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

Group Properties and Elements

(MCQs) with Answers & Explanations

(i) Which element exists in the strongest force of attraction between its atoms?

Options:

- (a) N_2
- (b) Cl_2
- (c) O_2
- **(d) F_2**

Answer: (d) F_2

Explanation:
Among the given options, **fluorine atoms (F_2)** have the **smallest atomic size** and the **highest electronegativity**, resulting in **stronger covalent bonding** between atoms. The strong attractive forces make **F_2** exhibit the strongest force among these diatomic molecules.

*(Note: While N≡N triple bond is very strong, the question asks about **force of attraction between atoms in a molecule**, and fluorine's **small bond length and high electronegativity** make this valid in this context. However, in deeper chemical terms, **N_2** would have the strongest bond due to the triple bond. If the question refers strictly to **bond energy**, then **(a) N_2** is a stronger answer.)*

If paper wants "strongest bond" — tick (a) N_2

If paper wants "strongest attraction due to electronegativity/small size" — tick (d) F_2

Safer tick for board exams: (a) N_2

(ii) Which compound you expect to be coloured?

Options:

- (a) KCl
- (b) $BaCl_2$
- (c) BaCl
- **(d) $NiCl_2$**

Answer: (d) $NiCl_2$

Explanation:
$NiCl_2$ (Nickel chloride) is a compound of a **transition metal** (Nickel), which has **partially filled d-orbitals**. These d-electrons can absorb certain wavelengths of visible light and reflect the rest, giving the compound **color**.
All other compounds (KCl, $BaCl_2$, BaCl) are from **s-block elements** and are **colorless**.

(iii) Elements of which group are coloured?

Options:

- (a) Second group
- (b) Sixth group
- (c) Fifth group
- **(d) Eighth group**

Answer: (d) Eighth group

Explanation:
The **eighth group** contains **transition metals** like **iron (Fe), cobalt (Co), nickel (Ni)**, etc. These elements have **incomplete d-orbitals**, which are responsible for **colored compounds** due to electronic transitions.

Other groups (2, 5, 6) contain **s- or p-block elements**, which typically form **colorless compounds**.

(iv) Which of the following is coloured?

Options:

- (a) Mg
- (b) Ca
- **(c) S**
- (d) Be

Answer: **(c) S (Sulphur)**

Explanation:
Sulphur is a **non-metal** that exists as a **yellow solid** at room temperature — hence it is **colored**.
Other options — **magnesium, calcium, and beryllium** — are **silvery-white metals**, not naturally colored.

(v) Which halogen acid is unstable at room temperature?

Options:

- (a) HBr
- (b) HI
- (c) HCl
- **(d) HF**

Answer: **(d) HF**

Explanation:
Hydrofluoric acid (**HF**) is **unstable** at room temperature because of **strong hydrogen bonding** between HF molecules. It also tends to **form polymeric chains**, making it behave unusually.
Also, it is **highly reactive** and stored in **plastic containers** rather than glass due to its corrosive nature.

(vi) Which oxide is the most basic oxide?

Options:

- **(a) Na_2O**
- (b) Li_2O
- (c) MgO
- (d) CO

Answer: **(a) Na_2O**

Explanation:
Basic oxides are usually formed by **metals**, especially **Group 1 metals (alkali metals)**.
Sodium oxide (Na_2O) is the most basic among these — it reacts strongly with water to form **sodium hydroxide (NaOH)**.
CO is a **neutral oxide**, and MgO is **less basic** than Na_2O.

(vii) Which group elements are the most reactive elements?

Options:

- (a) Transition metal group
- **(b) First group**
- (c) Second group
- (d) Third group

Answer: **(b) First group (Alkali Metals)**

Explanation:
Group 1 elements (Li, Na, K, Rb, Cs, Fr) are **alkali metals** and are the **most reactive metals**.
They easily **lose one electron** due to low ionization energy and react **violently with water**.

(viii) The following solutions of a halogen and sodium halide are mixed together. Which solution will turn dark because of reaction?

Options:

- (a) Br_2 and NaCl
- (b) Br_2 and NaF
- (c) Cl_2 and NaF
- **(d) Cl_2 and NaI**

Answer: **(d) Cl_2 and NaI**

Explanation:
In **halogen displacement reactions**, a **more reactive halogen displaces** a **less reactive halogen** from its salt.

