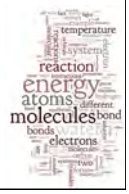
Quantum Numbers and Atomic Orbitals

CLUE: Chemistry, Life, the Universe & Everything



Energy levels of electrons in an atom are quantized (experimental evidence from spectroscopy)

Heisenberg's Uncertainty Principle tells us that we can't know both the energy and the position of an electron

Particles at the atomic-molecular level have wave-like properties (De Broglie)

We use equations derived from quantum mechanics to describe both the energy of an electron, and the probability of finding that electron in a region of space.

We call these regions of high probability for finding electrons - ATOMIC ORBITALS

and each orbital can be described by a set of quantum numbers - that are derived from quantum mechanical calculations

There are four types of quantum numbers
n, ℓ, m_ℓ, and m_s

They allow us to understand the arrangement of electrons in atoms

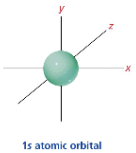
and the arrangement of the periodic table

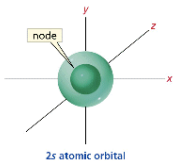
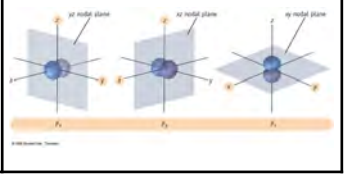
n is the principal quantum number
it can have values of 1, 2, 3, 4 .....etc

ℓ - the angular momentum quantum number
can have integer values of 0 up to n-1

m_ℓ (the magnetic quantum number) can have
integer values from $-\ell$ to $+\ell$
- that is $(2\ell + 1)$ values

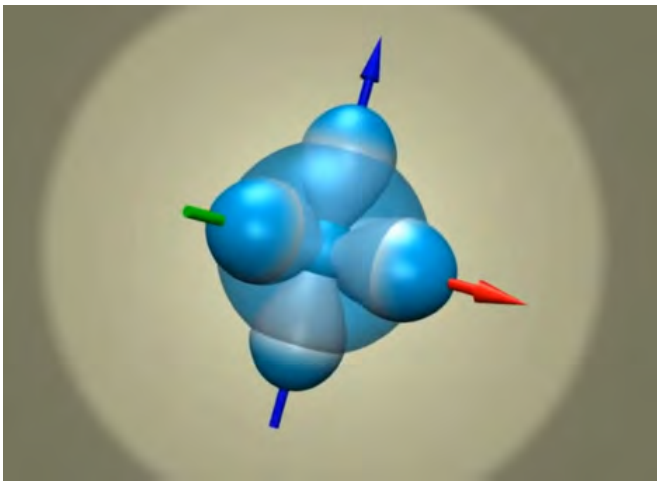
m_s the spin quantum number
can have values of +1/2 or –1/2

n	ℓ (0 to n-1)	m_ℓ(- ℓ + ℓ)	Orbital type
1	0	0	1s  1s atomic orbital

n	ℓ	m_ℓ	Orbital type
2	0	0	2s 
	1	1, 0, –1	$2p_x$ $2p_y$ $2p_z$ 

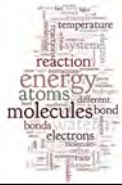
n	ℓ	m_ℓ	Orbital type
3	0	0	3s (like the 2s but with 2 nodes)
	1	1, 0, –1	three 3p orbitals, (like 2p but with 2 nodes)
	2	2, 1, 0, -1, -2	five 3d orbitals

Video of atomic orbitals



Important consequences
(why do we need to know this?)

Understanding the idea that electrons can be described by orbitals of different shapes and definite energies – allows us to understand how elements bond and react, and the arrangement of the periodic table.



