

CHEMICAL BONDING

Bent's Rule & Drago Rule Explained



Valbhav Trivedi

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ACKNOWLEDGMENT

To my teachers : I owe an enormous debt of thanks to my teachers, especially to Mr. Gurdev Bharadwaj & Dr Ram Kuntal Hazra who always blessed & supported me during my entire student life.

To my family : I express special thanks to my parents, bhaiya bhabhi & my wife who constantly motivated me to write this book & also to my sweet daughter Parluka who smile has been a constant source of motivation for me.

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This book is dedicated to my mother who always inspired me to go high but I couldn't touch.

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Preface

I wish to express my gratitude and indebtedness to all students and teachers who have been using the earlier editions. The book has been improved a lot as a result of their valuable suggestions and comments.

The present edition of this book has been thoroughly revised in accordance with the latest competitive trends while retaining the salient features and strengths of the previous editions.

In this edition, a new topic entitled 'Resonance' has been introduced. Errors in previous editions have also been rectified. Requisite modifications in some chapters and addition of problems in every chapter has been done keeping in mind the requirements of IIT-JEE aspirants.

A separate section comprising of true-false exercises has also been introduced at the end of the book with the primary aim of enabling the students to check their conceptual base and strengthen it accordingly.

I shall feel highly obliged, if the students and their fellow teachers send their constructive criticism and suggestions which we will be using in the publication of future editions.

I hope that the readers will enjoy and benefit from the experience of learning '**Chemical bonding**' as is presented in this revised edition.

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Contents

	Page No.
1. Some Basic Concepts of Atomic Structure & Periodicity Properties	1-6
2. Bonding	7-22
3. Valence Bond Theory & Resonance	23-34
4. Hybridization (VSEPR, Bent's & Drago's Rule)	35-66
5. Polarization, Dipole Moment & Hydration Energy	67-90
6. Molecular Orbital Theory & Metallic Bonding	91-112
7. Hydrogen Bond & Inter Molecular Force of Attractions	113-126
8. Miscellaneous Problems	127-152

➤ 1.1 Orbital and orbital wave function

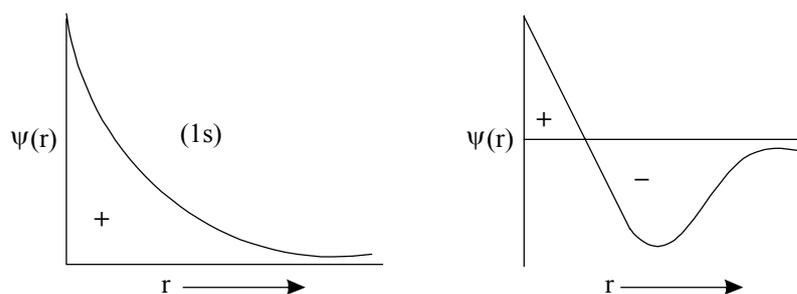
"The region around the nucleus where probability of finding electron is maximum is called orbital and the region where probability of finding electron is zero is called node"

In order to find out the probability of finding electron in a given space of volume within the nucleus, we take help of wave function (ψ). Orbital wave function (ψ) can be written in the form of product of two wave functions.

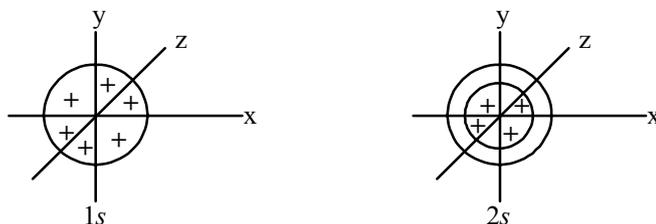
$$\psi = \psi(r) \times \psi(\theta, \phi)$$

(Radial function) (Angular function)

The radial part of orbital wave function i.e $\psi(r)$ gives the information about the size of orbital and depends on quantum number 'n' & 'l'. On the other hand, the angular part of wave function gives the information of shape of orbital and depends on quantum numbers 'l' & 'm'. The variation of the radial part of the orbital wave function for 1s and 2s orbitals is given below



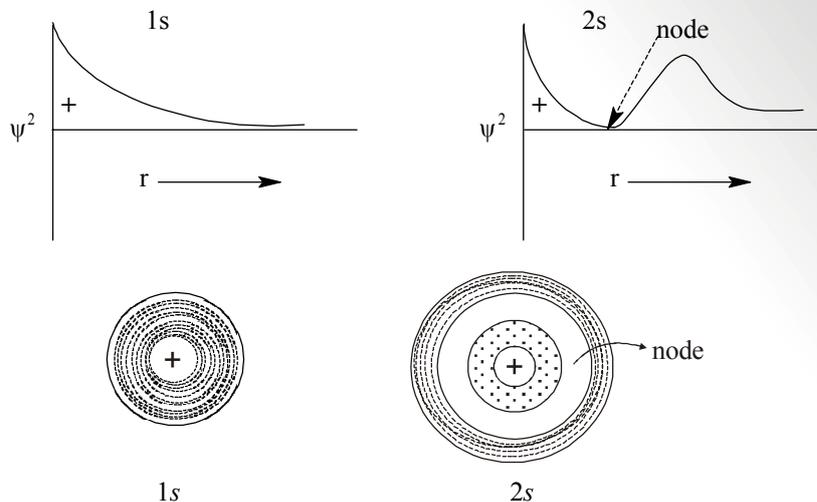
It is observed that the shape of 's' orbital does not depend on angular part of wave function but it only depend upon radial part of wave function. Therefore, all 's' orbitals are spherical because they have no directional dependence.



