Arrangement of Electrons in Atoms

Electrons in atoms are arranged as

- **SHELLS** (n)
- **SUBSHELLS** (l)
- **ORBITALS** (m_l)

Each orbital can contain no more than 2 electrons (from experiment).

This result is tied to the existence of a 4th quantum number, the electron spin quantum number, m_s.
It has been proven experimentally that the electron has a spin. There are two spin directions given by $m_s$ where $m_s = +1/2$ and -1/2.

**Electron Spin Quantum Number**

The presence of electron spin produces a magnetic field. This means that individual, unpaired electrons impart their magnetic properties to the atoms in which they reside.

- **Diamagnetic**: The substance is NOT attracted to a magnetic field. ($e^-$ are paired.)
- **Paramagnetic**: The substance IS attracted to a magnetic field. The substance has **unpaired electrons**.
- **Ferromagnetic**: The substance exhibits a permanent magnetic field. **It has unpaired electrons that are aligned.**
Pauli Exclusion Principle

No two electrons in the same atom can have the same set of 4 quantum numbers.
That is, each electron has a unique address.

\[ n \rightarrow \text{shell} \quad 1, 2, 3, 4, \ldots \]
\[ l \rightarrow \text{subshell} \quad 0, 1, 2, \ldots n - 1 \]
\[ m_l \rightarrow \text{orbital} \quad -l \ldots 0 \ldots +l \]
\[ m_s \rightarrow \text{electron spin} \quad +1/2 \text{ and } -1/2 \]

Electrons in Atoms

When \( n = 1 \), then \( l = 0 \).
This shell has a single orbital (1s) to which two \( e^- \) can be assigned.

When \( n = 2 \), then \( l = 0 \) or 1:
- one 2s orbital \( 2 \text{ e}^- \)
- three 2p orbitals \( 6 \text{ e}^- \)
TOTAL = \( 8 \text{ e}^- \)

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When $n = 3$, then $l = 0, 1, 2$
- one 3s orbital $2 \text{ e}^-$
- three 3p orbitals $6 \text{ e}^-$
- five 3d orbitals $10 \text{ e}^-$
- TOTAL = $18 \text{ e}^-$

When $n = 4$, then $l = 0, 1, 2, 3$
- one 4s orbital $2 \text{ e}^-$
- three 4p orbitals $6 \text{ e}^-$
- five 4d orbitals $10 \text{ e}^-$
- seven 4f orbitals $14 \text{ e}^-$
- TOTAL = $32 \text{ e}^-$

Assigning Electrons to Atoms

- Electrons generally are assigned to orbitals of successively higher energy.
- For H atoms, $E = - \text{Rhc}(1/n^2)$. That is, $E$ depends only on $n$.
- For many-electron atoms, energy depends on both $n$ and $l$.
- See Figure 8.4 and CD-ROM screen 8.5.