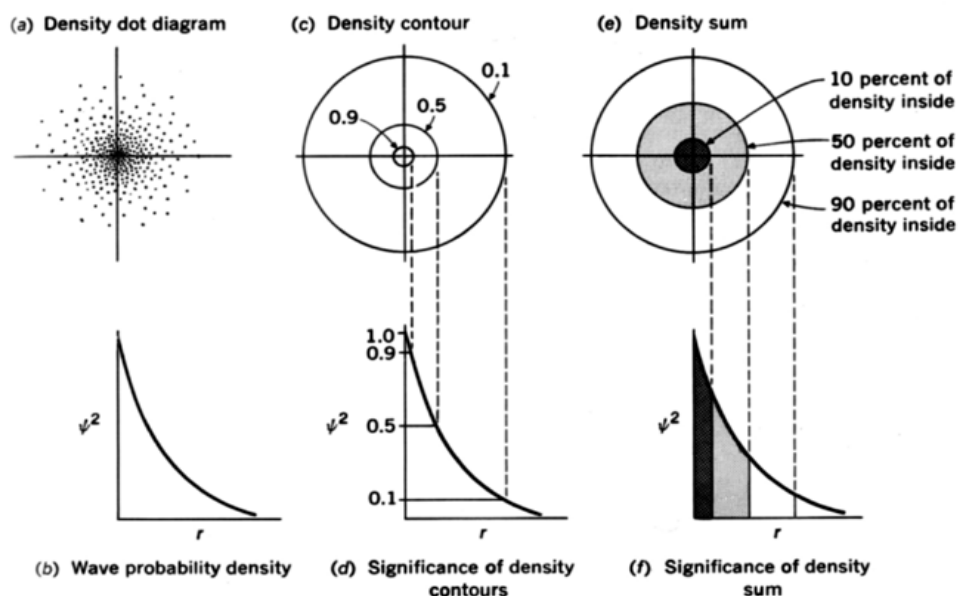


## The Meaning of the Wave Function

Solving the wave function gives us a series of solutions. Each solution has nodal surfaces and phase changes across the nodal boundaries.

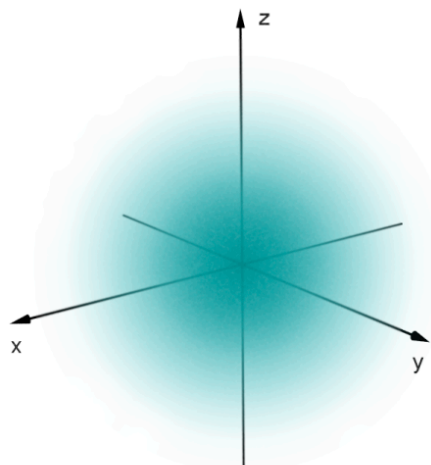
The solutions to the wave function are actually complex values. It is the square of the wave function that gives us a physical significance.

The square of the wave function gives us the probability of finding the electron at a given point in space. If we plot that probability for the hydrogen atom we get:



We define an orbital as a region of space where we are 90% likely to find an electron.

