Announcements

1.) Next week: I have misspoken to some. There are **no** labs and tutorials next week. Biology's announcement was correct. Classes are not cancelled. All this is in the detailed course outline.

2.) Starting the week of October 15th Group 1 is doing the tutorial on Strong Acids and Bases and Redox. Group 2 is doing the Acid/Base lab.

3.) For those who are going to their Commencements on Nov. 3rd, please fill out the form that is now on the main C020 web site and provide this and documentation to be exempted from the Term Test.

$$\overset{0}{P_4} + \overset{0}{P_4} \rightarrow \overset{-3}{P}\overset{+1}{H_3} + \overset{+1}{H_2}\overset{+1}{P}\overset{-4}{O_2^-}$$

Oxidation

Reduction

Half reactions:

$$12e^- + 12H_2O + P_4 \rightarrow 4PH_3 + 12OH^-$$

$$8OH^- + \cancel{8H_2O} + P_4 \rightarrow 4\ H_2PO_2^- + \cancel{8H_2O} + 4e^- \quad (X\ 3)$$

$$\cancel{12e^-} + 12H_2O + 4P_4 + \overset{12}{\cancel{24}}OH^- \rightarrow 4PH_3 + 12H_2PO_2^- + \cancel{12OH^-} + \cancel{12e^-}$$

$$= 12H_2O + 4P_4 + 12OH^- \rightarrow 4PH_3 + 12H_2PO_2^-$$

Divide equation by 4

$$\boxed{3H_2O + P_4 + 3OH^- \rightarrow PH_3 + 3H_2PO_2^-}$$

Mass check: 9H, 6O and 4 P on both sides of the equation

$\text{Charge}_{LHS} = -3$ $\text{Charge}_{RHS} = -3$ **Balanced**

Electronic Structure and Periodic Properties

C020

Electron Orbitals

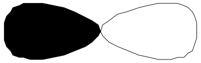
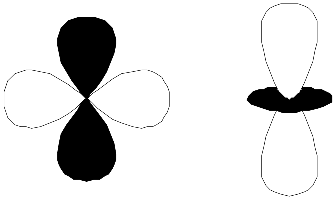
- The properties of elements result from the **electronic structure** of the atom
- Each electron in an atom is in an **orbital** of fixed energy; that is the orbitals are said to be **quantized**
- Each electron is described by **4 quantum numbers**

i) Principle quantum number n:

n = 1,2,3, ….   This quantum number determines the energy of the orbital

ii) Angular momentum quantum number, ℓ:

ℓ = 0, 1, 2, …., n-1   This quantum number determines the shape of various orbitals having the energy of quantum number n

ℓ	**orbital name**	**shape**
0	s	spherical
1	p	dumbbell 
2	d	complex 
3	f	complex

iii) Magnetic quantum number m_ℓ:

$m_\ell = -\ell, \ldots, 0, \ldots +\ell$ in integer steps.

This quantum number determines the number of orbitals of shape ℓ and energy n = $(2\ell + 1)$

∴ For a given n

orbital name	**# of orbitals**
s	1
p	3
d	5
f	7

iv) Electron spin quantum number, m_s:

Electrons act as though they have an intrinsic **spin** which gives them a magnetic moment

Thus, unpaired electrons are acted on by magnetic fields and are said to be **paramagnetic**
substances that are unaffected by magnetic fields are said to be **diamagnetic**

The two possible spin values for an electron are a consequence of the electron spin quantum number m_s where $m_s = \pm \frac{1}{2}$

These spins are often labeled “up” (↑) and “down” (↓) (although this is actually incorrect; electron spin doesn’t depend on coordinates!)

A maximum of 2 electrons can occupy each electron orbital, and then, only when their spins are **paired:**

↑↓

This is a consequence of the **Pauli Exclusion Principle**:

only 2 electrons maximum can be in any given atomic orbital;

two electrons in the same orbital can not have the same quantum numbers

The maximum number of electrons for any principle quantum number n, is given by $2n^2$.

For example: if $n = 2$, $2n^2 = 2(2)^2 = 8$: 2 in the one s-orbital + 6 in the three p-orbitals

Who was Pauli?

- Wolfgang Pauli was a German theorist.
- He was born 1900 and died 1958.
- He was a genius, a curmudgeon, and is considered one of the worst experimentalists who ever lived.