In this figure, +ve and -ve sign indicates that in particular region wave function is +ve and -ve. It has no relation with +ve and -ve charge.

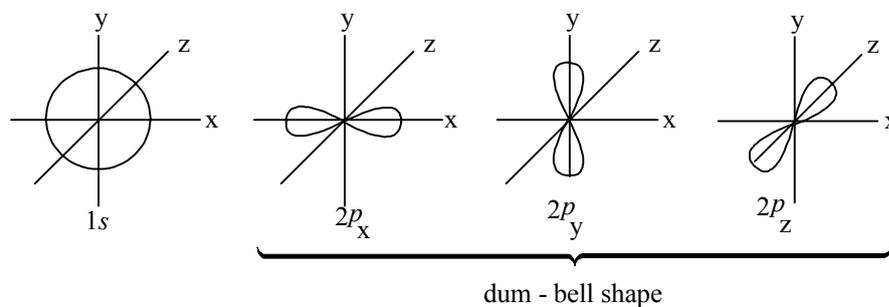
Probability density (ψ^2): - Wave function ψ only shows amplitude of electron wave whereas square of wave function ψ^2 shows the probability of finding electron in a definite region around the nucleus.

The graph between ψ^2 and r (distance from nucleus) denotes probability density curve. Here probability density curves for 1s & 2s orbitals are shown below

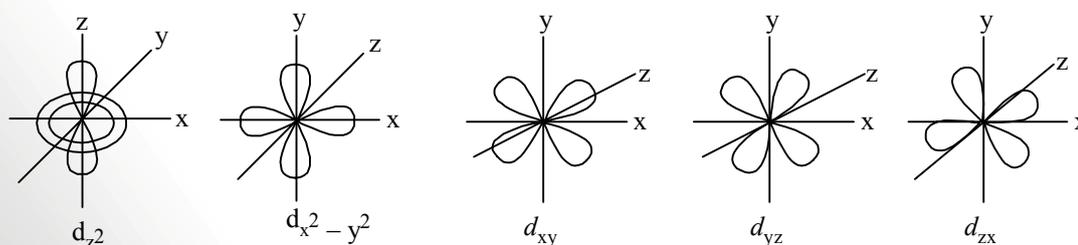


The shapes of the orbitals can be represented quite accurately with the help of boundary surface diagram. The boundary surface diagram for 's' orbitals are spherical in shape. The size of 's' orbital however increases with increase in number of shell. The boundary surface diagram of the three 2p orbitals is not spherical. Each 'p' orbital consists of two lobes which are separated by a region of zero probability (node).

In three 'p' orbitals lobes lie on p_x , p_y & p_z axis respectively



Shapes of d orbitals (double dumbbell):-

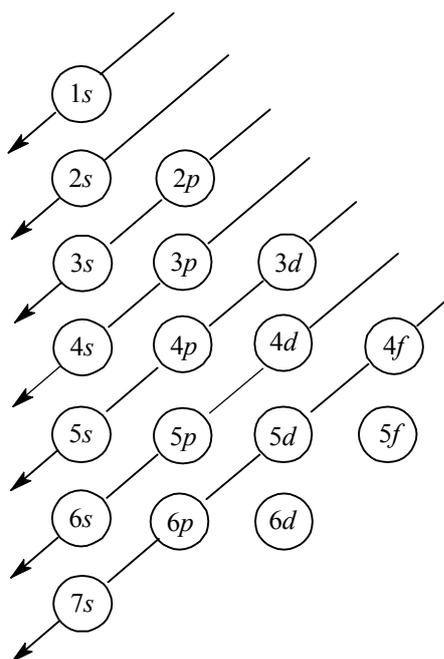


Out of five 'd' orbitals, only two 'd' orbitals d_{z^2} & $d_{x^2-y^2}$ have their lobes on the axis, rest all 'd' orbitals have their lobes in between the axis.

➤ 1.2 Aufbau principle and electronic configuration

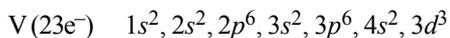
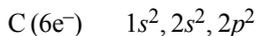
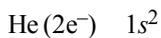
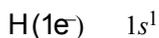
The electrons are added progressively to the various orbitals in their order of increasing energies starting with the orbital of lowest energy.

