Republic of Iraq
Ministry of Higher Education & Scientific research
Al-Mustaqbal University
Science College
Biochemistry Department

Introduction in Chemistry

For

First Year Student

Lecture 7

By

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Lewis structure and Octet rule

Lewis Theory

All elements except hydrogen (hydrogen have a duet of electrons) have octet of electrons once they from ions and covalent compounds. The Lewis dot symbols for atoms and ions shows how many electrons are need for a atom to fill the octet. Normally there are octet of electrons on most monoatomic ions

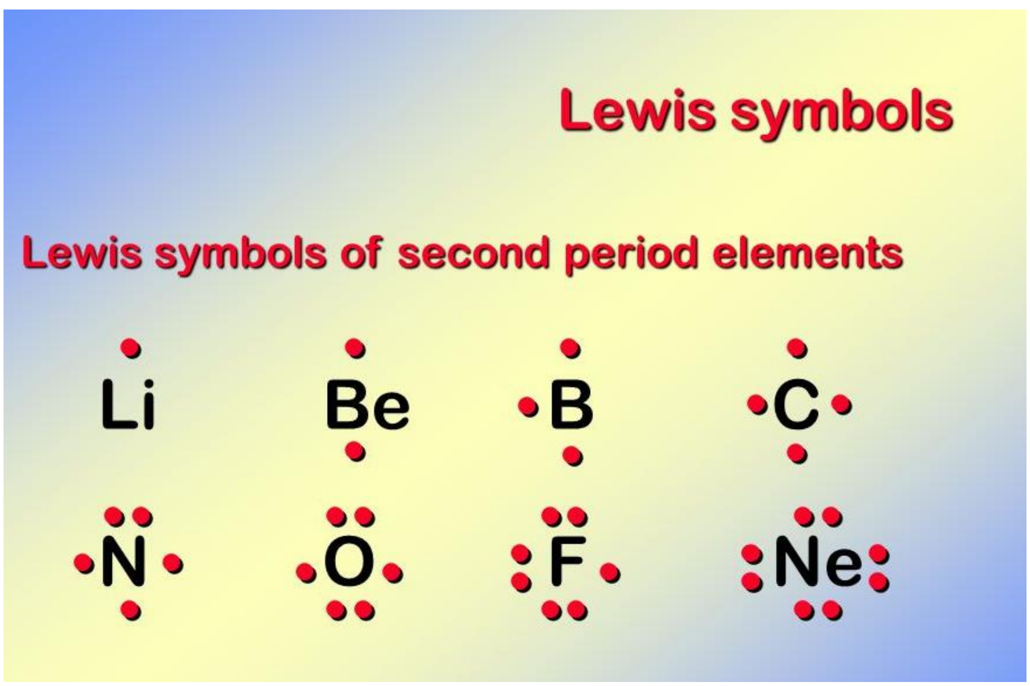
Basic rules drawing Lewis dot symbols:

1. Draw the atomic symbol.

2. Treat each side as a box that can hold up to two electrons.

3. Count the electrons in the valence shell.

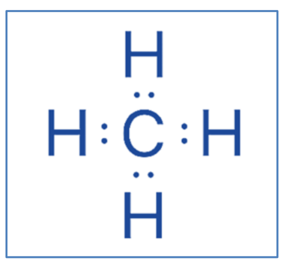
Start filling box - don't make pairs unless you need to.



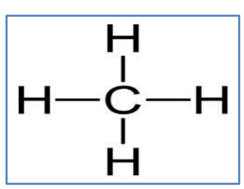
A Lewis symbol is a symbol in which the electrons in the valence shell of an atom or simple ion are represented by dots placed around the letter symbol of the element. Each dot represents one electron.

