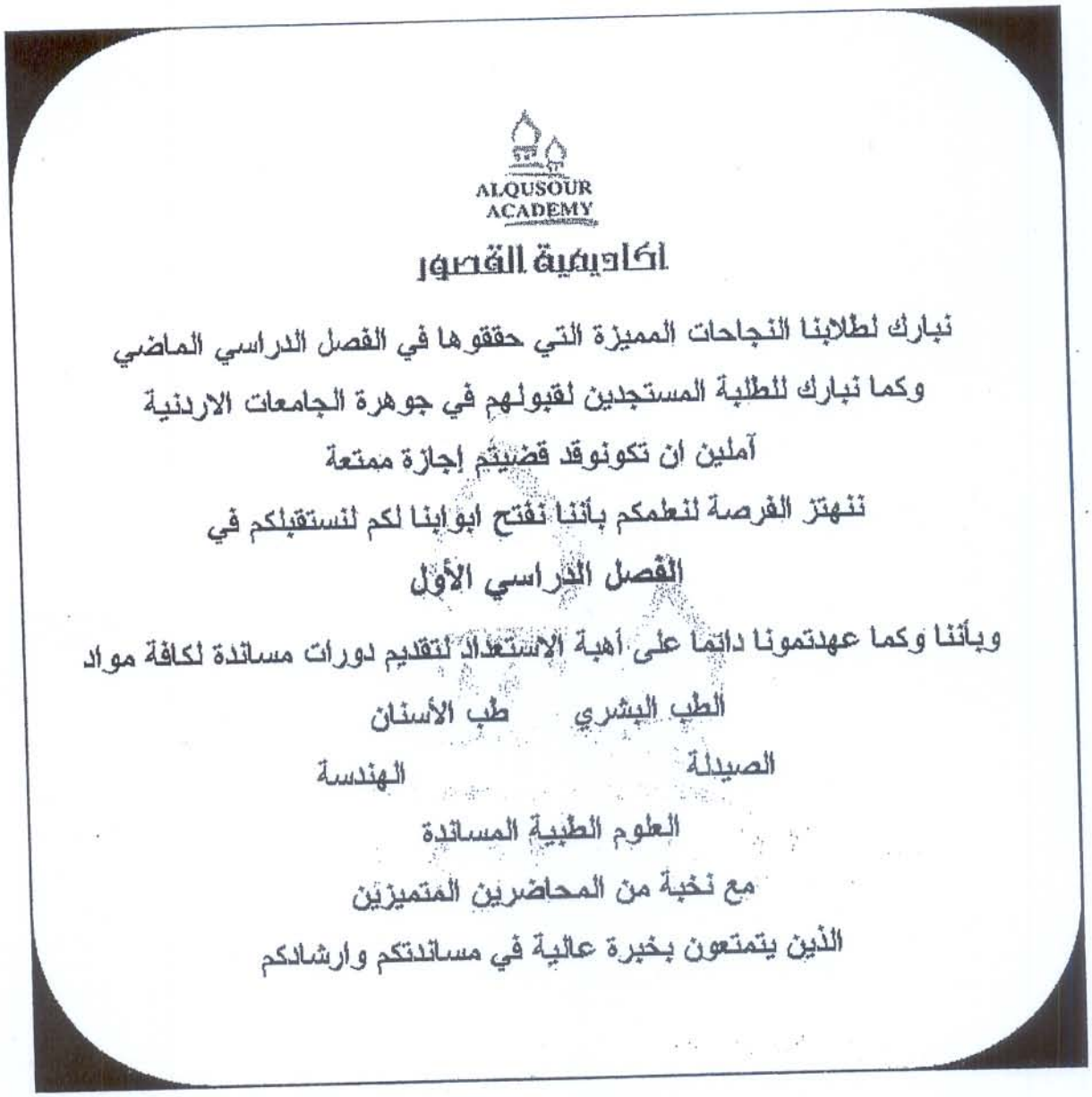
