Announcements

Monday, November 16, 2009

MasteringChemistry due dates (all at 11:59 pm)

- Ch 7: Wed, Nov 25
- Ch 8: Wed, Dec 2
- Ch 9: Fri, Dec 4

Uncertainty and indeterminacy

The wave and particle natures of the electron are **complimentary** properties - the more you know about one, the less you know about the other

Heisenberg uncertainty principle:

- Position of an electron: particle nature
- Momentum of an electron: wave nature
- It's impossible to know both precisely at any one time

$$\underbrace{(\Delta x)}_{\text{uncertainty in position}} \cdot \underbrace{(m\Delta v)}_{\text{uncert in momentum}} \geq \frac{h}{4\pi}$$

But, quantum mechanics allows us to calculate the **probability** of an electron behaving a certain way:

Wavefunction (ψ): mathematical equation that describes the wavelike properties of an electron

Quantum numbers: 4 variables in the wavefunction that, combined, describe a single electron

Orbital: a solution to a wavefunction with a certain combination of quantum numbers -
a 3-dimensional volume inside of which an electron is likely to be found

Principal quantum number, *n*

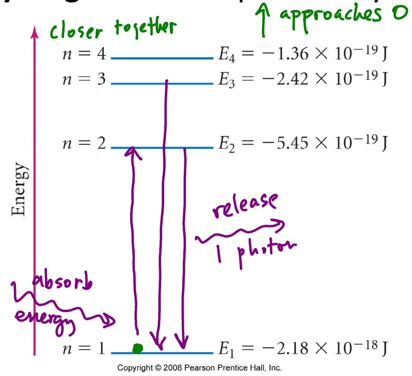
<u>Principal quantum number</u>, *n*: determines overall size and energy of an orbital.

$n = 1, 2, 3, \ldots$

smallest, lowest energy

Energy of an electron **in a hydrogen atom** depends only on *n*:

$E = -2.18 \times 10^{-18}\ \text{J} \cdot \frac{1}{n^2}$



Copyright © 2008 Pearson Prentice Hall, Inc.

$\Delta E = E_{final} - E_{initial}$

$\Delta E = -2.18E\text{-}18\text{J}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$

of electron in transition

$E_{photon} = -\Delta E_{electron}$

Calculate the energy and wavelength (in nm) of a photon emitted when an electron in a hydrogen atom makes a transition from an orbital in *n* = 3 *to n* = 2. $E = \frac{hc}{\lambda}$

$h = 6.626 \times \cancel{10^{34}}\ 10^{-34}$ J·s, $c = 3.00 \times 10^8$ m/s

$\Delta E_{electron} = -2.18E\text{-}18\text{J}\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = -3.0277E\text{-}19\text{J}$

$E_{photon} = -\Delta E_{electron} = \boxed{+3.03E\text{-}19\text{J}}$

orange-red light

$\lambda = \frac{hc}{E} = \frac{(6.626E\text{-}34\ \text{J}\cdot\text{s})(3.00E8\ \text{m/s})}{3.0277E\text{-}19\ \text{J}} = \boxed{657\ \text{nm}}$

Angular momentum quantum number, *ℓ*

(azimuthal)

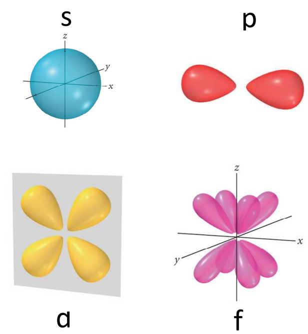
<u>Angular momentum quantum number</u>, *ℓ*, determines the shape of the orbital.

Possible values of *ℓ* = 0, 1, 2, … (n - 1)

ℓ	letter	shape
0	s	spherical
1	p	2 lobes
2	d	clover
3	f	complex

higher energy

alpha

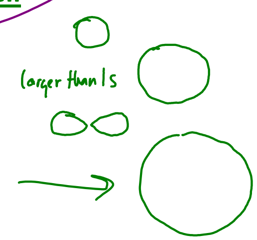


n and *ℓ* define **<u>subshells</u>**:

n	*ℓ*	subshell
1	0	1s
2	0	2s
2	1	2p
3	0	3s
3	1	3p
3	2	3d
4	0	4s
4	1	4p
4	2	4d
4	3	4f

n

orbital shape



Magnetic quantum number, m_ℓ

Magnetic quantum number, m_ℓ, defines the orientation of individual orbitals within a subshell

Possible values for m_ℓ: integers $-\ell$ to $+\ell$

any s subshell only has 1 orbital

n	ℓ	subshell	m_ℓ	number of orbitals
1	0	1s	0	1
2	0	2s	0	1
2	1	2p	-1, 0, 1	3
3	0	3s	0	1
3	1	3p	-1, 0, 1	3
3	2	3d	-2, -1, 0, 1, 2	5
4	0	4s		
4	1	4p		
4	2	4d		
4	3	4f	-3, -2, -1, 0, 1, 2, 3	7

subshell	# or orbitals
s	1
p	3
d	5
f	7

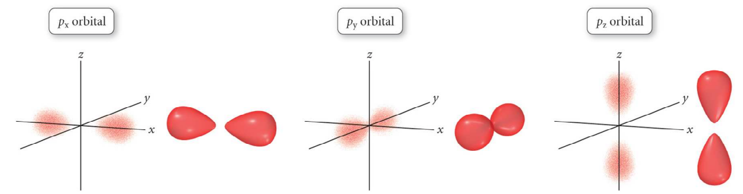
n, ℓ, and m_ℓ define an orbital

n: size & energy
ℓ: shape (slight Δ energy)
m_ℓ: orientation (all same energy)

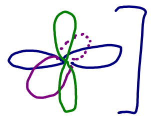
Orbitals

Every s subshell has a single spherical orbital

Every p subshell has 3 dual-lobed orbitals:



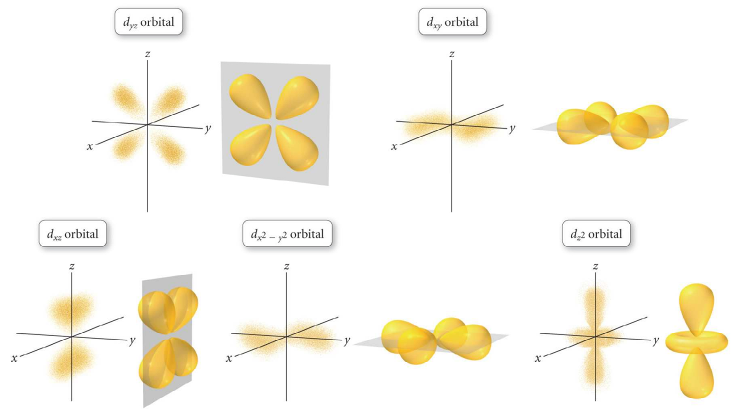
3 orbitals in same area



← a p subshell

n ℓ m_ℓ
2, 1, ~~3~~

Every d subshell has 5 orbitals:



ok: $\underbrace{5, 3}_{5f}$, 2 ← 6th of 7