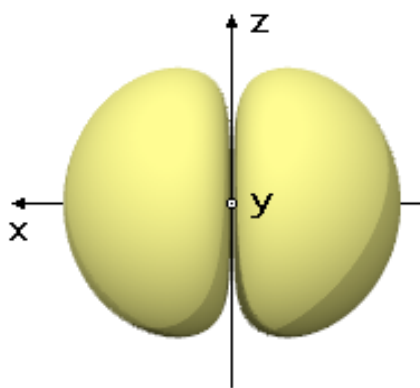
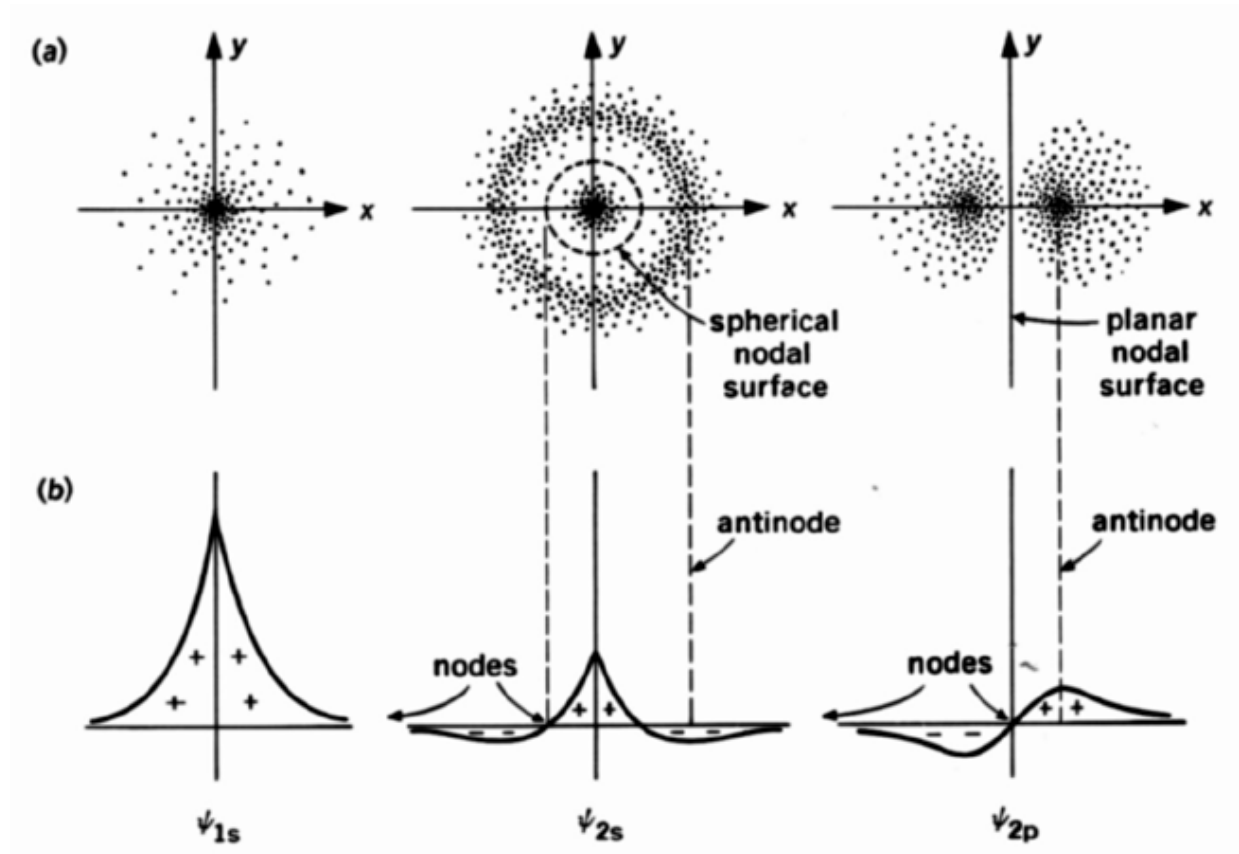
For the hydrogen atom the first solution to the wave function gives us an orbital that looks like:



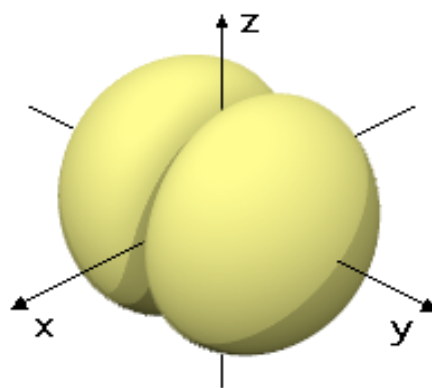
Orbital s ( $\ell = 0$ ,  $m_\ell = 0$ )

## Quantum Numbers

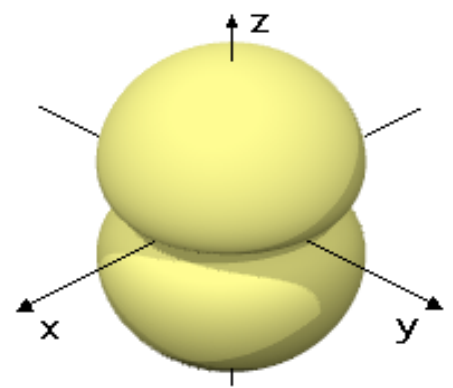
There are multiple solutions to the wave function. The second and third solutions for the hydrogen atom when plotted would look like:



Orbital  $p_x$



Orbital  $p_y$



Orbital  $p_z$

The solutions to the wave function can be described with three integer values:

$n$ - The principle quantum number, represents the overall energy level of the orbital and has integer values 1, 2, 3, ... $n$

$\ell$  - The angular quantum number, represents the shape of the orbital and has integer values  $0 \leq \ell \leq n-1$

$m_\ell$ - The magnetic quantum number represent the orientation in space of the orbital and has values  $-\ell \leq m_\ell \leq +\ell$

**Table 7.1** The Angular Momentum Quantum Numbers and Corresponding Letters Used to Designate Atomic Orbitals

<b>Value of <math>\ell</math></b>	0	1	2	3	4
<b>Letter Used</b>	<i>s</i>	<i>p</i>	<i>d</i>	<i>f</i>	<i>g</i>

**Table 7.2** Quantum Numbers for the First Four Levels of Orbitals in the Hydrogen Atom

<i>n</i>	<i>ℓ</i>	<i>Orbital Designation</i>	<i>m<sub>ℓ</sub></i>	<i>Number of Orbitals</i>
1	0	1 <i>s</i>	0	1
2	0	2 <i>s</i>	0	1
	1	2 <i>p</i>	-1, 0, +1	3
3	0	3 <i>s</i>	0	1
	1	3 <i>p</i>	-1, 0, 1	3
	2	3 <i>d</i>	-2, -1, 0, 1, 2	5
4	0	4 <i>s</i>	0	1
	1	4 <i>p</i>	-1, 0, 1	3
	2	4 <i>d</i>	-2, -1, 0, 1, 2	5
	3	4 <i>f</i>	-3, -2, -1, 0, 1, 2, 3	7

## Energy Levels in One Electron Atoms

Solving the wave function gives us orbitals of different shapes and energies.

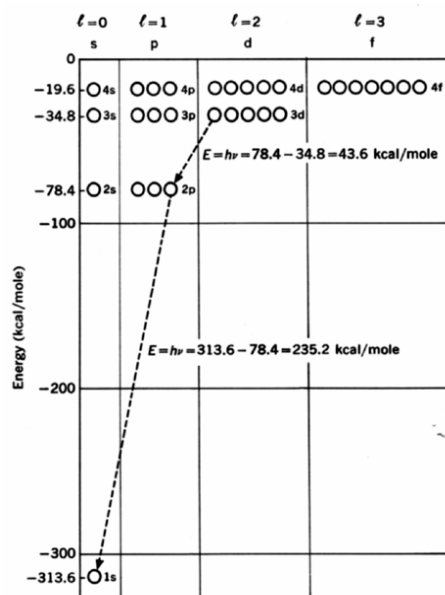


Figure 1-15 Hydrogen atom energy level diagram.

Changing the effective nuclear charge changes the spacing of the energy levels.