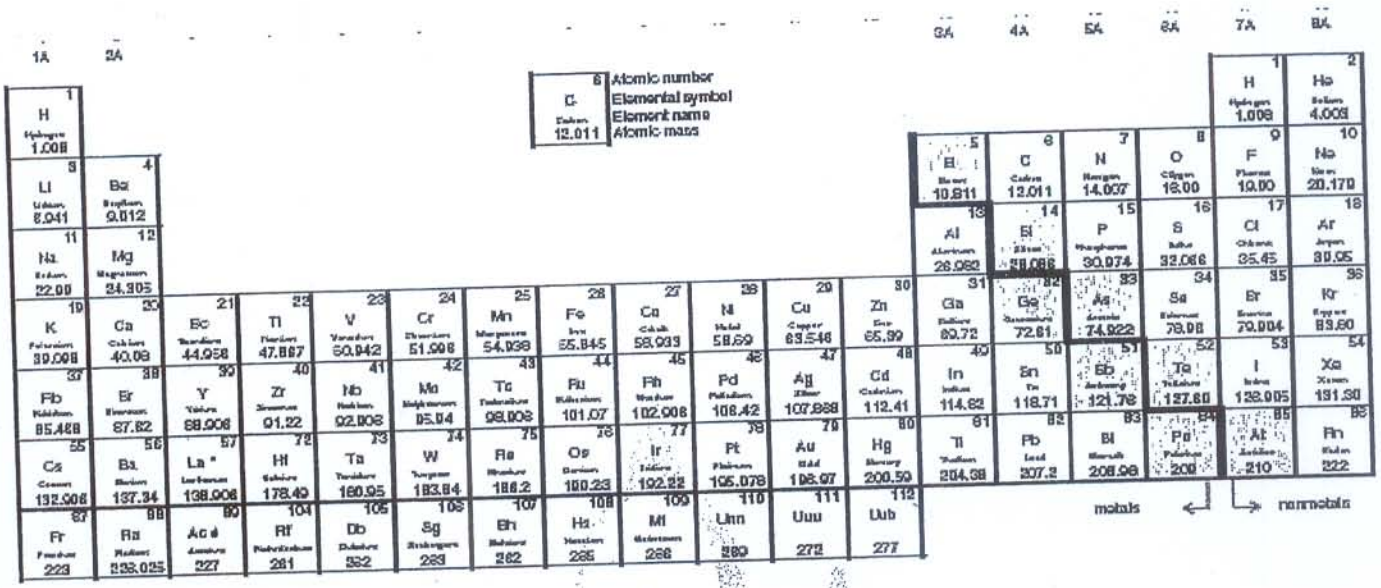
☺فريق اللجنة الأكاديمي