Reactivity order of halogens:
$F_2 > Cl_2 > Br_2 > I_2$

- **Cl_2 + NaI → NaCl + I_2 → Iodine is released**, solution turns **brown/dark**.
- No reaction in other options because Br_2 cannot displace Cl^- or F^-, and Cl_2 cannot displace F^-.

(ix) X is a monoatomic gas. Which statement about this is correct?

Options:

- (a) X burns in air
- (b) X is coloured
- **(c) X is unreactive**
- (d) X will displace iodine from its element

Answer: **(c) X is unreactive**

Explanation:
Monoatomic gases are **Group 18 noble gases** (He, Ne, Ar, etc.) — they exist as **individual atoms**, not molecules.
They have **complete outer electron shells**, so they are **chemically unreactive/inert**.

(x) Which property is correct for Group 18 elements?

Options:

- **(a) Low catalytic activity**
- (b) High density
- (c) Low electrical conductivity
- (d) High melting point

Answer: **(a) Low catalytic activity**

Explanation:
Group 18 elements (noble gases) are **inert** because their outermost shells are full.
Due to their **stability**, they:

- Don't easily react (low catalytic activity)
- Are gases at room temperature (low density, low melting point)
- Do **not conduct electricity well**

So, **(a) is correct**.

Short Answer Questions

i. Why does it become easier to cut an alkali metal when we move from top to bottom in a group?

Answer:
As we move down Group 1 (alkali metals), the atomic size increases and the **metallic bonding becomes weaker** due to increased distance between nuclei and valence electrons.
This makes the metal **softer**, so it becomes **easier to cut** (e.g., sodium is softer than lithium, potassium is softer than sodium).

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ii. Predict the reactivity of potassium towards halogens.

Answer:
Potassium is a very **reactive metal**, and halogens are **highly reactive non-metals**.
When potassium reacts with a halogen (like Cl_2), it **readily loses one electron** to form **K^+**, while the halogen **gains an electron** to form X^-.
So, potassium shows **vigorous reaction** with halogens and forms **ionic salts** like KCl.

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iii. In the following reaction, chlorine acts as an oxidising agent. Which is the reducing agent?

$Cl_2(aq) + 2NaBr(aq) \rightarrow 2NaCl(aq) + Br_2(aq)$

Answer:
Chlorine (Cl_2) **gains electrons** and gets **reduced**, so it is the **oxidising agent**.
Br^- ions (from NaBr) lose electrons and get **oxidised to Br_2**, so **Br^- (bromide ion)** is the **reducing agent**.

Reducing agent: Br^- (from NaBr)

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iv. Why does iodine exist in the solid state at room temperature?

Answer:
Iodine molecules (I_2) are **larger and heavier** compared to other halogens.
Due to their large size, they have **stronger Van der Waals forces** (intermolecular forces), which hold the molecules close together in a **solid form** at room temperature.

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v. How does Ni catalyse the reaction involving hydrogenation of oil?

Answer:
In hydrogenation of oil, **Nickel (Ni)** acts as a **solid catalyst**.
It provides a **surface** where **unsaturated oil molecules** and **hydrogen gas** can come together.
Ni helps **break the double bonds** in unsaturated fatty acids and adds **hydrogen atoms**, converting oil into solid **fat** (e.g., margarine).

Reaction becomes faster and more efficient due to the **Ni catalyst**.

Constructed Response Questions

1. Which noble gas should have the lowest boiling point and why?

Answer:
Among the noble gases, **helium (He)** has the **lowest boiling point**.

Explanation:

- Noble gases are monoatomic and held together by weak **Van der Waals (London dispersion) forces**.
- **Helium** has the **smallest atomic size** and **lowest atomic mass** among all noble gases.
- Due to this, the **intermolecular forces** between helium atoms are **extremely weak**.
- As a result, it requires **very little energy** to convert helium from liquid to gas.

Boiling Point of He ≈ –269°C, which is the **lowest boiling point** of any element.

2. Compare the reactions of alkali metals with chlorine.

Answer:
Alkali metals (Group 1: Li, Na, K, Rb, Cs) react **vigorously** with chlorine gas to form **ionic salts**.

General Reaction:

$2M + Cl_2 \rightarrow 2MCl$

(Where M = alkali metal like Na, K)

Explanation:

- Alkali metals have **one electron in their outermost shell**, which they easily lose to form a **+1 ion (M^+)**.
- Chlorine is a **halogen** with 7 valence electrons; it needs one electron to complete its octet.
- Chlorine **gains one electron** to form **Cl^-**.
- The reaction produces **white crystalline salts** like NaCl, KCl.

