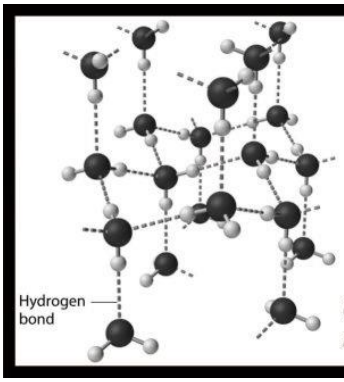

CHAPTER 4

STRUCTURE OF MOLECULES

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INTRODUCTION

Q.1 What is a chemical bond? **(RWP 2017)*(K.B)***

Ans:

CHEMICAL BOND

"A chemical bond is defined as ***force of attraction between atoms that holds them together in a substance****".*

Example:

A bond formed between H and Cl atoms in a molecule of HCl.

4.1 WHY DO ATOMS FORM CHEMICAL BOND?
4.2 CHEMICAL BOND

Q.1 What is a chemical bond and why do atoms form chemical bonds? **(Ex-Q.10)*(U.B+K.B)***

Ans:

CHEMICAL BOND

"A chemical bond is defined ***as force of attraction between atoms that holds them together in a substance****".*

Example:

A bond formed between H and Cl atoms in a molecule of HCl.

WHY DO ATOMS FORM CHEMICAL BONDS?

Atoms form bonds to get stability

Achievement of Stability:

It is a universal rule that everything in this world tends to become more stable.

Atoms achieve stability by **attaining electronic configuration of inert gases (He, Ne or Ar etc)** i.e. **ns^2 np^6 having 2 or 8 electrons in the valence shell** is sign of stability.

Rules to Complete Valence Shell:

Following are two rules by which atoms complete their valence shells:

(i) Duplet rule:

Attaining **two electrons** in the valence shell is called duplet rule. For example helium (He).

(ii) Octet Rule:

An atom having **eight electrons** in the valence shell is called octet rule. For example Neon (Ne).

Why Noble Gases are Non-reactive?

The noble gases do **have 2 or 8 electrons in their valence shells**. It means all the noble gases have **their valence shells completely filled**. Their atoms do not have vacant space in their valence shell to accommodate extra electrons. Therefore, noble gases do not gain, lose or share electrons. That is why they are non-reactive.

Importance of the Noble Gas Electronic Configuration:

The importance of the noble gas electronic configuration lies in the fact that all other atoms try their best to have the noble gas electronic configuration. For this purpose atoms combine with one another, which is called chemical bonding. In other words, atoms form chemical bonds to achieve stability by acquiring inert gas electronic configuration.

Q.2 What is octet rule? Why do atoms always struggle to attain the nearest noble gas electronic configuration? **(Ex-Q.11)*(U.B+K.B)***

Ans:

OCTET RULE

"The ***attaining of 8 electrons configuration in the valence shell****, either by sharing, by losing or by gaining electrons is called octet rule".*

Examples:

All noble gases except helium follow octet rule.

ATTAINING NEAREST NOBLE GAS CONFIGURATION

Atoms always struggle to **attain the nearest noble gas electronic configuration** in order to become more stable.

Methods to Accommodate 8 Electrons in Valence Shell:

An atom can accommodate 8 electrons in its valence shell in three ways:

(i) By **giving valence shell electrons** (if they are **less than four**) to other atoms.

(ii) By **gaining, electrons from other atoms** (if the **valence shell has five or more electrons in it**)

(iii) By **sharing valence electrons** with other atoms.

It means every atom has a natural tendency to achieve 2 or 8 electrons in its valence shell. The atoms having less than 2 or 8 electrons in their valence shells are unstable.

How Can We Identify the Way an Atom Reacts?

The position of an atom in the periodic table indicates its group number. The group number is assigned on the basis of valence shell electrons.

Examples:

- **Group 1** has only **1** electron in its valence shell.
- **Group 17** has **7** electrons in its valence shell.
- Mode of reaction of an atom depends upon its **number of valence shell electrons**.

Bond Formation:

(i) Between Ions:

If the bond formation is between ions, it is due to an **electrostatic force** between them.

(ii) Between Atoms:

If bond formation is between similar atoms or between the atoms that have **comparable electronegativities**, then the chemical bond formation is by 'sharing' of electrons. This sharing of electrons may be mutual or one sided.

(iii)Effect of Attractive and Repulsive Forces on Bond Formation:

When two approaching atoms come closer, the attractive as well as repulsive forces become operative. The formation of a chemical bond is a result of **net attractive forces** which **dominate**. The **energy of that system is lowered** and molecule is formed. Otherwise if repulsive forces become dominant no chemical bond will be formed. In that case there will be increase in the energy of the system due to creation of repulsive forces.

4.1 WHY DO ATOMS FORM CHEMICAL BOND?

4.2 CHEMICAL BOND

SHORT QUESTIONS

Q.1 Why do atoms form chemical bonds? ***(U.B)***

Ans: *Answer given on pg # 123*

Q.2 Why noble gases are non-reactive? ***(U.B)***

Ans: *Answer given on pg # 123*

Q.3 Importance of the noble gas electronic configuration. ***(U.B)***

Ans: *Answer given on pg # 123*

Q.4 Define duplet rule. ***(K.B)***

Ans: *Answer given on pg # 123*

Q.5 What is octet rule? ***(K.B)***

Ans: *Answer given on pg # 123*

Q.6 Define chemical bond. **(RWP 2017 G-II)*(K.B)***

Ans: *Answer given on pg # 123*

Q.7 What is the rule by which atom complete their valence shell? ***(U.B)***

Ans: **RULES TO COMPLETE VALENCE SHELLS**

Following are the rules by which atoms complete their valence shells:

Duplet Rule:

"Attaining of two electrons in the outermost shell either by sharing, gaining or losing of electrons is called duplet rule".

Octet Rule:

"The attaining of 8 electrons configuration in the valence shell, either by sharing, by losing or by gaining electrons is called octet rule".

4.1 WHY DO ATOMS FORM CHEMICAL BOND?

4.2 CHEMICAL BOND

MULTIPLE CHOICE QUESTIONS

1. Atoms react with each other because: **(GRW 2016)*(U.B)***

(A) They are attracted to each other (B) They are short of electrons
(C) They want to attain stability (D) They want to disperse

2. Atoms achieve stability by attaining electronic configuration of: ***(U.B)***

(A) Halogens (B) Transition metals (C) Noble gases (D) Non-metals

3. Electronic configuration of Ne is: ***(K.B)***

(A) $1s^2, 2s^2, 2p^6$ (B) $2s^2, 2p^5$ (C) $1s^2, 1s^2, 1p^3$ (D) $1s^2, 2s^2, 2p^4$

4. Noble gases have _____ or _____ electrons in their valence shell. ***(K.B)***

(A) 2 or 8 (B) 2 or 10 (C) 1 or 7 (D) 3 or 5

5. Noble gases are: ***(K.B)***

(A) Reactive (B) Very reactive (C) Unstable (D) Non-reactive

6. An atom can accommodate eight electrons in its valence shell by _____ electrons. ***(U.B)***

(A) Gaining (B) Sharing (C) Giving (D) All of these

7. The number of electrons in valence hell of halogens: **(FSD 2017 G-II)(K.B)**

(A) 5 (B) 6 (C) 7 (D) 8

4.3 TYPES OF CHEMICAL BOND

4.3.1 IONIC BOND

Q.1 (A) Name the types of chemical bonds? Also define bonding electrons. ***(K.B)***

(B) What is ionic bond? Discuss the formation of ionic bond between sodium and chlorine atoms. (DGK 2016, RWP 2016, SWL 2017, BWP 2016,17, GRW 2017 G-II, LHR 2016 G-I,II)*(U.B+K.B)*

Ans: **(A) TYPES OF CHEMICAL BOND**

There are **four** types of chemical bonds depending upon the way how valence electrons are involved in bonding.

(i) Ionic Bond
(ii) Covalent Bond
(iii) Dative Covalent or Coordinate Covalent Bond
(iv) Metallic Bond

Bonding Electrons:

*"The **valence electrons**, which are **involved in chemical bonding**, are termed as bonding electrons".*

They usually reside in the incomplete or partially filled outermost shell of an atom.

(B) IONIC BOND

Definition:

*"The type of chemical bond which is **formed due to complete transfer of electron from one atom to another atom** is called ionic bond".*

Examples:

- Bond between Na and Cl in NaCl
- Bond between K and Cl in KCl

Elements Forming Ionic Bond:

The elements of **Group-1** and **Group-2 being metals** have the tendency to **lose their valence electrons forming positively charged ions** whereas **non-metals of Group-15 to Group-17** have tendency to **gain or accept electrons**. They are electronegative elements with high electron affinities. If atoms belonging to these **two different groups, metals and non-metals, are allowed to react, chemical bond is formed**.

If the **difference of electronegativity** between two elements **is more than 1.7** then the bond between them will be predominantly **ionic bond**.

FORMATION OF IONIC BOND IN NACL

The formation of NaCl is a good example of this type of bond.

$$2Na_{(s)} + Cl_{2(g)} \longrightarrow 2NaCl_{(s)}$$

Sodium chloride is a simple compound formed from **sodium (Z=11)** and **chlorine (Z=17)**.

Ground State Electronic Configuration:

The ground state electronic configuration of these elements is:

$_{11}Na = 1s^2, 2s^2\ 2p^6, \boxed{3s^1}$ or $\boxed{Na^{\bullet}}$

$_{17}Cl = 1s^2, 2s^2\ 2p^6, \boxed{3s^2\ 3p^5}$ or $\boxed{\times\!\underset{\times\times}{\overset{\times\times}{Cl}}\!\times}$

The frames indicate electrons in valence shells of these elements; **sodium** has only **one electron** and **chlorine** has **seven electrons**.

Tendency to Lose and Gain Electrons:

Sodium being **electropositive** element has the tendency to **lose electron** and **chlorine** being an **electronegative** element, has the tendency to **gain electron**. Therefore, they form positive and negative ions by losing and gaining electrons respectively. They attain electronic configuration to the nearest noble gases. **$1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$ (Ar)**.

Steps for Bond Formation:

Following are the steps involved for the formation of ionic bond in sodium chloride (NaCl):

(i) Formation of Na^+ Ion:

Sodium atom loses one electron from the outermost shell and becomes sodium (Na^+) ion. Now the second shell becomes valance shell with 8 electrons.

(ii) Formation of Cl^- Ion:

Chlorine atom gains one electron in the outermost shell and become Cl^- ion with 8 electrons.

$$Na^{\bullet} \longrightarrow \underset{1s^2,\ 2s^2,\ 2p^6\ (Ne)}{Na^+} + e^-$$

$$\times\!\underset{\times\times}{\overset{\times\times}{Cl}}\!\times + e^- \longrightarrow \underset{1s^2,\ 2s^2,\ 2p^6,\ 3s^2,\ 3p^6\ (Ar)}{\times\!\underset{\times\times}{\overset{\times\times}{Cl}}\!\overset{-}{\bullet}\times} \quad or \quad Cl^-$$

(iii) Establishment of Ionic Bond:

Na^+ and Cl^- ions stabilize themselves by combining with each other due to **electrostatic force of attraction** between them.

