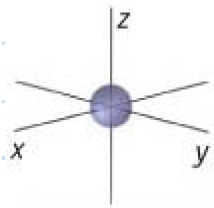
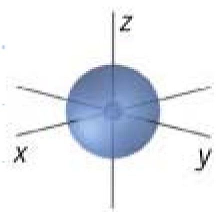
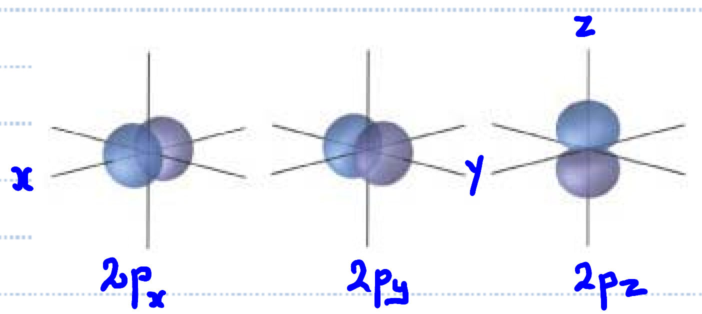
Announcements – Lecture VIII – Monday, June 2nd

1. Third Lab: Tuesday, June 3rd, ISB 155 (A-C)

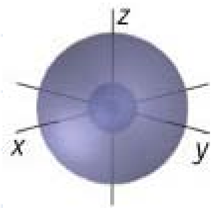
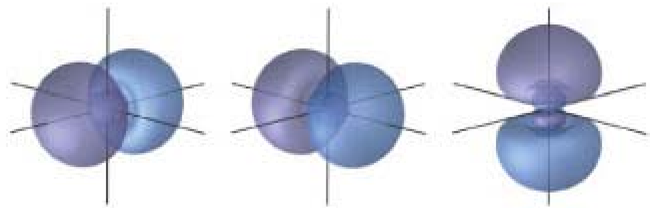
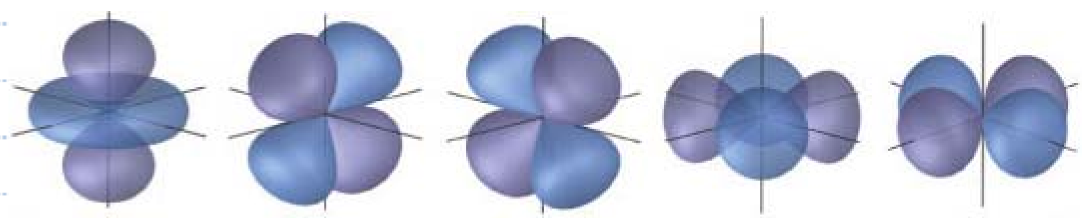
6.5 Quantum Numbers, Orbitals, and Nodes

B: Orbitals – n = 1 and 2

n	Orbitals		#	Label
1	1		1	1s
2	4		1	2s
			3	2p

6.5 Quantum Numbers, Orbitals, and Nodes

B: Orbitals – n = 3

n	Orbitals		#	Label
			1	3s
3	9		3	3p
		 $3d_{z^2}$ $3d_{xy}$ $3d_{yz}$ $3d_{xy}$ $3d_{x^2-y^2}$	5	3d

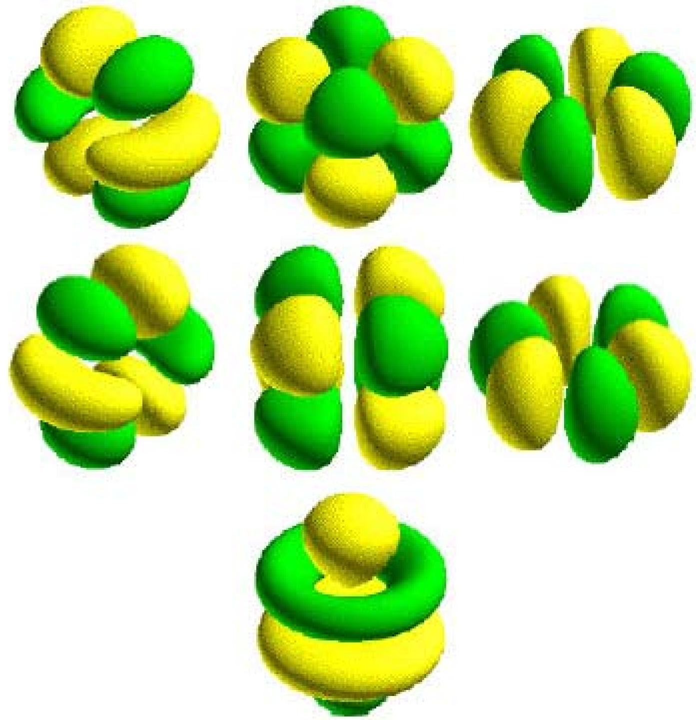
6.5 Quantum Numbers, Orbitals, and Nodes

