11/8/2019

Solve SE for H-atom

- get 4 Quantum #'s.

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

- size of ψ, E of ψ

② ℓ - angular mom. QN - $\ell = 0, 1, \ldots, n-1$

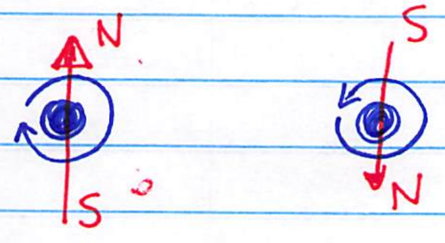
- shape of ψ

③ m_ℓ - magnetic QN - $m_\ell = -\ell, \ldots, 0, \ldots, +\ell$

- orientation of ψ

④ Electron-spin QN, m_s

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

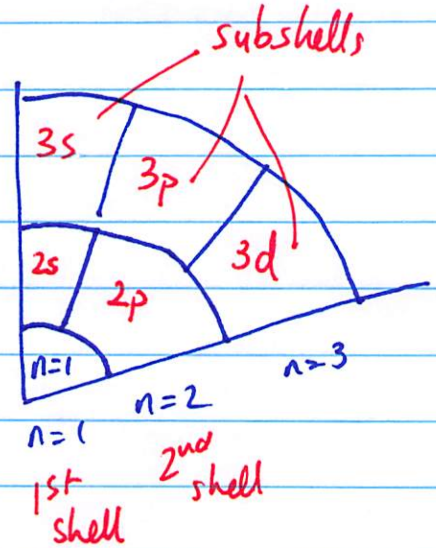


$m_s = +1/2$, $m_s = -1/2$

↑ ↓

Shell

- ψ's w/ same n



Subshell

- ψ's w/ same n, l

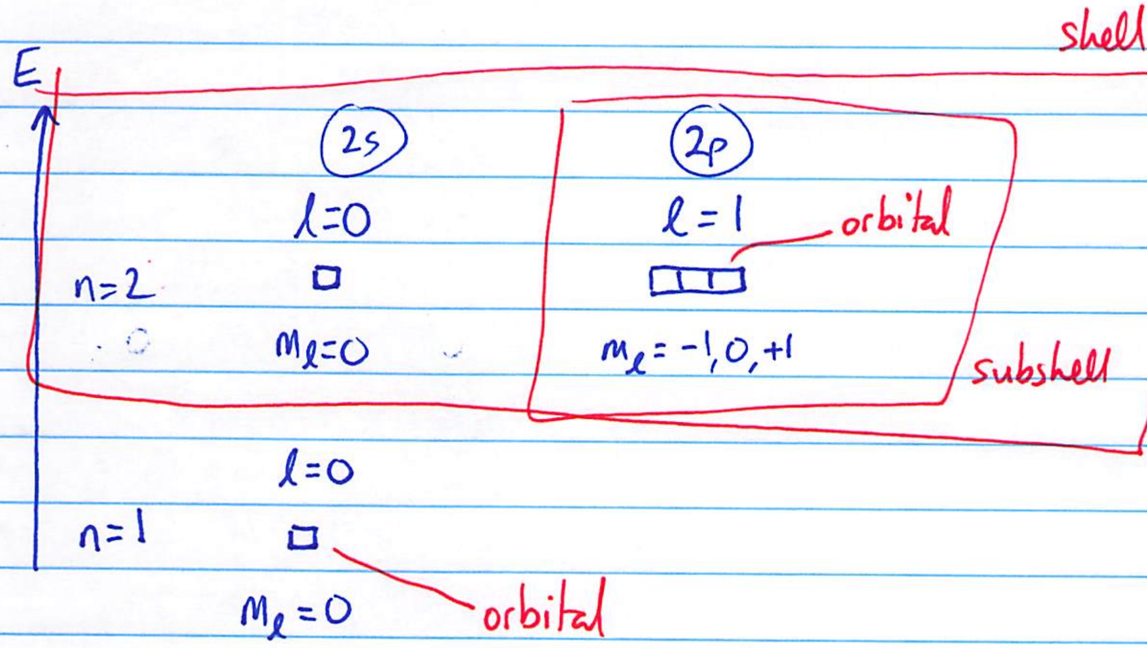
Orbital

- ψ's w/ same n, l, m_l

$n = 1, 2, \ldots$

$l = 0, \ldots, n-1$

$m_l = -l, \ldots, 0, \ldots, +l$



note:

subshells	# orbitals	
s ($l=0$)	1	($m_l=0$)
p ($l=1$)	3	($m_l=-1,0,+1$)
d ($l=2$)	5	($m_l=-2,-1,0,+1,+2$)
f ($l=3$)	7	($m_l=-3,-2,-1,0,+1,+2,+3$)

