# 9th Class Chemistry Chapter # 3 Exercise Solutions – Punjab Board

## Chemical Bonding

## Multiple Choice Questions (MCQs)

**1. When molten copper and molten zinc are mixed together, they give rise to a new substance called brass. Predict what type of bond is formed between copper and zinc.**

Options:
(a) Coordinate covalent bond
(b) Covalent bond

(c) Metallic bond
(d) Ionic bond

**Correct Answer: (c) Metallic bond**

**Explanation:**
Brass is formed by mixing two metals — **copper and zinc**. In metallic bonding, metal atoms share a **'sea of delocalized electrons'**, giving rise to properties like conductivity and luster. Hence, bonding in brass is **metallic** in nature.

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**2. Which element is capable of forming all the three types of bonds?**

Options:

(a) Carbon
(b) Oxygen
(c) Magnesium
(d) Silicon

**Correct Answer: (a) Carbon**

**Explanation:**
Carbon is a highly versatile element. It can form:

- **Covalent bonds** (e.g., $CH_4$)
- **Coordinate covalent bonds** (e.g., CO)

- **Ionic bonds** (e.g., $CaC_2$ where C acts as carbide ion)
  Due to this **tetravalency and bonding versatility**, carbon can exhibit all three major types of bonds.
- **(iii) Why is $H_2O$ a liquid while $H_2S$ is a gas?**
  Options:
  (a) Because in water, the atomic size of oxygen is smaller than that of sulphur

  (b) Because water is a polar compound and there exists strong forces of attraction between its molecules
  (c) Because $H_2O$ molecule is lighter than $H_2S$
  (d) Because water can easily freeze into ice

  **Correct Answer: (b)**
  **Explanation:**
  Water ($H_2O$) forms **strong hydrogen bonds** due to its polarity, which leads to **high intermolecular attraction**. This makes water a **liquid at room temperature**, whereas **$H_2S$**, being less polar, is a gas.

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**(iv) Which of the following bonds is expected to be the weakest?**
Options:
(a) O−O
(b) Cl−Cl
(c) N−N

(d) F−F

**Correct Answer: (d)**
**Explanation:**
The **F–F bond** is weak due to **repulsion between lone pairs** on fluorine atoms, despite its small size. Hence, it is the **weakest single bond** among the options.

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**(v) Which form of carbon is used as a lubricant?**
Options:
(a) Coal
(b) Diamond

(c) Graphite
(d) Charcoal

**Correct Answer: (c)**
**Explanation:**
**Graphite** has **layers of carbon atoms** that can slide over one another due to weak forces, making it useful as a **lubricant**.

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**(vi) Keeping in view the intermolecular forces of attraction, indicate which compound has the highest boiling point.**
Options:

(a) $H_2O$
(b) $H_2S$
(c) HF
(d) $NH_3$

**Correct Answer: (a)**
**Explanation:**
Water ($H_2O$) forms **extensive hydrogen bonding**, giving it the **highest boiling point** among the listed compounds.

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**(vii) Which metal has the lowest melting point?**
Options:
(a) Li
(b) Na
(c) K

(d) Rb

**Correct Answer: (d)**
**Explanation:**
**Rubidium (Rb)** is the **largest alkali metal** listed and has the **weakest metallic bonding**, resulting in the **lowest melting point** among them.

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**(viii) Which ionic compound has the highest melting point?**
Options:
(a) NaCl
(b) KCl

(c) LiCl
(d) RbCl

**Correct Answer: (c)**
**Explanation:**
**$Li^+$ and $Cl^-$** have the **smallest ionic sizes**, resulting in **stronger electrostatic forces** and hence a **higher melting point** compared to others.

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**(ix) Which compound contains both covalent and ionic bonds?**
Options:
(a) $MgCl_2$

(b) $NH_4Cl$

(c) CaO
(d) $PCl_5$

**Correct Answer: (b)**
**Explanation:**
**$NH_4Cl$** contains a **covalent bond** within the ammonium ion (**$NH_4^+$**) and forms **ionic bonds** between **$NH_4^+$ and $Cl^-$** — so it has **both bond types**.