Shape of the orbitals

In quantum mechanics the "shape" of an orbital is defined as 90% probability maps of where spatially one could expect to find the electron in question.

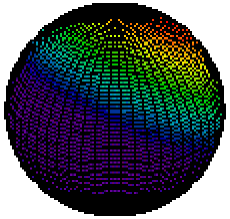
It says nothing about the actually motion (trajectory) of the electron.

We don't indicate 100% probability maps because if the electron exists it must be in the universe somewhere and that's too big to draw!

Luckily, electrons tend to stick "close" to the nucleus!

i) s-orbital

If $\ell = 0$, $m_\ell = 0$ which means there can only be 1 s-orbital for any given principle quantum number n.

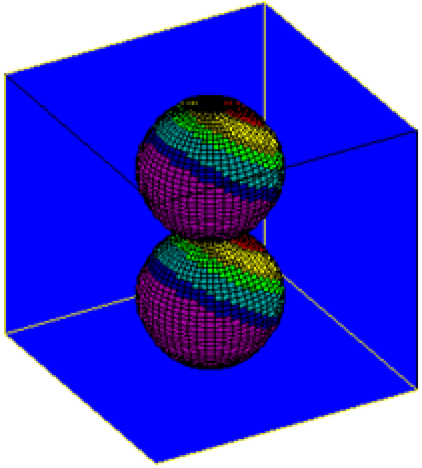


Notation: if, for example the s-orbital for $n = 2$ has just one electron we denote this by writing: $2s^1$. If it has two electrons (with opposite spins) then $2s^2$.

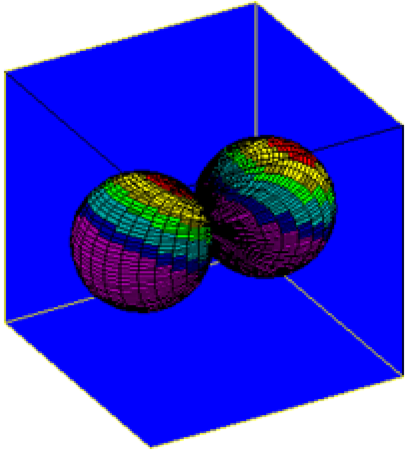
ii) p-orbitals

For a given n, if $\ell = 1$, $m_\ell = +1, 0, -1$.

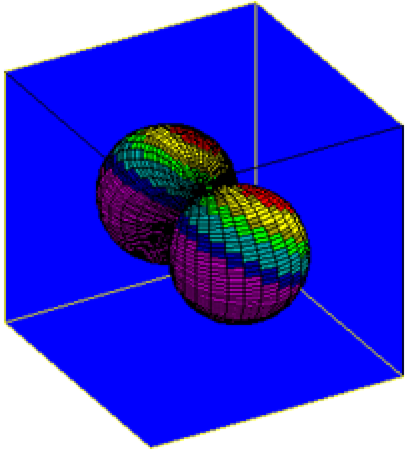
Note the rules indicate that there are no p-orbitals for n = 1 since $\ell_{max} = n-1$.



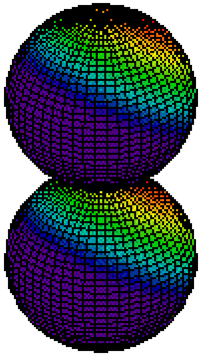
$\ell = 1$, $m_\ell = 0$



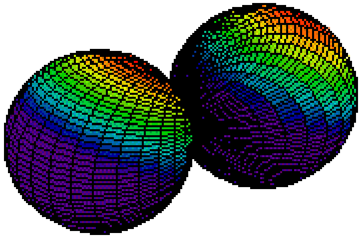
$\ell = 1$, $m_\ell = 1$



$\ell = 1$, $m_\ell = -1$



$\ell = 1, m_\ell = 0$

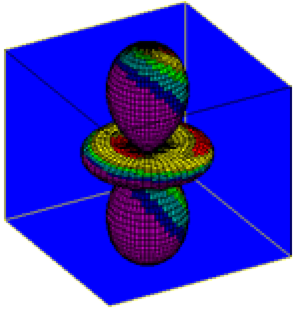


$\ell = 1, m_\ell = +1 \text{ or } -1$

iv) d-orbitals

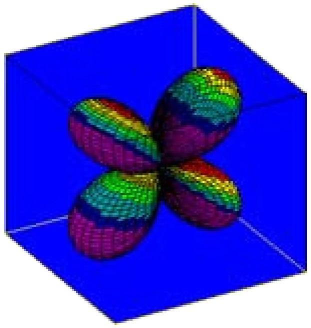
For a given n, if $\ell = 2$, $m_\ell = +2, +1, 0, -1, -2$.

