### Table 8.1 Mendeleev's Predicted Properties of Germanium ("eka Silicon") and Its Actual Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Predicted Properties of eka Silicon (E)</th>
<th>Actual Properties of Germanium (Ge)</th>
</tr>
</thead>
<tbody>
<tr>
<td>atomic mass</td>
<td>72 amu</td>
<td>72.61 amu</td>
</tr>
<tr>
<td>appearance density</td>
<td>gray metal</td>
<td>gray metal</td>
</tr>
<tr>
<td>molar volume</td>
<td>13 cm³/mol</td>
<td>13.65 cm³/mol</td>
</tr>
<tr>
<td>specific heat capacity</td>
<td>0.31 J/g*K</td>
<td>0.32 J/g*K</td>
</tr>
<tr>
<td>oxide formula</td>
<td>$\text{EO}_2$</td>
<td>$\text{GeO}_2$</td>
</tr>
<tr>
<td>oxide density</td>
<td>4.7 g/cm³</td>
<td>4.23 g/cm³</td>
</tr>
<tr>
<td>sulfide formula and solubility</td>
<td>$\text{ES}_2$; insoluble in $\text{H}_2\text{O}$; soluble in aqueous $(\text{NH}_4)_2\text{S}$</td>
<td>$\text{GeS}_2$; insoluble in $\text{H}_2\text{O}$; soluble in aqueous $(\text{NH}_4)_2\text{S}$</td>
</tr>
<tr>
<td>chloride formula (boiling point)</td>
<td>$\text{ECl}_4$ (+100°C)</td>
<td>$\text{GeCl}_4$ (84°C)</td>
</tr>
<tr>
<td>chloride density</td>
<td>1.9 g/cm³</td>
<td>1.844 g/cm³</td>
</tr>
<tr>
<td>element preparation</td>
<td>reduction of K$_2\text{EF}_6$ with sodium</td>
<td>reduction of K$_2\text{GeF}_6$ with sodium</td>
</tr>
</tbody>
</table>

### Figure 8.1 Observing the effect of electron spin.

### Table 8.2 Summary of Quantum Numbers of Electrons in Atoms

<table>
<thead>
<tr>
<th>Name</th>
<th>Symbol</th>
<th>Permitted Values</th>
<th>Property</th>
</tr>
</thead>
<tbody>
<tr>
<td>principal</td>
<td>$n$</td>
<td>positive integers(1, 2, 3, ...)</td>
<td>orbital energy (size)</td>
</tr>
<tr>
<td>angular momentum</td>
<td>$l$</td>
<td>integers from 0 to $n-1$</td>
<td>orbital shape (The $l$ values 0, 1, 2, and 3 correspond to s, p, d, and f orbitals, respectively.)</td>
</tr>
<tr>
<td>magnetic</td>
<td>$m_l$</td>
<td>integers from $-l$ to $+l$</td>
<td>orbital orientation</td>
</tr>
<tr>
<td>spin</td>
<td>$m_s$</td>
<td>+1/2 or -1/2</td>
<td>direction of electron spin</td>
</tr>
</tbody>
</table>

### Figure 8.2 Spectral evidence of energy-level splitting in many-electron atoms.
Factors Affecting Atomic Orbital Energies

The Effect of Nuclear Charge ($Z_{\text{effective}}$)

Higher nuclear charge lowers orbital energy (stabilizes the system) by increasing nucleus-electron attractions.

The Effect of Electron Repulsions (Shielding)

Additional electron in the same orbital
- An additional electron raises the orbital energy through electron-electron repulsions.

Additional electrons in inner orbitals
- Inner electrons shield outer electrons more effectively than do electrons in the same sublevel.

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Illustrating Orbital Occupancies

The electron configuration

\[ n^l \] of electrons in the sublevel

as $s, p, d, f$

The orbital diagram (box or circle)
Sample Problem 8.1

Determining Quantum Numbers from Orbital Diagrams

**PROBLEM:** Write a set of quantum numbers for the third electron and a set for the eighth electron of the F atom.

**PLAN:** Use the orbital diagram to find the third and eighth electrons.

F

**SOLUTION:**

The third electron is in the 2s orbital. Its quantum numbers are:

\[ n = 2 \quad l = 0 \quad m_l = 0 \quad m_s = +1/2 \]

The eighth electron is in a 2p orbital. Its quantum numbers are:

\[ n = 2 \quad l = 1 \quad m_l = -1, 0, +1 \quad m_s = -1/2 \]

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**Figure 8.8** Orbital occupancy for the first 10 elements, H through Ne.

**Figure 8.9** Condensed ground-state electron configurations in the first three periods.

**Figure 8.10** Similar reactivities within a group.
Sample Problem 8.2  Determining Electron Configurations

PROBLEM: Using the periodic table on the inside cover of the text (not Figure 8.11 or Table 8.4), give the full and condensed electron configurations, partial orbital diagrams showing valence electrons, and number of inner electrons for the following elements: (a) potassium (K; Z = 19) (b) molybdenum (Mo; Z = 42) (c) lead (Pb; Z = 82)

PLAN: Use the atomic number for the number of electrons and the periodic table for the order of filling for electron orbitals. Condensed configurations consist of the preceding noble gas and outer electrons.

SOLUTION: (a) for K: (Z = 19)

full configuration 1s²2s²2p⁶3s²3p⁶4s¹
condensed configuration [Ar] 4s¹
partial orbital diagram  

There are 18 inner electrons.

(b) for Mo: (Z = 42)

full configuration 1s²2s²2p³3s²3p⁶4s²3d¹⁰4p⁶5s²4d¹⁰
condensed configuration [Kr] 5s²4d¹⁰
partial orbital diagram  

There are 36 inner electrons and 6 valence electrons.

(c) for Pb: (Z = 82)

full configuration 1s²2s²2p³3s²3p⁶4s²3d¹⁰4p⁶5s²4d¹⁰5p²6s²4f²
condensed configuration [Xe] 6s²4f²5d¹⁰6p²
partial orbital diagram  

There are 78 inner electrons and 4 valence electrons.