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**(x) Which among the following has a double covalent bond?**
Options:
(a) Ethane
(b) Methane

(c) Ethylene
(d) Acetylene

**Correct Answer: (c)**
**Explanation:**
**Ethylene ($C_2H_4$)** contains a **double bond (C=C)** between the two carbon atoms, making it the correct choice.
*(Acetylene has a triple bond.)*

## Short Questions with Answers

**i. What type of elements lose their outer electron easily and what type of elements gain electron easily?**
**Answer:**

- **Metals** lose their outer electrons easily to form **positive ions (cations)**.
- **Non-metals** gain electrons easily to form **negative ions (anions)**.

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**ii. Why do lower molecular mass covalent compounds exist as gases or low boiling liquids?**
**Answer:**
Lower molecular mass covalent compounds exist as **gases or low-boiling liquids** because they have **weak intermolecular forces of attraction** (like van der Waals forces), which require **less energy** to overcome.

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**iii. Give one example of an element which exists as a crystalline solid and it has covalent bonds between its atoms.**
**Answer:**
**Diamond** is an example of a **crystalline solid** where each carbon atom is covalently bonded to four other carbon atoms, forming a **rigid 3D structure**.

**iv. Which property of metals makes them malleable and ductile?**
**Answer:**
The presence of **delocalized electrons** in a **metallic bond** allows metal atoms to slide over each other without breaking the bond. This makes metals **malleable (can be hammered)** and **ductile (can be drawn into wires)**.

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**v. Is coordinate covalent bond a strong bond?**
**Answer:**
Yes, a **coordinate covalent bond** is a **strong bond**, similar in strength to a regular covalent bond. The only difference is that **both electrons in the shared pair come from the same atom**.

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**vi. Write down dot and cross formula of $HNO_3$.**
**Answer:**

Here's the description:

- **H** is bonded to **one O** via a **single bond** (O–H).
- **N** is bonded to **two O atoms** — one via **double bond** (O=), and one via a **coordinate covalent bond** (with lone pair donation from $O^-$).
- The **structure is:**
- O
  ||
  H–O–N→$O^-$
- **Dot & cross notation**:
  - Use dots (•) for nitrogen electrons
  - Use crosses (×) for oxygen electrons
  - Hydrogen has one electron (× or •)
  - Coordinate bond is shown by an **arrow (→)** from oxygen to nitrogen.

# Constructed Response Questions

**i. Why is HF a liquid while HCl is a gas?**
**Answer:**
HF (hydrogen fluoride) is a **liquid at room temperature**, while HCl (hydrogen chloride) is a **gas**, due to **hydrogen bonding**:

- In **HF**, fluorine is **highly electronegative**, so it forms **strong hydrogen bonds** between HF molecules. These intermolecular forces hold the molecules close, making HF a **liquid**.

- In **HCl**, chlorine is less electronegative than fluorine and **does not form hydrogen bonds**, so the only intermolecular forces are **weak van der Waals forces**, making it exist as a **gas**.

**Conclusion:** Strong **hydrogen bonding** in HF results in higher boiling point and liquid state.

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**ii. Why are covalent compounds generally not soluble in water?**
**Answer:**
Most covalent compounds are **non-polar** or only **slightly polar**, while water is a **polar solvent**.

- According to the rule **"like dissolves like"**, polar substances dissolve in polar solvents, and non-polar substances dissolve in non-polar solvents.
- Covalent compounds do not form **ions** in water and **cannot interact strongly** with water molecules.

**Result:** Covalent compounds **do not dissolve well** in water (e.g., oil, wax, benzene).

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**iii. How do metals conduct heat?**
**Answer:**
Metals conduct heat due to the presence of **free electrons** in their **metallic structure**:

- In metallic bonding, **valence electrons are delocalized** and form a **"sea of electrons"**.
- These electrons **absorb heat energy**, become excited, and **transfer energy** quickly through the metal.
- The **kinetic energy** is rapidly passed from atom to atom, resulting in **efficient thermal conductivity**.

**Conclusion:** The mobility of delocalized electrons is responsible for metals being good conductors of heat.

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**iv. How many oxides does nitrogen form? Write down the formulae of oxides.**
**Answer:**
Nitrogen forms **five common oxides** due to its ability to show **variable oxidation states**.

