10. CHEMICAL BONDING

Questions and Answers

1. List the factors that determine the type of bond that will be formed between two atoms?

A. The factors that determine the type of bond that will be formed between two atoms are

(i) Number of valence electrons

(ii) The strength of force of attraction or repulsion between atoms

(iii) atomic size

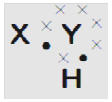
(iv) Nuclear charge of atom

2. Explain the difference between the valence electrons and the covalency of an element.

A. Valence electrons: The electrons present in the outer most orbital of an atom are called valence electrons. Number of valence electrons depends upon the total number of electrons present in that atom.

Covalency of an atom : The total number of covalent bonds that an atom forms with other atom is called covalency of that atom. Covalency depends upon the valence electrons and their number.

3 A chemical compound has the following Lewis notation:



a) How many valence electrons does element Y have?

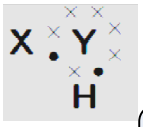
b) What is the valency of element Y?

c) What is the valency of element X?

d) How many covalent bonds are there in the molecule?

e) Suggest a name for the elements X and Y.

A. Given bond formation in a compound is



(a) The number of valence electrons in 'Y' is 6.

(b) The valency of element 'Y' is 2.

(c) The valency of element 'X' is 1.

(d) There are two covalent bonds in the molecules. One bond is in between 'X' and 'Y' and the other bond is in between 'H' and 'Y'.

(e) Suitable name for element 'X' is Hydrogen.
Suitable name for element 'Y' is Oxygen.

4. Why do only valence electrons involve in bond formation? Why not electron of inner shells? Explain.

A. The electrons in the inner shell s of an atom are strongly bounded with the force of attraction of nucleus. They are all ready stable electrons. The electrons in the outer most shell are responsible for the formation of bond between two atoms. To get stability, most of the atoms form bonds with other atoms. The valence electrons only involve in bond formation.

5. Explain the formation of sodium chloride and calcium oxide on the basis of the concept of electron transfer from one atom to another atom.

A. (i) Formation of Sodium chloride(NaCl):

Sodium (Na) atomic number is Z=11.
Electronic configuration is

$$1s^2\ 2s^2\ 2p^6\ 3s^1$$

Sodium can lose one electron and forms sodium ion (cation) to get octet configuration like Neon.

$Na \rightarrow Na^+ + e^-$

Chlorine (Cl) atomic number is Z=17.
Electronic configuration is

$$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$$

Chlorine can gain one electron and forms chloride ion (anion) to get octet configuration like Argon.

$Cl + e^- \rightarrow Cl^-$

These oppositely charged ions get together due to electro static forces to form Sodium chloride molecule.

$Na^+ + Cl^- \rightarrow NaCl$

This is an example for ionic bond. In this bond, one electron transfers from sodium atom to chlorine atom.

(ii) Formation of Calcium oxide (CaO):

Calcium (Ca) atomic number is Z=20.
Electronic configuration is

$$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$$

Calcium can lose two electrons and forms calcium ion (cation) to get octet configuration like Argon.

$Ca \rightarrow Ca^{+2} + 2\,e^-$

NAGA MURTHY- 9441786635
Contact at : nagamurthysir@gmail.com
Visit at : ignitephysics.weebly.com

Oxygen (O) atomic number is Z=8.
Electronic configuration is

$1s^2\ 2s^2\ 2p^4$

Oxygen can gain two electrons and forms oxide ion (anion) to get octet configuration like Neon.

$O + 2e^- \rightarrow O^{-2}$

These oppositely charged ions get together due to electro static forces to form Calcium oxide molecule.

$Ca^{+2} + O^{-2} \rightarrow CaO$

This is an example for ionic bond. In this bond, two electrons transfers from calcium atom to oxygen atom.

6. A, B, and C are three elements with atomic number 6, 11 and 17 respectively.

i. Which of these cannot form ionic bond? Why?

ii. Which of these cannot form covalent bond? Why?

iii. Which of these can form ionic as well as covalent bonds?

A. As per the given data:

Number of atom	Atom	Configura-tion	Number of valence electrons	Valency
6	A	2,4	4	4
11	B	2,8,1	1	1
17	C	2,8,7	7	1

(i) The element 'A' can not form ionic bond. Because the valency of that element is 4. It is impossible to get 4 electrons or to lose 4 electrons. So it forms only covalent bonds.

(ii) The element 'B' can not form covalent bond. Because the number of valence electrons in element 'B' is 1. So it can easily lose 1 electron to form ionic bond. It can not form covalent bond.

(iii) The element 'C' can form ionic as well as covalent bonds. Because it needs 1 electron to get octet configuration.

7. How bond energies and bond lengths of molecule helps us in predicting their chemical properties? Explain with examples.

