Electronic Configurations and Moles

Chem 11
Lecture 8
10-4-06
It was shown that electrons occupy energy sublevels within each level.

These sublevels are given the named as $s$, $p$, $d$, and $f$.

These names are in reference to the *sharp*, *principal*, *diffuse*, and *fine* lines in emission spectra.

The number of sublevels in each level = the number of the main level.
Energy Levels and Sublevels

- The first energy level has 1 sublevel: 1s
- The second energy level has 2 sublevels: 2s and 2p
- The third energy level has 3 sublevels: 3s, 3p, and 3d
Electron Occupancy in Sublevels

Each sublevel can hold different number of electrons:

- $s$ holds: maximum of 2 electrons.
- $p$ sublevel holds a maximum of 6 electrons.
- $d$ sublevel holds a maximum of 10 electrons.
- $f$ sublevel holds a maximum of 14 electrons.
## Distribution of Electrons per Energy Level and Sublevel

<table>
<thead>
<tr>
<th>ENERGY LEVEL (principal energy level)</th>
<th>ENERGY SUBLEVEL</th>
<th>MAXIMUM ELECTRON IN SUBLEVEL</th>
<th>MAXIMUM ELECTRON IN ENERGY LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1s</td>
<td>$2e^-$</td>
<td>$2e^-$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2s</td>
<td>$2e^-$</td>
<td>$8e^-$</td>
</tr>
<tr>
<td></td>
<td>2p</td>
<td>$6e^-$</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3s</td>
<td>$2e^-$</td>
<td>$18e^-$</td>
</tr>
<tr>
<td></td>
<td>3p</td>
<td>$6e^-$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3d</td>
<td>$10e^-$</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4s</td>
<td>$2e^-$</td>
<td>$32e^-$</td>
</tr>
<tr>
<td></td>
<td>4p</td>
<td>$6e^-$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4d</td>
<td>$10e^-$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4f</td>
<td>$14e^-$</td>
<td></td>
</tr>
</tbody>
</table>
Electron Configurations

• Electrons are arranged around the nucleus regularly. The first electrons fill the energy sublevel closest to the nucleus.

• Electrons continue filling each sublevel until it is full and start filling the next closest sublevel.

• A partial list of sublevels in order of increasing energy is:
  - $1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p < 5s < 4d$ ...
Filling Diagram for Sublevels

- The order does not strictly follow 1, 2, 3, etc.
- Using the figure we predict the order of sublevel filling.
Electron Configurations

Electron configuration: shorthand writing of the location of electrons by sublevel.

The sublevel is written followed by a superscript with the number of electrons in the sublevel.

If the $2p$ sublevel contains 2 electrons, it is written $2p^2$

The electron sublevels are arranged according to increasing energy.
Writing Electron Configurations

1) Determine how many electrons are in the atom. Iron has 26 electrons.

2) Arrange the energy sublevels according to increasing energy:
   
   \[ 1s \ 2s \ 2p \ 3s \ 3p \ 4s \ 3d \ldots \]

3) Fill each sublevel with electrons until you have used all the electrons in the atom:
   
   Fe: \[ 1s^2 \ 2s^2 \ 2p^6 \ 3s^2 \ 3p^6 \ 4s^2 \ 3d^6 \]

4) The sum of the superscripts equals the atomic number of iron (26)
Equivalencies and the Periodic table

• Equality Statements

  – Moles

  – Avogadro’s #

  – Atomic Mass
Avogadro’s number

By experimentation, it was determined that:

IF we have a sample of an element with a mass = its \textit{average} atomic mass expressed in grams, the sample will contain $6.02 \times 10^{23}$ atoms.

This is called \textbf{Avogadro’s number}. Anything that contains Avogadro’s number of items is called a \textit{mole} (mol).

\textbf{SO} . . .

1 mol of anything = $6.02 \times 10^{23}$ things
1 mol = 6.02 x 10^{23} atoms, things

1 mol = atomic mass of an element in grams

SO:
Weight of 6.02 x 10^{23} atoms = the atomic mass of an element in grams

These are important equality statements between moles, grams and atoms.
Mole Problem #1:

If a sample of lead has a mass of 499.75 g,

a) how many moles of lead are present?

b) how many atoms of lead are present?

We know:

1 mol Pb = 207.2 g Pb  
(from periodic table)

1 mol Pb = 6.02x10^{23} Pb atoms  
(by definition)
Mole Problem #2:

How many atoms of iron are in 375 g of Fe?
Molar Mass

→ The mass of 1 mol of a substance expressed in grams

→ For elements: atomic mass from the periodic table

→ For compounds:
  
  (subscript × atomic mass \( \text{E}_1 \))
  + (subscript × atomic mass \( \text{E}_2 \)) + ...

For example:

Molar mass of \( \text{Na}_2\text{CO}_3 \)

\[ \begin{align*}
\text{Na}: & \quad 2 \times 22.99\, \text{g} = 45.98\, \text{g} \\
\text{C}: & \quad 1 \times 12.01\, \text{g} = 12.01\, \text{g} \\
\text{O}: & \quad 3 \times 16.00\, \text{g} = 48.00\, \text{g}
\end{align*} \]

\[ 105.99\, \text{g} \]
Mole Problem #3:

How many $N_2$ molecules are contained in 1.25 g of nitrogen gas?