Trend:

- **Reactivity increases down the group** (Li < Na < K < Rb < Cs)
  Because atomic size increases and ionization energy decreases, making electron loss easier.

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3. Why are almost all the metals solids while non-metals generally exist as gases and solids?

Answer:
Metals:

- Have **strong metallic bonds** formed by the attraction between **positive metal ions** and a **'sea of delocalized electrons'**.
- These bonds are very strong and require **high energy to break**, so most metals are **solids at room temperature**.
- Exception: **Mercury (Hg)** is a metal but exists as **liquid** due to weak bonding and small size.

Non-Metals:

- Do not have metallic bonds.
- Exist mostly as **small molecules** (e.g., O_2, N_2, Cl_2) with **weak Van der Waals forces** between them.
- Hence, many non-metals are **gases** (like oxygen, nitrogen) or **brittle solids** (like sulphur, iodine).

Conclusion:
Metallic bonding gives metals their **solid nature**, while weak intermolecular forces cause non-metals to exist as **gases or soft solids**.

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4. Name any three elements in the periodic table which exist as liquids.

Answer:
Three elements that are **liquid at or near room temperature** are:

1. **Mercury (Hg)** – A **metal**, liquid at **room temperature (25°C)**.
   ➤ Used in thermometers, barometers.
2. **Bromine (Br_2)** – A **non-metal**, exists as **reddish-brown liquid**.
   ➤ Has strong intermolecular forces compared to other halogens.
3. **Gallium (Ga)** – A **metal**, melts at **~29.8°C**, just above room temperature.
   ➤ Can melt in hand due to low melting point.

*These are **rare exceptions** — most elements are either solid or gas at room conditions.*

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5. Why are transition elements different from normal elements?

Answer:
Transition elements (d-block elements) are unique and show properties different from **normal s- and p-block elements**.

Key Differences:

1. **Variable Oxidation States:**
   Transition metals can exhibit **more than one oxidation state** (e.g., Fe^{2+}, Fe^{3+}) due to similar energy of 3d and 4s orbitals.
2. **Colored Compounds:**
   They form **colored salts and solutions** due to **d-d electron transitions**.
   Example: $NiCl_2$ is green, $CuSO_4$ is blue.

3. **Catalytic Properties:**
   Transition metals and their compounds act as **catalysts** in many reactions. Example: Fe in Haber Process, Ni in hydrogenation.
4. **Formation of Complexes:**
   Transition metals easily form **complex ions** due to availability of empty d-orbitals.
5. **Magnetic Properties:**
   Some show **paramagnetism** due to unpaired d-electrons.

These features are **not commonly found** in normal (main group) elements, which makes transition elements **chemically versatile and industrially important**.

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6. Compare the reactivity of chlorine and bromine as an oxidising agent.

Answer:
Both **chlorine (Cl_2)** and **bromine (Br_2)** are **halogens** and act as **oxidising agents** (they gain electrons).

Comparison:

Property	Chlorine	Bromine
Atomic Size	Smaller	Larger
Electronegativity	Higher	Lower
Oxidising Strength	Stronger	Weaker
Reactivity	Higher	Lower

Reaction Example:

Cl2+2NaBr→2NaCl+Br2

Chlorine displaces bromine from bromide salt, showing it is a **stronger oxidising agent**.

Reason:

- Chlorine gains electrons **more easily** due to smaller size and higher electron affinity.

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7. Which element is the most reactive and which is the least reactive among halogens? Give two reasons to explain your answer.

Answer:

- **Most reactive halogen: Fluorine (F_2)**
- **Least reactive halogen: Iodine (I_2)**

Reasons:

1. **Electronegativity:**
   Fluorine has the **highest electronegativity** of all elements, so it strongly attracts electrons.
2. **Atomic Size:**
   Fluorine has the **smallest atomic radius**, so the nucleus exerts **greater pull on electrons**.
   Iodine has larger atoms with **weaker attraction**, making it less reactive.

Additional Info:
Fluorine can oxidize all other halide ions (Cl^-, Br^-, I^-), but iodine cannot displace any halogen from its salt.

Descriptive Questions

1. Explain the role of catalytic converter in an automobile.

Answer:
A **catalytic converter** is a device installed in the **exhaust system** of automobiles to reduce **harmful gases** emitted from the engine.

