General Chemistry

Atomic Structure

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Chapter Description

- **Expected Outcome:**

  At the end of the lecture, the students should be able to understand and solve the problems regarding Atomic model, Quantum mechanical model and electron configuration.

- **Reference:**

  1) Martin S. Silberberg. Principles of General Chemistry. McGraw-Hill.

  2) Raymond Chang. General Chemistry: The essential concepts. McGraw-Hill.

Contents

- Bohr's Atomic Model
- Electronic configuration
- Quantum Mechanical Model

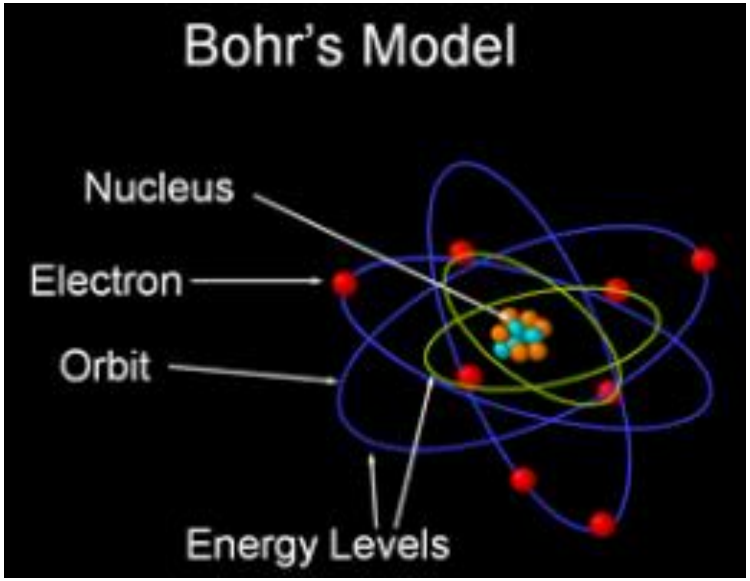
Bohr's Atomic Model

Bohr's Postulates:

- **An electron moves in a circular path (orbit) around the nucleus of an atom, but the electron does not radiate or absorbing any energy**
- **Energy of an electron is quantised**