**Oxides of nitrogen:**

1. **$N_2O$** – Dinitrogen monoxide (nitrous oxide)
2. **NO** – Nitric oxide

3. **$N_2O_3$** – Dinitrogen trioxide
4. **$NO_2$** – Nitrogen dioxide
5. **$N_2O_5$** – Dinitrogen pentoxide

Each oxide has different chemical and physical properties and is used in various industrial and environmental processes.

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**v. What will happen if NaBr is treated with $AgNO_3$ in water?**
**Answer:**
When sodium bromide (**NaBr**) is mixed with silver nitrate (**$AgNO_3$**) in aqueous solution, a **double displacement reaction** (precipitation) occurs.

**Chemical Equation:**

$NaBr\ (aq) + AgNO_3\ (aq) \rightarrow NaNO_3\ (aq) + \mathbf{AgBr\ (s)} \downarrow$

- **Silver bromide (AgBr)** is formed as a **yellowish-white precipitate**.
- Sodium nitrate remains dissolved in solution.

**Conclusion:** This reaction confirms the **presence of bromide ions** in NaBr.

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**vi. Why does iodine exist as a solid while $Cl_2$ exists as a gas?**
**Answer:**
The physical state of a substance at room temperature depends on the strength of **intermolecular forces**:

- **Iodine ($I_2$)** is a **larger molecule** than chlorine ($Cl_2$), and its electron cloud is bigger.
- Larger molecules have stronger **London dispersion forces** (van der Waals forces).
- These strong forces hold iodine molecules tightly together, making it a **solid**.
- In contrast, $Cl_2$ molecules have **weaker intermolecular forces**, so chlorine remains a **gas** at room temperature.

**Conclusion:** Stronger intermolecular forces in iodine cause it to exist as a solid.

# Descriptive Questions

## i. Explain the formation of an ionic bond and a covalent bond.

**Ionic Bond:**
An ionic bond is formed when **one atom transfers its electrons** to another atom.

- Usually occurs between a **metal and a non-metal**.
- The metal **loses electrons** to form a **positive ion (cation)**, and the non-metal **gains electrons** to form a **negative ion (anion)**.
- These oppositely charged ions attract each other to form an **ionic bond**.

*Example:* Sodium (Na) + Chlorine (Cl) → NaCl
$Na \rightarrow Na^{+} + e^{-}$
$Cl + e^{-} \rightarrow Cl^{-}$
$Na^{+} + Cl^{-} \rightarrow NaCl$

**Covalent Bond:**
A covalent bond is formed when **two non-metal atoms share electrons** to complete their outer shells.

- Each atom contributes one or more electrons.
- No ions are formed; instead, **a shared pair** of electrons forms the bond.

*Example:* Hydrogen molecule ($H_2$)
Each H atom shares one electron to form a single bond → H–H

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## ii. How do ions arrange themselves to form NaCl crystal?

**Answer:**
In a solid NaCl crystal, **sodium ions ($Na^{+}$)** and **chloride ions ($Cl^{-}$)** are arranged in a **regular 3D lattice** structure known as **crystal lattice**.

- Each $Na^{+}$ ion is surrounded by **six $Cl^{-}$ ions**, and each $Cl^{-}$ ion is surrounded by **six $Na^{+}$ ions**.
- This regular, repeating pattern forms a **strong electrostatic force of attraction** between oppositely charged ions.
- This gives NaCl its **high melting point, hardness**, and **brittle nature**.

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## iii. Explain the properties of metals keeping in view the nature of metallic bond.

**Answer:**
In metals, atoms are held together by **metallic bonding**, where **positive metal ions** are surrounded by a **"sea of delocalized electrons"**.

**Properties due to metallic bonding:**

1. **Electrical conductivity:**
   Free-moving electrons allow metals to **conduct electricity**.
2. **Thermal conductivity:**
   Electrons transfer heat energy efficiently.
3. **Malleability and ductility:**
   Layers of atoms can **slide over each other** without breaking the bond.
4. **Luster:**
   Free electrons reflect light, giving **shiny appearance**.
5. **Strength and toughness:**
   Strong attraction between positive ions and electrons gives metals their **hardness**.