A. Bond length: It is the equilibrium distance between the nuclei of two atoms which form a covalent bond.

Bond Energy: The energy released when a new covalent bond is formed is called bond energy. This energy is equal to the energy required to break the same bond in the molecule.

Bond lengths and bond energies help in predicting whether the reaction is endothermic or exothermic. If bond lengths are small then the bond energies are high.

Ex: Bond	**Bond energy**
H-H	104.2 K.Cal/mole
Cl-Cl	57.8 K.Cal/mole
H-Cl	103 K.Cal/mole

Reaction: $H_2 + Cl_2 \rightarrow 2HCl$

We declare that this is an exothermic reaction.

8. Predict the reasons for low melting point for covalent compounds when compared with ionic compound.

A. The force of attraction among atoms in covalent molecule is weak compared with ionic compounds. Electrostatic forces are present among atoms in ionic molecules.

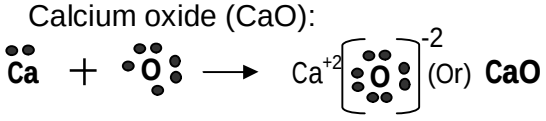
So covalent compounds have low melting point where as ionic compounds have high melting points.

10. Draw simple diagrams to show how electrons are arranged in the following covalent molecules:

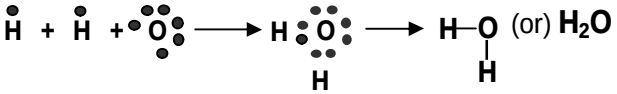
(a) Calcium oxide (CaO)

(b) Water (H_2O) **(c) Chlorine (Cl_2)**

A. (a) Arrangement of electrons in Calcium oxide (CaO):



(b) Arrangement of electrons in Water molecule (H_2O):

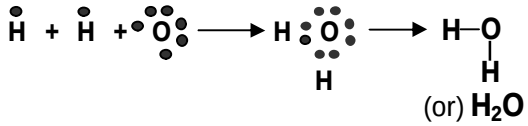


(c) Arrangement of electrons in Chlorine molecule (Cl_2):

NAGA MURTHY- 9441786635
Contact at : nagamurthysir@gmail.com
Visit at : ignitephysics.weebly.com

11. Represent the molecule H_2O using Lewis notation.

A. Arrangement of electrons in Water molecule (H_2O) as per Lewis notation:



12. Represent each of the following atoms using Lewis notation:
(a) beryllium (b) calcium (c) lithium

A. Representation of atoms using Lewis notation:

(a) Beryllium atomic number is Z=4
Electronic configuration is $1s^2\ 2s^2$
Number of valence electrons is 2.
Lewis notation is 

(b) Calcium atomic number is Z=20
Electronic configuration is
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$
Number of valence electrons is 2.
Lewis notation is 

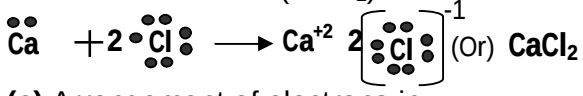
(c) Lithium atomic number is Z=3
Electronic configuration is $1s^2\ 2s^1$
Number of valence electrons is 1.
Lewis notation is 

13. Represent each of the following molecules using Lewis notation:
(a) bromine gas (Br_2)
(b) calcium chloride ($CaCl_2$)
(c) carbon dioxide (CO_2)
(d) Which of the three molecules listed above contains a double bond?

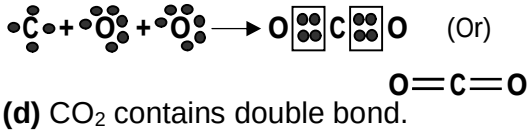
A. Representation of molecules using Lewis notation:

(a) Arrangement of electrons in Bromine molecule (Br_2):

(b) Arrangement of electrons in Calcium chloride ($CaCl_2$):



(c) Arrangement of electrons in Carbon dioxide (CO_2):



(d) CO_2 contains double bond.

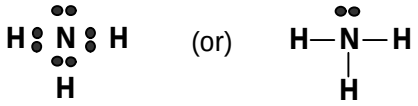
14. Two chemical reactions are described below.

- Nitrogen and hydrogen react to form ammonia (NH_3)
- Carbon and hydrogen bond to form a molecule of methane (CH_4).

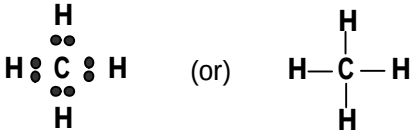
For each reaction, give:
(a) The valency of each of the atoms involved in the reaction.
(b) The Lewis structure of the product that is formed.

A. (a) The valency of Hydrogen is 1.
The valency of Nitrogen is 3.
The valency of Carbon is 4.

(b) The Lewis structure of the Ammonia (NH_3) molecule is



The Lewis structure of the Methane (CH_4) molecule is



15. How Lewis dot structure helps in understanding bond formation between atoms?

A. <u>Significance of Lewis dot structure:</u>

(i) We know that the electrons in outer most shell can only participate in the formation of chemical bonds.