Atoms	Electronic Configuration	Lewis Symbol
sodium	[Ne]$3s^1$	Na •
magnesium	[Ne]$3s^2$	• Mg •
aluminum	[Ne]$3s^2 3p^1$	• Ȧl •
silicon	[Ne]$3s^2 3p^2$	• Si • (4 dots)
phosphorus	[Ne]$3s^2 3p^3$	• P • (5 dots)
sulfur	[Ne]$3s^2 3p^4$	: S • (6 dots)
chlorine	[Ne]$3s^2 3p^5$	: Cl • (7 dots)
argon	[Ne]$3s^2 3p^6$	: Ar : (8 dots)

A covalent bond is a chemical bond formed by the sharing of a pair of electrons between two atoms. The Lewis structure of a covalent compound or polyatomic ion shows how the valence electrons are arranged among the atoms in the molecule to show the connectivity of the atoms

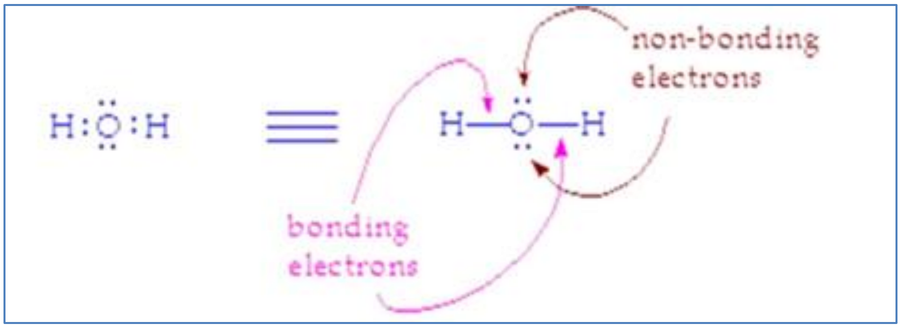


Instead of using two dots to indicate the two electrons that comprise the covalent bond, a line is substituted for the two dots that represent the two electrons.



The Lewis structure for water

Two hydrogens (H) are separately covalently bonded to the central oxygen (O) atom. The bonding electrons are indicated by the dashes between the oxygen (O) and each hydrogen (H) and the other two pairs of electrons that constitute oxygens octet, are called non-bonding electrons as they are not involved in a covalent bond.



Rules for getting Lewis Structures

1.Determine whether the compound is covalent or ionic. If covalent, treat the entire molecule. If ionic, treat each ion separately. For a monoatomic ion, the electronic configuration of the ion represents the correct Lewis structure. For compounds containing complex ions, you must learn to recognize the formulas of cations and anions.

2. Determine the total number of valence electrons available to the molecule or ion by:

(a) summing the valence electrons of all the atoms in the unit

(b) adding one electron for each net negative charge or subtracting one electron for each net positive charge. Then divide the total number of available electrons by 2 to obtain the number of electron pairs (E.P.) available.

3. Organize the atoms so there is a central atom (usually the least electronegative) surrounded by ligand (outer) atoms. Hydrogen is never the central atom.

4. Determine a provisional electron distribution by arranging the electron pairs (E.P.) in the following manner until all available pairs have been distributed:

a) One pair between the central atom and each ligand atom.

b) Three more pairs on each outer atom (except hydrogen, which has no additional pairs), yielding 4 E.P. (i.e., an octet) around each ligand atom when the bonding pair is included in the count.

c) Remaining electron pairs (if any) on the central atom.

Lewis Structure of PCl_3 (atm.no. P=15, Cl=17)

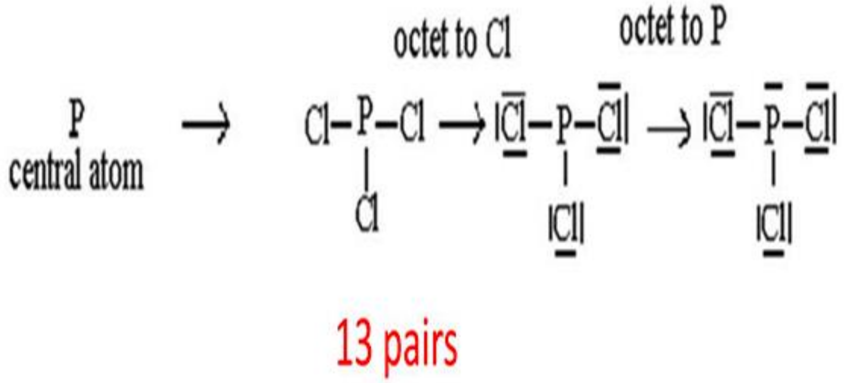
1.Valence electrons: 5 + 3 x 7 = 26 (13 pairs)

2.Central atom is P

3.Connect the terminal atoms to central atom

4. Give octet to P and give octets to Cl

5. Count electron pairs: 3 bond pairs = 3 pairs 1 + 3 x 3 = 10 lone pairs = 10 pairs



Types of Electrons Pairs Bond pair:

Bond pair: electron pair shared between two atoms.