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## iv. Compare the properties of ionic and covalent compounds.

| **Property** | **Ionic Compounds** | **Covalent Compounds** |
|---|---|---|
| Bond type | Transfer of electrons (ionic bond) | Sharing of electrons (covalent bond) |
| Components | Metal + Non-metal | Non-metal + Non-metal |
| Physical state | Usually solids | Gases, liquids, or soft solids |
| Melting/boiling point | High | Low to moderate |
| Solubility in water | Mostly soluble | Mostly insoluble |
| Electrical conductivity | Conducts in molten/aqueous state | Usually poor conductor |
| Example | NaCl, MgO | $H_2O$, $CO_2$, $CH_4$ |

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### v. How will you explain the electrical conductivity of graphite crystals?

**Answer:**
Graphite is an **allotrope of carbon** in which each carbon atom is **covalently bonded to three other carbon atoms** in **hexagonal layers**.

- The **fourth electron** of each carbon atom is **free (delocalized)** and moves between layers.
- These **free electrons** allow **electric current to pass through graphite**, making it a **good conductor of electricity**.
- This property makes graphite useful in **electrodes, batteries**, and **conductive materials**.

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### vi. Why are metals usually hard and heavy?

**Answer:**
**Hardness and heaviness of metals** are due to:

1. **Strong metallic bonds:**
   The **tight packing** of metal atoms and the strong attraction between **positive metal ions and delocalized electrons** gives metals their **hard and rigid structure**.
2. **High density:**
   Metal atoms are **closely packed**, and many metals have **high atomic masses**, resulting in greater **density (heaviness)**.

**Conclusion:** The **compact crystal structure** and **strong bonding** make most metals **hard and heavy**.

## Investigative Questions

### i. The formula of $AlCl_3$ in vapour phase is $Al_2Cl_6$ which means it exists as a dimer. Explain the bonding between its two molecules.

**Answer:**
In the **vapour phase**, aluminum chloride (**$AlCl_3$**) does not remain as a single molecule. Instead, it **dimerizes** to form **$Al_2Cl_6$** due to **electron deficiency** in aluminum atoms.

*Why does dimerization occur?*

- In $AlCl_3$, aluminum has **only 6 electrons** in its valence shell after bonding with three Cl atoms — it needs **2 more electrons** to complete its **octet**.

- To achieve stability, **two $AlCl_3$ molecules combine** and **share two chloride ions** through **coordinate covalent bonds**.

*Structure of $Al_2Cl_6$:*

- Two Al atoms are **bridged by two Cl atoms**.
- Each bridging Cl donates a **lone pair** to Al using a **coordinate bond** (Al ← Cl).
- This results in both Al atoms completing their **octet**. Cl Cl

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\ /
Cl–Al←Cl→Al–Cl
/ \
Cl Cl
```

**Conclusion:**
$Al_2Cl_6$ is stabilized in the vapour phase through **two coordinate covalent bonds** involving **bridging chloride ions**, allowing both aluminum atoms to complete their octets.

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## ii. Explain the structure of sand ($SiO_2$).

**Answer:**
**Sand** is mainly composed of **silicon dioxide ($SiO_2$)**, which has a **giant covalent (network) structure** — not simple discrete molecules.

*Structure:*

- Each **silicon (Si)** atom is **covalently bonded** to **four oxygen (O)** atoms in a **tetrahedral geometry**.
- Each **oxygen atom** is shared between **two silicon atoms**.
- This arrangement forms a **continuous 3D network** of strong Si–O bonds throughout the crystal.

*Characteristics of $SiO_2$:*

- **Hard and rigid** structure due to strong covalent bonding.
- **Very high melting and boiling points.**
- **Insoluble** in water and most solvents.
- **Does not conduct electricity**, as there are **no free ions or electrons**.

**Conclusion:**
Sand ($SiO_2$) has a **giant covalent lattice**, with each silicon atom bonded to four oxygen atoms, forming a **strong, stable, and hard structure** typical of network solids.