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

(iv) Conditions of Ionic Bond Formation:

- It is to be noted that only **valence shell electrons** take part in this type of bonding while other electrons are not involved.
- In such type of reaction **heat** is usually **given out**.
- The compounds formed due to this type of bonding are called **ionic compounds**.

4.3 TYPES OF CHEMICAL BOND

4.3.1 IONIC BOND

SHORT QUESTIONS

Q.1 Which electrons are involved in chemical bonding? ***(U.B+K.B)***

Ans: Valence shell electron are involved in chemical bonding.

Q.2 What are bonding electrons? ***(K.B)***

Ans: *Answer given on pg # 125*

Q.3 What is ionic bond? ***(K.B)***

Ans: *Answer given on pg # 126*

4.3 TYPES OF CHEMICAL BOND

4.3.1 IONIC BOND

MULTIPLE CHOICE QUESTIONS

1. The types of chemical bond are: **(GRW 2014)(K.B)**

(A) 1 (B) 2 (C) 3 (D) 4

2. Chlorine has _____ electrons in its outer most shell: **(GRW 2014)*(K.B)***

(A) 3 (B) 4 (C) 7 (D) 8

3. After gaining one electron, chlorine atom attains the electronic configuration of which noble gas? **(LHR 2015)*(U.B)***

(A) Helium (B) Neon (C) Argon (D) Krypton

4. The formation of ionic bond between the ions is due to: ***(K.B)***

(A) Hydrogen bonding (B) Electrostatic forces (C) Metallic forces (D) All of these

5. How many valence shell electrons are there in Na^+ ion? ***(U.B)***

(A) 8 (B) 9 (C) 10 (D) 11

6. Electronic configuration of sodium is: ***(U.B)***

(A) $1s^2, 2s^2, 2p^6, 3s^1$ (B) $1s^2, 2s^2, 2p^6$ (C) $1s^2, 2s^2, 2p^5$ (D) $1s^2, 2s^2, 2p^6, 3s^2$

4.1 TEST YOURSELF

i. Why does sodium form a chemical bond with chlorine? ***(U.B)***

Ans: **BOND FORMATION BETWEEN SODIUM AND CHLORINE**

Sodium forms chemical bond with chlorine because:

- Sodium has only one electron in its valence shell and has tendency to lose one electron while chlorine has seven electrons in its valence shell and has tendency to gain one electron, this favours the transfer of electron from sodium to chlorine and forms chemical bonds.
- Sodium is electropositive in nature, and is at high energy state while chlorine is electronegative and is at low energy state. This energy difference favours the formation of chemical bond between them.

ii. Why does sodium lose an electron and attains +1 charge? ***(U.B)***

Ans: **ATTAINING OF +1 CHARGE**

Sodium is electropositive in nature, it easily loses its valence electron to attain noble gas electronic configuration like $_{10}Ne$.

$$Na_{11} \xrightarrow{\text{loss one electron}} Na^{+} + le^{-}$$

$$(2,8,1) \qquad (2,8)$$

iii. How do atoms follow octet rule? ***(U.B)***

Ans: **OCTET RULE**

Atoms follow octet rule to achieve stability by attaining noble gases electronic configuration. Atoms follow octet rule in three ways:

- By giving valence electrons (If less than 3) to other atoms.
- By gaining electrons from other atoms (if the valence shell have 5 or more electrons in it).
- By sharing electron with other atoms.

iv. Which electrons are involved in chemical bonding? ***(U.B+K.B)***

Ans: **ELECTRONS INVOLVED IN BONDING**

Only valence shell electrons are involved in chemical bonding which are called bonding electrons. The inner shell electrons do not take part in chemical bonding.

v. Why does group 1elements prefer to combine with group 17 elements? ***(U.B)***

Ans: **COMBINATION OF GROUP 1 AND 17 ELEMENTS**

Group I elements are highly electropositive with low ionization energies. Thus they have tendency to lose electrons easily and become positive ions. On the other hand group 17 elements are highly electronegative with high ionization energies. Thus they have tendency to gain electron easily and become negative ion. Therefore group I elements prefer to combine with group 17 elements to form ions and develop ionic bond due to electrostatic force of attraction.

vi. Why chlorine can accept only 1 electron? ***(U.B)***

Ans: **ACCEPTANCE OF 1 ELECTRON BY Cl**

Chlorine has seven electrons in its outermost shell. It requires only one electron to complete its valence shell to gain electronic configuration of noble gas (Argon ($_{18}Ar$). That's why it accepts only one electron.

4.3.2 COVALENT BOND

Q.1 Define covalent bond. Explain the types of covalent bond.

(MTN 2016, BWP 2016, FSD 2017, GRW 2016 G-I)*(U.B+K.B)*

OR

Explain the types of covalent bond with at least one example of each. **(Ex-Q.5)**

Ans: **COVALENT BOND**

Definition:

"The type of bond, which is ***formed due to mutual sharing of electrons****, is called covalent bond."*

Examples:

Bonds formed between atoms in hydrogen, chlorine, nitrogen and oxygen are covalent in nature.

Elements Forming Covalent Bond:

The **elements of Group-13 to Group-17** when allowed to react with each other, they form a chemical bond by mutual sharing of their valence shell electrons.

When bonding atoms have **comparable values of electronegativity** they share their electrons and form covalent bonds.

Formation of Covalent Bond:

The energy changes during the covalent bond formation are of considerable value. When two atoms approach each other attractive forces develop between electrons of one atom and nucleus of other atom. Simultaneously repulsive forces between electrons of the two atoms as well as between their nuclei are also created. When the **attractive forces dominate** due to **decrease in distance** between those two atoms, a **chemical bond is formed** between them. By this mutual sharing of valence shell electrons each of the contributing **atom attains the 'octet'** or **nearest noble gas electronic configuration**.

Bond Pair:

*The covalent bond is formed by mutual sharing of electrons between two atoms. The **electrons that pair up to form a chemical bond** are called 'bond pair' electrons.*

TYPES OF COVALENT BONDS

Depending upon the number of bond pairs, covalent bond is classified into following three types:

- Single Covalent bond
- Double Covalent bond
- Triple Covalent bond

(i) Single Covalent Bond:

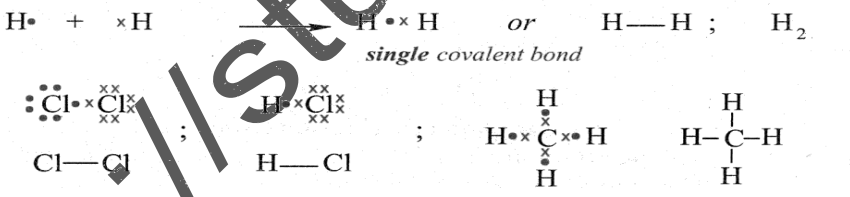
*"When **one electron is contributed by each bonded atom, one bond pair is formed** and it forms a single covalent bond".*

Representation:

It is indicated by **single line (–)** between two bonded atoms.

Examples:

Hydrogen (H_2), chlorine (Cl_2), hydrochloric acid (HCl) and methane (CH_4).



(ii) Double Covalent Bond:

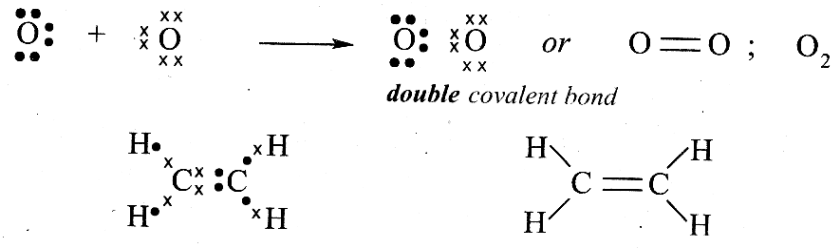
*"When **two electrons are contributed by each bonded atom, two bond pairs are formed** and it forms a double covalent bond".*

Representation:

It is indicated by **two lines (=)** between two bonded atoms.

Examples:

Oxygen (O_2) gas, ethene (C_2H_4).



(iii) Triple Covalent Bond:

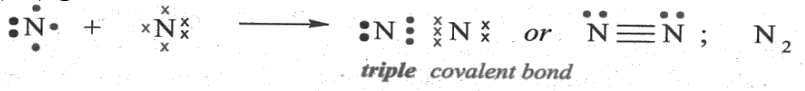
"When ***three electrons are contributed by each bonded atom, three bond pairs are formed*** *and it forms a triple covalent bond".*

Representation:

It is indicated by **three lines (≡)** between two bonded atoms.

Examples:

Nitrogen (N_2) gas:



Ethyne (C_2H_2) gas:

By this **mutual sharing of valence shell electrons,** each of the **contributing atom attains the 'octet'** or **nearest noble gas electronic configuration**.

4.3.2 COVALENT BOND

SHORT QUESTIONS

Q.1 Define covalent bond. **(BWP 2016, MTN 2016, FSD 2017 G-I)*(K.B)***

Ans: *Answer given on pg # 128*

Q.2 Define single covalent bond. Give examples. ***(K.B)***

Ans: *Answer given on pg # 129*

Q.3 Define double covalent bond? Give examples. **(SGD 2016, GRW 2016 G-I)*(K.B)***

Ans: *Answer given on pg # 129*

4.3.2 COVALENT BOND

MULTIPLE CHOICE QUESTIONS

1. A bond formed between two non-metals is expected to be: ***(K.B)***

(A) Covalent (B) Ionic (C) Coordinate (D) Metallic

2. The example of single covalent bond is: ***(U.B+A.B)***

(A) N_2 (B) Cl_2 (C) O_2 (D) C_2H_4

3. H_2C_2 is an example of: ***(U.B+A.B)***

(A) Single bond (B) Double bond (C) Triple bond (D) None of these

4. The bond which is formed due to mutual sharing of electrons is called: ***(K.B)***

(A) Ionic bond (B) Covalent bond (C) Dative bond (D) Hydrogen bond

5. C_2H_6 is an example of: ***(U.B+A.B)***

(A) Single covalent bond (B) Double covalent bond

(C) Triple covalent bond (D) Coordinate covalent bond

6. The number of electrons participating in double covalent bond is: **(GRW 2017 G-I)*(U.B)***

(A) 2 (B) 4 (C) 6 (D) 8

7. Which molecule has triple covalent bond? **(LHR 2017 G-II)*(U.B+A.B)***

(A) H_2 (B) O_2 (C) N_2 (D) C_2H_4

8. How many electrons are involved in the formation of single covalent bond? **(RWP 2017 G-II)*(U.B)***

(A) Two (B) Four (C) Six (D) Eight

4.3.3 DATIVE COVALENT OR COORDINATE COVALENT BOND

Q.1 Define the coordinate covalent bond. Explain coordinate covalent bond with the help of example. ***(U.B+K.B+A.B)***
(SWL 2016,17, FSD 2016, RWP 2016,17, SGD 2017, DGK 2017, BWP 2017, GRW 2017 G-I, LHR 2016 G-I)

OR

How a coordinate covalent bond is formed? Explain with examples. **(Ex-Q.6) (SGD 2017 G-I)**

Ans:

COORDINATE COVALENT BOND

Definition:

"Coordinate covalent or dative covalent bonding is a ***type of, covalent bonding*** *in which the* ***bond pair of electrons is donated by one bonded atom only.****"*

Examples:

- Bond between NH_3 and BF_3 in NH_3BF_3
- Bond between NH_3 and H^+ in NH_4^+

Donor:

*"****An atom*** *which* ***donates the electron pair*** *is called donor".*

Acceptor:

*"****An atom*** *which* ***accepts the electron pair*** *is called acceptor".*

Representation:

A **small arrow (→)** is usually used to indicate the atom and pair of electron being donated. The **head of arrow is towards the acceptor atom**.