In order to remember the various orbitals in increasing order of energy, we take help of following diagram



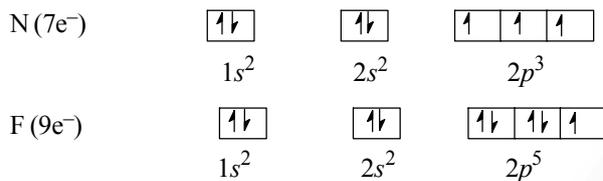
$1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, 5s, 4d, 5p, 6s, 4f, 5d, 6p, 7s$

Electronic configurations of some elements are given below



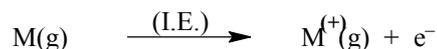
➤ 1.3 Hund's rule of maximum multiplicity

Pairing of electron in degenerate orbitals (orbitals with same energy) belonging to same sub shell does not occur till each orbital of that sub shell is singly occupied with parallel spin.



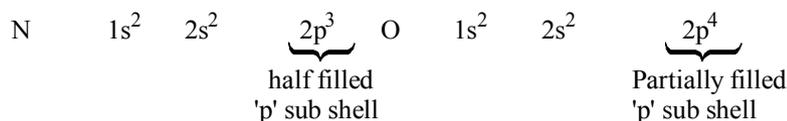
The radius of cation is smaller than its parent atom because when atom releases an electron to form cation, its effective nuclear charge ($Z^* = p/e$ theoretically) increases and valence electron feels more attraction from the nucleus, consequently radius decreases. On the other hand the radius of anion is more than its parent atom because when an atom gains electron to form anion its effective nuclear charge ($Z^* = p/e$) decreases and valence electron feels less attraction from the nucleus resulting in small ionic radius.

- (c) **Ionization energy (I.E) or Ionization potential (I.P):** - It is the amount of energy required to remove an electron from an isolated gaseous atom to produce cation

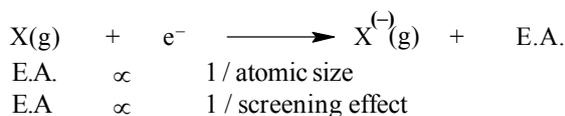


In general I.E. decreases on moving down the group because on moving down the group atomic size increases & valence electron feels less attraction from nucleus.

If an atom has exactly half filled or completely filled sub shells, then such an atom requires more ionization energy than the atom with partially filled sub shell. For example first I.E. of nitrogen is greater than oxygen.

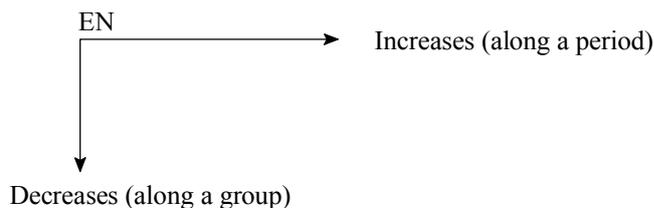


- (d) **Electron gain enthalpy of electron affinity (E.A):**- It is the energy released when an electron is added to a neutral gaseous atom to convert it in to an anion



- (e) **Electronegativity (E.N)**

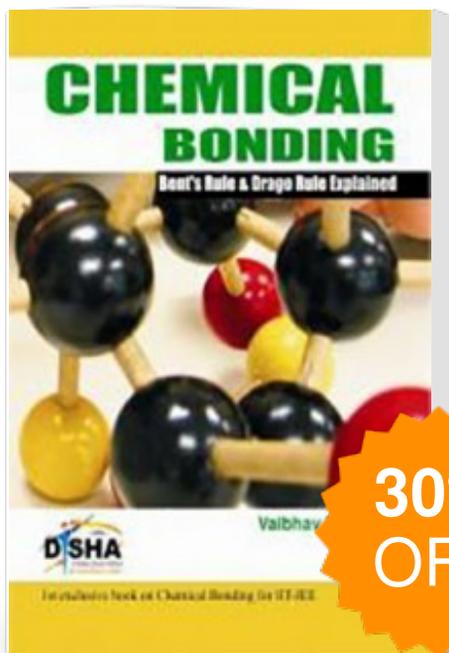
Electronegativity is a measure of the tendency of an element to attract electrons towards it self in a covalently bonded molecules



There is no direct method to measure the value of electronegativity; however there are some scales like Pauling scale, Mulliken scale & Allred - Rochow scale, to measure its value. In chemical bonding, we often use Pauling scale. Electronegativity of some elements on Pauling scale is given below.

Li	Be	B	C	N	O	F
(1.0)	(1.5)	(2.0)	(2.5)	(3.0)	(3.5)	(4.0)
Na						Cl
(0.9)						(3.0)
K						Br
(0.8)						(2.8)
Rb						I
(0.8)						(2.5)
Cs						
(0.7)						

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