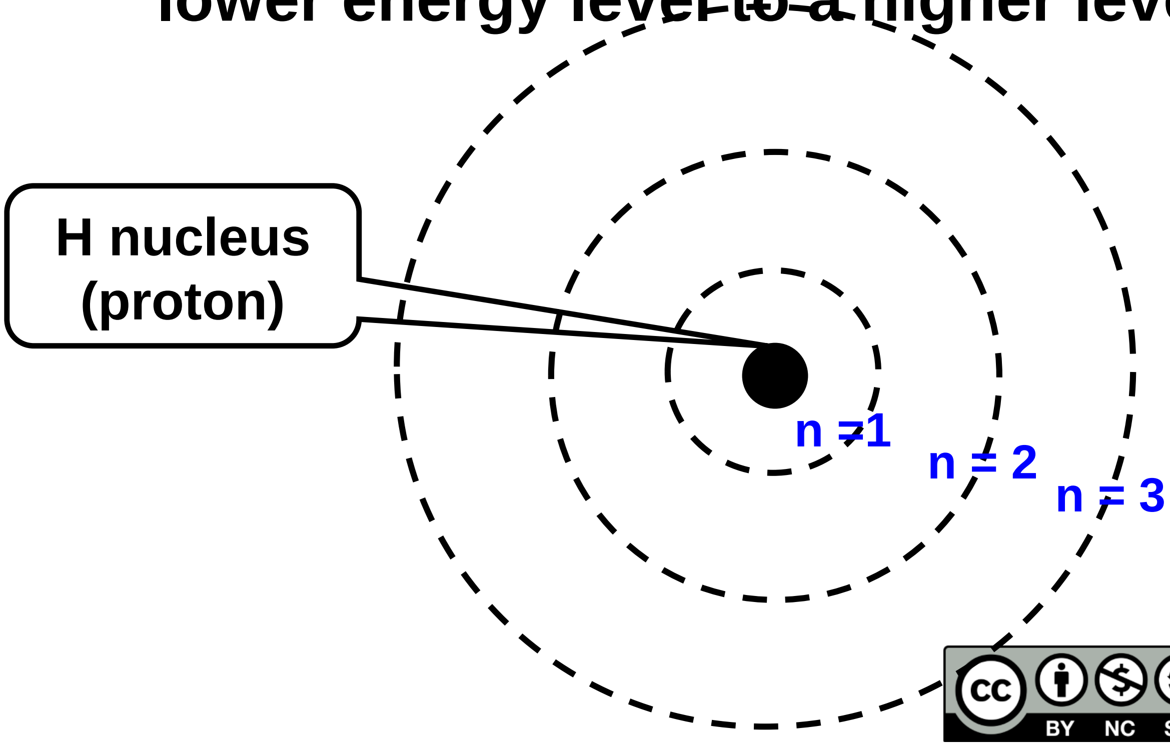
Bohr's Atomic Model

- Picture source: http://byjus.com/chemistry/bohrs-atomic-model-and-its-limitations/



Bohr's Postulate

- **At ordinary condition the electron is at the ground state (lowest level). If energy is supplied, electron will absorb the energy and promoted from lower energy level to a higher level**



Bohr's Postulate

Electron at excited states is unstable. It will go back to lower energy level and releases energy in form of light.

ENERGY DIFFERENCE during transition (ΔE)

$$E_{\text{photon}} = \Delta E = E_{\text{f}} - E_{\text{i}}$$

$$E_f = -\,R_H\left(\frac{1}{n_f^2}\right) \qquad E_i = -\,R_H\left(\frac{1}{n_i^2}\right)$$

Energy differences between two levels:

$$\Delta E = R_H\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right)$$

$$= h\nu$$

Note: i = initial ; f = final

- The amount of energy released is called a photon
- Photon is emitted in the form of radiation with a frequency and wavelength.

$$\Delta E = h\nu$$

$$\nu = \frac{c}{\lambda}$$

$$\Delta E = \frac{hc}{\lambda}$$

λ : wavelength (m)