Lone Pair of Electrons:

The ***non-bonded electron pair available on an atom in a molecule*** *is called lone pair of electrons.*

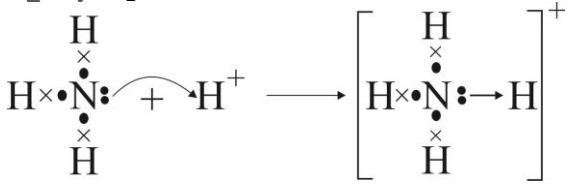
Example:

The **electron pair** available on **nitrogen atom** in **ammonia (NH_3)** molecule is called lone pair of electrons.

FORMATION OF COORDINATE COVALENT BOND

Example 1 (Formation of Ammonium Radical (NH_4^+):

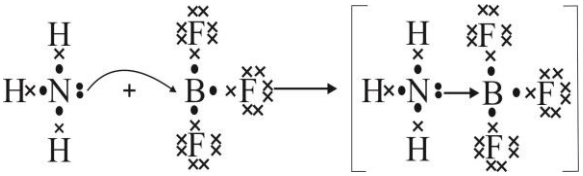
In the formation of ammonium ion, the **nitrogen of NH_3** is the **donor atom** while **hydrogen ion H^+** is the **acceptor atom**.



Ammonia (donor) Hydrogen ion (acceptor) Ammonium ion (adduct)

Example 2 (Formation of Co-ordinate Covalent Bond Between Ammonia and Boron trifluoride):

In the formation of BF_3 (boron trifluoride) molecule, three valence electrons of boron atom (Z = 5) pair up with three electrons, one from each three fluorine atoms. The boron atom even after this sharing of electrons (covalent bond formation), remains short or deficient of two electrons in its outermost shell. Now if a molecule with a lone pair approaches this molecule, it accepts lone pair from that donor and forms a coordinate covalent bond. The lone pair on nitrogen of ammonia molecule makes it a good donor molecule to form a coordinate covalent bond.



(donor) (acceptor) (adduct)

4.3.3 DATIVE COVALENT OR COORDINATE COVALENT BOND

SHORT QUESTIONS

Q.1 What is meant by lone pair of electrons? **(RWP 2016, SGD 2017)*(K.B)***

Ans: **LONE PAIR OF ELECTRONS**

The non-bonded electron pair available on an atom in a molecule is called lone pair of electrons.

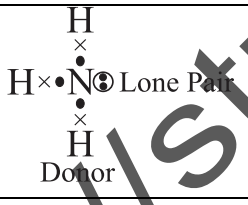
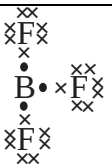
Example:

The electron pair available on nitrogen atom in ammonia (NH_3) molecule is called lone pair of electrons.

Q.2 What is the difference between donor and acceptor? **(FSD 2017 G-I)*(U.B)***

Ans: **DIFFERENTIATION**

The differences between donor and acceptor are as follows:

Donor	Acceptor
Definition	
• An atom which donate the electron pair is called donor.	• An atom which accept the electron pair is called acceptor.
Example	
 Lone Pair Donor	 (Acceptor)
Donor always contain at least one lone pair of electrons.	Acceptor must be deficient of two electrons in valence shell.

4.3.3 DATIVE COVALENT OR COORDINATE COVALENT BOND

MULTIPLE CHOICE QUESTIONS

1. **Which one of the following is an electron deficient molecule?** **(LHR 2016 G-I)*(U.B)***

(A) NH_3 (B) BF_3 (C) N_2 (D) O_2

2. A dative bond is formed between ammonia and boron trifluoride the donor atom is: ***(U.B)***

(A) Fluorine (B) Boron (C) Hydrogen (D) Nitrogen

3. NH_4Cl is an example of: ***(U.B)***

(A) Covalent bond (B) Ionic bond (C) Dative covalent bond (D) All of these

4. Coordinate covalent bond is also known as: ***(K.B)***

(A) Dative covalent bond (B) Double covalent bond

(C) Ionic bond (D) Triple covalent bond

5. BF_3 is deficient of electrons: ***(U.B)***

(A) Three (B) Four (C) Two (D) Five

4.3.4 POLAR AND NON POLAR COVALENT BOND

Q.1 Explain in detail the polar and nonpolar covalent bond. **(SWL 2016)*(U.B+K.B)***

OR

How can you justify that bond strength in polar covalent compounds is comparable to that of ionic compounds? **(Ex-Q.2)*(U.B)***

Ans:

POLAR AND NON-POLAR COVALENT BOND

(i) Non-Polar Covalent Bond:

*"A covalent bond is formed between **two similar atoms (homo-atoms)** in which **shared pair of electrons is attracted by both the atoms equally**, called non-polar covalent bond".*

Explanation:

These bonds are formed by **equal sharing of electron pair** between the two bonding atoms. This type of bond is called a **pure covalent bond**.

Examples:

Bond formation in H_2, Cl_2, O_2, N_2 and F_2.

(ii) Polar Covalent Bond:

*"A covalent bond is formed **between two different types of atoms (hetero-atom)** in which **bond pair of electrons is not attracted by both the atoms equally** is called polar covalent bond".*

Examples:

Water, hydrogen fluoride, hydrogen chloride etc.

Formation of Polar Bond:

The **difference between electronegativities of hydrogen and chlorine is 1.0**. As the **electronegativity of chlorine is more**, it attracts the shared pair of electron towards itself with a greater force. A **partial negative charge** is therefore created on **chlorine** and in turn a **partial positive charge** on **hydrogen** due to electronegativity difference. It creates **polarity** in the bond and is called polar covalent bond.

Delta (δ) sign:

The delta (δ) sign indicates **partial positive** or **partial negative** charge that is developed due to **unequal sharing** of shared pair or bonded pair of electrons.

Polar Compounds:

*"The compounds resulting from **polar covalent bonds** are called polar compounds".*

Examples:

HCl, HBr, H_2O etc.

Determination of Nature of Chemical Bond:

By using electronegativity values, it is possible to predict whether a chemical bond will be ionic or covalent in nature.' A bond formed between elements of **high electronegativity (halogen group)** and elements of **low electronegativity (alkali metals)** are **ionic** in nature there is **complete transfer of electrons** between them.

Criteria:

- If the **difference of electronegativities** between two elements is **more than 1.7** the bond between them will be predominantly **ionic bond**.
- If it is **less than 1.7**, the bond between two atoms will be **predominantly covalent**.
- If the **difference of electronegativities** between two elements is **zero**, the bond between them will be **non-polar**.

4.3.4 POLAR AND NON POLAR COVALENT BOND

SHORT QUESTIONS

Q.1 Define non-polar covalent bond. **(MTN 2017, FSD 2017, SWL 2016, LHR 2016)*(K.B)***

Ans: *Answer given on pg # 133*

Q.2 What is polar covalent bond? **(SWL 2017)*(K.B)***

Ans: *Answer given on pg # 133*

4.3.4 POLAR AND NON POLAR COVALENT BOND

MULTIPLE CHOICE QUESTIONS

1. Identify which pair has polar covalent bond? ***(U.B)***

(A) O_2 and Cl_2 (B) H_2O and N_2 (C) H_2O and C_2H_2 (D) H_2O and HCl

2. Which one is polar molecule? **(LHR 2016 G-II)*(U.B+K.B)***

(A) H_2 (B) HCl (C) Cl_2 (D) O_2

3. In non-polar covalent bond the bonded atoms share the electrons: ***(U.B)***

(A) Unequally (B) Equally (C) Differently (D) Oppositely

4. In polar covalent bond molecules are: ***(U.B+K.B)***

(A) Homoatomic (B) Tri-atomic (C) Heteroatomic (D) Monoatomic

5. Indicate which molecule is non-polar? ***(U.B)***

(A) NaCl (B) KBr (C) CO_2 (D) KI

4.2 TEST YOURSELF

i. Give the electronic configuration of carbon atom. ***(U.B+A.B)***

Ans: **ELECTRONIC CONFIGURATION OF CARBON**

The electronic configuration of carbon ($_6C$) is:

In shells = K L
2 4

In subshells= $1s^2, 2s^2, 2p^2$

ii. What type of elements have tendency of sharing of electrons? ***(U.B)***

Ans: **TENDENCY OF SHARING OF ELECTRONS**

The non-metallic elements with comparable values of electronegativity have tendency of sharing electrons.

Examples:

The elements of Group-13 to Group-17 usually have tendency of sharing of electrons.

iii. If repulsive forces dominate the attractive forces, will a covalent bond form? ***(U.B)***

Ans: **DOMINANCE OF REPULSIVE FORCES**

If repulsive forces dominate the attractive forces, covalent bond will not be formed. This is due to increase in energy. The bond formation takes place when the attractive forces dominate rather than repulsive forces.

iv. Considering the electronic configuration of nitrogen atom, how many electrons are involved in bond formation and what type of covalent bond is formed. ***(U.B)***

Ans: **ELECTRONIC CONFIGURATION OF NITROGEN**

Electrons configuration of $_7N = 1s^2, 2s^2, 2p^3$

There are 3 unpaired electrons in a nitrogen atom which are involved in bond formation. Nitrogen atoms will form three covalent bonds with other nitrogen atoms:

$$:\dot{N}\cdot + \cdot\dot{N}: \longrightarrow :N\vdots N: \longrightarrow N \equiv N \text{ or } N_2$$

Triple covalent bond is formed between nitrogen atoms.

v. Point out the type of covalent bonds in the following molecules. ***(U.B)***

CH_4, C_2H_4, H_2, N_2, and O_2

Ans: **TYPES OF COVALENT BOND**

- CH_4 : Single covalent bond.
- C_2H_4 : Double covalent bond.
- H_2 : Single covalent bond.
- N_2: Triple covalent bond.
- O_2 : Double covalent bond.

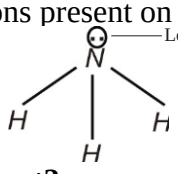
vi. What is a lone pair? How many lone pairs of electrons are present on nitrogen in ammonia? **(SGD 2017, RWP 2016)*(U.B+K.B)***

Ans: **LONE PAIR**

The non-bonded electron pair available on an atom in a molecule is called lone pair of electrons.

Example:

There is one lone pair of electrons present on nitrogen in ammonia.



vii. Why is the BF_3 electron deficient? ***(U.B)***

Ans: **BF_3 ELECTRON DEFICIENT**

Boron atom has total 5 electrons out of which 3 electrons are present in valence shell. These electrons share with three atoms of fluorine to form BF_3.

Now boron has 6 electrons in valence shell in BF_3, it still needs two electrons to complete its octet. That is why it is called electron deficient molecule.

viii. What types of electron pairs make a molecule good donor? ***(U.B)***

Ans: **GOOD DONOR**

Lone pairs of electrons present on atoms in a molecule make a molecule good donor. These electrons are not involved in bonding so they can be used to form further bonds.