Lone pair: electron pair found on a single atom. Molecules obeying the octet rule.

In many molecules, each atom (except hydrogen) is surrounded by eight bonding or lone-pair electrons. There is a special stability associated with this configuration. Examples are water, ammonia and methane.

is used when the spin motion does not couple much with the angular momentum of the orbital L of each electron with the rest, resulting in a single resultant symbolized by the quantum letter for that case. Also, the spin momentum of each electron couples with the rest, resulting in a resultant momentum S and L values, S of all the spin motions, which are symbolized by the quantum letter

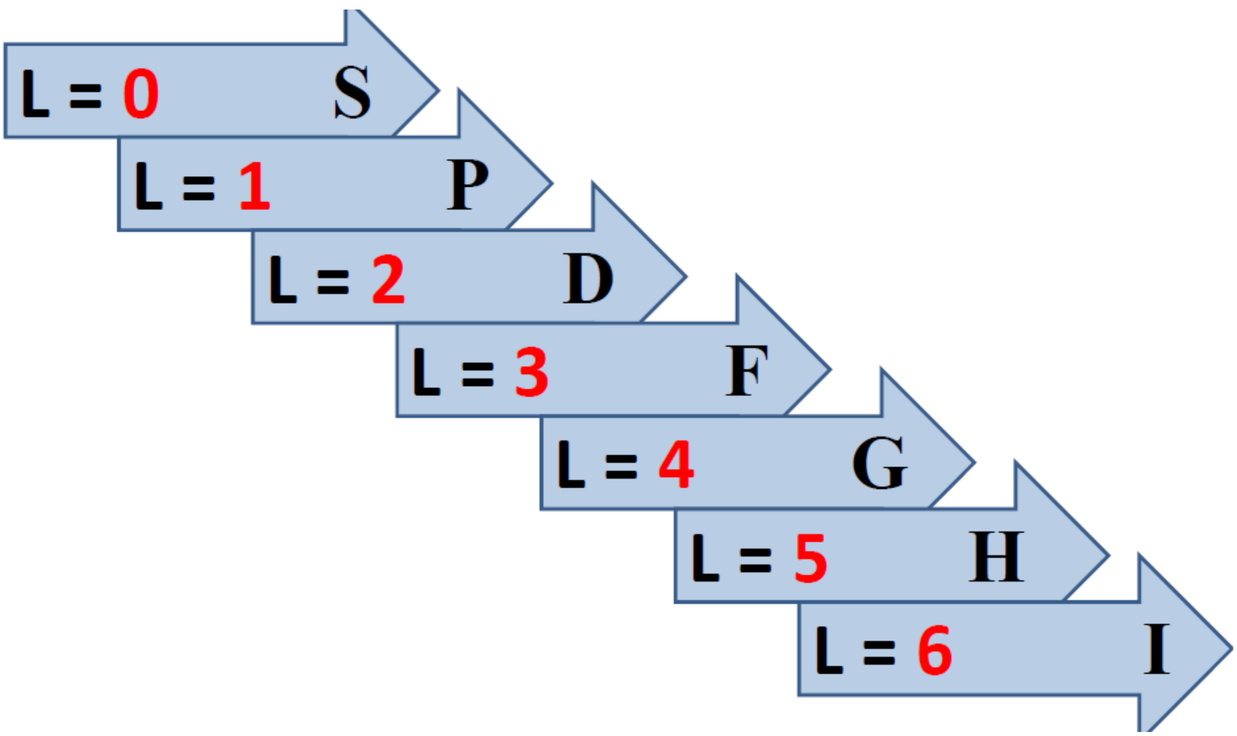
2-The second method (jj coupling)

is used when the spin motion of the electron is coupled with the angular momentum of the orbital to a large degree. This method can be explained by saying that the angular momentum of the spin motion for each electron, then the values of j for the electron are coupled with the momentum of the orbital to give one value J for all electrons to give one value, which is J.

Term symbol ($^{2S+1}L_J$)

1- Electrons are distributed in orbitals of equal energy as much as possible, so that we can calculate the value of (S) to calculate the value of 2S+1, which is called the Bermi multiple.