c : speed of light = 3.00×10^{8} m/s

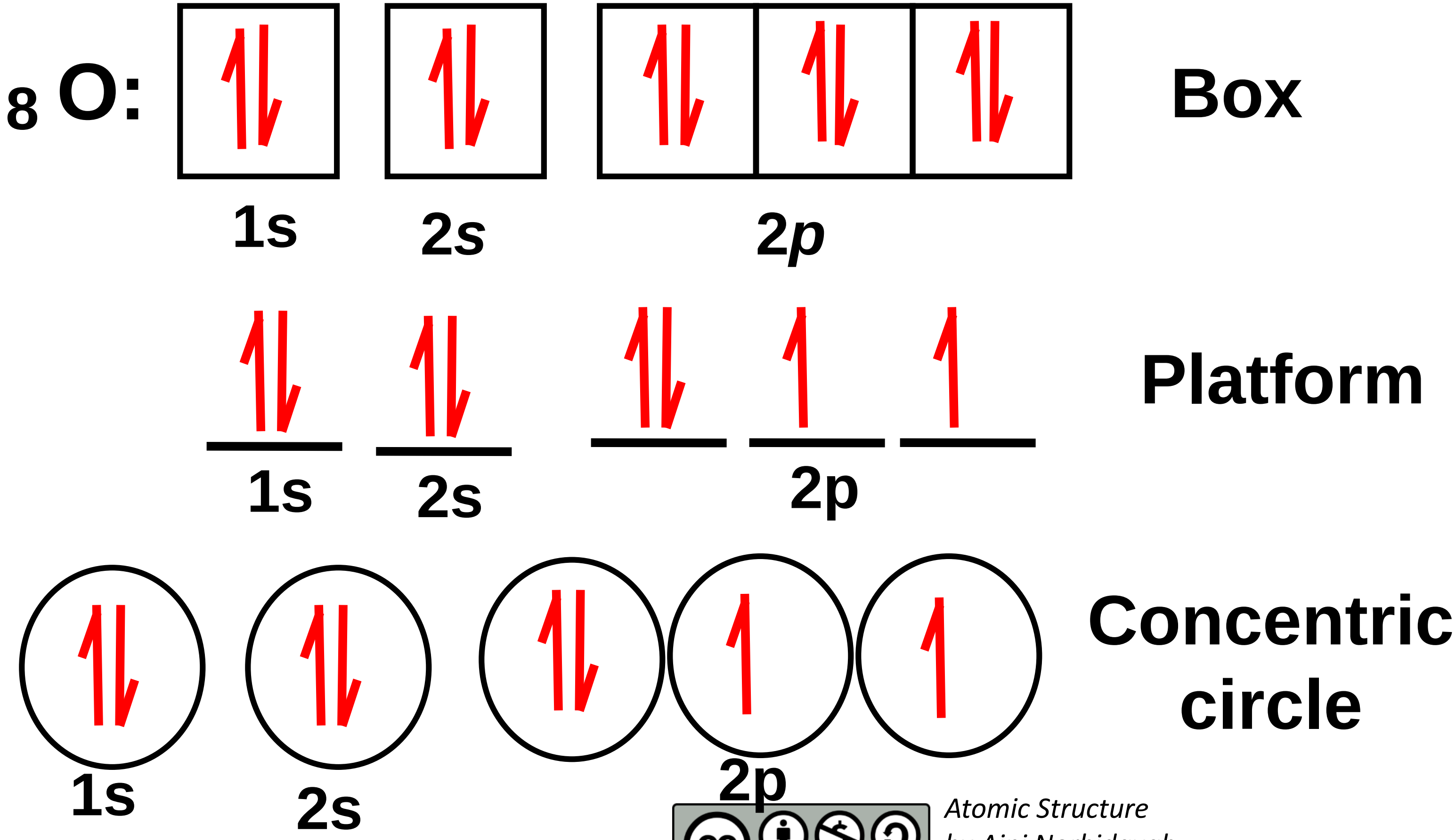
h : planck constant = 6.63×10^{-34} Js

Electron configuration

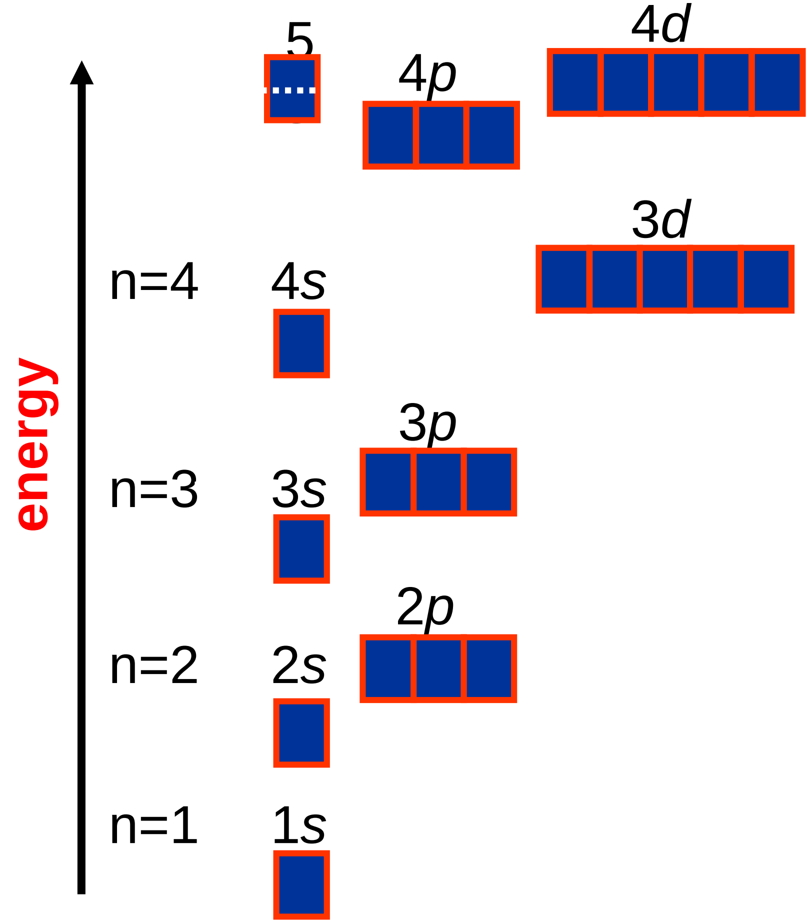
Shows how electrons are distributed in various atomic orbitals