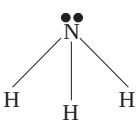
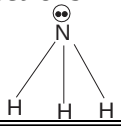
Example:

In ammonia, there is one lone pair of electrons on nitrogen atom which can form a coordinate covalent bond with H^+ to form NH_4^+;

ix. What is difference between bonded and lone pair of electron 'and how many bonded pair of electrons is present is NH_3 molecule? **(RWP 2017, GRW 2016 G-II)*(U.B)***

Ans: **DIFFERENTIATION**

The differences between bond pair and lone pair are as follows:

Bonded Pair	Lone Pair
Definition	
• Bond pair of electrons is involve in bond formation	• Lone pair of electron is not involved in bond formation.
Example	
• In a ammonia molecule there are three bond pairs. 	• In a ammonia molecule there are three lone pair of electrons 

x. What do you mean by delta sign and why it develops? ***(U.B)***

Ans: **DELTA SIGN**

The delta(s) sign indicates partial positive or partial negative charge that is developed due to unequal sharing of shared pair or bonded pair of electrons.

xi. Why does oxygen molecule not form a polar covalent bond? ***(U.B)***

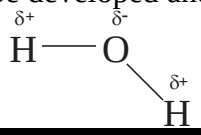
Ans: **NON POLARITY OF OXYGEN MOLECULE**

Oxygen molecule does not form a polar covalent bond because it consists of two similar oxygen atoms (homoatomic). There is no difference of electronegativity and shared pair of electrons is attracted by both the atoms equally.

xii. Why has water polar covalent bonds? **(DGK 2017)*(U.B)***

Ans: **WATER HAS POLAR COVALENT BOND**

Water has polar covalent bond because there is difference of electronegativity (1.3) between H and O atoms. The shared pairs of electrons are unequally attracted by both the bonded atoms. Hence poles will be developed and molecule will become polar.



4.3.5 METALLIC BOND

Q.1 What is metallic bond? Explain metallic bonding with the help of diagram. **(Ex-7)**
(SGD 2016, FSD 2016, 17)*(U.B+K.B)*

Ans: **METALLIC BOND**

"*The metallic bond is defined as a* ***bond formed between metal atoms (positively charged ions) due to mobile or free electrons****"*.

Example:

The bond found between atoms in sodium, calcium and magnesium metals.

Different Type of Metallic Bond:

The different properties shown by metals such as **high melting and boiling points, good conductions of heat and electricity, hard and heavy nature,** suggest existence of different types of chemical bond between atoms of metals.

FORMATION OF METALLIC BOND

Weak Hold of Nucleus over Outermost Electrons:

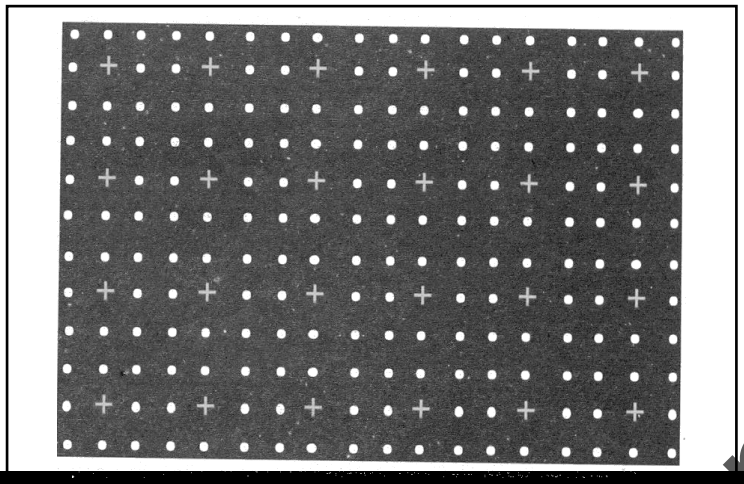
In case of metals, the hold of nucleus over the outermost electrons is weak because of large sized atoms and greater number of shells in between nucleus and valence electrons.

Loss of Electrons:

Because of **low ionization potentials, metals** have the tendency to **lose** their **outer most shell electrons** easily. The loose or free electrons of all metal atoms move freely in the spaces between atoms of a metal. None of these electrons is attached to any particular atom.

Fate of Free Electrons:

They belong to a common pool or belong to all the atoms of that metal. Nuclei of metal atoms appear submerged in sea of these **free mobile electrons**. These mobile electrons are responsible for holding the atoms of metals together forming a metallic bond.



4.3.5 METALLIC BOND

SHORT QUESTIONS

Q.1 What is metallic bond? **(GRW 2017 G-I, GRW 2016 G-II)*(K.B)***

Ans: *Answer given on pg # 136*

Q.2* What types of elements form metallic bond?** ***(U.B+K.B)

Ans:

ELEMENTS FORMING METALS

Metals form metallic bond because they have low ionization energies and high shielding effect due to these properties metal atom lose electrons easily and form a sea of mobile electrons with positive ions.

Examples:

- Sodium
- Calcium

4.4 INTER MOLECULAR FORCES

Q.1 What are intermolecular forces? Compare this forces with chemical bond forces with reference to HCl molecule. **(Ex-Q.9) (SWL 2016, MTN 2016, RWP 2016, FSD 2016,17)*(U.B+K.B)***

Ans:

INTERMOLECULAR FORCES

Definition:

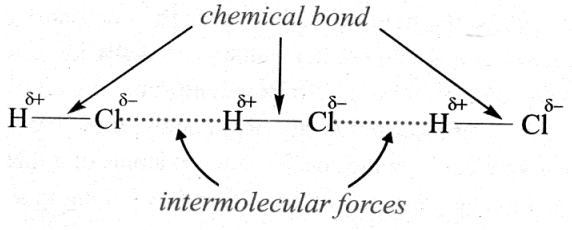
*"The **forces of attraction present between molecules of a substance** are called intermolecular forces".*

OR

*"The forces that hold atoms in a compound are chemical bonds. In addition to these strong bonding forces, relatively **weak forces** also exist in **between the molecules**, which are called intermolecular forces".*

Example:

The bonding and intermolecular forces of hydrochloric acid.



Comparison of Strength of Intermolecular and Intramolecular Forces:

(i) Intermolecular Forces:

Intermolecular forces are **weaker them chemical bond (intramolecular forces)**.

Example:

It requires about **17 kJ** energy to break these intermolecular forces between **one mole** of liquid hydrogen chloride molecules to convert it into gas.

(ii) Intramolecular Forces:

About **430 kJ** are required to break the chemical bond between hydrogen and chlorine atoms in **1 mole** of hydrogen chloride (Intramolecular forces).

TYPES OF INTRAMOLECULAR FORCES

All intermolecular forces, which are collectively called **van der Waals forces,** are **electrical** in nature. Following are the types of intermolecular forces:

(i) Dipole-Dipole Forces

(ii) Hydrogen Bonding

Q.2 Write a note on dipole-dipole interaction.

(FSD 2016, SWL 2016, SGD 2016, BWP 2016, MTN 2017)*(U.B+K.B)*

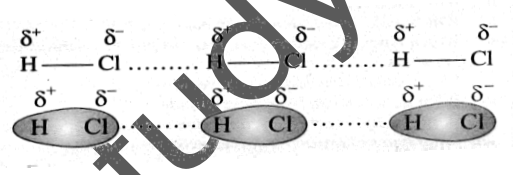
Ans:

DIPOLE–DIPOLE INTERACTION

Definition:

*"The **force of attraction present between partial positive end of one polar molecule and partial negative end of other polar molecule** is called dipole - dipole force".*

Example:



Occurrence:

These forces occur between molecules in **polar** substances.

Dependence:

These forces depend upon:

- **Electronegativity difference** between bonded atoms
- **Distance** between molecules

Development of Dipole-Dipole Forces:

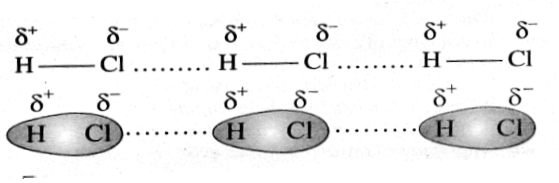
(i) They result from the attractions of opposite charges which may be **temporary** or **permanent**.

(ii) The **unequal sharing of electrons** between two different types of atoms make one end of molecule **slightly positive** and other end **slightly negatively** charged.

(iii) As shared pair of electron is drawn towards more electronegative atom, it is partially negatively charged, as chlorine in hydrogen chloride. The other end automatically becomes partially positively charged.

$$H^{\delta+} - Cl^{\delta-}$$

(iv) When partial positive and partial negative charges exist at different positions in a molecule, the adjacent molecules will arrange themselves in such a way that **negative end** of that molecule **comes near to positive end** of other molecule.



Q.3 Explain hydrogen bonding in detail.

(LHR 2016, FSD 2016, SGD 2016, MTN 2016, DGK 2016, SWL 2016, BWP 2017)*(U.B+K.B)*

OR

Define hydrogen bonding. Explain that how these forces affect the physical properties of compounds. **(Ex-Q.8)*(U.B+K.B)***

Ans:

HYDROGEN BONDING

Definition:

*"The **forces of attraction present between partially positively charge hydrogen atom of one molecule and partially negatively charged atom (N, O or F) of another molecule** is called hydrogen bonding".*

Partially positively hydrogen of one molecule attracts and forms a bond with the partially negatively charge atom of the other molecule, the bonding is called hydrogen bonding.

Explanation:

Occurrence:

Hydrogen bonding is a special type of intermolecular forces present in the **permanently polar molecules**. This bonding can be considered unique **dipole-dipole attraction**.

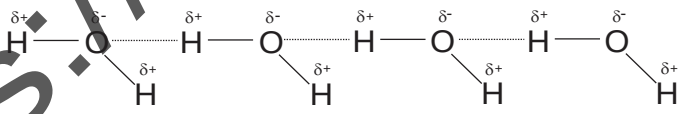
Development of Hydrogen Bonding:

This force of attraction develops between **molecules** that **have a hydrogen atom bonded to a small, highly electronegative atom with lone pairs of electrons such as nitrogen, oxygen and fluorine**. The covalent bond between hydrogen atom and other atom becomes polar enough to create a partial positive charge on hydrogen atom and a partial negative charge on the other atom. The small size and high partial positive charge on the hydrogen atom enables it to attract highly electronegative **(N, O or F)** atom of the other molecule.

Representation:

This force of attraction is represented by a **dotted line (……)** between the molecules:

Example:



Effect of Hydrogen Bonding on Physical Properties:

(i) Boiling Points:

- Due to this, boiling points of the compounds are affected greatly.
- It enhances the force of attraction between molecules.

Example:

Boiling point of **water (100^{o}C)** is **higher** than that of **alcohol (78°C)** because of **more and stronger hydrogen bonding in water**.

(ii) Density of Water:

The important phenomenon of **floating of ice over water** is because of **hydrogen bonding.** The **density of ice** at **0 ^{0}C (0.917 gcm^{-3})** is less than that of **liquid water at 0°C (1.00 g/cm^{3})**. In the liquid state water molecules move randomly, however. When water freezes the molecules arrange themselves in an ordered form that gives them open structure. This process expands the molecules. That results in ice **being less dense as compared to water**.

