Light: ~ and o→ o→ o→

matter: o→ AND? ~

de Broglie Suggested $\lambda = \frac{h}{m \cdot u}$

h: Planck's Constant

m: mass (kg)

u: speed (m/s)

e^- : $m_e = 9.1094 \times 10^{-31}$ kg

$u = 25{,}000$ m/s

$\lambda = 29$ nm

VIS Light: λ : 400 - 700 nm

Blue Red

UV-light, X-rays } v. small λ

⇒ can see very small objects!

(in theory... in practice, it is impossible to focus UV-light / X-rays!)

~~UV~~ - Lens

~~X-Ray~~ Lens

~~Move~~ moving e⁻s have λ

e^- : charged!

⇒ can use electric + magnetic lenses to focus the e^- waves!

ELECTRON MICROSCOPE!

Quantum Mechanics

Schrödinger.

e^- : λ : wave 

3-D

symbol: Ψ (psi)

- wavefunction.

$\Psi(x,y,z)$

Ψ^2 = prob of finding e^-

(Born interpretation)

For an e^- in an atom

Ψ (wavefunction) is commonly called an **atomic orbital**

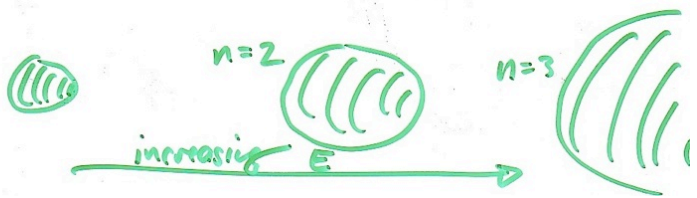
When we solve the Schrödinger equation for an atom (which gives us Ψ) we'll end up needing 4 numbers - Quantum Numbers (QN) as part of the solution.

(1) Principal QN, n

principally determines E + size of Ψ

$n = 1, 2, 3, 4, \ldots$

ex: n=1 n=2 n=3



(2) Angular Momentum Quantum Number, ℓ

ℓ: 0, 1, ..., (n-1)

ex: if n = 4
then ℓ = 0, 1, 2, or 3

ℓ: determines <u>shape</u> of ψ

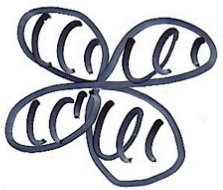
<u>$\ell = 0$</u>

s

<u>$\ell = 1$</u>

p

<u>$\ell = 2$</u>



d

<u>$\ell = 3$</u>

f

for atoms w/ >1 e^-, the value of ℓ does effect E (but not as much as n)

n ~ shell

n, ℓ ~ subshell

n ↓ ℓ ↓

ex: n=1, ℓ=0 ⟶ 1s

ex: n=5, ℓ=2 ⟶ 5d

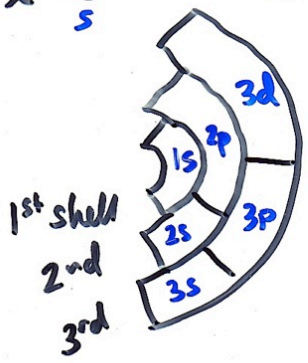
ex: n=3, ℓ=1 ⟶ 3p

<u>n=1</u>
ℓ=0
s

<u>n=2</u>
ℓ=0, 1
s p

<u>n=3</u>
ℓ=0, 1, 2
s p d

<u>n=4</u>
ℓ=0, 1, 2, 3



(3) Magnetic QN, m_ℓ

m_ℓ: takes values from $-\ell$ to $+\ell$ in whole # units.

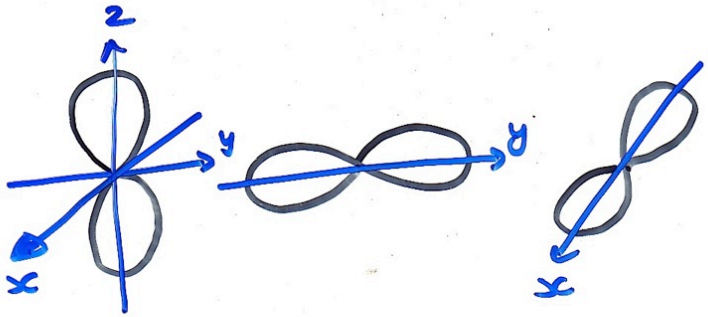
ex: $\ell = 2$, $m_\ell = -2, -1, 0, +1, +2$

ex: $\ell = 1$, $m_\ell = -1, 0, +1$

m_ℓ ~ describes orientation of orbital in space.