8.1: Types of Chemical Bonds

Mg, Cs, Pd: are examples of metals معادن
Si, As, Sb: are examples of semi-metals (metalloids) أشباه معادن
Cl, I, N: are examples of non-metals غازات معادن

مستمرون بالعطاء



Ionic Bond:

Due to electrostatic forces between opposite charges (metal + nonmetal) Ex.: (K – O) bond

Covalent Bond:

Sharing of electrons between two atoms (nonmetal + nonmetal) Ex.: (F – C) bond

Metallic Bond:

In metals where each atom bonded to several atoms and bonding electrons move freely around them (metal + metal) Ex.: (Fe – Fe) bond

Valence Electrons

The outer shell (valence shell) electrons (that participate in chemical bonding)

Valence Electrons

Group	e⁻ configuration	# of valence e⁻
1A	ns^1	1
2A	ns^2	2
3A	$ns^2\ np^1$	3
4A	$ns^2\ np^2$	4
5A	$ns^2\ np^3$	5
6A	$ns^2\ np^4$	6
7A	$ns^2\ np^5$	7

القاعدة الثمانية

Octet Rule:

Atoms tend to gain, lose, or share electrons until they are surrounded by 8 valence electrons (noble gas configuration)

Na: [Ne] $3s^1$ Na^+: [Ne] lose

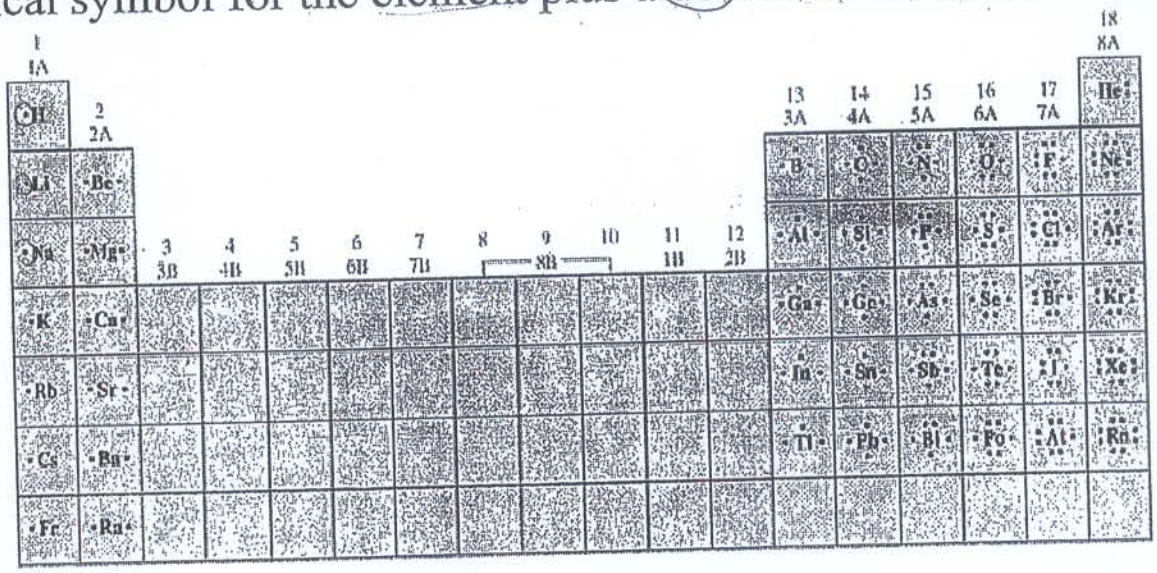
Cl: [Ne] $3s^2\ 3p^5$ Cl^-: [Ne] $3s^2\ 3p^6$ gain

Cl_2: [Ne] $3s^2\ 3p^5$:Cl· ·Cl: Share

رموز لويس

Lewis Symbols

Chemical symbol for the element plus a dot for each valence electron



7.3 Sizes of ions:

حجم الايونات

Ionic Size (Radius)

Ions

Cation (+ve)	Anion (-ve)
K^+	Cl^-

Note:

⊕ Cation Smaller size than its neutral atom $K > K^+$ (more attraction)

⊖ Anion Larger size than its neutral atom $Cl^- > Cl$ (more repulsion)

Ex. Arrange the following ions in order to decreasing ionic radius?

K^+ S^{-2} Na^+ Mg^{+2} F^- Ca^{+2}

العدد الذري

$S^{-2} > K^+ > Ca^{+2} > F^- > Na^+ > Mg^{+2}$

Since same charge we go to atomic radius ($K > Na$ & $Ca > Mg$)

التصنيف بالعدد الذري

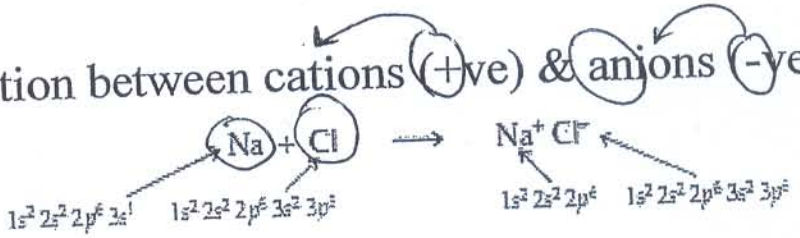
Ex. Arrange the following ions in order to decreasing ionic radius?

O^{-2} F^- Ne Na^+ Mg^{+2} Al^{+3}

$O^{-2} > F^- > Ne > Na^+ > Mg^{+2} > Al^{+3}$

8.2 Ionic Bond

Electrostatic attraction between cations (+ve) & anions (-ve)



How Strong is the Ionic Bond?

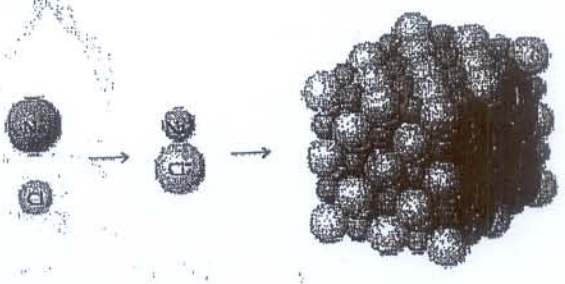
Strength measured by the lattice energy of the ionic compound.