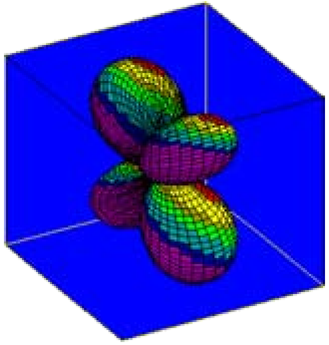
Note the rules indicate that there are no d-orbitals for n = 1 and 2 since $\ell_{max} = n-1$.



$\ell = 2$, $m_\ell = 0$

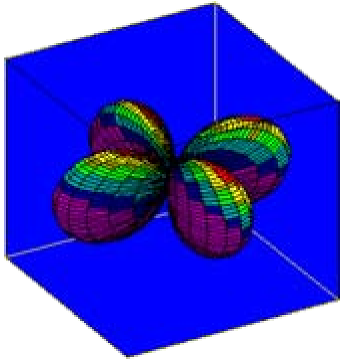
$\ell = 2$, $m_\ell = 1$

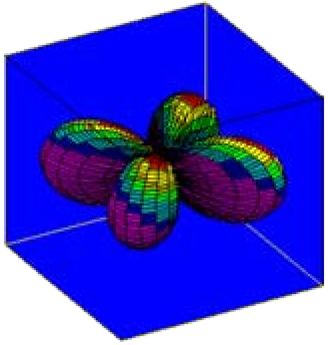




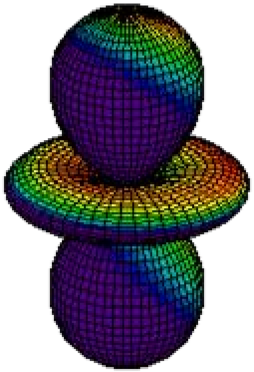
$\ell = 2$, $m_\ell = -1$

$\ell = 2$, $m_\ell = 2$

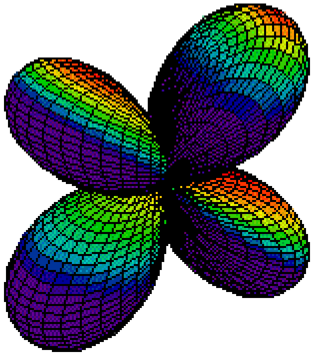




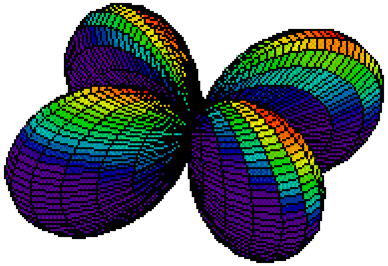
$\ell = 2$, $m_\ell = -2$



$\ell = 2, m_\ell = 0$



$\ell = 2, m_\ell = 1$ or -1

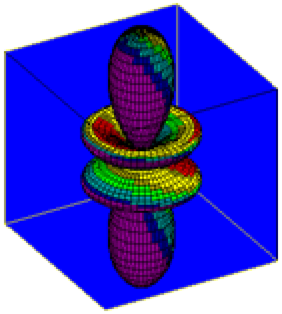


$\ell = 2, m_\ell = 2$ or -2

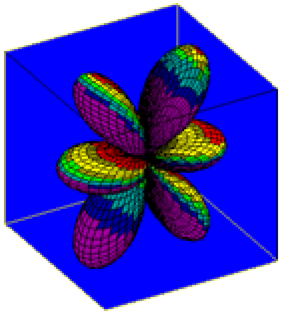
v) f-orbitals

For a given n, if $\ell = 3$, $m_\ell = +3, +2, +1, 0, -1, -2, -3$.

