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FSc / ICS Part-II Chemistry — Punjab Board

CHAPTER 5
The Halogens and Noble Gases

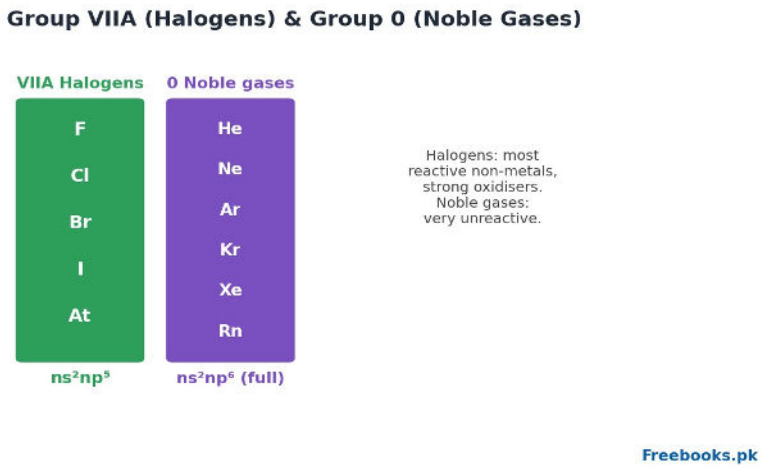

Figure 5.1 — Group VIIA (halogens) and Group 0 (noble gases).

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1. Chapter Overview

This chapter deals with the last two families of the p-block: the halogens of Group VIIA (F, Cl, Br, I, At) and the noble gases of Group 0 / VIIIA (He, Ne, Ar, Kr, Xe, Rn). The two groups are almost opposites. Halogens have the configuration $ns^2\ np^5$ — just one electron short of a full shell — so they are the most reactive non-metals and powerful oxidising agents. Noble gases have completely filled shells ($ns^2\ np^6$, or $1s^2$ for He), which makes them extremely stable and unreactive.

Even so, the very unreactive noble gases surprised chemists when xenon was found to form real compounds. In this chapter we study the properties and trends of the halogens, their important compounds, and the uses and chemistry of the noble gases.

2. Learning Objectives

- List the halogens and noble gases with their electronic configurations.
- Explain why halogens are strong oxidising agents and how their reactivity changes down the group.
- Describe the trend in acid strength of the hydrogen halides.
- Explain the bleaching and germicidal action of chlorine.
- Explain why noble gases are unreactive and yet xenon can form compounds.
- State the important uses of the halogens and the noble gases.

3. Key Concepts

3.1 The Halogens (Group VIIA)

The halogens ('salt-formers') exist as diatomic molecules (F_2, Cl_2, Br_2, I_2). At room temperature fluorine and chlorine are gases, bromine is a liquid and iodine is a solid — showing that melting and boiling points increase down the group. Because each atom needs just one more electron to complete its octet, halogens are the most reactive non-metals and strong oxidising agents; they gain an electron to form halide ions (X^-) or share one to form a covalent bond.

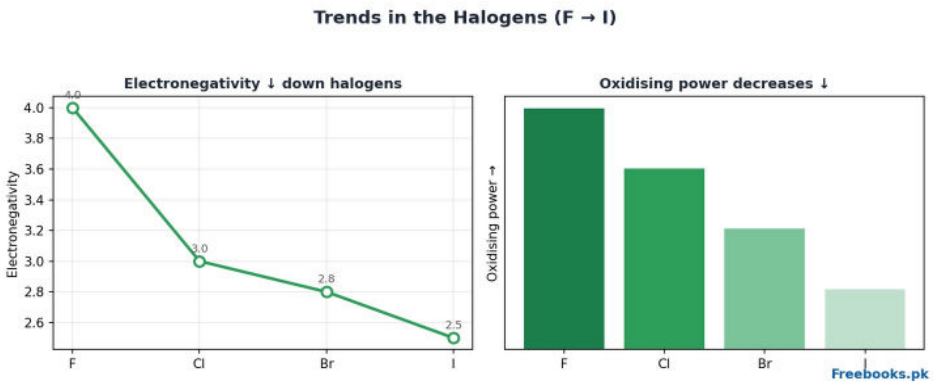

Figure 5.2 — Down the halogens, electronegativity and oxidising power decrease.

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Memory Trick

Reactivity/oxidising power decreases down: F > Cl > Br > I. 'Fluorine is the Fiercest.'