(ii) According to Lewis dot structure, the valence electrons in an atom are represented by a dot (•) or cross (x) around the symbol of atom.

(iii) The atoms having 8 electrons in outer shell are stable and chemically inactive.

(iv) By Lewis dot structure, we understand easily about the type of bond that an atom is going to be established.

Ex: Magnesium atomic number is Z=12
Number of valence electrons = 2
Lewis dot structure is 

We understood that Mg can lose 2 electrons and establish ionic bond.

NAGA MURTHY- 9441786635
Contact at : nagamurthysir@gmail.com
Visit at : ignitephysics.weebly.com

16. What is octet rule? How do you appreciate role of the 'octet rule' in explaining the chemical properties of elements?

A. Octet rule: The atoms of elements tend to undergo chemical changes that help to leave their atoms with eight outer shell electrons.

Role of Octet rule: All inert gases have octet configuration except helium. So they do not participate in any chemical bonds or reactions. Chemically active elements do not have octet configuration. The atoms of these elements try to gain or lose electrons or can try to share electrons with another atoms to form bonds like ionic bond, covalent bond.

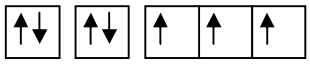
Ionic compounds, covalent compounds have different chemical properties.

So I appreciate the role of Octet rule in explaining the chemical properties of elements.

17. Explain the formation of the following molecules using valence bond theory
a) N_2 molecule b) O_2 molecule

A. (a) Formation of N_2 molecule:

Electronic configuration of Nitrogen(Z=7) is $1s^2 2s^2 2p^3$.

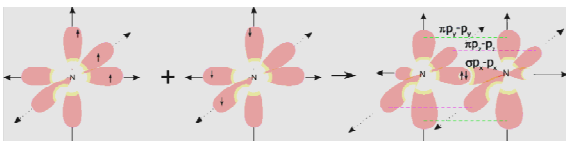


1s 2s $2p_x$ $2p_y$ $2p_z$

It has unpaired electrons in $2p_x$, $2p_y$, $2p_z$ orbitals. The $2p_x$ orbitals which are having unpaired electrons in two nitrogen atoms overlap end-on-end to give rise to sigma bond. It is $\sigma (p_x\text{-}p_x)$.

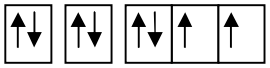
Next the $2p_y$ and $2p_z$ orbitals in two nitrogen atoms overlap sideways (laterally) giving rise to two Pi bonds. They are $\pi(p_x\text{-}p_x)$ and $\pi(p_z - p_z)$

Thus in Nitrogen molecule there are formed one σ bond and two π bonds. It is an example for triple bond.



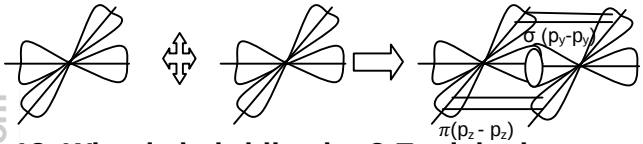
(b) Formation of O_2 molecule:

Electronic configuration of Oxygen(Z=8) is $1s^2 2s^2 2p^4$.



1s 2s $2p_x$ $2p_y$ $2p_z$

It has unpaired electrons in $2p_y$, $2p_z$ orbitals. The $2p_y$ orbitals which are having unpaired electrons in two Oxygen atoms overlap end-on-end to give rise to sigma bond. It is $\sigma (p_y\text{-}p_y)$. Next the $2p_z$ orbitals in two Oxygen atoms overlap sideways (laterally) giving rise to one Pi bond. It is $\pi(p_z - p_z)$. Thus in Oxygen molecule there exist one σ bond and one π bond. It is an example for double bond.



18. What is hybridisation? Explain the formation of the following molecules using hybridisation
a) $BeCl_2$ b) BF_3

A. Hybridisation: The intermixing of atomic orbitals of almost equal energies of an atom and their redistribution into an equal number of identical orbitals is called hybridization.

(a) Formation of $BeCl_2$ molecule:

(i) Electronic configuration of Beryllium(Z=4) is $1s^2 2s^2$.

(ii) The configuration in excited state is $1s^2 2s^1 2p^1$.

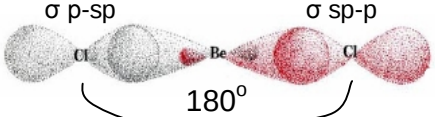
(iii) Due to hybridization of 2s and 2p orbitals, two identical sp-hybrid orbitals are formed and Separated by 180^o.

(iv) Electronic configuration of Chlorine (Z=17) is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$.