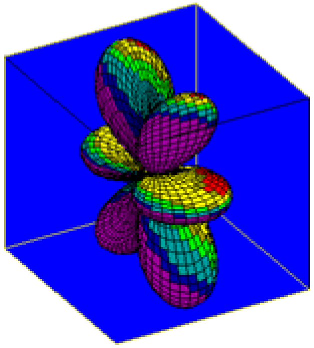
Note the rules indicate that there are no f-orbitals for n = 1, 2, and 3 since $\ell_{max} = n-1$.



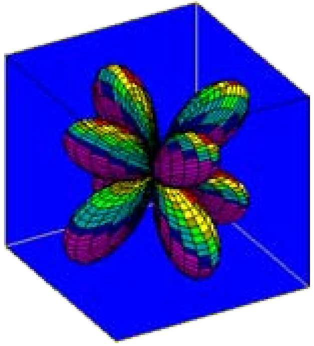
$\ell = 3$, $m_\ell = 0$



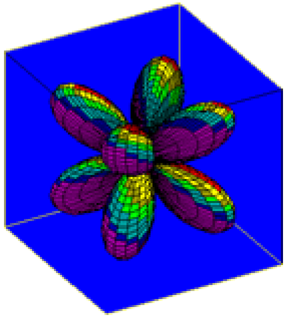
$\ell = 3$, $m_\ell = 1$



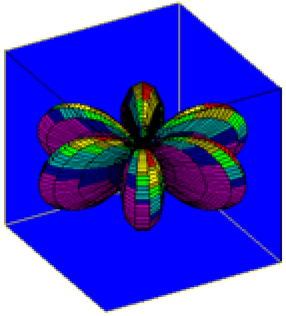
$\ell = 3$, $m_\ell = -1$



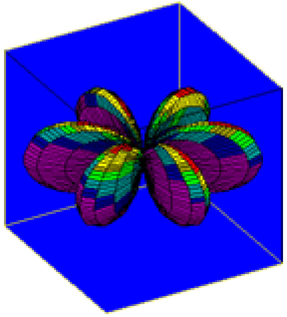
$\ell = 3$, $m_\ell = 2$



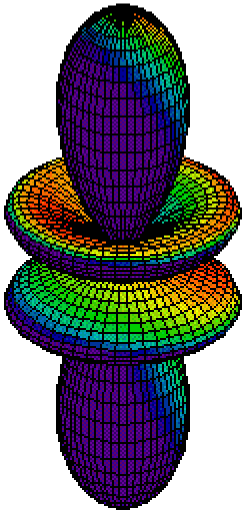
$\ell =3$, $m_\ell = -2$



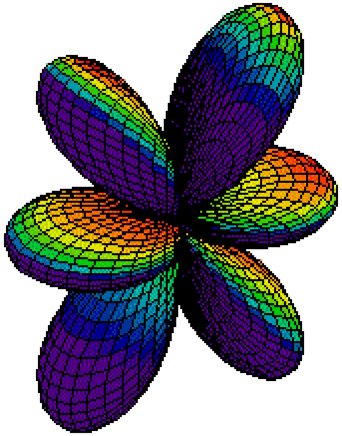
$\ell = 3$, $m_\ell = 3$



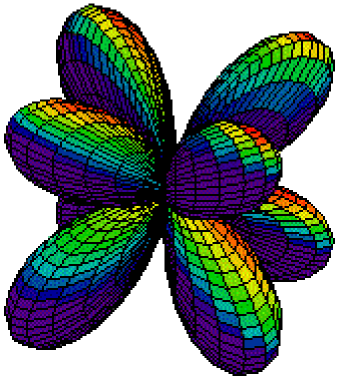
$\ell = 3$, $m_\ell = -3$



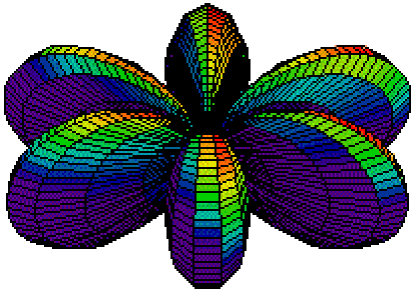
$\ell = 3$, $m_\ell = 0$



$\ell = 3$, $m_\ell = 1$ or -1



$\ell = 3$, $m_\ell = 2$ or -2



$\ell = 3$, $m_\ell = 3$ or -3