States at room temp: F, Cl = gas; Br = liquid; I = solid (down the group they get 'heavier').

3.2 Oxidising Power and Displacement

Because fluorine and chlorine attract electrons most strongly, a higher halogen can displace a lower one from its salt. For example, chlorine displaces bromine from potassium bromide: Cl_2 + 2KBr → 2KCl + Br_2. This confirms the order of oxidising power F > Cl > Br > I.

3.3 Hydrogen Halides

The halogens form hydrogen halides (HF, HCl, HBr, HI), which dissolve in water to give acids. Their acid strength increases down the group (HF < HCl < HBr < HI) because the H–X bond becomes weaker and easier to break as the halogen gets larger. HF is the weakest because of its strong hydrogen bonding and strong H–F bond, while HI is the strongest acid of the four.

Teacher's Note

A common confusion: HF is the weakest ACID but has the strongest bond and hydrogen bonding. Emphasise that acid strength depends on how easily the H–X bond breaks in water, not on electronegativity.

3.4 Chlorine — Bleaching and Water Treatment

Chlorine is an important industrial chemical. With water it forms a mixture of hydrochloric and hypochlorous acids; the hypochlorous acid (HOCl) releases nascent oxygen, which bleaches coloured materials and kills germs. This is why chlorine (and bleaching powder) is used to bleach cloth and paper and to disinfect drinking water and swimming pools.

3.5 The Noble Gases (Group 0)

The noble gases have completely filled outer shells, giving them very high ionization energies and almost zero electron affinity, so they are chemically very unreactive (inert) and exist as single (monatomic) atoms. For a long time they were thought to form no compounds at all.

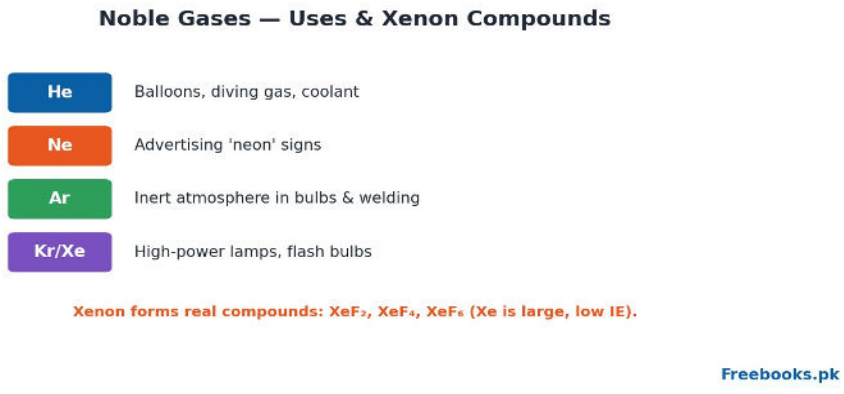

Figure 5.3 — Uses of noble gases and the xenon fluorides.

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3.6 Compounds of Xenon

In 1962 it was discovered that xenon — the largest, most easily ionised of the common noble gases — can react with the strongly electronegative fluorine to form real compounds: xenon difluoride (XeF_2), xenon tetrafluoride (XeF_4) and xenon hexafluoride (XeF_6). This is possible because xenon's outer electrons are far from the nucleus and relatively easy to involve in bonding. Helium, neon and argon are still not known to form stable compounds.

4. Important Definitions

Term	Definition
Halogens	Group VIIA non-metals (F, Cl, Br, I, At) that form salts with metals.
Noble gases	Group 0 elements with completely filled shells and very low reactivity.
Oxidising agent	A species that gains electrons and oxidises another substance.
Displacement reaction	A reaction in which a more reactive halogen replaces a less reactive one from its salt.
Nascent oxygen	Freshly formed, very reactive atomic oxygen responsible for bleaching.
Monatomic	Existing as single atoms (as the noble gases do).

5. Formulas / Rules

Must-Know Facts

Halogens: ns^2np^5, diatomic X_2, strong oxidisers; power F > Cl > Br > I.

States: F_2, Cl_2 gas; Br_2 liquid; I_2 solid.

Acid strength of HX: HF < HCl < HBr < HI (increases down).

Displacement: $Cl_2 + 2KBr \rightarrow 2KCl + Br_2$.

Xenon compounds: XeF_2, XeF_4, XeF_6.