4.4 INTER MOLECULAR FORCES

SHORT QUESTIONS

Q.1 What are intermolecular forces? **(FSD 2017 G-II)*(K.B)***

Ans: *Answer given on pg # 137*

Q.2 Define hydrogen bonding. **(GRW 2016 G-II, LHR 2016 G-I)*(K.B)***

Ans: *Answer given on pg # 139*

Q.3 What are dipole-dipole interactions?

Ans: *Answer given on pg # 138*

4.4 INTER MOLECULAR FORCES

MULTIPLE CHOICE QUESTIONS

1. Energy required to break forces of one mole liquid HCl molecule is: ***(K.B)***

(A) 16kJ (B) 15kJ (C) 17kJ (D) 18kJ

2. The density of ice at 0°C is: ***(K.B)***

(A) 0.917g/cm^3 (B) 0.719g/cm^3 (C) 0.197g/cm^3 (D) 0.0917g/cm^3

3. Which properties are affected by hydrogen bonding? ***(U.B)***

(A) Physical (B) Chemical (C) Ionic (D) Metallic

4. The bond dissociation energy of HCl molecule is: **(GRW 2016)*(K.B)***

(A) 430 kJ/mol (B) 340 kJ/mol (C) 403 kJ/mol (D) 304 kJ/mol

5. The boiling point of alcohol is: **(GRW 2016 G-II)*(K.B)***

(A) 44°C (B) 19°C (C) 53°C (D) 78°C

6. Ice floats on water because: ***(U.B)***

(A) Ice is denser than water (B) Water is denser than ice

(C) Ice is crystalline in nature (D) Water molecule move randomly

7. Which type of force is present in hydrogen bonding? **(LHR 2015)*(U.B)***

(A) Intermolecular forces (B) Ionic forces (C) Covalent forces (D) Metallic force

8. Hydrogen bonding is present in: ***(U.B+K.B)***

(A) Non polar molecule (B) Temporary polar molecule

(C) Permanently polar molecule (D) Homoatomic molecule

9. Weakest force among the molecules is: ***(U.B+K.B)***

(A) Ionic force (B) Metallic force

(C) Covalent force (D) Intermolecular force

10. Metals have _____ or free electrons. ***(K.B)***

(A) Mobile (B) Tightly bonded (C) Free (D) None of these

11. Metals are good conductor of heat and: ***(K.B)***

(A) Electricity (B) Energy (C) None of these (D) All of these

12. Metals have tendency to lose electrons due to: ***(U.B)***

(A) High ionization energy (B) Low ionization energy

(C) High electron affinity (D) Less number of free electrons

4.3 TEST YOURSELF

i. What type of elements form metallic bonds? ***(K.B)***

Ans: **METALLIC BOND**

Metals form metallic bond because they have low ionization energies and high shielding effect. Due to these properties metal atoms lose electrons easily and form a sea of mobile electrons with positive ions.

Examples:

- Sodium
- Calcium

ii. Why is the hold of nucleus over the outermost electrons in metals weak? ***(U.B)***

Ans: **WEAK HOLD OF NUCLEUS**

The hold of nucleus over the outermost electrons in metals is weak because of:

- Large sized atoms
- Greater number of shells in between nucleus and valence electrons
- Low ionization energy

iii. Why the electrons move freely in metals? ***(U.B)***

Ans: **FREE MOVEMENT OF ELECTRONS**

Electrons move freely in metals because of large sized atoms, increased shielding effect and low ionization energy. Due to these properties the metals have the tendency to lose their outer electrons easily. Resultantly loose or free electrons of all metal atoms move freely in the spaces between atoms of a metal. None of these electrons is attached to any particular atoms.

iv. Which types of electrons are responsible for holdings the atoms together in metals? ***(K.B)***

Ans: **ELECTRON HOLDING THE ATOM**

Mobile electrons present within the metals are responsible for holding the atoms of metals together forming a metallic bond.

v. Why a dipole develops in a molecule? ***(U.B)***

Ans: **DEVELOPMENT OF DIPOLE**

A dipole develops in a molecule due to electronegativity difference between the two bonded atoms. The unequal sharing of electrons between two different types of atoms makes one end of the molecule slightly positive and other end slightly negatively charged. Hence a dipole develops in a molecule.

Example:

$H^{\delta+}$—— $C1^{\delta-}$------ $H^{\delta+}$—— $C1^{\delta-}$------ $H^{\delta+}$ —— $C1^{\delta-}$

vi. What do you mean by induced dipole? ***(U.B)***

Ans: **INDUCED DIPOLE**

"A temporary dipole which is produced in a non-polar molecule due to the influence of a polar molecule is called an induced dipole".

The positive end of polar molecule attracts the mobile electrons of the nearby non polar molecule and induce the polarity in non-polar molecule.

vii. Why are dipole forces of attraction not found in halogen molecules? ***(U.B)***

Ans: **NO DIPOLE FORMATION IN HALOGENS**

Dipole forces of attraction are not found in halogen molecules because halogens are homo atomic molecules. Due to no difference of electronegativity between atoms halogen molecules have no dipoles and thus are non-polar.

Example:

Cl_2, I_2, Br_2 and F_2

viii. What types of attractive forces exist between HCl molecules? ***(U.B)***

Ans: **ATTRACTIVE FORCES BETWEEN HCl MOLECULES**

HCl forms a polar covalent bond between atoms due to difference of electronegativity between bonded atoms. There exists a dipole in the molecule. The positive end of one molecule attracts the negative end of other molecule. Hence dipole forces (intermolecular forces) exist between HCl molecules.

Example:

$H^{\delta+}$—— $C1^{\delta-}$------ $H^{\delta+}$ —— $C1^{\delta-}$

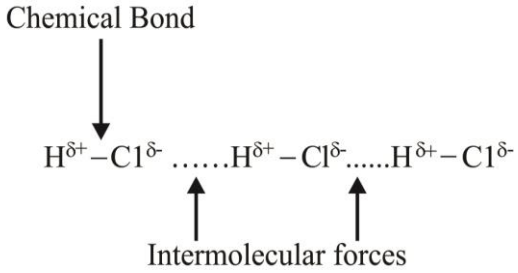
ix. Define intermolecular forces; show these forces among HCl molecule.

(BWP 2017, FSD 2017 G-II)*(U.B+K.B)*

Ans: **INTERMOLECULAR FORCES**

"The forces that hold atoms in a compound are chemical bonds. In addition to these strong bonding forces, relatively weak forces also exist in between the molecules, which are called intermolecular forces".

Example:



4.5 NATURE OF BONDING AND PROPERTIES

4.5.1 IONIC COMPOUNDS

Q.1 Write down the properties of ionic compounds.

(FSD 2016, SWL 2016, DGK 2016, 17, RWP 2016,17, MTN 2017, GRW 2016 G-I, II)*(U.B+K.B)*

Ans: **IONIC COMPOUNDS**

Definition:

*"The **compounds which contain ionic bond** in them are called ionic compounds."*

Examples:

NaCl, KCl, KNO_3, $CaCO_3$ etc.

Composition:

Ionic compounds are made up of positively and negatively charged ions. Thus they **consist of ions** and not the molecules.

Attractive Forces:

These positively and negatively charged ions are held together in a solid or crystal form with **strong electrostatic attractive forces**.

Ordered Arrangement of Ions:

The orderly arrangement of Na^+ and Cl^- ions in a solid crystal of sodium chloride is given below:

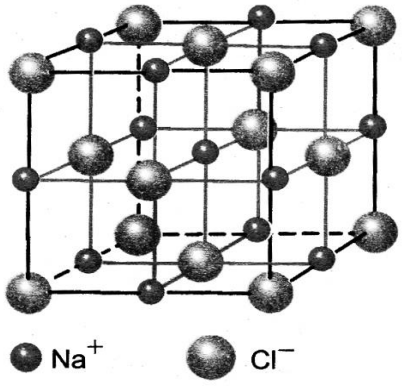


Figure: Regular Arrangement of Na^+ and Cl^- ions in Solid Crystal of NaCl.

PROPERTIES OF IONIC COMPOUNDS

The ionic compounds have following properties:

(i) Crystalline Solids:

Ionic compounds are mostly **crystalline solids**.

(ii) Electrical Conductivity:

Ionic compounds in **solid state** have **negligible electrical conductance** but they are **good conductors in solution and in the molten form.** It is due to the presence of **free ions** in them.

(iii) Melting and Boiling Points:

Ionic compounds have **high melting and boiling points**. For example, **sodium chloride** has **melting point 800°C** and a **boiling point 1413 °C**. As ionic compounds are made up of positive and negative ions, there exist strong electrostatic forces of attraction between oppositely charged ions. So, a great amount of energy is required to break these forces.

(iv) Solubility:

They dissolve easily in **polar solvents like water**. **Water has high dielectric conductance** that weakens the attraction between ions.

Q.2 What are covalent compounds? Describe the properties of covalent compounds.

(MTN 2016, RWP 2016, BWP 2017, SGD 2017, LHR 2016 G-I)*(U.B+K.B)*

Ans:

COVALENT COMPOUNDS

Definition:

*"The **compounds which contain covalent bond in them** are called covalent compounds."*

Composition:

The covalent compounds are made up of molecules that are formed by mutual sharing of electrons between their atoms i.e. **covalent bond**.

Strength of Bond:

A covalent bond is generally regarded as **weaker than an ionic bond**. Covalent compounds are made up of two or more **non-metals**.

Example:

H_2, Cl_2, CO_2, H_2SO_4, $C_6H_{12}O_6$ etc.

Physical States:

Lower molecular mass covalent compounds are **gases** or **low boiling** liquids. Contrary to it, **higher molecular mass** covalent compounds are **solids**.

PROPERTIES OF COVALENT COMPOUNDS

The properties of covalent compounds are as follows:

(i) Melting and Boiling Points:

They have usually **low** melting and boiling points.

(ii) Electrical Conductivity:

They are usually **bad conductors** of electricity. The compounds having polar character in their bonding are conductor of electricity when they dissolve in polar solvents.

(iii) Solubility:

They are usually **insoluble in water** but are soluble in non-aqueous solvents like benzene, ether, alcohol and acetone.

(iv) Crystal Formation:

Large molecules with **three dimensional bonding** form covalent crystals which are very stable and hard. They have **high melting and boiling points**.

Q.3 Write a note on polar and non-polar compounds. ***(U.B+K.B)***

Ans: (A) Polar Compounds

*"A **compound having polar** covalent bond is called polar compound."*

Examples:

HF, HCl, H_2O, NH_3 etc.

Development of Polarity in Chemical Bond:

Polarity in a chemical bond is due to **difference in electro negativities** of the bonding atoms.

Electronegativity Scale:

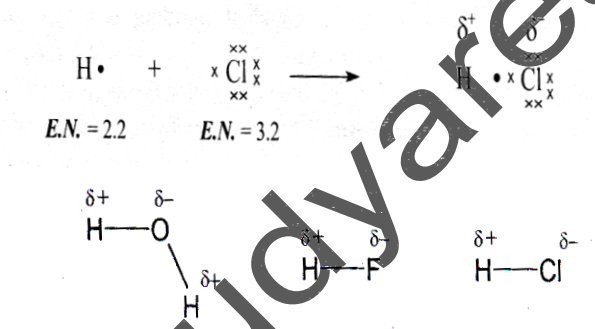
On the **Pauling Scale fluorine** has been given an electronegativity value of **4.0.** The values for other elements are calculated relative to it.