Representing electronic configuration

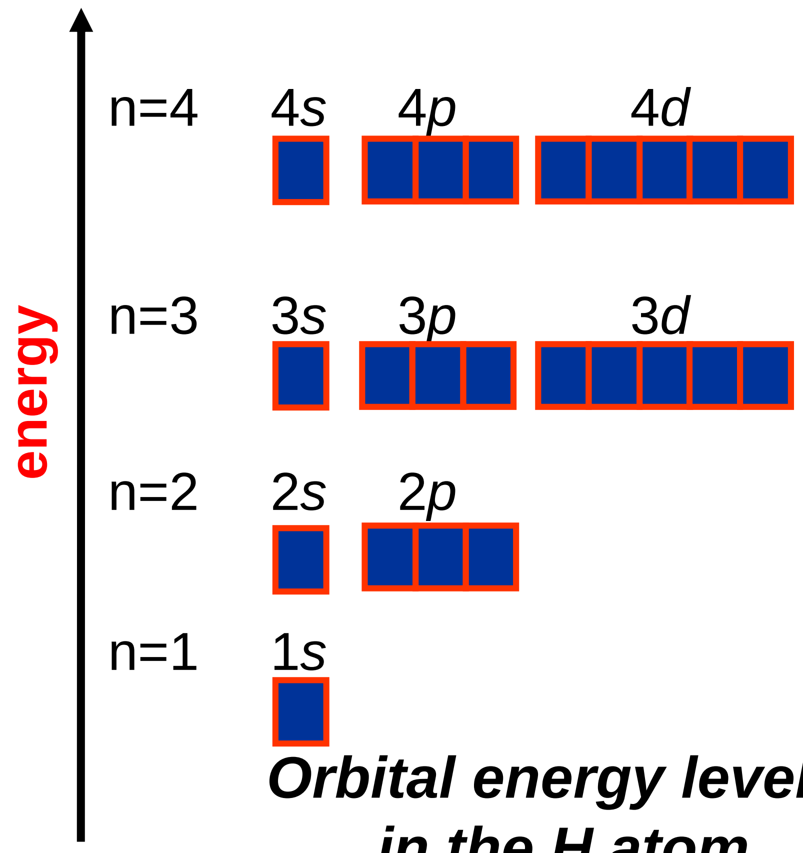
- **Method 1: Orbital diagram**



Relative energy of atomic orbital



Orbital energy levels in a many-electron atom

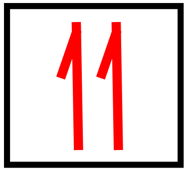


Orbital energy levels in the H atom

Pauli Exclusion Principle

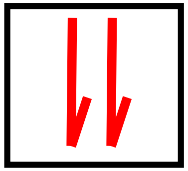
No 2 electrons in the same atom can have same quantum numbers

He atom
$1s^2$



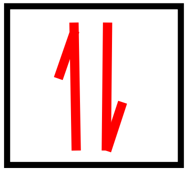
(1,0,0, +½)

(1,0,0, +½)



(1,0,0, -½)

(1,0,0, -½)



(1,0,0, +½)