ex: if $n=2$, and $\ell=1$ → 2p

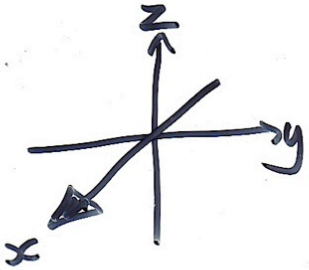
then $m_\ell = -1$ or 0 or $+1$

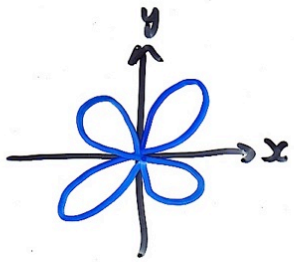


$2p_z$ $2p_y$ $2p_x$

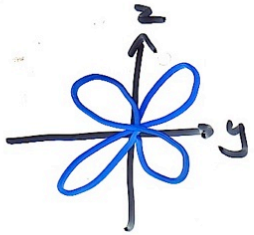
ex: $n=3, \ell=2$ $\quad m_\ell = -2, -1, 0, +1, +2$

3d

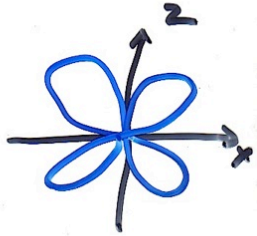




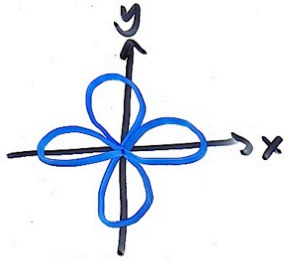
$3d_{xy}$



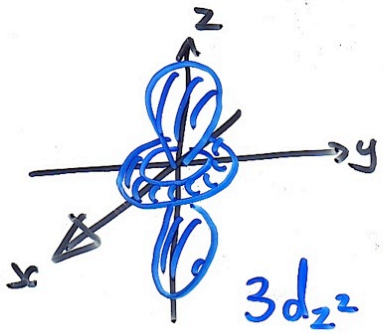
$3d_{yz}$



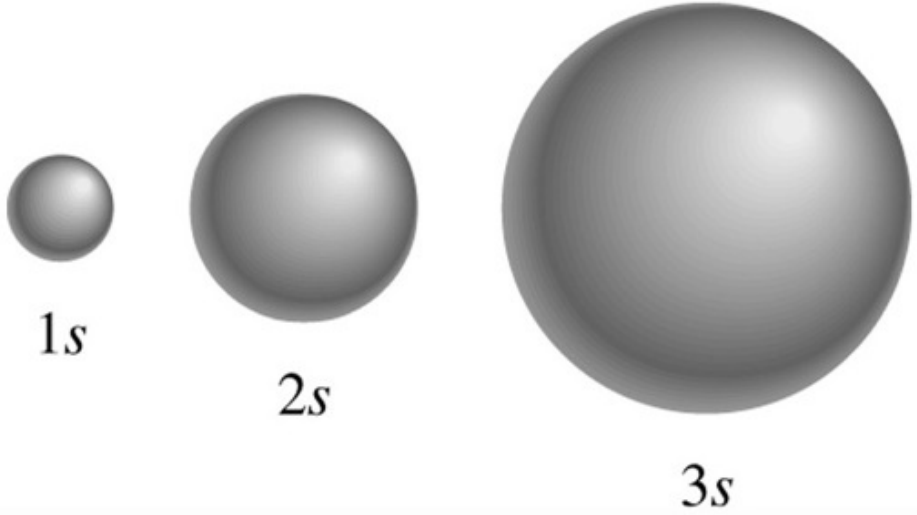
$3d_{xz}$

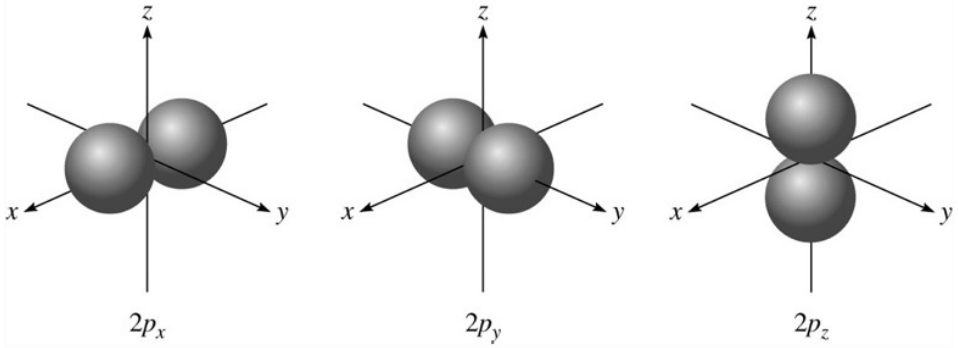


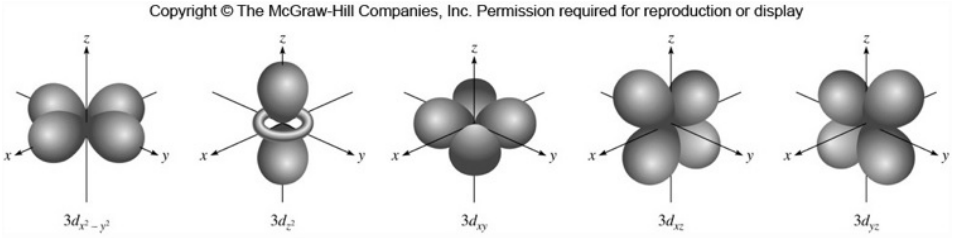
$3d_{x^2-y^2}$



$3d_{z^2}$







4th Quantum Number, m_s, Electron Spin

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

