Electron Configuration
(Section 5.2)

Dr. Walker
Objectives

• To determine the electron configuration of any of the first 38 elements of the periodic table
• To determine the identity of an element from its electron configuration
• To complete an orbital diagram using arrows to represent electrons
Where are Electrons?

• Electrons exist in different energy levels (previously described as “shells”)

• The energy levels correspond to the horizontal rows on the periodic table
Where are Electrons?

• **Orbitals** are areas within shells where the electrons are located
  – These orbitals may have different shapes
  – There may be different numbers of orbitals within a shell

• We know the electron is somewhere in the orbital, but we can’t know exactly where it is or how fast it is moving
  – Heisenberg’s Uncertainty Principle

• Each orbital can hold two electrons (Pauli Exclusion Principle)
# Periodic Table of the Elements

<table>
<thead>
<tr>
<th>PERIOD</th>
<th>GROUP 1A (1)</th>
<th>GROUP 2A (2)</th>
<th>GROUP 3A (13)</th>
<th>GROUP 4A (14)</th>
<th>GROUP 5A (15)</th>
<th>GROUP 6A (16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H  1.0079</td>
<td>He  4.0026</td>
<td>Li  6.941</td>
<td>Be  9.0122</td>
<td>B  10.811</td>
<td>C  12.0115</td>
</tr>
<tr>
<td>3</td>
<td>K  39.102</td>
<td>Ca  40.078</td>
<td>Sc  44.956</td>
<td>Ti  47.867</td>
<td>V  50.942</td>
<td>Cr  52.000</td>
</tr>
<tr>
<td>4</td>
<td>Rb  85.468</td>
<td>Sr  87.621</td>
<td>Y  88.906</td>
<td>Zr  91.224</td>
<td>Nb  92.906</td>
<td>Mo  95.943</td>
</tr>
<tr>
<td>5</td>
<td>Cs  132.91</td>
<td>Ba  137.33</td>
<td>La  138.91</td>
<td>Ce  140.12</td>
<td>Pr  140.91</td>
<td>Nd  144.24</td>
</tr>
<tr>
<td>6</td>
<td>Fr  223</td>
<td>Ra  226</td>
<td>Ac-Lr  89-103</td>
<td>Rf  261</td>
<td>Db  262</td>
<td>Sg  263</td>
</tr>
</tbody>
</table>

**Lanthanide**

| La  138.91 | Ce  140.91 | Pr  140.91 | Nd  144.24 | Pm  145 | Sm  150.36 | Eu  151.96 | Gd  157.25 | Tb  158.93 | Dy  162.50 | Ho  164.93 | Er  167.26 | Tm  168.93 | Yb  173.04 | Lu  174.97 |

**Actinide**

| Ac  227 | Th  232 | Pa  231 | U  238 | Np  237 | Pu  244 | Am  243 | Cm  247 | Bk  247 | Cf  251 | Es  252 | Fm  257 | Md  261 | No  269 | Lr  262 |
Learning Check

• What are orbitals?

• Where are orbitals?

• How many electrons reside in each orbital?
Learning Check

- What are orbitals? A place where electrons can be found

- Where are orbitals? Outside the nucleus

- How many electrons reside in each orbital? 2
Types of Orbitals (subshells)

• S orbitals – 1 orbital per shell – holds ___ electrons total

• P orbitals – 3 orbitals per shell – holds ___ electrons total

• D orbitals – 5 orbitals per shell – holds ___ electrons total

• F orbitals – 7 orbitals per shell – holds ___ electrons total
Types of Orbitals (subshells)

- **S orbitals** – 1 orbital per shell – holds 2 electrons total
- **P orbitals** – 3 orbitals per shell – holds 6 electrons total
- **D orbitals** – 5 orbitals per shell – holds 10 electrons total
- **F orbitals** – 7 orbitals per shell – holds 14 electrons total
Electron Configuration

• Defined
  – Electron configuration is the arrangement of electrons around the nucleus of an atom based on their energy level.
Actual Electron Configurations

• Total electrons = atomic number
• Electrons are added one at a time to the lowest energy levels first (Aufbau principle)
• Fill energy levels with electrons until you run out
• A superscript states how many electrons are in each level
Order of Orbitals

- Low Energy to High Energy (# of electrons)
  - 1s (2)
  - 2s (2)
  - 2p (6)
  - 3s (2)
  - 3p (6)
  - 4s (2)
  - 3d (10)
  - 4p (6)
  - 5s (2)
  - Continues for the whole periodic table
  - You’re expected to know through here
Making Sense of the Order
Another option

- Draw the orbitals in this format, use diagonal lines to determine order of orbitals to fill
Actual Electron Configurations

• Total electrons = atomic number
• Fill energy levels with electrons until you run out
• A superscript states how many electrons are in each level
  – Hydrogen – 1s$^1$ – 1 electron total
  – Helium – 1s$^2$ – 2 electrons total
  – Lithium – 1s$^2$2s$^1$ – 3 electrons total
  – Beryllium – 1s$^2$2s$^2$ – 4 electrons total
Actual Electron Configurations

• Bigger Elements
  – Fill the energy levels until you run out of electrons
    – Oxygen
    – Sodium
    – Titanium
Actual Electron Configurations

• Bigger Elements
  – Fill the energy levels until you run out of electrons
    – Oxygen
      • $1s^22s^22p^4$
    – Sodium
      • $1s^22s^22p^63s^1$
    – Titanium
      • $1s^22s^22p^63s^23p^64s^23d^2$
Practice

• Potassium
Practice

• Potassium
  – Atomic Number = 19
  – $1s^22s^22p^63s^23p^64s^1$

  – Superscripts add up to atomic number
The s suborbital fills

The orbitals and the periodic table
The orbitals and the periodic table

The p suborbitals fill
The orbitals and the periodic table

The d suborbitals fill
Shorthand

• Shorter form of electron configuration

• \([\text{Ne}] = 1s^22s^22p^6\)
• \([\text{Ar}] = 1s^22s^22p^63s^23p^6\)

• Potassium
  – Atomic Number = 19
  – \(1s^22s^22p^63s^23p^64s^1\)
  – \([\text{Ar}]4s^1\)
Pauli Exclusion Principle

• Two electrons in same orbital have different spins
Orbital Diagrams

- Each electron is an arrow
- They have opposing “spins” – think of two bar magnets together
- Orbital diagrams are visual representations of electron configuration
Hund’s Rule

• When electrons are filling orbitals of the same energy, they prefer to enter empty orbitals first. These electrons all have the same spin.

• A diagram of nitrogen is shown below (7 total electrons):
Hund’s Rule

• The orbital diagram below violates Hund’s rule because the third electron does not enter the empty 2p orbital.
Terms to Know & Skills to Master

• Terms
  – Orbitals
  – Hund’s Rule
  – Aufbau principle
  – Pauli Exclusion principle

• Skills
  – Determining electron configuration from number of electrons
  – Determining the identity of an element from its electron configuration
  – Completing orbital diagrams using arrows to represent electrons