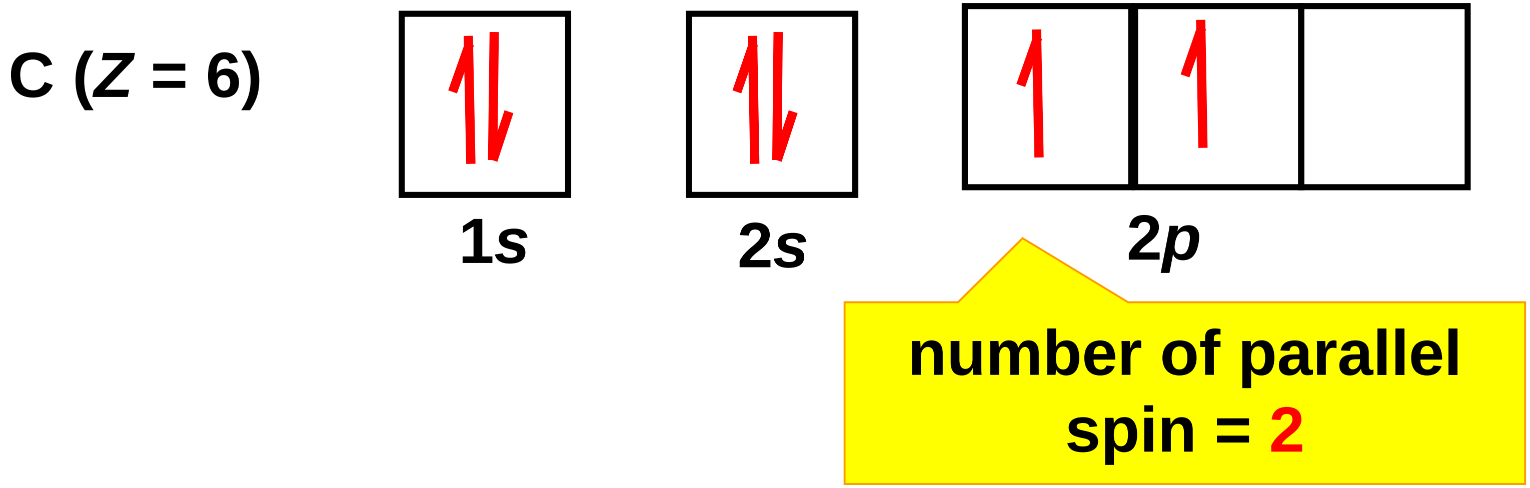
(1,0,0, -½)

☑ correct

Hund's Rule

Before any one orbital is doubly occupied, every orbital in a subshell is singly occupied with one electron

All electrons in singly occupied orbitals have the same spin.



Quantum number

Principal quantum number (*n*)

Angular momentum quantum number (*ℓ*)

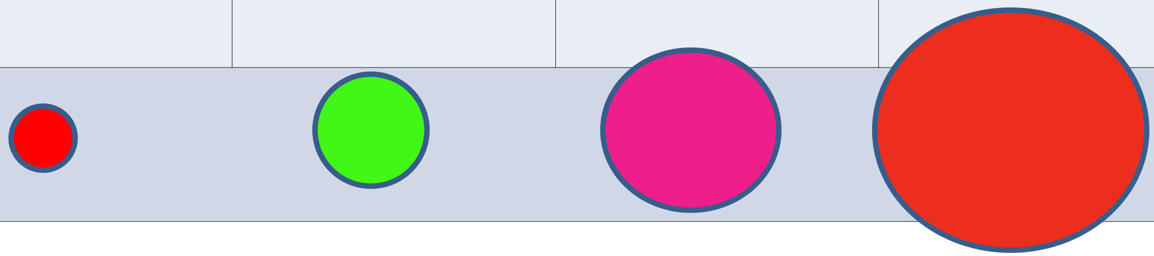
Magnetic quantum number (*m*)

electron spin quantum number (*s*)

Principle of Quantum number

The *value* of *n* determines the *energy* of an orbital thus determining the energy of an electron in that particular orbital

n	**1**	**2**	**3**	**4**
shell	**K**	**L**	**M**	**N**
Orbital size	**increase →**			
Energy				



Angular momentum number

ℓ = Integer 0 to (n – 1)

Indicates the shape and types of orbital

n **determine** ℓ

EXAMPLE:

$n = 1 \quad \ell = 0$

$n = 2 \quad \ell = 0 , 1$

$n = 3 \quad \ell = 0 , 1 , 2$

Magnetic quantum number

m **= integer from – ℓ through 0 to + ℓ**

Indicates orientation of orbital in the space around the nucleus

ℓ determine *m*

Number of possible *m* values = 2ℓ + 1

EXAMPLE:

1 possible orbitals
(*s* subshell)

possible orbitals
(*p* subshell)

5 possible orbitals
(*d* subshell)

$\ell = 0$ $\quad m = 0$

$\ell = 1$ $\quad m = -1, 0, +1$

$\ell = 2$ $\quad m = -2, -1, 0, +1, +2$

Hierarchical relationship

n —limits→ ℓ —limits→ m

EXAMPLE:

$n = 2$ possible ℓ values = 0 , 1

$\ell = 1$ possible m values = – 1 , 0 , +1

$\ell = 0$ possible m values = 0

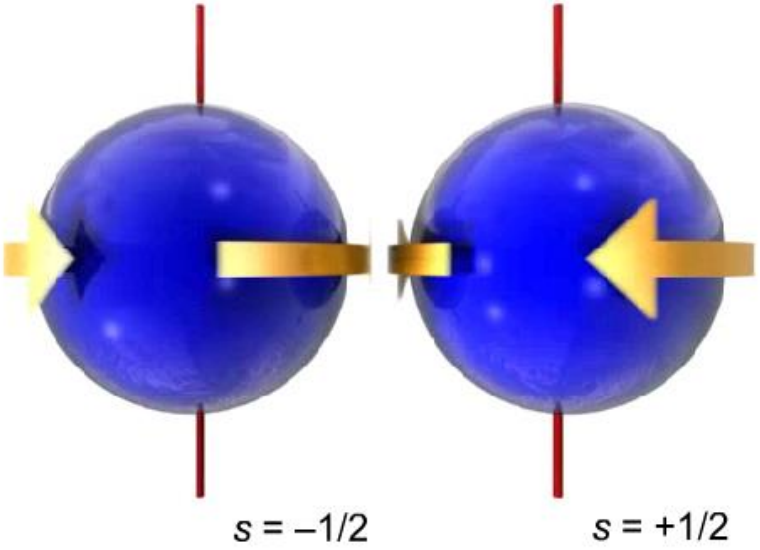
- **max no. of e^- = $2n^2$**

Electron Spin Quantum Number

***s* value of : +½ and –½**

Two possible motions of an electron

- ☞ **clockwise and anti–clockwise**

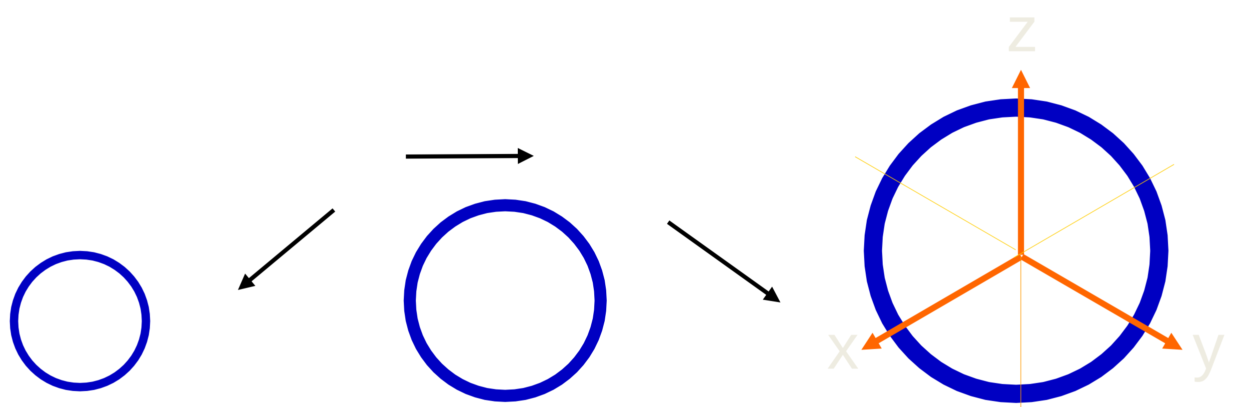


Shape of *s* orbital

Spherical shape with nucleus at the center

2*s* orbital larger than 1*s*

Only have 1 orientation (*ℓ* = 0, *m* = 0)



1*s* **2*s*** **3*s***

Shape of *p* orbital

- When $\ell = 1$
- Dumbbell shaped
- 3*p*-orbitals p_x, p_y, and p_z.
- Correspond *m* of -1, 0, and +1.
- As *n* increases, the *p*-orbitals get larger.
- All *p*-orbitals have a node at the nucleus.

Shape of *d* orbital

- 4 ***d*** **orbitals have 4 lobes (perpendicular),**
- **1 d orbital has 2 major lobes along z axis and a donut-shaped girdles the center.**

When $\ell = 2$

m **= -2, -1,0,1,2**

the orbitals are: d_{yz}, d_{xz}, d_{xy}, $d_{x^2-y^2}$, d_{z^2}

Author Information

Aini Hidayah Mohamed is a lecturer from Faculty of Industrial Sciences & Technology Industry, Universiti Malaysia Pahang, Malaysia. She is also a chemist who has experiences in general chemistry, industrial chemistry and natural product subject.