6. Diagrams / Illustrations

Key diagrams for revision:

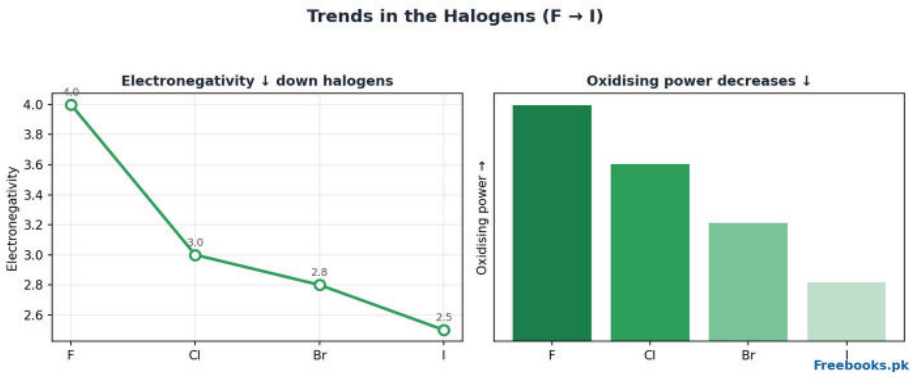

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Diagram 1 — Halogen trends (F → I).

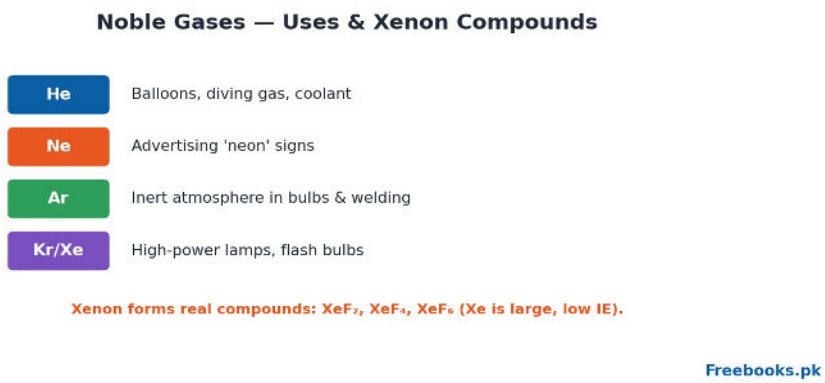

Diagram 2 — Noble gas uses and xenon fluorides.

7. Solved Examples

Example 1 — Displacement

Q: Will bromine displace chlorine from sodium chloride? Explain.

Solution: No. Chlorine is a stronger oxidising agent than bromine, so bromine cannot displace it. The reverse happens: chlorine displaces bromine from bromides.

Example 2 — Acid strength

Q: Arrange HF, HCl, HBr and HI in order of increasing acid strength.

Solution: HF < HCl < HBr < HI. Down the group the H–X bond becomes weaker and breaks more easily in water, increasing acid strength.

Example 3 — Xenon

Q: Why can xenon form compounds while helium cannot?

Solution: Xenon is much larger and its outer electrons are far from the nucleus with a low ionization energy, so they can take part in bonding with fluorine. Helium's two electrons are held very tightly, so it stays inert.

8. Short Questions

Q1. Why are halogens strong oxidising agents?
Ans. Each atom needs only one electron to complete its octet, so it strongly attracts and gains electrons, oxidising others.

Q2. Why does halogen reactivity decrease down the group?
Ans. Atomic size increases and electronegativity decreases, so the tendency to gain an electron falls.

Q3. Which is the strongest acid: HF or HI?
Ans. HI, because its H–X bond is the weakest and breaks most easily in water.

Q4. Why is HF a weak acid?
Ans. Because of its strong H–F bond and strong hydrogen bonding, which resist ionization.

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Q5. How does chlorine bleach?
Ans. In water it forms hypochlorous acid, which releases nascent oxygen that oxidises (bleaches) coloured matter.

Q6. Why are noble gases unreactive?
Ans. They have completely filled outer shells, very high ionization energies and almost zero electron affinity.

Q7. Name three compounds of xenon.
Ans. XeF_2, XeF_4 and XeF_6.

Q8. Give one use each of helium and neon.
Ans. Helium fills balloons and is used in diving gas; neon is used in advertising (neon) signs.

