Electron Configurations and Orbital Diagrams

According to the Quantum Mechanical model of the atom, every electron of an atom is described by four quantum numbers. The quantum numbers describe the orbitals that the electrons are located in. Each orbital has a unique size (n value), shape (l value), and spatial orientation (m_l value). Each orbital can hold at most two electrons, with a full orbital having two electrons with a different spin direction (m_s value). The location of the electrons within the various orbitals is often expressed by orbital diagrams and electron configuration symbols.

Electrons fill the orbitals of an atom starting with the lowest energy level. Once each orbital at the same energy sublevel is filled, electrons begin filling the orbitals of the next energy sublevel. The ordering of the energy of the various orbital types is shown in the diagram at the left. It might be surprising to observe that the 4s orbitals of an atom have slightly lower energy than the 3d orbitals. While they are very close in energy, the 4s orbital is slightly lower in energy. The diagram at the right represents a convenient way of remembering the order in which the orbitals fill. Simply follow the arrows beginning with the lowest one. A final rule for filling orbitals with electrons is that each orbital at the same energy sublevel must have an electron before electrons begin pairing up inside the same orbital; this is known as Hund’s rule.

The diagram below represents the so-called orbital diagram for chromium. The 24 electrons of a chromium atom will fill each of the atomic orbitals in the manner shown.

An orbital diagram naturally leads to the writing of an electron configuration. The electron configuration for chromium is:

$$1s^22s^22p^63s^23p^64s^23d^6$$

The orbital diagram above is formatted in such a manner as to place the various orbital types at different energy levels. A similar format that is used in the textbook (and serves to save space) is the format below in which the orbitals are listed in order of their energies but along the same line.
1. Show the orbital diagram for the following elements.

Be:  
C:  
F:  
Na:  
Al:  
S:  

2. Write electron configurations (showing where all the electrons are located) for the following. If necessary, use the orbital diagram to assist in the process.

<table>
<thead>
<tr>
<th>Element</th>
<th># of Electrons</th>
<th>Electron Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td></td>
<td></td>
</tr>
<tr>
<td>He</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Li</td>
<td></td>
<td></td>
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<tr>
<td>Be</td>
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<td>C</td>
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<tr>
<td>F</td>
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<tr>
<td>Ne</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Na</td>
<td></td>
<td></td>
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<tr>
<td>Mg</td>
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<td>Al</td>
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<td>S</td>
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<tr>
<td>Ar</td>
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<tr>
<td>K</td>
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<td></td>
</tr>
<tr>
<td>Ca</td>
<td></td>
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</tr>
</tbody>
</table>
3. Fill in the orbital diagram and write the electron configuration of the following:
   a. Kr
      
      
      
      
      
      
      
      
      e- Configuration:

   b. Br
      
      
      
      
      
      
      
      
      e- Configuration:

   c. Rb
      
      
      
      
      
      
      
      
      e- Configuration:

   d. Sc
      
      
      
      
      
      
      
      
      e- Configuration:

   e. Mn
      
      
      
      
      
      
      
      
      e- Configuration:

   f. Cu
      
      
      
      
      
      
      
      
      e- Configuration:

   g. Fe
      
      
      
      
      
      
      
      
      e- Configuration:

   h. Rh
      
      
      
      
      
      
      
      
      e- Configuration:

4. For the following groups of atoms and ions, circle those which have the same electron configuration:
   a. Al      B      F      Mg²⁺      O²⁻
   b. Ca²⁺      Na⁺      S²⁻      Ba²⁺      V³⁺
   c. Se²⁻      I⁻      Sr²⁺      Se      Ba
   d. Y³⁺      Rb      Xe      Br⁻      Kr
5. On the periodic table below, identify the s-block, p-block, d-block and f-block elements. Then make the connection between the various orbitals and the elements in the periodic table.

![Periodic Table]

6. Use the noble gases to write **abbreviated electron configurations** for the following:
   
   a. H ________________________________
   
   b. Li ________________________________
   
   c. O ________________________________
   
   d. Mg ________________________________
   
   e. Cl ________________________________
   
   f. V ________________________________
   
   g. EE ________________________________
   
   h. Se\(^{2-}\) ________________________________
   
   i. Cr\(^{2+}\) ________________________________
   
   j. I\(^{-}\) ________________________________
   
   k. Ag ________________________________
   
   l. Sn\(^{2+}\) ________________________________

7. An ion of an isotope has a 2\(^+\) charge, an atomic mass of 56.9397 amu, 2 electrons at the n=4 energy level and 13 electrons at the n=3 energy level. Determine the ...

   a. ... atomic number: ________________  
   
   b. ... mass number: ________________

   c. ... total number of electrons: ________  
   
   d. ... total number of s electrons: ________

   e. ... total number of p electrons: ________  
   
   f. ... total number of d electrons: ________