PROPERTIES

(i) Properties of non-polar and polar covalent compounds differ to some extent.

(ii) Polar covalent compounds usually dissolve in water while non polar do not dissolve.

(iii) An aqueous solution of a polar compound usually conducts electricity due to the formation of ions as a result of its reaction with water.



(B) NON-POLAR COMPOUNDS

"*A **compound having non polar** covalent bond is called non polar compound."*

Examples:

CO_2, CH_4, C_6H_6, C_2H_2, CCl_4 etc.

PROPERTIES

(i) Non-polar covalent compounds usually **do not dissolve in water**.

(ii) Similarly non-polar compounds **do not conduct electricity.**

Q.4 Write down the properties of coordinate covalent compounds. ***(K.B)***

Ans: COORDINATE COVALENT COMPOUNDS

*"The **compounds which contain coordinate covalent bond in them** are called coordinate covalent compounds".*

Examples:

$NH_3 - BF_3$, NH_4Cl, $NH_3 - AlCl_3$ etc.

PROPERTIES

(i) Their properties are mostly **similar** to those of **covalent compounds**.

(ii) As the nuclei in these compounds are held by shared electrons, therefore, they **do not form ions in water**.

(iii) Due to their covalent nature they form solutions in organic solvents and are **very less soluble in water**.

(iv) Usually they are **rigid compounds with a dipole**.

Q.5 Write down the properties of metals. **(FSD 2016, 17, RWP 2017, SGD 2016, GRW 2016 G-I)** ***(K.B)***

Ans:

METALS

Definition:

*"The elements which are usually **hard**, are **good conductors of heat and electricity** and are **malleable and ductile** are called metals."*

Metals have common property of conducting heat and electricity. It gives them prime role in many industries.

Examples:

Iron, cobalt, nickel, gold, silver etc.

PROPERTIES

The properties of metals are as follows:

(i) They show **metallic luster**.

(ii) They are usually malleable and ductile. **Malleability** is the property by virtue of which a **metal can be rolled into sheets,** while **ductility** is the property by virtue of which a **metal can be drawn into wires**.

(iii) They have usually **high melting and boiling points**.

(iv) Being greater in size they have **low ionization energies** and form **cations (M^+)** very easily.

(v) They are **good conductors of heat and electricity** in solid and liquid state due to **mobile and free electrons**.

(vi) Metals have **shining surface**.

4.5 NATURE OF BONDING AND PROPERTIES

4.5.1 IONIC COMPOUNDS

SHORT QUESTIONS

Q.1 Write properties of non-polar compounds. ***(K.B)***

Ans: Answer given on pg # 144

Q.2 What is the composition of ionic compounds? **(MTN 2016)** ***(K.B)***

Ans:

COMPOSITION OF IONIC COMPOUNDS

Ionic compounds are made up of positively and negatively charged ions. Thus they consist of ions and not the molecules.

Q.3 Write any two properties of ionic compounds. **(RWP 2017 G-I, II)** ***(K.B)***

Ans:

PROPERTIES OF IONIC COMPOUNDS

The two properties of ionic compounds are as follows:

Crystalline Solids:

Ionic compounds are mostly crystalline solids.

Electrical Conductivity:

Ionic compounds in solid state have negligible electrical conductance but they are good conductors in solution and in the molten form. It is due to presence of free ions in them.

4.5 NATURE OF BONDING AND PROPERTIES

4.5.1 IONIC COMPOUNDS

MULTIPLE CHOICE QUESTIONS

1. The boiling point of sodium chloride is: **(RWP 2015, 17 G-II)** ***(K.B)***

(A) 1413°C (B) 1414°C (C) 1415°C (D) 1416°C

2. Ionic compounds mostly exist in: ***(K.B)***

(A) Solid (B) Crystalline solid (C) Amorphous (D) Liquid

3. Ionic compounds do not conduct electricity in: *(K.B+U.B)*
(A) Solid state (B) Liquid state (C) Molten state (D) Both A and C

4. Melting point of NaCl is: *(K.B)*
(A) 1413°C (B) 800°C (C) 799°C (D) 780°C

5. Ionic compounds dissolve easily in: *(K.B)*
(A) Ether (B) Benzene (C) Petrol (D) Water

6. Non-polar covalent compound usually dissolve in: *(K.B)*
(A) Water (B) Alcohol (C) Acid (D) Ether

7. Covalent compounds have melting and boiling points: *(K.B)*
(A) Low (B) High (C) Moderate (D) Very high

8. Non polar covalent compound usually _____ conduct electricity. *(K.B)*
(A) Do (B) Do not (C) Both (D) None of these

9. Benzene is: *(K.B)*
(A) Polar compound (B) Non-polar compound
(C) Homoatomic compound (D) Monoatomic compound

10. Metals usually have melting and boiling points: *(K.B)*
(A) High (B) Low (C) Both (D) None of these

4.4 TEST YOURSELF

i. Why the ionic compounds have high melting and boiling points? *(U.B)*

Ans:

IONIC COMPOUND

As ionic compounds are made up of positive and negative ions, there exist strong electrostatic forces of attraction between oppositely charged ions. So, a great amount of energy is required to break these forces, therefore ionic compounds have high melting and boiling points.

ii. What do you mean by malleability? **(SGD 2017 G-II)** *(K.B)*

Ans:

MALLEABILITY

Malleability is a special property of metal, by virtue of metal can be rolled into sheets.

Examples:

Metals such as gold, silver, copper, are malleable.

iii. Why are ionic compounds easily soluble in water? *(U.B)*

Ans:

IONIC COMPOUNDS

Ionic compounds are easily soluble in water, because water is a polar solvent and has high dielectric constant that weakens the attraction between ions of ionic compounds like dissolved like similar solvents dissolve similar solutes. Ionic compounds are polar that's why they are soluble in polar solvent like water.

Examples:

Sodium chloride can easily be soluble in water.

iv. What type of bond exists in sodium chloride? *(U.B)*

Ans:

BOND EXIST IN SODIUM CHLORIDE

Sodium chloride is an ionic compound therefore ionic bond is present in sodium chloride.

v. Why the covalent compounds of bigger size molecules have high melting points? *(U.B)*

Ans:

HIGH MELTING POINT

The covalent compounds of bigger size molecules have three dimensional bonding in them, which forms covalent crystals which are very stable and hard. So, they have high melting and boiling points.

Examples:

SiO_2, SiC_4 etc.

vi. How much there is electronegativity difference between the following pair or elements (atoms). Predict the nature of the bond between them? ***(U.B+A.B)***

(A) Hand Cl (B) Hand Na (C) Na and I (D) K and Cl

b. Comparing the electronegativity differences, arrange these compounds in increasing ionic strength. ***(U.B+A.B)***

Ans:

Pair of Elements	Electronegativity Differences	Nature of Bond
(A) H and CI (H=2-2, Cl=3.2)	1.0	Polar covalent bond
(B) H and Na (H=2-2, Na=0.9)	1.3	Ionic bond
(C) Na and I (Na=0.9, I=2.5)	1.6	Ionic bond
(D) K and CI (K=0.8, Cl=3.2)	2.4	Ionic bond

b. Comparing the electronegativity differences, arrange these compounds in increasing ionic strength.

The order of increasing ionic strength of compounds is:

$$H - Cl < H - Na < Na - I < K - Cl$$

Least ionic Most ionic

ANSWER KEYS

4.1 WHY DO ATOMS FORM CHEMICAL BOND

4.2 CHEMICAL BOND

1	C	2	C	3	A	4	A	5	D	6	D	7	C

4.3 TYPES OF CHEMICAL BOND

4.3.1 IONIC BOND

1	D	2	C	3	C	4	B	5	A	6	A

4.3.2 COVALENT BOND

1	A	2	B	3	C	4	B	5	A	6	B	7	C	8	A

4.3.3 DATIVE COVALENT OR COORDINATE COVALENT BOND

1	B	2	D	3	C	4	A	5	C

4.3.4 POLAR AND NON POLAR COVALENT BOND

1	D	2	B	3	B	4	C	5	C

4.4 INTER MOLECULAR FORCES

1	C	2	A	3	A	4	A	5	D	6	B	7	A	8	C	9	D	10	A	11	A	12	B

4.5 NATURE OF BONDING AND PROPERTIES

4.5.1 IONIC COMPOUNDS

1	A	2	B	3	A	4	B	5	D	6	D	7	A	8	B	9	B	10	A

EXERCISE SOLUTION

MULTIPLE CHOICE QUESTIONS

1. Atoms react with each other because: **(GRW 2016 G-I)*(U.B)***

(A) They are attracted to each other. (B) They are short of electrons
(C) They want to attain stability (D) They want to disperse

2. An atom having six electrons in its valence shell will achieve noble gas electronic configuration by: ***(U.B)***

(A) Gaining one electron (B) Losing all electrons
(C) Gaining two electrons (D) Losing two electrons

3. Considering the electronic configuration of atoms which atom with the given atomic number will be the most stable one? ***(U.B)***

(A) 6 (B) 8 (C) 10 (D) 12

4. Octet rule is: **(BWP 2016 G-II, SGD 2016 G-I)*(K.B)***

(A) Description of eight electrons (B) Picture of electronic configuration
(C) Pattern of electronic configuration (D) Attaining of eight electrons

5. Transfer of electrons between atoms results in: ***(K.B)***
(GRW 2017 G-II, DGK 2017 G-II, SWL 2017 G-II, BWP 2016 G-II, FSD 2016 G-I, SGD 2016 G-II)

(A) Metallic bonding (B) Ionic bonding
(C) Covalent bonding (D) Coordinate covalent bonding

6. When an electronegative element combines with electropositive element the type of bonding is:*(U.B)*

(A) Covalent (B) Ionic (C) Polar covalent (D)Coordinate covalent

7. A bond formed between two non-metals is expected to be:
(RWP 2017 G-I, SGD 2017 G-II, BWP 2016 G-I, II, SGD 2016 G-II, FSD 2016 G-I)*(U.B+K.B)*

(A) Covalent (B) ionic (C) Coordinate covalent (D) Metallic

8. A bond pair in covalent molecules usually has: **(GRW 2016 G-I, RWP 2017 G-I)*(U.B)***

(A) One electron (B) Two electrons (C) Three electrons (D) Four electrons

9. Which of the following compounds is not directional in its bonding? ***(U.B)***

(A) CH_4 (B) KBr (C) CO_2 (D) H_2O

10. Ice floats on water because: **(SGD 2017 G-I, SWL 2017 G-I)*(U.B)***

(A) Ice is denser than water (B) Water is denser than ice
(C) Ice is crystalline in nature (D) Water molecules move randomly

11. Covalent bond involves the: **(LHR 2016 G-I)*(U.B)***

(A) Donation of electrons (B) Acceptance of electrons
(C) Sharing of electrons (D) Repulsion of electrons

