collection

A. Click on the "NEXT" button to display the atoms from Na to Ar. Record your observations concerning how the orbitals are filled and how the added electrons influence the energies of the orbitals at the third energy level.

B. Sketch the diagram for the argon atom.

C. The next atom is potassium. Predict where the 19^{th} electron will be placed. Confirm your prediction and sketch a diagram of the 3^{rd} and 4^{th} energy levels for K.

XII. Data Analysis, Interpretation, and Conclusions

A. Why does the 19^{th} electron representing the potassium atom enter the s orbital in the 4^{th} energy level instead of the d orbital in the 3^{rd} energy level?

B. Locate argon on the periodic table. How many atoms are accommodated by the third period (row) of the periodic table? How is this related to the energy level diagram?

C. How does the location of K on the periodic table account for the location of the 19^{th} electron in the energy level diagram?

XIII. Data Collection

A. Click on the "NEXT" button to display the atoms from K to V. Record your observations concerning how the orbitals are filled and how the added electrons influence the relative energies of the 4s and 3d orbitals.

B. Sketch your prediction for the electron distribution in the 4s and 3d orbitals for the Cr atom.

C. Click on the "NEXT" button to display the chromium atom. Record your observations concerning how the orbitals are filled. Sketch the diagram for the third and fourth energy levels for the Cr atom.

D. Click on the "NEXT" button to display the atoms from chromium to nickel. Record your observations concerning how the orbitals are filled.

E. Click on the "NEXT" button to display the atom copper. Record your observations concerning how the orbitals are filled. Sketch the diagram for the third and fourth energy levels for the Cu atom..

F. Click on the "NEXT" button to display the atom zinc. Record your observations concerning how the orbitals are filled.

G. Click on the "NEXT" button to display the atoms from gallium to krypton. Record your observations concerning how the orbitals are filled.

XIV. Data Analysis and Interpretation

A. Speculate why the energies of the 4s and 3d orbitals become equalized as electrons are added to the atoms from K to Cr?

B. Rationalize the electron arrangement of Cr. Why does the electron arrangement of Cr have a half-filled 4s orbital rather than a filled 4s orbital?

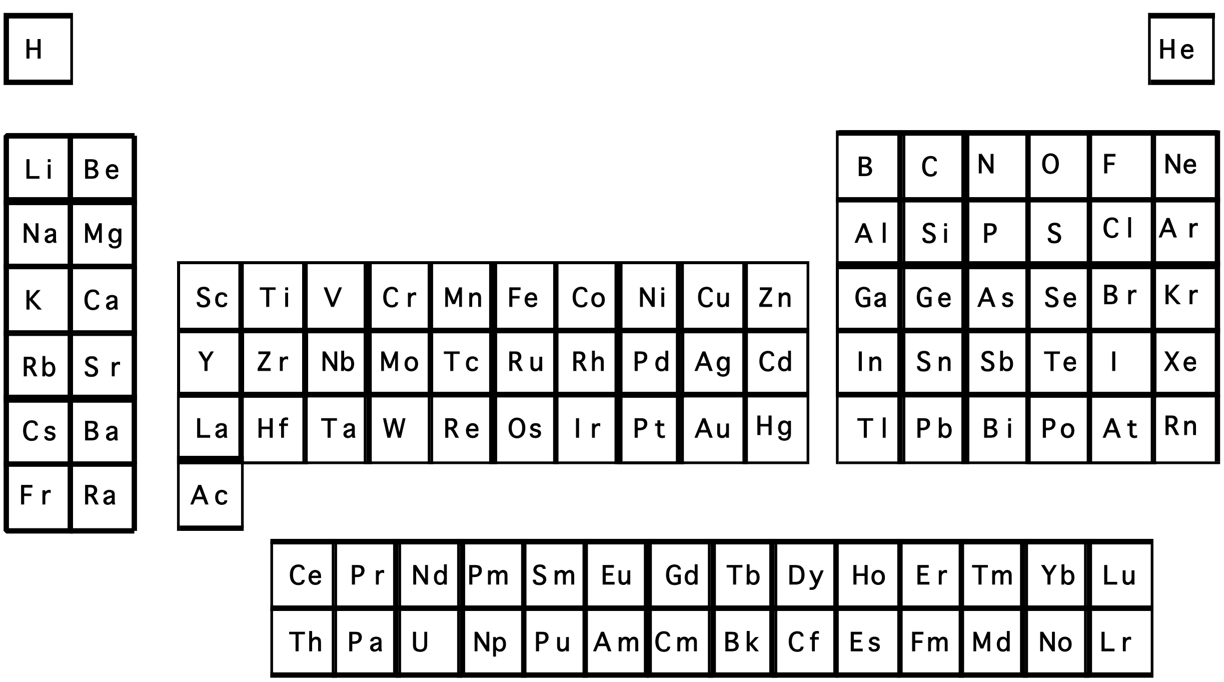
C. Rationalize the electron arrangement of Cu. Why does the electron arrangement of Cu have a half-filled 4s orbital rather than a filled 4s orbital? How might you account for the Cu^{+} and Cu^{2+} ions using different possible electron arrangements in the 4s and 3d orbitals?

XV. Conclusions

A. Consider the elements Sc through Zn on the periodic table. What orbitals and energy levels do these elements represent?

B. Locate krypton on the periodic table. How many atoms are accommodated by the fourth period (row) of the periodic table? How is this related to the energy level diagram? Count the number of atoms in the fourth period. How is this number related to the number of orbitals utilized by these elements?

C. Label the periods (rows) of the periodic table in the following diagram with the corresponding energy level, and the families (columns) with the corresponding orbitals. (The two rows at the bottom of the table represent f electrons.)



D. The two rows at the bottom of the periodic table (called the lanthanides and actinides) can be inserted into the main body of the periodic table after elements 57 and 89 (see the sequence of the atomic numbers for these elements). The atoms of these elements have electrons entering f orbitals. What orbitals are filled right before the 4f orbitals?