(v) It has unpaired electrons in $3p_z$ orbital.

(vi) The two sp-hybrid orbitals in beryllium forms sigma bond with each of p-orbitals in two chlorine atoms.

(vii) Thus $BeCl_2$ is formed with linear shape.



(b) Formation of BF_3 molecule:

(i) Electronic configuration of Boron(Z=5) is $1s^2\ 2s^2\ 2p^1$.

(ii) The configuration in excited state is $1s^2\ 2s^1 2p^2$.

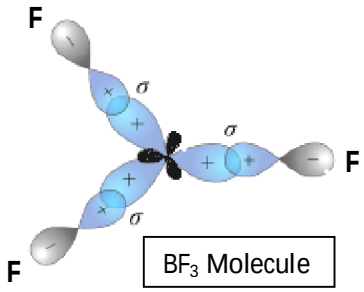
(iii) Due to hybridization of 2s and 2p orbitals, three identical sp^2-hybrid orbitals are formed and Separated in a planar triangular shape.

(iv) Electronic configuration of Flulorine (Z=9) is $1s^2\ 2s^2\ 2p^5$.

(v) It has unpaired electrons in $2p_z$ orbital.

(vi) The three sp^2-hybrid orbitals in boron forms sigma bonds with each of p-orbitals in three Fluorine atoms.

(vii) Thus BF_3 is formed with planar triangular shape.



BF_3 Molecule

19. Explain the formation of the following molecules using hybridisation

a) CH_4

A. (a) Formation of CH_4 molecule:

(i) Electronic configuration of Carbon(Z=6) is $1s^2\ 2s^2\ 2p^2$.

(ii) The configuration in excited state is $1s^2\ 2s^1 2p^3$.

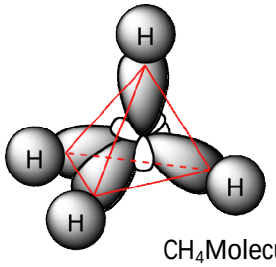
(iii) Due to hybridization of 2s and 2p orbitals, four identical sp^3-hybrid orbitals are formed and Separated in a planar tetrahedral shape.

(iv) Electronic configuration of Hydrogen (Z=1) is $1s^1$.

(v) It has unpaired electrons in 1s orbital.

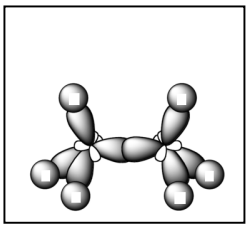
(vi) The four sp^3-hybrid orbitals in carbon forms sigma bonds with each of s-orbitals in four Hydrogen atoms.

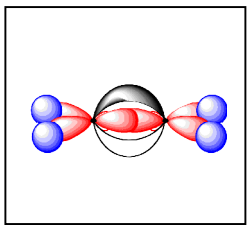
(vii) Thus CH_4 is formed with tetrahedral shape.

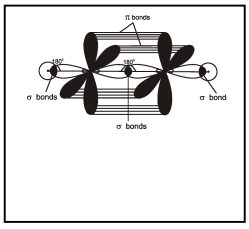


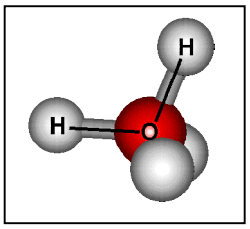
CH_4Molecule

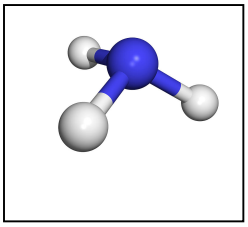
IDENTIFY THE FOLLOWING MOLECULAR SHAPES

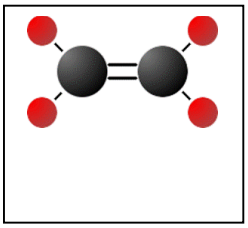


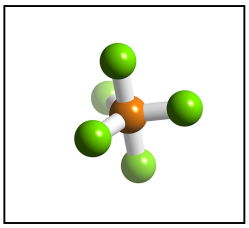


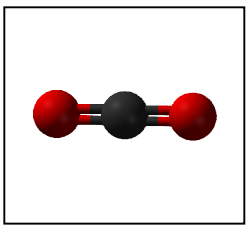


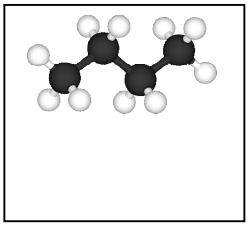


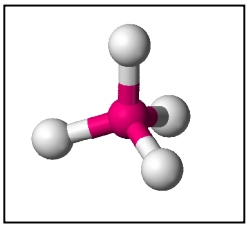












NAGA MURTHY- 9441786635
Contact at : nagamurthysir@gmail.com
Visit at : ignitephysics.weebly.com