B: Orbitals – n = 4

n = 4 16 Orbitals

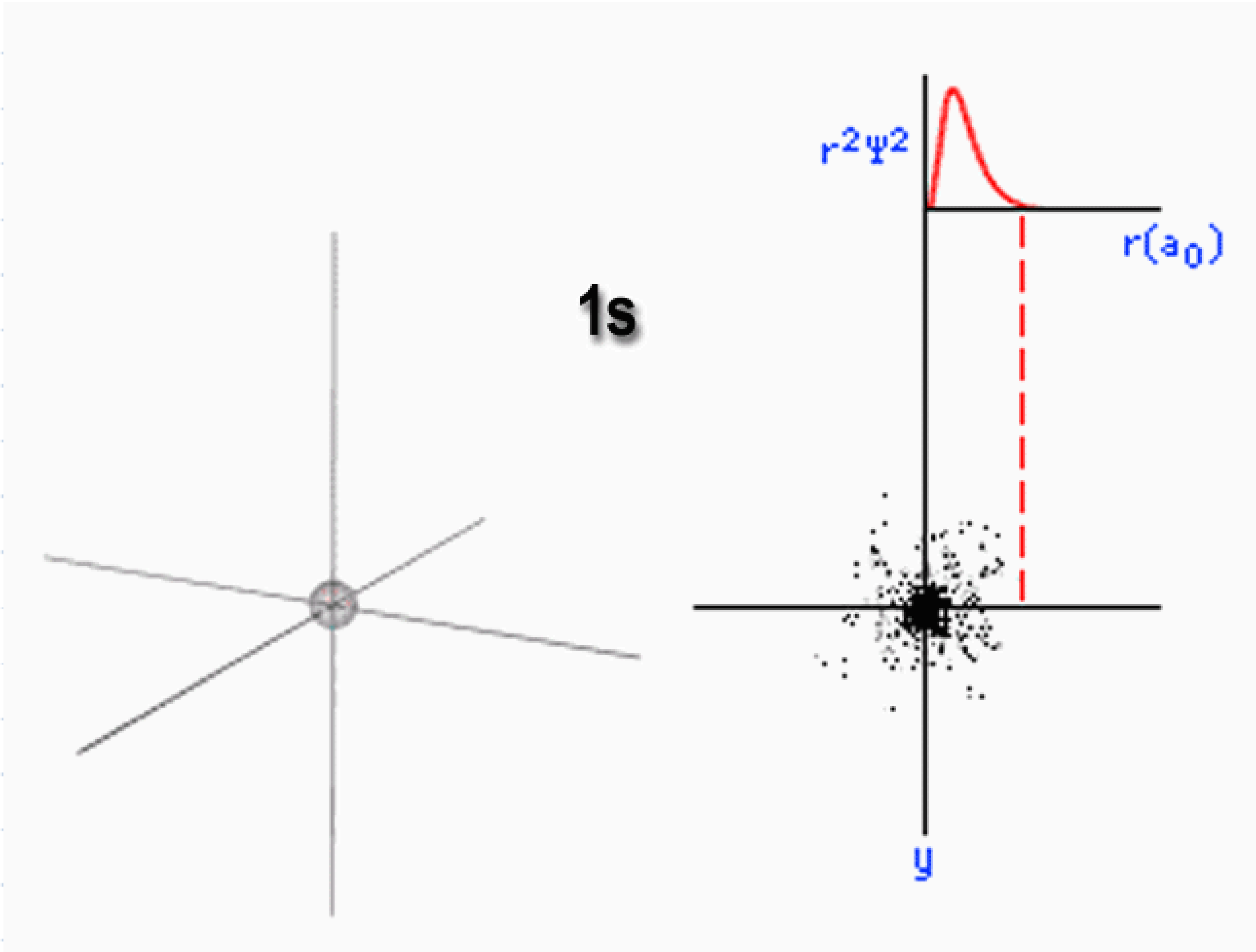
1	4s
3	4p
5	4d
7	4f

f orbitals



6.5 Quantum Numbers, Orbitals, and Nodes

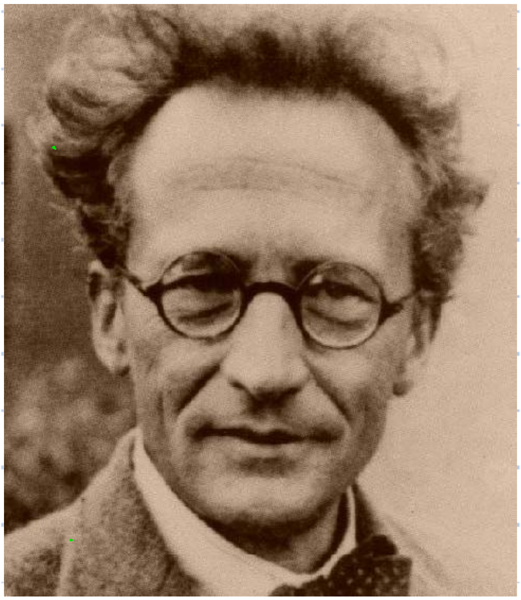
B: Orbital Shapes with Increasing n



6.5 Quantum Numbers, Orbitals, and Nodes

C: Quantum Numbers

Erwin Schrödinger (1887- 1961)



Schrödinger's Equation

$$i\hbar \frac{\partial}{\partial t}\psi(\mathbf{r},t) = -\frac{\hbar^2}{2m}\nabla^2\psi(\mathbf{r},t) + V(\mathbf{r},t)\psi(\mathbf{r},t)$$

i is the imaginary number, $\sqrt{-1}$.