مركب

Lattice Energy (E_L):

Energy required to completely separating one mole of a solid ionic compound into gaseous ions.

$$NaCl_{(s)} \rightarrow Na^{+}_{(g)} + Cl^{-}_{(g)}$$



For the lattic energy we can make comparison ionic compound by:

مقارنة

$$E_{.I} = k\frac{Q_+ \cdot Q_-}{r}$$

Where, Q+ , Q- : ionic charges (+ve , -ve) , r : ionic radius (see CH.8) , k :constant

نصف قطر الأيون

ثابت

طردي ↑ الشحنة الأيونية ionic charge → ↑ Lattice Energy

عكسي ↑ ionic size → ↓ Lattice Energy ↓

**** Ionic Charge effect more than ionic radius.

Ex. Arrange the following in order of decreasing lattice energy?

KCl CuO $FeCl_3$ Cr_2O_3

Ans.:

$K^{+}Cl^{-}$ $Cu^{+2}O^{-2}$ $Fe^{+3}\ 3Cl^{-}$ $2Cr^{+3}\ 3O^{-2}$

Q = 2 4 (+3 3x-1) = 6 (2x+3 , 3x-2) = 12

Since, Q is different we can arrange without looking for r

>>>> $Cr_2O_3 > FeCl_3 > CuO > KCl$

** **Cations (+ve):** Within a series of compounds that have the same anion but different cations,

Lattice energy increases as the cation size decreases

Ex. Comparing LiF, NaF, KF, cation size order $K^{+} > Na^{+} > Li^{+}$

Since, Q is same we compare d, since K larger size than Na than Li

So lattice energies order (d inversely proportional to E.l.):

>>>>> LiF > NaF > KF

** **Anion (-ve):** Within a series of compounds that have the same cation but different anions,

Lattice energy increases as anion size decreases

Ex. Comparing LiF, LiCl, LiBr, LiI, anion size follows the order $I^{-} > Br^{-} > Cl^{-} > F^{-}$ so lattice energies follow the reverse order LiF > LiCl > LiBr > LiI

Ex. Which has the larger lattice energy, NaCl or CsI?

Since, Na^+ smaller than Cs^+ & Cl^- smaller than I^- the distance between ions is smaller in NaCl than in CsI ----→ NaCl has larger Lattice Energy

Ex. Arrange the following in order of increasing lattice energy?

A) MgF_2 ScF_3 LiF

$LiF < MgF_2 < ScF_3$

B) LiI LiF LiCl

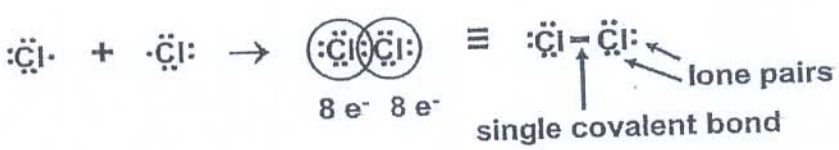
$LiI < LiCl < LiF$

Q. One of the following has the highest lattice energy:

a) MgO b) $CaCl_2$ c) K_2O d) KCl

8.3: Covalent Bond

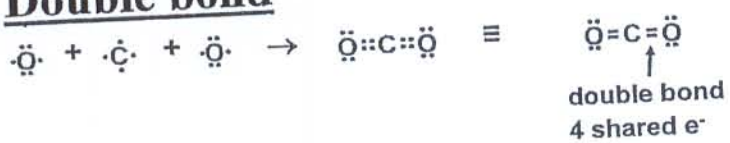
Two atoms in a molecule share a pair of e^- (one e^- from each atom)



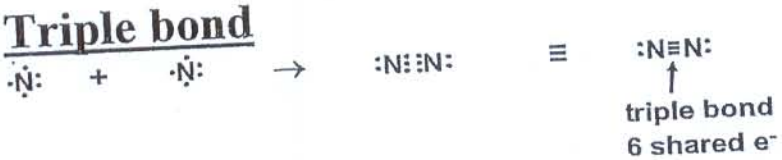
Single bond

NH_3 molecule:

Double bond



Triple bond



Note:
As the number of shared e^- between the two atoms **increases** bond strength **increases** & length **decreases**

Bond Strength:

Triple > double > single

Bond Length:

Triple < double < single

Q. Number of single covalent bonds must Magnesium (Mg) form to complete octet is:

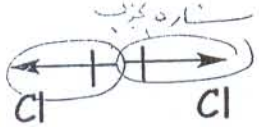
a) 1 b) 2 c) 3 d) 4

8.4: Electronegativity :(E.N)

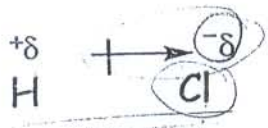
The ability of atom to attract (e^-) toward itself in a chemical bond

Cl_2 e^- → covalent bond → shared equally (non-polar)

HCl e^- → not equally shared between H and Cl atoms due difference in Electronegativity



non-polar (No difference in E.N.)



polar (difference in E.N.)