9. Long Questions

Q1. Describe the general characteristics and trends of the halogens.
The halogens are the non-metals of Group VIIA, with the outer configuration $ns^2\ np^5$. They exist as diatomic molecules and, because each atom needs only one more electron to complete its octet, they are the most reactive non-metals and powerful oxidising agents. Going down the group, atomic size increases and electronegativity decreases, so both reactivity and oxidising power fall in the order F > Cl > Br > I; a higher halogen can therefore displace a lower one from its salt. Their physical states change from gases (F_2, Cl_2) through a liquid (Br_2) to a solid (I_2) as melting and boiling points rise down the group. The hydrogen halides they form are acids whose strength increases down the group (HF < HCl < HBr < HI) as the H–X bond weakens. Because of their reactivity, halogens are never found free in nature.

Q2. Why are the noble gases inert, and how does xenon form compounds?
The noble gases are chemically inert because their outermost shells are completely filled (helium has $1s^2$, the others $ns^2\ np^6$). This stable arrangement gives them very high ionization energies and almost zero electron affinity, so they neither lose, gain nor share electrons easily, and they exist as single atoms. For many years they were believed to form no compounds. However, xenon is the largest of the common noble gases and its outer electrons are far from the nucleus with a comparatively low ionization energy. When combined with the extremely electronegative element fluorine, xenon's electrons can be drawn into bonds, forming real compounds such as XeF_2, XeF_4 and XeF_6. The lighter noble gases (He, Ne, Ar) hold their electrons too tightly and remain inert.

Q3. Discuss the uses of the halogens and the noble gases.
The halogens and their compounds are widely used. Fluorine compounds are used in toothpaste (fluoride), non-stick coatings and refrigerants; chlorine is used to bleach cloth and paper, to disinfect drinking water and swimming pools, and to make PVC, solvents and bleaching powder; bromine is used in photographic chemicals and flame retardants; and iodine is used as an antiseptic (tincture of iodine) and in medicines. The noble gases are valued for their inertness and light-giving properties: helium fills balloons and airships and is used in deep-sea diving gas and as a coolant; neon glows in advertising signs; argon provides an inert atmosphere in light bulbs and in welding; and krypton and xenon are used in high-power and flash lamps.

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10. Multiple Choice Questions (MCQs)

1. The outer configuration of halogens is:
(A) ns^2np^4 (B) ns^2np^5 (C) ns^2np^6 (D) ns^2np^3

2. The strongest oxidising agent among halogens is:
(A) Cl (B) Br (C) I (D) F

3. Which halogen is a liquid at room temperature?
(A) F_2 (B) Cl_2 (C) Br_2 (D) I_2

4. The strongest acid is:
(A) HF (B) HCl (C) HBr (D) HI

5. Chlorine bleaches by releasing:
(A) Hydrogen (B) Nascent oxygen (C) Chlorine gas (D) Water

6. Noble gases are unreactive because they have:
(A) One valence electron (B) Filled outer shells (C) Empty shells (D) High electron affinity

7. Which noble gas forms fluorides?
(A) He (B) Ne (C) Ar (D) Xe

8. Which gas is used in advertising signs?
(A) He (B) Ne (C) Ar (D) Kr

9. $Cl_2 + 2KBr \rightarrow 2KCl + Br_2$ is a:
(A) Neutralisation (B) Displacement (C) Addition (D) Combustion

10. Noble gases exist as:
(A) Diatomic molecules (B) Monatomic atoms (C) Ions (D) Polymers

MCQ Answer Key

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

11. Quick Revision / Summary

- Halogens (F,Cl,Br,I,At) = ns^2np^5, diatomic, strongest non-metals & oxidisers.
- Oxidising power & electronegativity decrease down: F > Cl > Br > I.
- States: F,Cl gas; Br liquid; I solid. HX acid strength: HF < HCl < HBr < HI.
- Chlorine bleaches/disinfects via nascent oxygen from HOCl.
- Noble gases = filled shells, inert, monatomic; used for their inertness.
- Xenon forms XeF_2, XeF_4, XeF_6; He, Ne, Ar remain inert.

12. Exam Tips

Teacher's Note

Remember the trend direction: reactivity/oxidising power decrease down halogens but acid strength of HX increases down.

HF weakest acid, HI strongest — a very common MCQ.

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Learn one displacement equation ($Cl_2 + 2KBr \rightarrow 2KCl + Br_2$) to prove the oxidising-power order.

Explain noble-gas inertness with 'completely filled shell, high IE'.

Only xenon (large, low IE) forms fluorides — He, Ne, Ar do not.

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