Describing an Orbital

- Each set of n, l, and m_l describes one orbital.
- Orbitals with the same value of n are in the same **principal energy level**.
  - Also called the principal shell
- Orbitals with the same values of n and l are said to be in the same **sublevel**.
  - Also called a subshell

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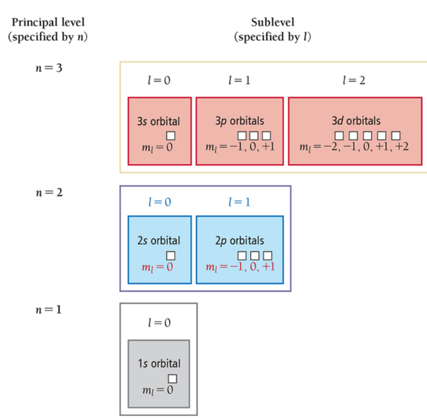
Energy Levels and Sublevels



The $n = 2$ principal energy level contains two sublevels:

a. The $l = 0$: 2*s* sublevel with one orbital with $m_l = 0$

b. The $l = 1$: 2*p* sublevel with three *p* orbitals with $m_l = -1, 0, +1$

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Ch9: Periodic properties of elements.

Dmitri Mendeleev, late 1860's

- organized known elements by "atomic mass"

- chemical properties lined up in columns.
- reordered a few elements to match up better!

Te	I
127.6	126.9

- left gaps... undiscovered elements

	Al	Si	P
Zn	?	?	As
	In	Sn	Sb

Moseley, early 1900s - discovered p^+ in nucleus

$\# p^+ = Z$

Mendeleev's Predictions

Gallium (eka-aluminum)

	Mendeleev's predicted properties	Actual properties
Atomic mass	About 68 amu	69.72 amu
Melting point	Low	29.8 °C
Density	5.9 g/cm^3	5.90 g/cm^3
Formula of oxide	X_2O_3	Ga_2O_3
Formula of chloride	XCl_3	$GaCl_3$

Germanium (eka-silicon)

	Mendeleev's predicted properties	Actual properties
Atomic mass	About 72 amu	72.64 amu
Density	5.5 g/cm^3	5.35 g/cm^3
Formula of oxide	XO_2	GeO_2
Formula of chloride	XCl_4	$GeCl_4$

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What Versus Why

- Mendeleev's periodic law allows us to predict **what** the properties of an element will be based on its position on the table.
- It doesn't explain **why** the pattern exists.
- Quantum mechanics is a theory that explains **why** the periodic trends in the properties exist.
  - Knowing **why** allows us to predict **what**.

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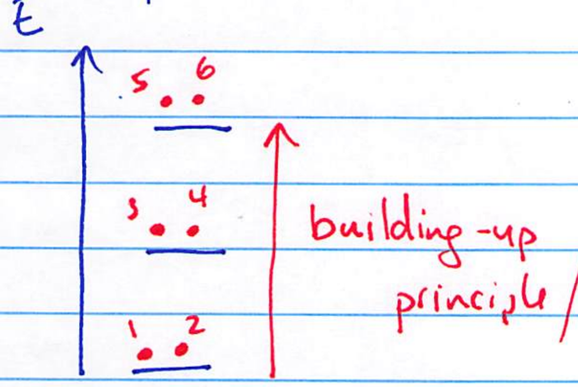
Electron configurations

- arrangement of e^-s in orbitals.
- lowest E (ground state)
  - put e^-s in orbitals w/ lower energies before higher energies.

E



/ Auf Bau principle

For multi-electron atoms, order is:

$$1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p < 5s < \ldots$$

lower E — higher E

ex:

${}_1H$, $1e^-$ $\quad$ $\underbrace{1s}_{\text{subshell }(n,\ell)}{}^{1}$ (#e^-s) $\quad$ (electron configuration)

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

$\boxed{\uparrow}$ $\quad$ (orbital diagram)

1s

$n=1$ $\quad$ $\ell=0$

$m_\ell = 0$

$_2He$, $2e^-$: $1s^2$ (electron config).

$n : 1$
$\ell : 0$
$m_\ell : 0$
$m_s : +\frac{1}{2}$

$\boxed{\uparrow\downarrow}$ (orbital diagram)
1s

$n = 1$
$\ell = 0$
$m_\ell = 0$
$m_s = -\frac{1}{2}$

Pauli exclusion principle (2e^-/orbital)
- each e^- has to have a diff't set of QN's