Note:
If difference in E.N.

(≥ 2) >>>>>>>> Ionic Bond

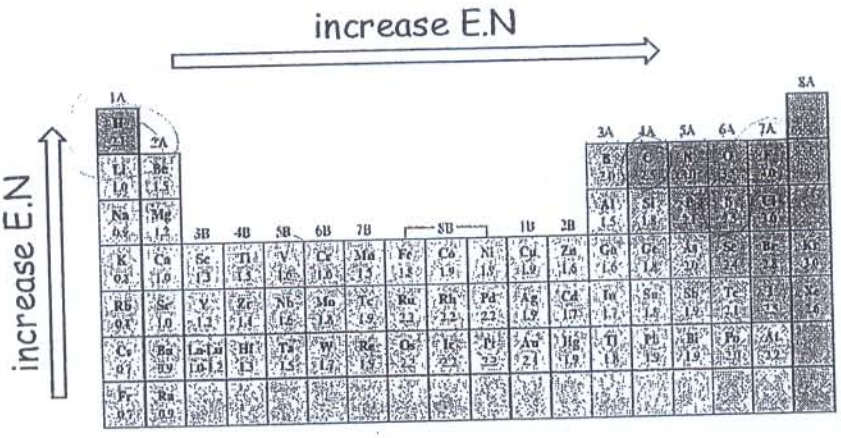
(< 2) >>>>>>>> Covalent polar

= 0 >>>>>>>> Covalent Non-polar

Ex.: What is the type of bond between X = 1.2 , Y = 2.8?

Ans.:

2.8 - 1.2 = 1.6 >>> Covalent polar bond



Note:

- As atoms far away each to other in periodic table they are more polar, because difference in E.N. becomes larger

Q. Which is the highest polarity?

C-S C-F Br-N Na-I

Q. The most polar covalent bond would form in which of these pairs:

a) Al-I b) P-Cl c) Si-Cl d) O-F

9.6 Lewis Structure

A general method of drawing electron-dot structures that works for any compound is to use the following steps:

Step 1.

Find the total number of valence electrons for all atoms in the molecule. Add one additional electron for each negative charge in an anion & subtract one electron for each positive charge in a cation.

Ex.: Draw lewis structure for NF_3

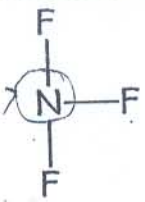
The total valence electrons is 26 (5 from N & 7 from each of 3 F)

Step 2.

Write the skeleton structure of the compound

- Put least E.N. as central atom & surround with other atoms
- H & F atoms will always be outer atoms

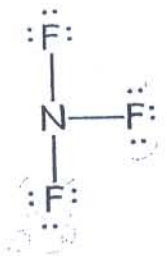
>>> make one bond to sulfur, which occurs as the central atom



Step 3.

Subtract the number of valence electrons used in bonding from the total number calculated in step 1 to find the number that remain. Assign as many of these remaining electrons as necessary to the

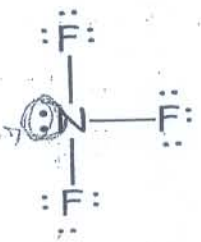
terminal atoms (other than H) so that each has an octet. In NF_3, 8 of 26 total valence electrons are used in covalent bonding >>>> 26 - 8 = 18 24 e⁻s of 26 are assigned to 3-F atoms to reach an octet configuration for each:



Step 4.

If unassigned electrons remain after step 3, place them on the central atom,

In NF_3 24 of 26 e⁻s have been assigned, leaving the final 2 to be placed on the central N atom



Step 5.

If no unassigned electrons remain after step 3 but the central atom does not yet have an octet, use one or more lone pairs of electrons from a neighboring atom to form a multiple bond (either double or triple). O, C, N, & S often form multiple bonds.