12. How many covalent bonds does C_2H_2 molecule have? **(MTN 2016 G-I)*(U.B)***

(A) Two (B) Three (C) Four (D) Five

13. Triple covalent bond involves how many number of electrons? **(LHR 2017 G-I, 2016 G-II, FSD 2016 G-I, II)*(U.B)***

(A) Eight (B) Six (C) Four (D) Only three

14. Which pair of the molecules has same type of covalent bonds? **(DGK 2016 G-I)*(U.B)***

(A) O_2 and HCl (B) O_2 and N_2 (C) O_2 and C_2 (D) O_2 and C_2H_2

15. Identify the compound which is not soluble in water: ***(K.B)***

(A) C_6H_6 (B) NaCl (C) KBr (D) $MgCl_2$

16. Which one of the following is an electron deficient molecule? **(LHR 2016 G-I, MTN 2016 G-I, II, RWP 2016 G-I)*(K.B)***

(A) NH_3 (B) BF_3 (C) N_2 (D) O_2

17. Identify which pair has polar covalent bonds: ***(U.B)***

(A) O_2 and Cl_2 (B) H_2O and N_2 (C) H_2O and C_2H_2 (D) H_2O and HCl

18. Which one of the following is the weakest force among the atoms? ***(K.B)***

(A) Ionic force (B) Metallic force (C) Intermolecular force (D) Covalent force

ANSWER KEY

1	C	2	C	3	C	4	D	5	B	6	B	7	A	8	B	9	B	10	C
11	C	12	D	13	B	14	D	15	A	16	B	17	D	18	C				

EXERCISE SHORT QUESTIONS

1. Why do atoms react? **(LHR 2017 G-I, SGD 2017 G-II)*(U.B)***

Ans: **REACTIVITY OF ATOM**

Atoms react to form chemical bonds in order to get stability. Atoms achieve stability by attaining electronic configuration of inert gases by losing, gaining or sharing of electron.

2. Why is the bond between an electropositive and an electronegative atom ionic in nature?(U.B)

Ans: **IONIC NATURE**

The bond between an electropositive and an electronegative atom is ionic in nature because electropositive atom due to low I.E. can lose electron easily and forms a positive ion whereas electronegative atom due to high electron affinity will accept that electron easily and forms a negative ion. In this way positive and negative ions are attracted by electrostatic force of attraction to form ionic bond.

3. Ionic compounds are solids. Justify.

(MTN 2016, DGK 2016, FSD 2017, RWP 2017 G-II, LHR 2016 G-I)*(U.B)*

Ans: **IONIC COMPOUNDS**

Ionic compounds are solids because they have strong electrostatic forces of attraction between positively and negatively charged ions which hold them in a three dimensional crystalline or solid form.

Example:

Potassium chloride (KCl) is a crystalline solid.

4. More electronegative elements can form bonds between themselves. Justify.

(BWP 2017)*(U.B)*

Ans: **JUSTIFICATION**

More electronegative elements have high values of ionization energy and do not lose electrons. They share electrons between their own atoms to complete their valence shells and form covalent bond.

5. Metals are good conductor of electricity. Why? **(RWP 2017 G-I, SGD 2017 G-II)*(U.B)***

Ans: **METALS ARE GOOD CONDUCTOR**

Metals are good conductors of electricity due to presence of mobile or free electrons.

6. Ionic compounds conduct electricity in solution or molten form. Why?
(DGK 2017, SWL 2017, BWP 2016)*(U.B)*

Ans: **IONIC COMPOUNDS**

Ionic compounds conduct electricity in solution or molten form because in these two states ionic compounds have free ions in them. When these free ions move in solution or molten state they become conductor of electricity.

7. What type of covalent bond is formed in nitrogen molecule? **(SGD 2017 G-I)*(U.B)***

Ans: **BOND IN NITROGEN MOLECULE**

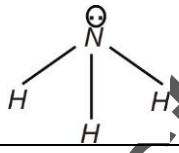
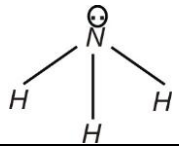
Triple covalent bond is formed in nitrogen molecule. In nitrogen molecule three bond pairs are involved in bond formation.

$$:N\dot{\times}+\dot{\times}N\times \longrightarrow :N\dot{\times}\dot{\times}N\times \longrightarrow N\equiv N \text{ or } N_2$$

8. Differentiate between lone pair and bond pair of electron.
(SWL 2016, DGK 2016, GRW 2016 G-II, RWP 2017 G-I, SGD 2017 G-II)*(U.B)*

Ans: **DIFFERENTIATION**

The differences between bond pair and lone pair are as follows:

Bond Pair	Lone Pair
Definition	
• Bond pair of electrons is involve in bond formation	• Lone pair of electron is not involved in bond formation.
Example	
In a ammonia molecule there are three bond pairs of electrons. 	In a ammonia molecule there is one lone pair of electrons. 

9. Describe at least two necessary conditions for the formation of a covalent bond.*(U.B)*

Ans: **NECESSARY CONDITIONS**

Two necessary conditions for the formation of a covalent bond are as follows:

- Elements should be electronegative in nature.
- Electronegativity difference between bonding atoms should be very small or zero.
- The elements should share the electrons mutually.
- There should be 4 or more valance electrons.
- The ionization energies of the elements must be high.

Examples:

HCl, Cl_2, C_6H_6 and C_2H_2.

10. Why HCl has dipole-dipole forces of attraction? **(DGK 2016)*(U.B)***

Ans: **DIPOLE-DIPOLE FORCES IN HCl**

HCl forms a polar covalent bond between atoms due to difference of electronegativity between bonded atoms. There exists a dipole in the molecule. The positive end of one molecule attracts the negative end of other molecule. Hence dipole-dipole forces. (intermolecular forces) exist between HCl molecules.

Example:

$$H^{\delta+}\text{—— } C1^{\delta-}\text{------ } H^{\delta+}\text{ —— } C1^{\delta-}$$

11. What is a triple covalent bond, explain with an example?
(SWL 2017, DGK 2017, BWP 2017, GRW 2016 G-II)*(K.B+A.B)*

Ans: **TRIPLE COVALENT BOND**

When each bonded atom contributes three electrons, three bond pairs are involved in bond formation. This type of bond is called triple covalent bond.

Representation:

It is represented by three lines $(\equiv)$ between two bonded atoms.

Example:

Triple covalent bond is formed in nitrogen molecule. In nitrogen molecule three bond pairs are involved in bond formation.

$$:\dot{N}: + \dot{\underset{\times}{\overset{\times}{N}}}\times \longrightarrow :N:: \dot{\underset{\times}{\overset{\times}{N}}}\times \longrightarrow N \equiv N \text{ or } N_2$$

12. What is difference between polar and non-polar covalent bonds, explain with one example of each?
(GRW 2017 G-I, LHR 2016 G-II)*(U.B+A.B)*

Ans: **DIFFERENTIATION**

The differences between polar and non-polar covalent bond is as follows:

Polar Covalent Bond	Non-Polar Covalent Bond
Definition	
• It is a bond formed between two different types of atoms (heteroatom).	• It is a bond formed between two similar atoms (homo atoms).
Extent of Attraction	
• The shared pair of electron is attracted by both the atoms unequally.	• The shared pair of electrons is attracted by both the atoms equally.
Electronegativity Difference	
• There **exist electronegativity difference** between two atoms.	• There exist **no electronegativity difference** between two atoms.
Examples	
• HCl, HBr, HF, H_2O are examples of polar covalent bond.	• H_2, Cl_2, N_2, O_2 are examples of non-polar covalent bond.

13. Why a covalent bond becomes polar? **(LHR 2017 G-I)*(U.B)***

Ans: **POLARITY OF COVALENT BOND**

When there is a difference of electronegativity between two covalently bonded atoms, there will be unequal attraction for the bond pair of electrons between such atoms. It will result in the formation of polar covalent bond.

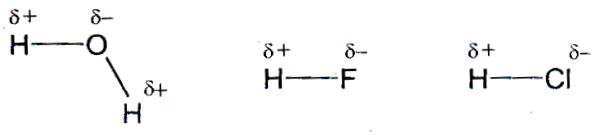
Examples:

HCl, H_2O etc.

14. What is relationship between electronegativity and polarity? **(GRW 2017 G-II)*(U.B)***

Ans: **RELATIONSHIP BETWEEN ELECTRONEGATIVITY AND POLARITY**

The polarity of a covalent bond depends upon the electronegativity difference between the bonded atoms. Higher the electronegativity difference between bonded atoms, greater will be the polarity. Thus electronegativity and polarity are directly related:



15. Why does ice float on water? ***(U.B)***
(FSD 2016, MTN 2016, DGK 2016, SGD 2016, RWP 2016, 17 G-I, LHR 2016 G-II, GRW 2016 G-I, 2017 G-II)

Ans: **FLOATING OF ICE**

Ice floats on the water because of the hydrogen bonding. Density of ice ($0.917 g/cm^3$) is less than that of liquid water ($1.00 g/cm^2$) at 0°C.

16. Give the characteristic properties of ionic compounds. **(GRW 2016 G-II)*(K.B)***

Ans: **CHARACTERISTICS PROPERTIES OF IONIC COMPOUNDS**

The characteristics properties of ionic compounds are as follows:

(i) Ionic compounds are mostly crystalline solids.
(ii) Ionic compounds are good conductors in solution and in molten form due to presence of free ions in them.
(iii) Ionic compounds have high melting and boiling points. For example NaCl has melting point 800^0C and boiling point 1413°C.
(iv) Ionic compounds dissolve in polar solvents e.g. NaCl dissolves in water.

17. What characteristic properties do the covalent compounds have?
(BWP 2016, LHR 2017 G-I)*(K.B)*

Ans: **CHARACTERISTIC PROPERTIES OF COVALENT COMPOUNDS**

The characteristics properties of covalent compounds are as follows:

(i) Melting Boiling Points:
They have usually low melting and boiling point.

(ii) Electrical Conductivity:
They are usually bad conductors of electricity. Polar compounds are conductors in their solutions in polar solvents.

(iii) Solubility:
They are usually insoluble in water but soluble in non-aqueous solvents like benzene, ether, alcohol and acetone.

(iv) Crystal Formation:
Bigger molecules with three dimensional bonding form covalent crystals which are very stable and hard. They have high melting and boiling points.

EXERCISE LONG QUESTIONS

1. What is an ionic bond? Discuss the formation of ionic bond between sodium and chlorine atoms.

Ans: Answer given on pg # 125 (Topic 4.3 and 4.3.1)

2. How can you justify that bond strength in polar covalent compounds is comparable to that of ionic compounds?

Ans: Answer given on pg # 133 (Topic 4.3.4)

3. What type of covalent bonds are formed between hydrogen, oxygen and nitrogen? Explain their bonding with dot and cross model. ***(U.B+A.B)***

Ans: **TYPES OF COVALENT BOND**

(i) Hydrogen:
Single covalent bond is present in hydrogen.

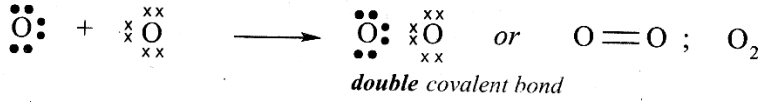
Dot and Cross Model:

$$H\bullet + \times H \longrightarrow H\bullet\times H \quad or \quad H—H \; ; \quad H_2$$

single covalent bond

(ii) Oxygen:
Double covalent bond is present in oxygen.