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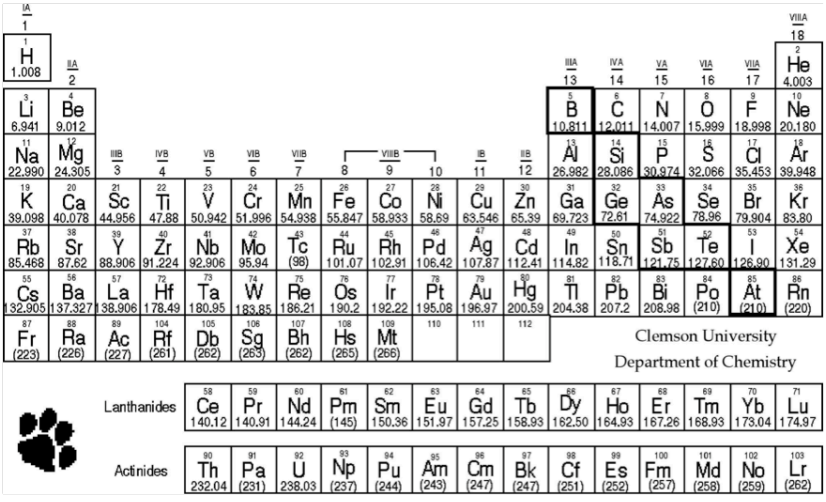
Recap

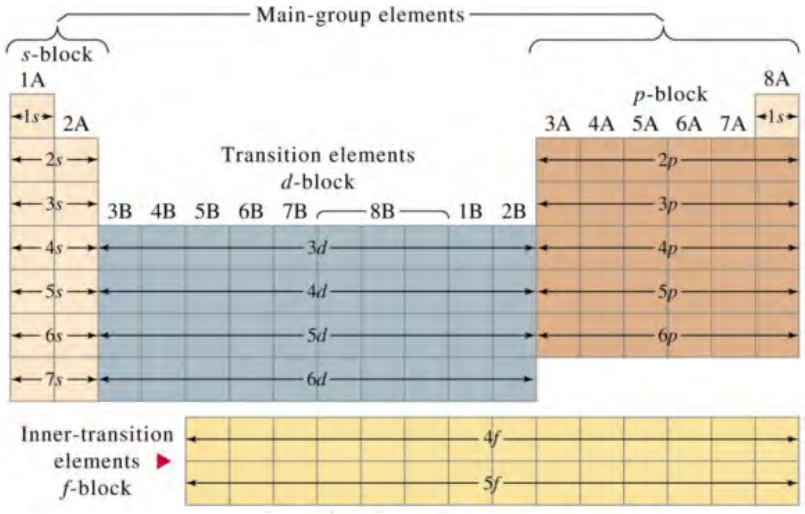
Each atomic orbital can contain a maximum 2 electrons

We can think of quantum numbers as a set of descriptors for electrons in an atom

Electrons in the same orbital have opposite spins, $m_s = +1/2$ or $-1/2$

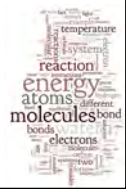
atomic orbitals and the periodic table





Atomic Orbitals and the Periodic Table

link to video



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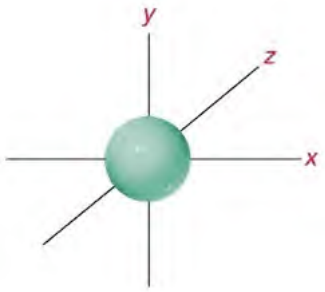
Recall

The position and energies of electrons in atoms can be described by atomic orbitals

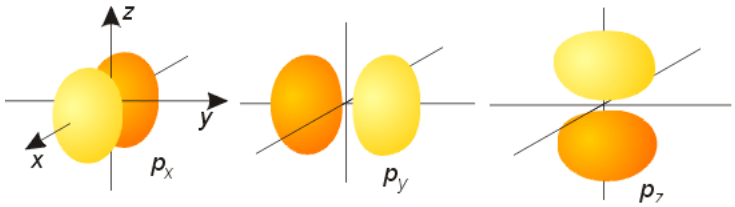
Each atomic orbital can describe a maximum 2 electrons