Ex. Draw Lewis structure for PCl_3

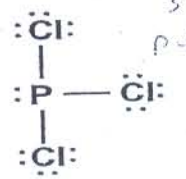
Valence e⁻ 1 (5) + 3 (7) = 26 e⁻

in structure = 24 e⁻

Short by 2 e⁻,

add to central

Check octets

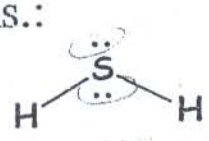


Q. Give the Lewis structure for the following:

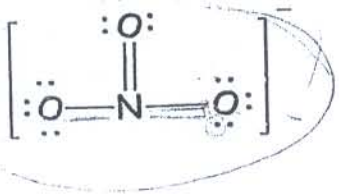
a) H_2S b) N_2

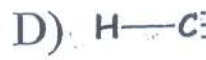
c) NO_3^- (Hint: add one electron to the valence) d) HCN

Ans.:

A) 

B) 

C) 

D) 

Q. The Lewis structure for, ClO_3^-, have --- single bonds, and ---- double bond(s)

A) 3, 1 B) 3, 0 C) 2, 1 D) 2,0

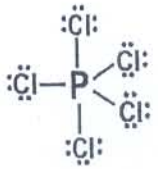
>> Exceptions to the Octet Rule

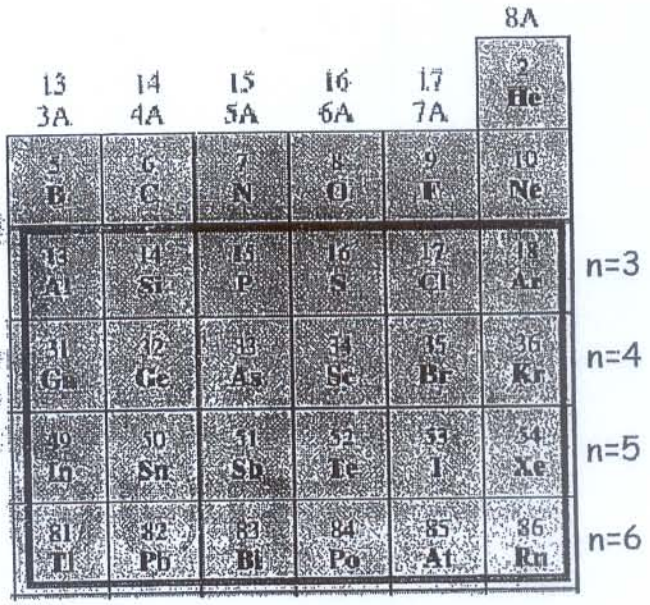
1- Less than octet

H	2 electrons (1 bond)	H–Cl:
Be	4 electrons (2 bonds)	:Cl–Be–Cl:
B	6 electrons (3 bonds)	:F–B(–F:)–F:

2- More than octet (expanded octet)

Elements in the 3rd period or higher can have more than 8 e^- (expanded octet) due to empty orbitals.





3- Odd number of electrons

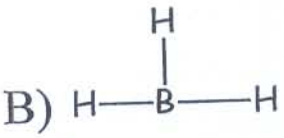
NO	11 e^-	N=O ⟷ N=O
ClO_2	19 e^-	:O–Cl–O: ⟷ :O–Cl–O· ⟷ ·O–Cl–O:

Ex. Draw the Lewis structure for the following molecules?

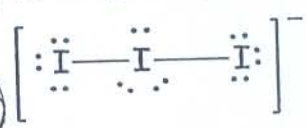
a) $BeCl_2$ b) BH_3 c) NO_2 d) I_3^-

Ans.:

A) 

B) 

C) 

D) 

Q. The Lewis dot structure of HCN (H bonded to C):

a) Gives C one nonbonding pair
b) Gives H one nonbonding pair
c) Gives C two nonbonding pairs
d) Gives N one nonbonding pair

Questions

Q1.The most polar covalent bond would form in which of these pairs:

A) C-F b) N-F c) Cl-F d) O-F

2) Which of these atoms is the least electronegative?

a) Cs b) Li c) P d) As

Q3.In which of these pairs of atoms would the bond have the greatest percent ionic character (i.e., most polar)?

a) O-F b) N-F c) C-F d) Cl-F

Q4.In which of the following molecule the carbon-carbon distance shorter:

a) $H_2C=CH_2$
b) H_3C-CH_3
c) $H_3C-CH_2-CH_3$
d) $H-C\equiv C-H$

Q5.Which one of the following bonds would be the most polar:

a) Na-S b) P-S c) C-F d) Si-Cl

Q6.Of the bonds C-N, C=N and C≡N, the C-N bond is

a) strongest/ shortest
b) strongest/ longest
c) weakest/ longest
d) weakest/ shortest

Answers

Questions	Answer
1	A
2	A
3	C
4	D
5	A
6	C

نعتز بثقتكم