Role:

- It contains **platinum (Pt), palladium (Pd), or rhodium (Rh)** as **catalysts**.
- It helps convert harmful gases into **less toxic substances** through **redox reactions**.

Main reactions in catalytic converter:

1. **Carbon monoxide (CO)** → converted to **carbon dioxide (CO_2)**
   2CO+O2→2CO2
2. **Unburnt hydrocarbons** → converted to **CO_2 and H_2O**
3. **Nitrogen oxides (NOx)** → converted to **nitrogen gas (N_2)**

Conclusion:
Catalytic converters help in **reducing air pollution** and protect the environment by controlling the emission of **toxic gases**.

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2. Why do the chemical reactivities of alkali metals increase down the group whereas they decrease down the group in case of halogens?

Answer:

(a) Alkali Metals (Group 1):

- Reactivity **increases down the group** (Li < Na < K < Rb < Cs).
- Atomic size increases → outer electron is farther from nucleus.
- Ionization energy decreases → **easier to lose electron**.
- Therefore, **more reactive** as we go down.

(b) Halogens (Group 17):

- Reactivity **decreases down the group** (F > Cl > Br > I).
- Atomic size increases → attraction for incoming electron decreases.
- Electron affinity decreases.
- So, halogens **become less reactive** down the group.

Conclusion:
Alkali metals react by **losing electrons**, and halogens react by **gaining electrons**. These opposite trends explain their respective reactivity patterns.

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3. Why are metals generally tough and strong whereas non-metals are neither tough nor strong?

Answer:
Metals:

- Have **strong metallic bonding** — attraction between **positive metal ions** and **delocalized electrons**.
- Layers of atoms are **closely packed**, and they can slide without breaking.

- This makes metals **tough, strong**, and **ductile**.

Non-metals:

- Lack metallic bonding.
- Exist as **molecules or weak lattices**.
- Held by **weak Van der Waals or covalent bonds**.
- Hence, they are generally **brittle**, **non-ductile**, and **not strong**.

Result:

Metallic bonding gives strength and flexibility to metals, while non-metals lack such bonding.

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4. Both alkali metals and halogens are very reactive elements with roles opposite to each other. Explain.

Answer:

Alkali Metals (Group 1):

- Have **1 valence electron**.
- **Lose** 1 electron easily to form **+1 cations (M^+)**.
- Highly **electropositive** and reactive metals.

Halogens (Group 17):

- Have **7 valence electrons**.
- **Gain** 1 electron easily to form **–1 anions (X^-)**.
- Highly **electronegative** and reactive non-metals.

Opposite Roles:

- Alkali metals are **electron donors** (reducing agents).
- Halogens are **electron acceptors** (oxidizing agents).
- They readily form **ionic salts**, e.g., Na + Cl → NaCl.

Their **reactivity complements** each other, leading to stable compounds.

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5. Why hydrogen bromide is thermally unstable as compared to hydrogen chloride?

Answer:

Hydrogen bromide (HBr) is **less thermally stable** than **hydrogen chloride (HCl)**.

Reasons:

1. **Bond Strength:**
    - H–Br bond is **weaker** than H–Cl bond.
    - Less energy is needed to break the bond in HBr, making it **easier to decompose**.
2. **Atomic Size:**
    - Bromine atom is **larger** than chlorine.
    - Larger atomic radius results in **longer bond**, which is weaker and **less stable**.

Therefore, HBr decomposes more easily upon heating than HCl.

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6. Compare the properties of metals and non-metals.

Property	Metals	Non-Metals
State	Mostly solids	Solids, gases (few liquids)
Appearance	Shiny (lustrous)	Dull
Malleability	Malleable	Brittle (if solid)
Ductility	Ductile	Non-ductile
Conductivity	Good conductor of heat & electricity	Poor conductor (except graphite)
Density	Generally high	Generally low

Property	Metals	Non-Metals
Reactivity	Lose electrons (form cations)	Gain/share electrons (form anions/covalent bonds)
Bonding	Metallic bonding	Covalent or Van der Waals forces
Examples	Iron, Copper, Sodium	Sulphur, Oxygen, Chlorine

This table helps in quick understanding and revision.

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7. V_2O_5 catalyst is preferred over platinum in the oxidation of sulphur dioxide. Give reasons.

Answer:
Vanadium pentoxide (V_2O_5) is used as a catalyst in the **Contact Process** for producing **sulphur trioxide (SO_3)** from sulphur dioxide (SO_2).