2- Electrons take the orbitals that have the largest value for the number, then the next one, and so on, so that we get the largest value for the angular orbital momentum, L (ml). Scientists have agreed to give capital letter values according to the following system:



3- If the number of electrons in the secondary orbital is:

J - more than half saturated, then we take the highest value for

J - less than half saturated, then we take the lowest value for

J - saturated or half saturated, then there is only one value for

$$J = /L+S/ \ldots\ldots\ldots\ldots /L-S/$$

To fined **Term symbol ($^{2S+1}L_J$) calculate:**

1) S

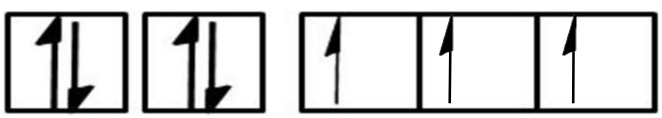
2) 2S+1

3) L

4) J

Example 1/ What is the symbol of the term in the stable state of nitrogen ($_7N$)?

$_7N$:$1S^2$ $2S^2$ $2P^3$



S = (+1/2) + (+1/2)+(+1/2)= 3/2

2S+1 =2× 3/2 + 1= 4

L = (+1) + (0)+(-1)= 0

J = /L+S/ ………/L-S/

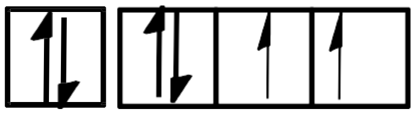
J = /0+3/2/ ………/0-3/2/= 3/2

$$^{2S+1}L_J$$

$$^{4}S_{3/2}$$

Example 2/ What is the symbol of the term in the steady state of oxygen ($_{8}O$)?

$_{8}O$:$1S^2\ 2S^2\ 2P^4$



S = (+1/2)+(+1/2) = 1

2S+1 =2× 1 + 1= 3

L = (+1×2) + (0)+(-1)= 1

J = /L+S/ ………/L-S/

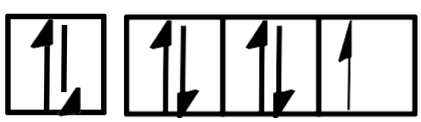
J = /1+1/ ………/1-1/= 2, 1, 0

$$^{2S+1}L_J$$

$$^{3}P_2$$

Example 3/ What is the therm symbol in the stable state of a chlorine atom($_{17}Cl$)?

$_{17}Cl$:$1S^2\ 2S^2\ 2P^6\ 3S^2\ 3P^5$



S = +1/2 = 1/2

2S+1 =2× 1/2 + 1= 2

L = (+1 ×2) + (0×2) + (-1×1) = 1

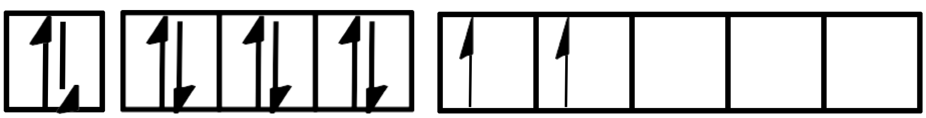
J = /1+1/2/ ………/1-1/2/= 3/2, …,1/2

$$^{2S+1}L_J$$

$$^{2}P_{3/2}$$

Example 4/ What is the thermionic symbol in the stable state of the vanadium ion in the compound VF_3?

