Unit 1, Lesson 03: Representing Electron Configurations using Orbital Diagrams and Quantum Numbers

A. Orbital Diagrams

Sometimes it is helpful to use orbital diagrams to help visualize where the electrons are found in an atom. Orbital diagrams include the same information as the electron configuration, but they also show the electrons' locations and spins in the sub-levels.

$_{25}Mn$ ____ or ______________________

1s	2s	$2p_x$	$2p_y$	$2p_z$	3s	$3p_x$	$3p_y$	$3p_z$	4s	$3d_{yz}$	$3d_{xz}$	$3d_{xy}$	$3d_{z2}$	$3d_{x2-y2}$	$4p_x$	$4p_y$	$4p_z$	5s

B. Quantum Numbers

Another method of describing the energy and location of an electron is "quantum numbers", which substitutes a numerical value for the letters in the electron configuration. Quantum numbers work like an address to tell us where an electron is in the space around the nucleus, and how it is moving. Each electron in an atom has a unique set of four quantum numbers.

1. The **principal quantum number** (n): indicates the distance that the electron is from the nucleus (which indicates the energy of the electron); the same as when writing electron configurations

- the allowed values for n are 1, 2, 3 …4

2. The **orbital shape (or angular momentum) quantum number** (l): substitutes a number for the letter that indicates the orbital's shape

- the allowed values for l are 0, 1, 2, 3 … (n – 1)

s is represented by $l = 0$
p is represented by $l = 1$
d is represented by $l = 2$
f is represented by $l = 3$

3. The **magnetic quantum number** (m_l): indicates the orientation of the orbital in 3-D space

- the allowed values for m_l are $-l$ …. $+l$

s is represented by $m_l = 0$

> when $\boldsymbol{l} = 0$ (s), there is only one possible orientation: spherical

p_x is represented by $m_l = -1$
p_x is represented by $m_l = 0$
p_x is represented by $m_l = +1$

> when $\boldsymbol{l} = 1$ (p), there are three possible orientations, in three planes

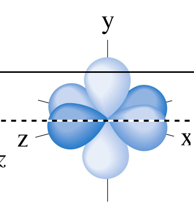
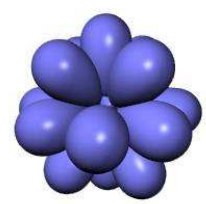
$3d_{yz}$ is represented by $m_l = -2$
$3d_{xz}$ is represented by $m_l = -1$
$3d_{xy}$ is represented by $m_l = 0$
$3d_{z2}$ is represented by $m_l = +1$
$3d_{x2-y2}$ is represented by $m_l = +1$

> when $\boldsymbol{l} = 2$ (d), there are five possible orientations, in five planes

4. The **magnetic spin quantum number** (m_s) indicates the spin on the electron:

$m_s = +½$ indicates an electron spinning "up" ↑
$m_s = -½$ indicates an electron spinning "down" ↓

Summary:

Description	Electron Configuration Notation	Quantum Number Notation
1. The Principal Quantum Number (n): • this is the same for both electron configurations and quantum numbers • indicates how far the electron is from the nucleus • the higher the number, the greater the potential energy of the electron • the allowed values for n are 1, 2, 3 …4	n = 1, 2, 3, 4 …4	n = 1, 2, 3, 4 …4
2. The Orbital Shape or Angular Momentum Quantum Number (l): • uses a number to represent the energy sub-levels (types of orbitals) within each principal quantum level • indicates the shape that the electron wi moving in • the allowed values for l are 0, 1, 2, 3 … (n – 1)	s, p, d, f , g …	l = 0, indicates an "s" orbital l = 1, indicates a "p" orbital l = 2, indicates a "d" orbital l = 3 , indicates a "f" orbital
3. The Magnetic Quantum Number (m_l): • indicates the three dimensional orientation of an electron (which plane the electron is found in) • the allowed values for m_l are $-l$ …. $+l$	s	m_l= 0
	p_x, p_y, and p_z 	m_l= -1 means p_x m_l= 0 means p_y m_l= +1 means p_z
	d_{yz}, d_{xz}, d_{xy}, d_{z2}, and d_{x2-y2} 	m_l= -2 means d_{yz} m_l= -1 means d_{xz} m_l= 0 means d_{xy} m_l= +1 means d_{z2} m_l= +2 means d_{x2-y2}
4. The Magnetic Spin Quantum Number (m_s): • each orbital can hold a maximum of two electrons with opposite spin (the Pauli Exclusion Principle) • allowed values for m_s are – ½ or + ½	up (↑) down (↓)	+ ½ means an electron with an "up" spin, – ½ means an electron with a "down" spin