s orbital

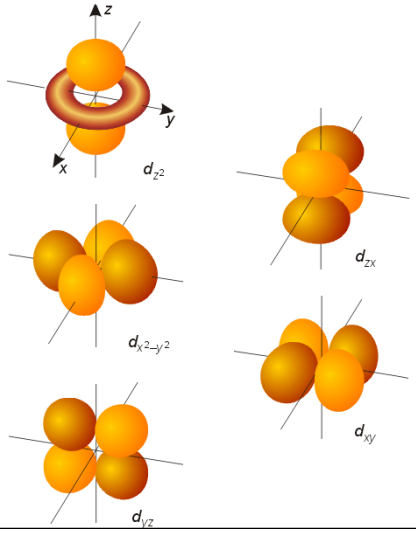


1*s* atomic orbital

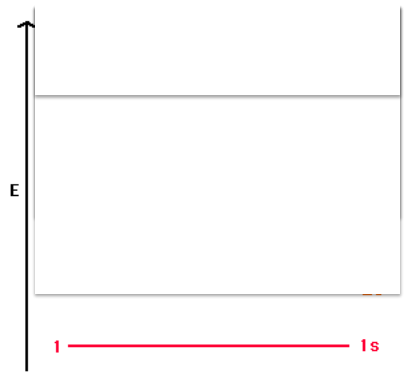
p orbitals



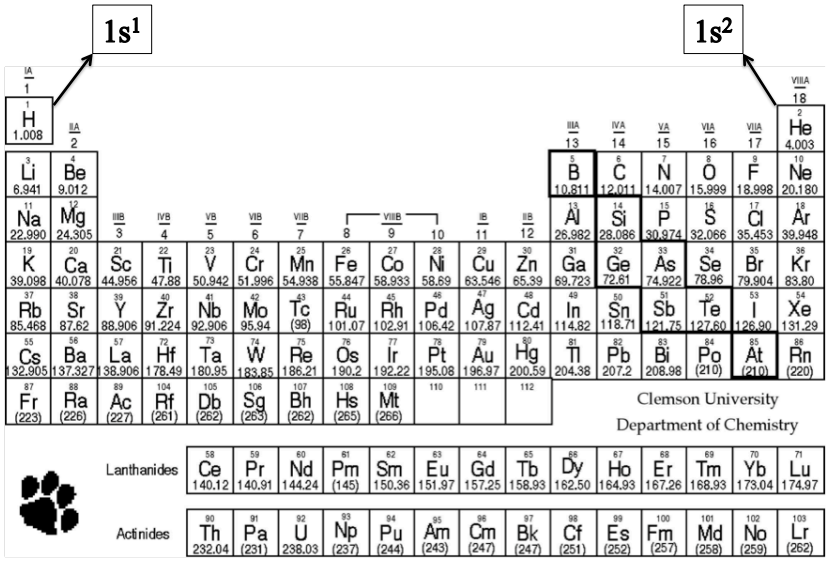
d orbitals

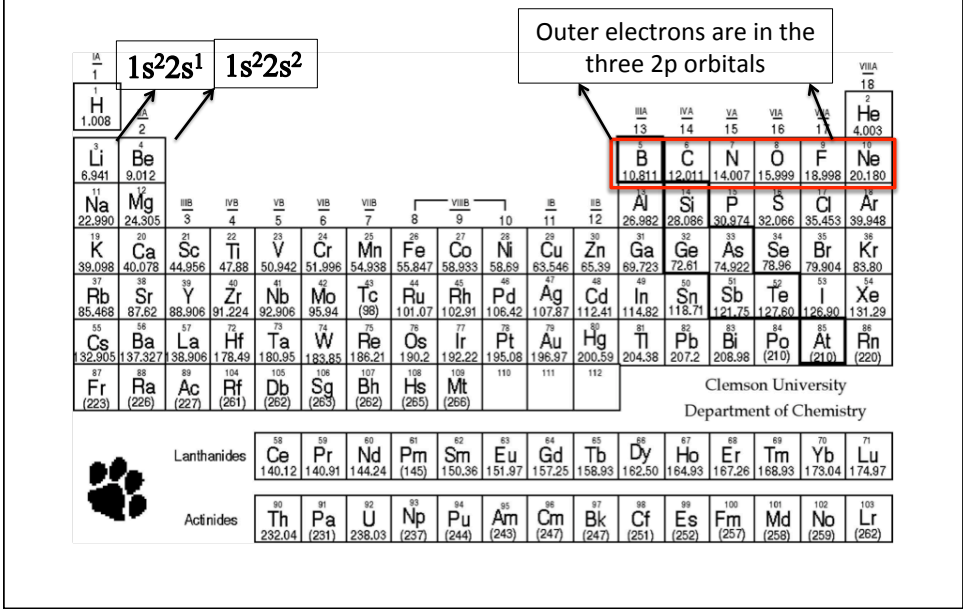


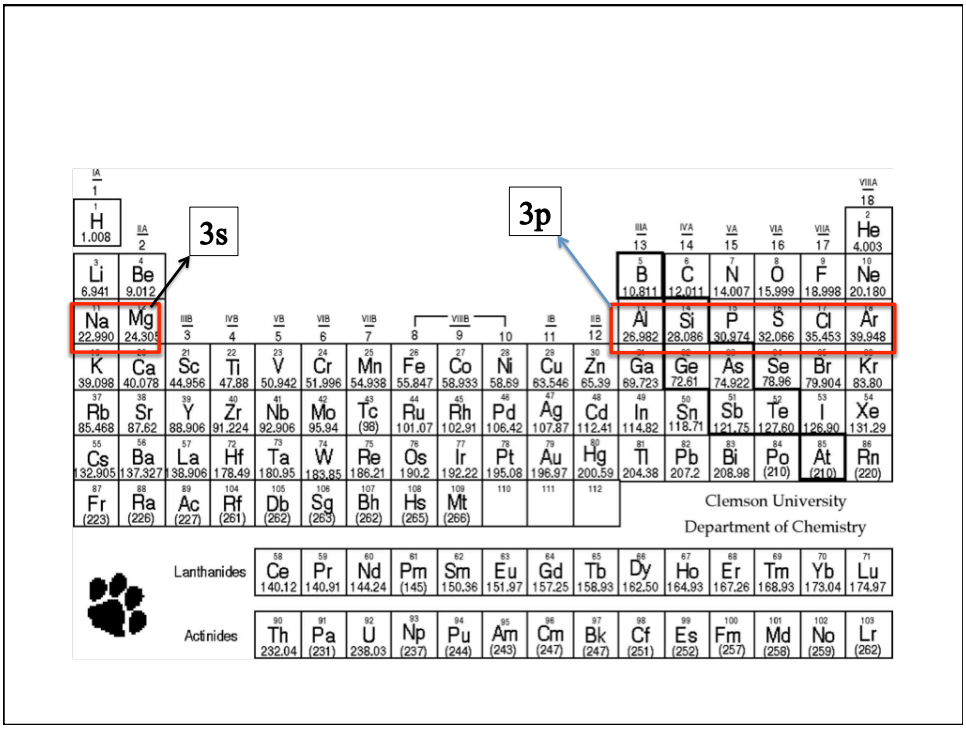
Orbitals have different energies

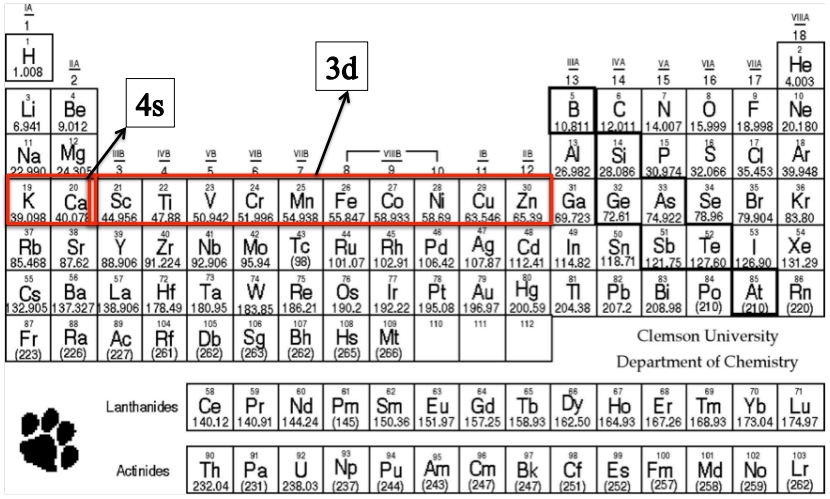


Atomic orbitals and the periodic table




1s²2s¹
1s²2s²
Outer electrons are in the three 2p orbitals
Clemson University
Department of Chemistry
