

Chem 115 notes
4/15/08

The Game of Quantum Numbers

Degenerate = all having same energy

l orbital

0 = s

1 = p

2 = d

3 = f

$m_l = 0 \rightarrow \pm l$

if $l = 1$ there are three possible values for m_l

if $l = 2$ there are five possible values for m_l

if $l = 1 \rightarrow m_l = 0, \pm 1$

if $l = 2 \rightarrow m_l = 0, \pm 1, \pm 2$

$n = 3$

$l = 2$

= 3d orbital

$n = 4$

$l = 1$

= 4p orbital

Where Orbitals Are

If $l = 0$ then $m_l = 0$

*Shape of orbital shows how electron spends most of its time

*In an atom, majority of space is taken up by electrons

Summary of the First Three Numbers

*Boxes show where on energy axis electrons can go

* m_l values \rightarrow places electrons can go

*If there are 3 values ($0, \pm 1$) = 3 places electrons can go, there are 3 degenerate orbitals

*This QM model can be used to predict emission of elements other than hydrogen

Orbital Energies in Hydrogen (Only)

*Hydrogen has only one electron – spends most of its time in 1s orbital (ground state)

*Energy of different l values of hydrogen orbitals is degenerate

Orbital Energies in Multielectron Atoms

*Elements other than Hydrogen have l energy levels that are not degenerate (not straight line)

***Ground state of an element is when electrons are in the lowest possible energy state**

***Elements have only one ground state**

Magnetism of Materials

*4th quantum number is where the electron is

*Some materials will magnetize others will not

*Electricity and magnetism are coupled

Magnetism of Materials

*In every energy level – two electrons can fit, but have to be spinning the opposite way

How to Find the Ground State

* l can only go up to $n - 1$

*If one electron is spin up ($m_s = +1/2$), the other electron must be spin down ($m_s = -1/2$).

*You need to know if a particular set of quantum numbers specifies an orbital which is possible or not

$n = 3$

$l = 1 \rightarrow 3p$ orbital

$m_l = 0$

$n = 4$

$l = 1 \rightarrow$ not possible because m_l cannot be 2 (can only go up to $\pm l$)

$m_l = 2$

$n = 2$

$l = 2 \rightarrow$ not possible because l cannot go up to $n - 1$

$m_l = 0$

*Quantum mechanics explains why the periodic table has its structure

Aufbau (Building) Elements

*No two electrons can have exact same numbers (one of the four must be different)

*An up arrow and a down arrow = 2 electrons in the same orbital with opposite spins

*Electrons spin up until all electrons are spinning up in one orbital, then they are paired with electrons that are spinning down

- Put up arrows in all boxes of an orbital

- Then go back and enter the down arrows

*Key is to give 2 different m_l values – any two of the possible – when writing the orbital states

Book's Representation

$1s^2 2s^1 = 2$ electrons in 1s orbital (having opposite spins), 1 electron in 2s orbital

*When writing shorthand notation, need to know if there are degenerate energy levels

*Hint to identifying elements by shorthand notation

Which corresponds to Neon?

1. Add superscripts together (total number of electrons)
2. Total # electrons = Atomic number
3. Atomic number identifies element

Aufbau (Building) Elements

*Very important

- Valence electrons
- Core electrons

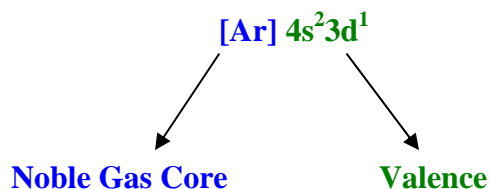
*Noble gas core

Core = Number of electrons in first noble gas underneath the element in question

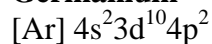
Valence = Number of electrons outside of the core (extra electrons)

Scandium

spdf notation written with noble gas core



Germanium



*Argon is the closest noble gas below Germanium

*Start counting electrons at the lowest orbital

*Argon has 18 Electrons (core)

*There are 14 electrons left over (valence)

*To know the noble gas core, you need the periodic table

The game of Quantum Mechanics: What you need to know

Know this slide