# Atomic Theory 1.7

Quantum Numbers

## The Four Quantum Numbers

$n$ → Principal Quantum Number

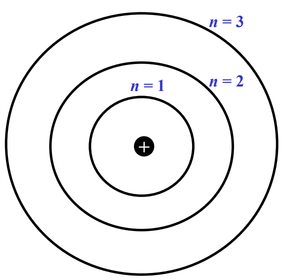
$l$ → Angular Momentum Quantum Number

$m$ → Magnetic Quantum Number

$m_s$ → Electronic Spin Quantum Number

## Principal Quantum Number ($n$)

**$n$ = 1, 2, 3, 4, 5, 6, 7**




All electrons that have the same **'$n$'** value are described as being in the same **'shell'**.

## Angular Momentum Quantum Number ($l$)

$l = 0, 1, 2, \ldots, (n - 1)$

Any principal quantum number ($n$), may contain sublevels from 0 to $n - 1$.

$n = 1$ has one sublevel ($l = 0$)

$n = 2$ may have two sublevels ($l = 0$ and $l = 1$)

$n = 3$ may have three sublevels ($l = 0$, 1, and 2)

## Angular Momentum Quantum Number ($l$)

($l$) Defines the shape or type of orbital

| $l$ | 0 | 1 | 2 | 3 |
|---|---|---|---|---|
| **Type of Orbital** | **s** | **p** | **d** | **f** |

## Magnetic Quantum Number ($m$)

$m = -l$ to $+l$

$m$ → Defines the orientation of the orbital in three dimensional space.

## Quantum Numbers when $n = 1$

When $n = 1$

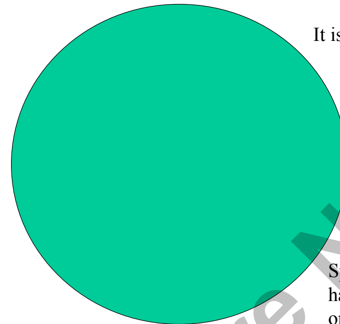
$l = 0$

$n = 1$ can only have a s-orbital

$m = 0$

which means there is only one orientation

## 1s Orbital



It is spherical.

Spheres can only have one orientation.

## Quantum Numbers when $n = 2$

When n = 2

$l = 0$

Which defines a **s-orbital**

and

$l = 1$

Which defines a **p-orbital**

**So $n = 2$ can have s and p-orbitals.**

## Quantum Numbers when $n = 2$

Again, when $l = 0$, m = 0.

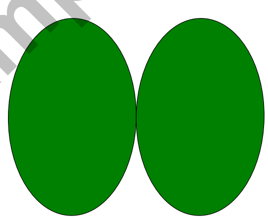
There is one orientation, as it is an s-orbital.

When $l = 1$, m can be –1, 0, or +1.

There are three orientations for a p-orbital.

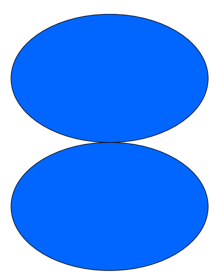
**$p_x$, $p_y$, and $p_z$**

## There are three 2p orbitals



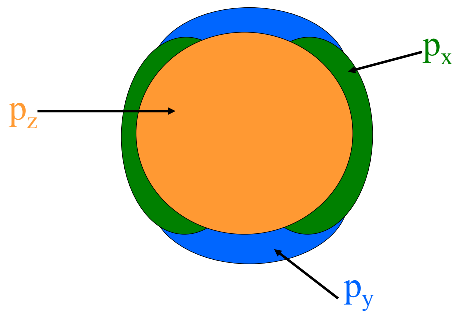
$p_x$

## There are three 2p orbitals



$p_y$

## The three p-orbitals together




## Quantum Numbers when $n = 3$

When $n = 3$
$l = 0$ **(s-orbital)**
$l = 1$ **(p-orbital)**
or $l = 2$ (d-orbital)
$m = -2, -1, 0, +1, \text{or } +2$

Thus, there are 5 d-orbitals.

## Quantum Numbers when $n = 4$

When $n = 4$
$l = 0$ **(s-orbital)**
$l = 1$ **(p-orbital)**
$l = 2$ (d-orbital)
$l = 3$ (f-orbital)
$m = -3, -2, -1, 0, +1, +2, \text{or } +3$

Thus, there are 7 f-orbitals.

## Electron Spin Quantum Number ($m_s$)

$m_s = +\frac{1}{2}$ or $-\frac{1}{2}$

- There is a maximum of two electrons per orbital.
- They spin in opposite directions.
- Spin up or spin down

## Pauli's Exclusion Principle

It is not possible for two electrons in an atom to have the same four quantum numbers.

## Ex) Quantum Numbers

Ex) What are the possible angular momentum, magnetic, and electron spin quantum numbers associated with a single electron in a p-orbital of $n = 3$?