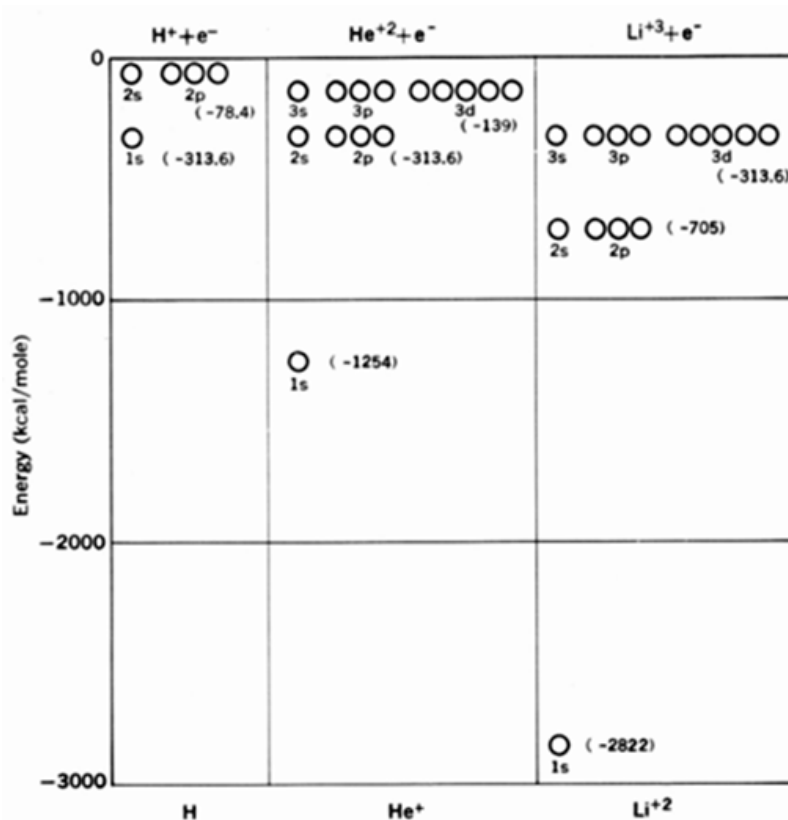
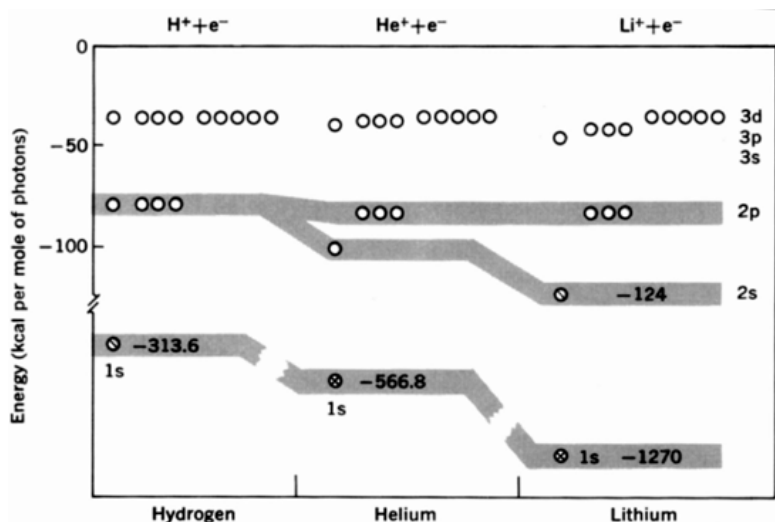


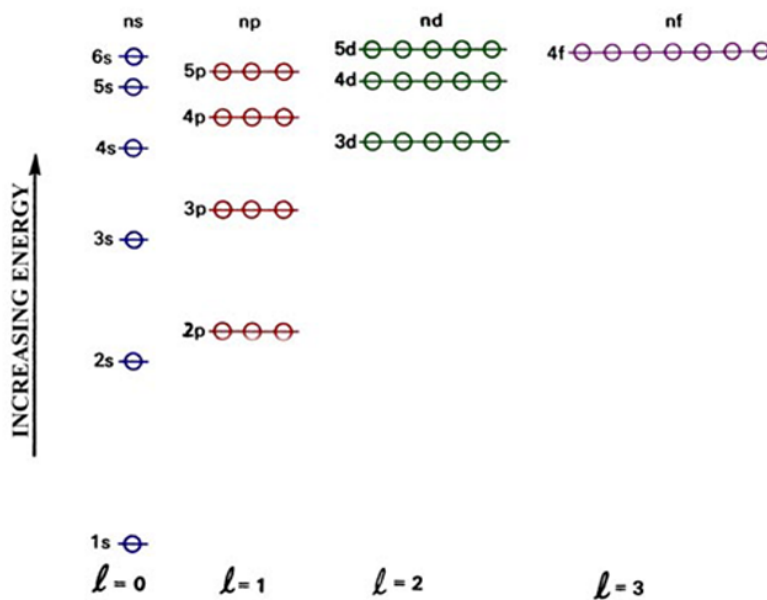
Figure 1-17 Energy level diagrams of one-electron atoms and ions.

## Polyelectron Atoms

Adding more than one electron causes splitting in the energy levels due to e--e- repulsion.



By the third energy level the splitting becomes so great that we begin to get over lap.



## Orbital Filling

To explain the properties of atoms we need to understand how electrons are arranged in the orbitals the wave function gives us. It is the arrangements of the electrons that determine the chemical properties of an atom.

There are three rules that govern the way electrons fill orbitals:

The Pauli exclusion principle- no two electrons in an atom can have the same set of quantum numbers. This includes the electron spin( $m_s$ ) which can have values of  $+1/2$  and  $-1/2$ .

The Aufbau principle- as the number of electrons in an atom increases, electrons are always added to the lowest energy orbital available.

Hund's rule- degenerate orbitals are filled so as to generate the maximum amount of unpaired electrons. (this is also known as the rule of maximum multiplicity)