$\hbar$ is Planck's constant divided by 2π: 1.05459×10^{-34} joule·second.

$\psi(\mathbf{r},t)$ is the wave function, defined over space and time.

m is the mass of the particle.

∇^2 is the Laplacian operator, $\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}$.

$V(\mathbf{r},t)$ is the potential energy influencing the particle.

Principal Quantum Number = n ... Number of solutions ... n^2

... number of Nodes ... $n-1$ { planar Nodes + spherical Nodes

6.5 Quantum Numbers, Orbitals, and Nodes

C: Nodes

	1s	2s	3s	4s
Planar Nodes:	0	0	0	0
Spherical Nodes:	0	1	2	3

Increasing size →
Getting further away from the nucleus

	2p	3p	4p
Planar Nodes:	1	1	1
Spherical Nodes:	0	1	2

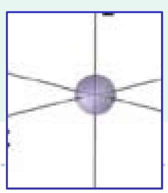
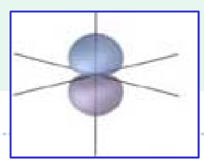
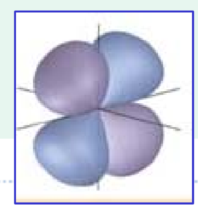
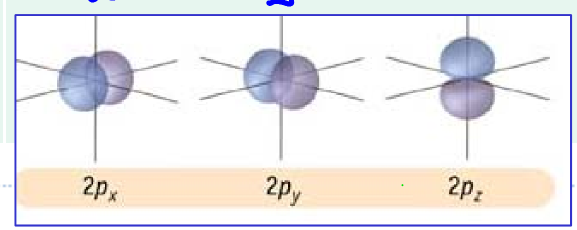
→

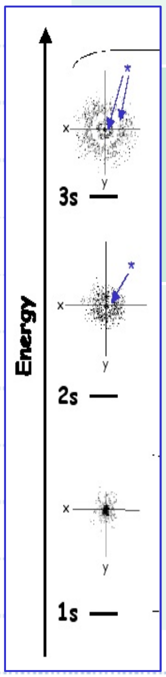
	3d	4d
Planar Nodes	2	2
Spherical Nodes	0	1

→

C: Quantum Numbers

Each orbital (shape) described by 3 Quantum Numbers

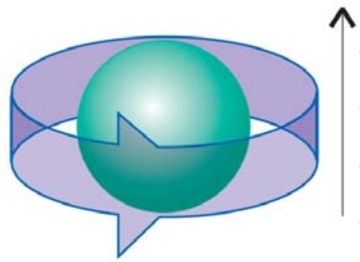
n	ℓ	m_ℓ
Principal	***Angular Momentum***	***Magnetic***
Size	Shape	Orientation
$n = 1, 2, 3 \ldots$	limited by n ← $0, 1, \ldots (n-1)$	limited by ℓ ← $-\ell, \ldots 0 \ldots, +\ell$
as $n \uparrow$, further away from the Nucleus. Bigger!	$\ell = 0$ s  $\ell = 1$ p  $\ell = 2$ d 	x y z 



6.5 Quantum Numbers, Orbitals, and Nodes

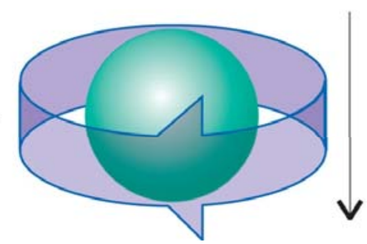
Electron Spin

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



2 orientations
2 values for m_s

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



align with field

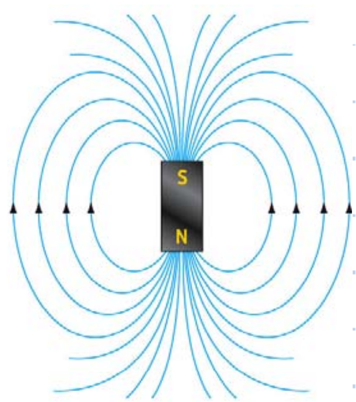
Spin "up"

$m_s = +1/2$

align against field

Spin "down"

$m_s = -1/2$



(b) A bar magnet

6.5 Quantum Numbers, Orbitals, and Nodes

C: Quantum Numbers

Each electron described by 4 Quantum Numbers.

n	l	m_l	m_s
Principal Q #	Angular Momentu Q #	Magnetic Q #	Spin Quantum Number
Size	Shape	Orientation	electron orientation
n = 1, 2, 3, ...	l = 0, 1, ... (n-1)	-l, ..., 0, ..., l	$+\frac{1}{2}$, $-\frac{1}{2}$
			↑ ↓

No two electrons can have the same 4 Quantum Numbers!