Lanthanides
Actinides

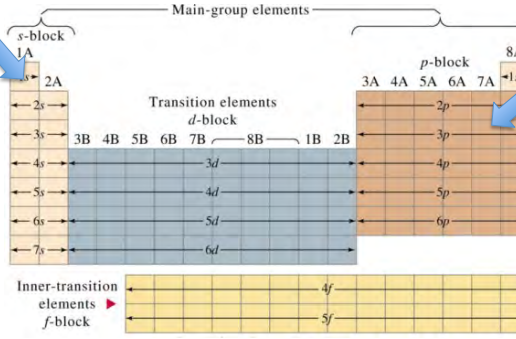

3s
3p
Clemson University
Department of Chemistry
Lanthanides
Actinides



We often refer to elements by the location of their electrons in the outermost orbitals

Alkali and alkaline earth metals are part of the "s-block"

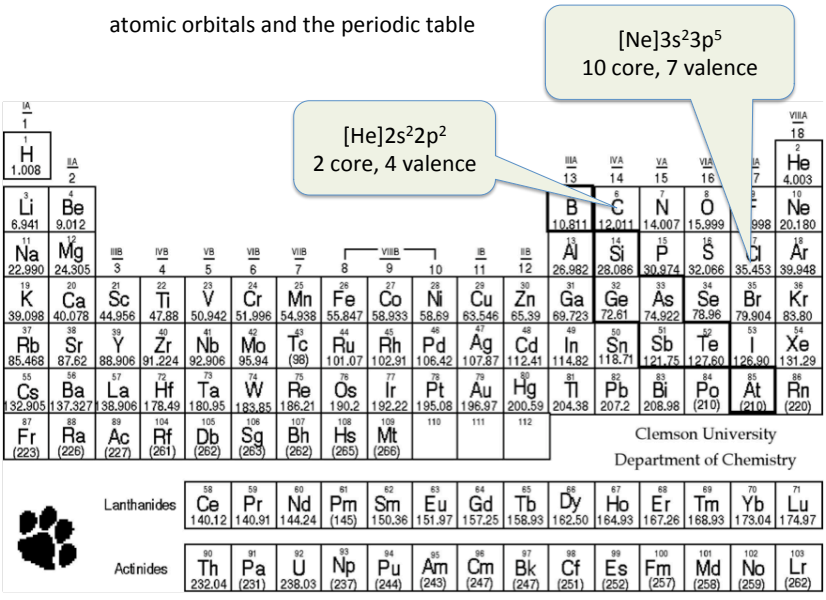
Non-metals are part of the "p-block"



Core and valence electrons

- We are not particularly interested in electron configurations (will not be on exam)
- BUT – core and valence electrons are important!
- Core – is the last noble gas (gp 18) eg Ne or Xe, + any full d shell (transition metals) (a closed shell of electrons is very stable)
- Valence are the electrons that are higher in energy – outside the closed shell

atomic orbitals and the periodic table



How many core, valence does X have?

A. 18 core, 2 valence
B. 10 core, 3 valence
C. 28 core, 7 valence

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