$_{23}V^{+3}$: $1S^2\ 2S^2\ 2P^6\ 3S^2\ 3P^6\ 4S^0\ 3d^2$



S = +1/2 +1/2 = 1

2S+1 =2× 1 + 1= 3

L = (+2× 1) + (+1 × 1) = 3

J = /L+S/ ………/L-S/

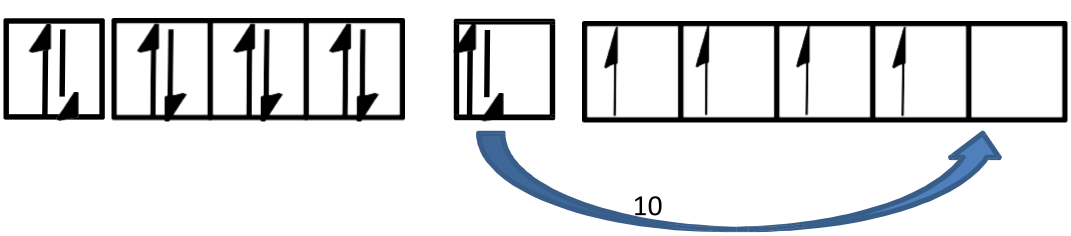
J = /3+1/ ………/3-1/= 4, 3, 2

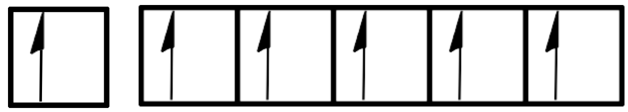
$$^{2S+1}L_J$$

$$^{3}F_2$$

Example 5/ What is the therm symbol in the stable state of the chromium atom($_{24}Cr$) ?

$_{24}Cr$:$1S^2\ 2S^2\ 2P^6\ 3S^2\ 3P^6$ $4S^2\ 3d^4$





S = +1/2 +1/2 +1/2 +1/2 +1/2 +1/2 = 3

2S+1 =2× 3 + 1= 7

L = 1 (+2) +1 (+1)+ 0 + 1(-2) +1 (-1) = 0

J = /0+3/ ………/0-3/= 3

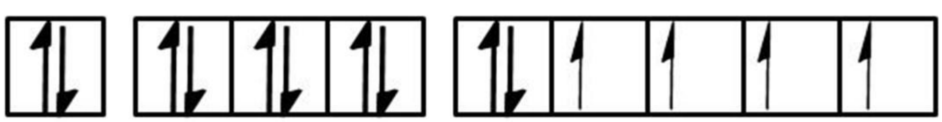
J = /L+S/ ………/L-S/

$$^{2S+1}L_J$$

$$^{7}S_3$$

Example 6/ What is the term symbol in the steady state of the iron ion in the compound The atomic number of iron Fe = 26, O = 8?

$_{26}Fe^{+2}$:$1S^2$ $2S^2$ $2P^6$ $3S^2$ $3P^6$ $3d^6$



S = +1/2 +1/2 +1/2 +1/2 = 2

2S+1 =2× 2 + 1= 5

L = (+2×2) + (+1×1)+ 0 + (-1×1)+ (-2×1)= 2

J = /2+2/ ………/2-2/= 4, 3, 2, 1, 0

$$^{2S+1}L_J$$

$$^{5}D_4$$

Question/ Find the term symbols for the stable state of the following atoms: (The solution is in parentheses, prove that it is correct)

1) $_{14}Si$ ($^3P_0$)

2) $_{22}Ti$ ($^3F_2$)

3) $_{27}Co$ ($^4F_{9/2}$)

4) $_{28}Ni$ ($^3F_4$)

5) $_{29}Cu$ ($^2S_{1/2}$)

Oxidation States:

An oxidation state, or oxidation number, is a number assigned to an element within a compound or molecule to represent how many electrons the element is capable of gaining or losing. Charge and formal charge are similar to the oxidation state, but these are different and separate concepts, even though the values tend to be the same in most cases. The following rules work for most compounds. If there is a conflict between two rules, always pick the rule that comes first.

1. An individual atom that is uncombined with any other element has an oxidation state of 0.

• O_2, N_2, H_2, C, and Ag would all have oxidation states of 0.

• The sum of the oxidation states of all the atoms in a compound must equal the charge.

• The oxidation state of a calcium ion (Ca^{+2}) would be +2.

• Since NaCl doesn't have a charge, the sum of the oxidation state for Na and Cl must be zero, so Na has a oxidation number of +1, while Cl has one of -1.

• In a compound, the oxidation state for Group 1 metals is +1 and Group 2 metals is +2.

• Sodium's oxidation state is +1 since it is a Group 1 metal.

• The oxidation state for F is -1 in a compound.

• The oxidation state for H is +1 in a compound.

• The oxidation state for O is -2 in a compound.

• In a two-element compound with metals, Group 15 elements will have an oxidation state of -3, Group 16 elements will have one of -2, and Group 17 elements will be -1.
• In HBr, H would have an oxidation state of +1 and Br would have an oxidation number of +1. For most compounds, you can immediately identify almost all of the elements' oxidation states; usually, you're left with one unknown oxidation state. In these cases, you would solve for the remaining oxidation number using Rule 2