e^- has a magnetic moment ()

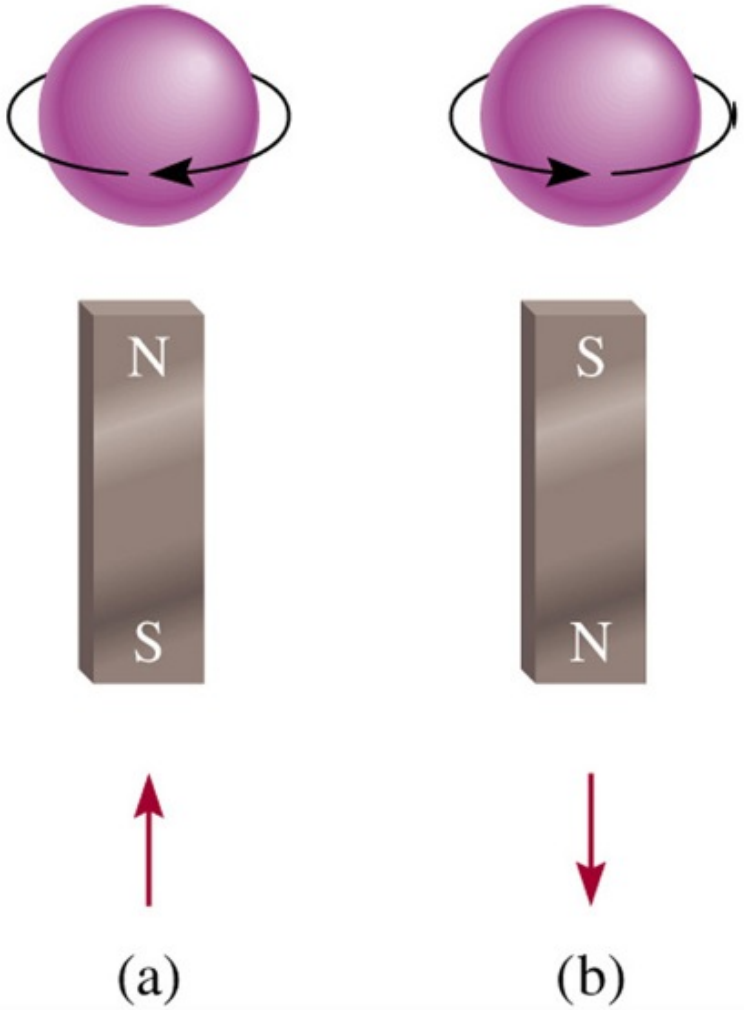
if e^- were spinning...

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

COUNTER CLOCKWISE SPINNING  $m_s = -\frac{1}{2}$

OR ↑

OR ↓



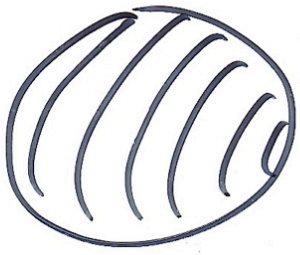
Drawing Orbitals

ψ^2 = prob. of finding e^-.

it is conventional to draw the orbitals as shapes that have a 90% probability of finding e^- within!

1s 

2s 

3s 

Notes about orbitals.

atoms w/ >1 e^-

energy:

$1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p <$

two electrons can occupy the same orbital (n, l, m_l) as long as they have different spins ($m_s = -\frac{1}{2}$ or $+\frac{1}{2}$)