2SO2+O2→V2O52SO3

Reasons why V_2O_5 is preferred over platinum:

1. **Cost-effective:**
   V_2O_5 is **much cheaper** than platinum, which is an expensive noble metal.
2. **Less Poisoning:**
   V_2O_5 is **less affected by impurities** like arsenic.
   Platinum can be **poisoned** by impurities, reducing its efficiency.
3. **Effective at High Temperature:**
   V_2O_5 remains effective at industrial temperatures (~450°C), making it ideal for continuous production.

Hence, V_2O_5 is widely used as a **practical and efficient catalyst** in SO_2 oxidation.

Investigative Questions

1. Explain the role of sodium as heat transfer agent in the atomic nuclear power plant. Which property of sodium is utilized in this role?

Answer:
In **nuclear power plants**, especially in **fast breeder reactors**, **molten sodium** is used as a **heat transfer agent** (coolant).

Role of Sodium:

- When nuclear fission takes place, a large amount of **heat is produced**.
- **Molten sodium** absorbs this heat from the reactor core and **transfers** it to water in a heat exchanger to produce **steam**.
- The steam drives turbines to generate **electricity**.

Why Sodium is used:

1. **High Thermal Conductivity:**
   Sodium conducts heat very efficiently, making it ideal for rapid heat transfer.
2. **Low Melting Point (98°C):**
   It melts easily and can be pumped like a liquid.
3. **High Boiling Point (~883°C):**
   It remains liquid even at high reactor temperatures, preventing vaporization.
4. **Chemically Stable (in inert environment):**
   Though reactive with water and air, in **controlled reactor environment**, it's safe.

Conclusion:
Sodium's **excellent thermal conductivity and wide liquid temperature range** make it a reliable heat transfer agent in nuclear reactors.

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2. Why and how does lithium behave differently from the rest of the alkali metals?

Answer:
Although **lithium (Li)** is an alkali metal (Group 1), it **shows different chemical behavior** compared to other members like Na, K, Rb, and Cs.

Reasons for Different Behavior:

1. **Small Atomic and Ionic Size:**
   Lithium has the **smallest size** in the group, leading to **higher charge density** and stronger bonds.
2. **High Polarizing Power:**
   Li^+ ion has strong polarizing ability → **more covalent character** in its compounds (e.g., LiI, Li_2CO_3), unlike other alkali metals that form more **ionic compounds**.
3. **Formation of Oxide Only:**
   Lithium forms **only lithium oxide (Li_2O)** when burned in air, while sodium and others form **peroxides or superoxides**.
4. **Solubility & Hydrolysis:**
   Lithium salts like **LiF, LiOH** are **less soluble** in water and often undergo **hydrolysis**, unlike the highly soluble salts of other alkali metals.
5. **Diagonal Relationship with Magnesium:**
   Lithium resembles **magnesium (Group 2)** in properties (similar ionic size, reactions, etc.), causing **anomalous behavior**.

Conclusion:
Lithium's **small size, high charge density**, and **unique bonding characteristics** make its chemical behavior different from other alkali metals.

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3. Why aluminum metal is used in the manufacture of cooking utensils whereas magnesium is not considered useful for this purpose?

Answer:

Aluminum (Al) is preferred for cooking utensils due to:

1. **Good Thermal Conductivity:**
   It quickly conducts heat, allowing uniform cooking.
2. **Corrosion Resistance:**
   A **protective oxide layer (Al_2O_3)** forms on the surface, preventing rust or further corrosion.
3. **Light Weight and Malleability:**
   Easy to shape and light to handle.
4. **Non-toxic and Economical:**
   Safe for food and cheaper than many metals.

Magnesium (Mg) is not suitable because:

1. **Highly Reactive:**
   Reacts with acids in food (e.g., tomatoes), forming **magnesium salts** which can be harmful or spoil taste.
2. **Easily Oxidized:**
   Forms oxide layer that is not as stable as aluminum's and can degrade over time.
3. **Low Melting Point (650°C):**
   Not suitable for high-heat cooking as it may warp or degrade under continuous use.
4. **Mechanical Weakness:**
   Magnesium is **less strong and less durable**, making it unsuitable for daily cookware.

Conclusion:

Aluminum is used because it is **durable, safe, corrosion-resistant**, and **conducts heat efficiently**, while magnesium lacks these qualities.