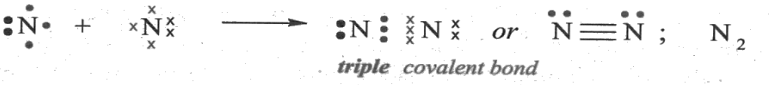
Dot and Cross Model:



(iii) Nitrogen:

Triple covalent bond is present in nitrogen.

Dot and Cross Model:



4. How a covalent bond develops ionic character in it? Explain.

Ans: *Answer given on pg #* 128 (Topic 4.3.4)

5. Explain the types of covalent bonds with at least one example of each type.

Ans: *Answer given on pg #* 128 (Topic 4.3.2)

6. How a coordinate covalent bond is formed? Explain with examples?

Ans: *Answer given on pg #* 131 (Topic 4.3.3)

7. What is metallic bond? Explain the metallic bonding with the help of a diagram.

Ans: *Answer given on pg #* 136 (Topic 4.3.5)

8. Define hydrogen bonding. Explain how these forces affect the physical properties of compounds.

Ans: *Answer given on pg #* 139 (Topic 4.4)

9. What are intermolecular forces? Compare these forces with chemical bond forces with reference to HCl molecule?

Ans: *Answer given on pg #* 137 (Topic 4.4)

10. What is a chemical bond and why do atoms form a chemical bond?

Ans: *Answer given on pg #* 123 (Topic 4.1& 4.2)

11. What is octet rule? Why do atoms always struggle to attaint be nearest noble gas electronic configuration?

Ans: *Answer given on pg #* 123 (Topic 4.1 & 4.2)

ADDITIONAL CONCEPTUAL QUESTIONS

Q.1 Why do atoms struggle to attain the nearest noble gas electronic configuration? ***(U.B)***

Ans:

NOBLE GAS ELECTRONIC CONFIGURATION

Atoms always struggle to attain the nearest noble gas electronic configuration in order to become more stable. For this purpose they follow two rules i.e., duplet and octet rule.

Q.2 How we assign group number to an element? ***(U.B)***

Ans:

ASSIGNING GROUP NUMBER

The position of an atom in the periodic table indicates its group number. The group number is assigned on the basis of valence shell electrons.

Examples:

- Group 1 has only 1 electron in its valence shell.
- Group 17 has 7 electrons in its valence shell.

Q.3 What is the effect of attractive and repulsive forces on bond formation? ***(U.B)***

Ans:

EFFECTIVE AND REPULSIVE FORCES

(i) When Attractive Forces Dominate:

When two approaching atoms come closer, the attractive as well as repulsive forces become operative. The formation of a chemical bond is a result of net attractive forces which dominate.

(ii) When Repulsive Forces Dominate:

The energy of that system is lowered and molecule is formed. Otherwise if repulsive forces become dominant no chemical bond will be formed. In that case there will be increase in the energy of the system due to creation of repulsive forces.

Q.4 Which type of element follow duplet rule and why? ***(U.B)***

Ans: **TYPE OF ELEMENT FOLLOW DUPLET RULE**

Elements which have only s-subshell usually follow duplet rule.

Example:

Hydrogen and Helium.

Reason:

Because s-subshell has maximum capacity of 2 electrons.

Q.5 What are ionic compounds? ***(K.B)***

Ans: **IONIC COMPOUNDS**

Definition:

"The compounds containing ionic bond in them are called ionic compounds".

Examples:

NaCl, KCl, Na_2SO_4 etc.

Q.6 What is Lewis structure diagram? **(Do you know Pg. # 63)(K.B)**

Ans: **LEWIS STRUCTURE**

The electronic configuration of the valence shells of atoms is shown in small 'dots' or 'crosses' around the symbol of the element. Each dot or cross represent an electron. This is a standard method of Lewis to describe the electronic configuration of valence shell of an atom. It is called Lewis structure diagram or Lewis dot and cross model.

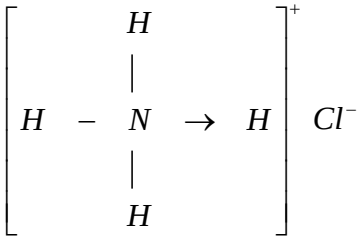
Example:

Lewis dot and cross structure of CO_2 is as follows:

Q.7 What types of chemical bonds are present in NH_4Cl? **(U.B)**

Ans: NH_4Cl has three types of chemical bonds

- Three **covalent bonds** are formed between nitrogen and three hydrogen atoms
- One **coordinate covalent bond** is formed between nitrogen and one hydrogen atoms
- In NH_4Cl, **ionic bond** is formed between $\overset{+}{N}H_4$ and Cl^-



Q.8 What are coordinate covalent compounds? **(K.B)**

Ans: **COORDINATE COVALENT COMPOUNDS**

Definition:

"The compounds which contain coordinate covalent bond in them are called coordinate covalent compounds".

Examples:

$NH_3 - BF_3$, NH_4Cl, $NH_3 - AlCl_3$ etc.

Q.9 CO_2, BF_3, CCl_4, CH_4 etc. all have polar bonds but the molecules are non-polar. Why? ***(U.B)***

Ans: All these molecules are non-polar because individual polar bonds (dipoles) are cancelled out with one another due to symmetrical geometries or shapes of molecule.

Q.10 Why does water has stronger hydrogen bonding than alcohol? ***(U.B)***

Ans: Water shows stronger hydrogen bonding than alcohol because each water molecule forms two hydrogen bonds and each alcohol molecule can from only one hydrogen bonds.

Q.11 Why boiling point of water is higher than that of alcohol? **(GRW 2017 G-I)*(U.B)***

Ans:

BOILING POINT OF WATER

Boiling point of water (100^oC) is higher than that of alcohol (78°C) because of more and stronger hydrogen bonding in water.

Q.12 Why ice is less denser than water? **(RWP 2017 G-II)*(U.B)***

Ans:

LESS DENSITY OF ICE THAN WATER

Density of ice at 0°C (0.917 g/cm^3) is less than that of liquid water at 0°C (1.0 g/cm^3) because of hydrogen bonding.

Mechanism:

In the liquid state water molecules move randomly. However, when water freezes, the molecules arrange themselves in an ordered form that gives them open structure. This process expands the molecules and decreases density of ice.

Q.13 What are effects of intermolecular forces? **(GRW 2017 G-II)*(U.B)***

Ans:

EFFECTS OF INTER

Intermolecular forces determine the physical state of substances. They affect the density, melting point, boiling point, heat of evaporation and other physical properties of substances.

Q.14 What is meant by dielectric constant? ***(K.B)***

Ans:

DIELECTRIC CONSTANT

"The extent to which the force of attraction between two oppositely charged ions is decreased due to a solvent is called dielectric constant".

Water has high value of dielectric constant (80 at 20°C).

Q.15 What are non-polar compounds? ***(K.B)***

Ans:

NON-POLAR COMPOUNDS

Definition:

"*A compound having non polar molecule is called non polar compound."*

Examples:

CO_2, CH_4, C_6H_6, C_2H_2, CCl_4 etc.

Q.16 Differentiate between Malleability and Ductility? ***(U.B)***

Ans: The difference between malleability and ductility is as follows.

Malleability	Ductility
• Malleability is the property by virtue of which a metal can be rolled into sheets.	• Ductility is the property by virtue of which a metal can be drawn into wires.

Q.17 Why ionization energy of metals is low? **(GRW 2017 G-II)*(U.B)***

Ans:

IONIZATION ENERGY OF METALS

Ionization energy of metal is low due to large size and less nuclear attraction on valence electrons.

TERMS TO KNOW

Terms	Definitions
Chemical Bond	*A chemical bond is defined as **force of attraction between atoms that holds them together in a substance**"*
Duplet Rule	Attaining **two electrons** in the valence shell is called duplet rule. For example helium (He)
Octet Rule	An atom having **eight electrons** in the valence shell is called octet rule. For example Neon (Ne).
Ionic Bond	*"The type of chemical bond which is **formed due to complete transfer of electron from one atom to another atom** is called ionic bond".*
Covalent Bond	*"The type of bond, which is **formed due to mutual sharing of electrons**, is called covalent bond."*
Co-ordinate Covalent Bond	*"Coordinate covalent or dative covalent bonding is a **type of, covalent bonding** in which the **bond pair of electrons is donated by one bonded atom only.**"*
Polar Covalent Bond	***"**A covalent bond is formed **between two different types of atoms (hetero-atom)** in which **bond pair of electrons is not attracted by both the atoms equally** is called polar covalent bond".*
Non-Polar Covalent Bond	*"A covalent bond is formed between **two similar atoms (homo-atoms)** in which **shared pair of electrons is attracted by both the atoms equally**, called non-polar covalent bond".*
Metallic Bond	*The metallic bond is defined as a **bond formed between metal atoms (positively charged ions) due to mobile or free electrons***
Intermolecular forces	*"The **forces of attraction present between molecules of a substance** are called intermolecular forces".*
Dipole – Dipole Interaction	*The **force of attraction present between partial positive end of one polar molecule and partial negative end of other polar molecule** is called dipole - dipole force".*
Hydrogen Bonding	*"The **forces of attraction present between partially positively charge hydrogen atom of one molecule and partially negatively charged atom (N, O or F) of another molecule** is called hydrogen bonding".*
Ionic Compounds	*"The **compounds which contain ionic bond** in them are called ionic compounds."*
Covalent Compounds	*"The **compounds which contain covalent bond in them** are called covalent compounds."*
Co-ordinate Covalent Bond	"*The **compounds which contain coordinate covalent bond in them** are called coordinate covalent compounds".*

SELF TEST

Time: 35 Minutes **Marks: 25**

Q.1 Four possible answers (A), (B), (C) and (D) to each question are given, mark the correct answer. (6×1=6)

1. Molecules with double covalent Bond is:

(A) H_2 (B) C_2H_2 (C) O_2 (D) N_2

2. Which of the following atoms obey duplet rule?

(A) H (B) F (C) O (D) Na

3. How much energy is required to break the bon of HCl?

(A) 17kJ (B) 470 kJ (C) 430 kJ (D) 71 kJ

4. The boiling point of sodium chloride is:

(A) 1450ºC (B) 800ºC (C) 1413ºC (D) 1314ºC

5. Identify the compound which is not soluble in water:

(A) C_6H_6 (B) NaCl (C) KBr (D) $MgCl_2$

6. The density of ice is:

(A) 1.00g/cm^3 (B) 0.917g/cm^3 (C) 0.971g/cm^3 (D) 0.719g/cm^3

Q.2 Give short answers to the following questions. (5×2=10)

(i) Ionic compounds are solids. Justify.

(ii) Differentiate between bond pair and lone pair.

(iii) Why has water polar covalent bond?

(iv) Why is BF_3 electron deficient?

(v) Which type of elements follow duplet rule, and why?

Q.3 Answer the following questions in detail. (5+4=9)

(i) Define covalent Bond. Explain the types of Covalent Bond. (5)

(ii) Write a note on dipole-dipole Interaction? (4)

Note:

Parents or guardians can conduct this test in their supervision in order to check the skill of students.