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CHAPTER NOTES

The p-Block Elements Class 12 Notes — CBSE Chemistry Chapter 7

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The p-Block Elements Class 12 Notes — CBSE Chemistry Chapter 7

Chapter 7 — **The p-Block Elements** — covers Groups 15, 16, 17 and 18 of the periodic table. This is a fact-heavy chapter with **8-10 marks** in Boards, making it one of the highest-weightage chapters. Focus on the preparation and properties of key compounds: NH_3, HNO_3, H_2SO_4, ozone, and interhalogen compounds.

Key Concepts

Group 15 — Nitrogen Family (N, P, As, Sb, Bi)

General electronic configuration: ns^2np^3

Trends Down the Group

- Metallic character increases: N, P (non-metals) → As, Sb (metalloids) → Bi (metal)
- Oxidation states: –3 to +5; stability of +5 state decreases and +3 increases down the group (inert pair effect)
- Bi shows +3 more stable than +5 (inert pair effect)

Ammonia (NH_3)

Preparation (Haber Process): $N_2 + 3H_2 \rightleftharpoons 2NH_3$ ($\Delta H = -92$ kJ/mol)
Conditions: 450-500°C, 200 atm, Fe catalyst + Mo promoter

Lab preparation: $NH_4Cl + Ca(OH)_2 \rightarrow CaCl_2 + 2H_2O + 2NH_3\uparrow$

Properties:

- Colourless gas with pungent smell, highly soluble in water (forms NH_4OH)
- Basic nature: donates lone pair → acts as Lewis base and Brønsted base
- Forms complexes: $Cu^{2+} + 4NH_3 \rightarrow [Cu(NH_3)_4]^{2+}$ (deep blue — test for Cu^{2+})

Nitric Acid (HNO_3)

Ostwald Process:
$4NH_3 + 5O_2 \xrightarrow{Pt/Rh,\ 500°C} 4NO + 6H_2O$

$2NO + O_2 \rightarrow 2NO_2$

$3NO_2 + H_2O \rightarrow 2HNO_3 + NO$

Properties: Strong oxidising acid. Dissolves all metals except Au and Pt. Makes metals passive (concentrated HNO_3 makes Fe, Cr, Al passive by forming oxide layer).

Aqua Regia: 3 parts conc. HCl + 1 part conc. HNO_3 — dissolves gold and platinum!

$Au + 3HCl + HNO_3 \rightarrow HAuCl_4 + NO + 2H_2O$

Oxides of Nitrogen

Oxide	Name	Nature	Oxidation State of N
N_2O	Nitrous oxide (laughing gas)	Neutral	+1
NO	Nitric oxide	Neutral	+2
N_2O_3	Dinitrogen trioxide	Acidic	+3
NO_2	Nitrogen dioxide	Acidic	+4
N_2O_5	Dinitrogen pentoxide	Acidic	+5

Allotropes of Phosphorus

White P	Red P	Black P
P_4 tetrahedral	Polymeric chains	Layered structure
Waxy, poisonous, glows in dark	Non-poisonous, doesn't glow	Most stable allotrope
Soluble in CS_2	Insoluble in CS_2	Insoluble in CS_2
Catches fire at 35°C	Ignites at 260°C	Most unreactive

Group 16 — Oxygen Family (O, S, Se, Te, Po)

General electronic configuration: ns^2np^4

Ozone (O_3)

Preparation: $3O_2 \rightarrow$(UV / silent electric discharge) $2O_3$

Structure: Angular/V-shaped, O–O bond length = 128 pm (between single and double bond), resonance hybrid

Properties: Powerful oxidising agent, decomposes to O_2 on heating, decolourises $KMnO_4$, liberates I_2 from KI (used as test).

Sulphuric Acid (H_2SO_4) — "King of Chemicals"

Contact Process:

$S + O_2 \rightarrow SO_2$

$2SO_2 + O_2 \rightarrow$(V_2O_5, 450°C) $2SO_3$

$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$ (oleum)

$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$

Properties:

- **Dehydrating agent:** Removes water from compounds (chars sugar, formic acid)
- **Oxidising agent:** Hot conc. H_2SO_4 oxidises metals, non-metals, and compounds
- **Dibasic acid:** $H_2SO_4 \rightarrow H^+ + HSO_4^- \rightarrow 2H^+ + SO_4^{2-}$

Oxoacids of Sulphur

Acid	Formula	Key Feature
Sulphurous acid	H_2SO_3	Reducing agent
Sulphuric acid	H_2SO_4	Strong acid, dehydrating
Thiosulphuric acid	$H_2S_2O_3$	S replaces one O in H_2SO_4
Peroxodisulphuric acid	$H_2S_2O_8$	Contains S–O–O–S (peroxide linkage)

Group 17 — Halogens (F, Cl, Br, I)

General electronic configuration: ns^2np^5

Trends

- Most electronegative elements; electronegativity decreases down group
- Oxidising power: $F_2 > Cl_2 > Br_2 > I_2$

- All show –1 oxidation state; Cl, Br, I also show +1, +3, +5, +7 (F never shows positive states)
- Bond dissociation energy: $Cl_2 > Br_2 > F_2 > I_2$ (F_2 unexpectedly low due to small size → lone pair repulsion)

Hydrogen Halides (HX)

Property	HF	HCl	HBr	HI
Acidic strength	Weakest	↓	↓	Strongest
Thermal stability	Most stable	↓	↓	Least stable
Reducing power	Least	↓	↓	Most
Boiling point	High (H-bonding)	189 K	206 K	238 K

Interhalogen Compounds

Type	Shape	Examples
XX’	Linear	ClF, BrF, ICl, IBr
XX'_3	T-shaped	ClF_3, BrF_3, ICl_3
XX'_5	Square pyramidal	BrF_5, IF_5
XX'_7	Pentagonal bipyramidal	IF_7

Group 18 — Noble Gases (He, Ne, Ar, Kr, Xe, Rn)

Fully filled orbitals → very stable, low reactivity.

Xenon Compounds

Compound	Hybridisation	Shape	Oxidation State
XeF_2	sp^3d	Linear	+2
XeF_4	sp^3d^2	Square planar	+4
XeF_6	sp^3d^3	Distorted octahedral	+6
XeO_3	sp^3	Pyramidal	+6
$XeOF_2$	sp^3d	T-shaped	+4

Important Definitions

Term	Definition
Inert Pair Effect	Reluctance of s-electrons to participate in bonding in heavier elements
Allotropy	Existence of an element in two or more forms with different physical properties
Interhalogen Compound	Compound formed between two different halogen atoms
Ozone	Triatomic allotrope of oxygen (O_3), powerful oxidising agent
Aqua Regia	Mixture of 3:1 conc. HCl and HNO_3 that dissolves gold and platinum

Solved Examples — NCERT Based

Example 1: Structures of Oxoacids

Q: Why does H_3PO_3 (phosphorous acid) act as a diprotic acid despite having 3 hydrogen atoms?

Solution: In H_3PO_3, only 2 hydrogen atoms are attached to oxygen (O–H bonds) and can be ionised. The third hydrogen is directly bonded to phosphorus (P–H bond), which is not ionisable. Hence it is **diprotic (dibasic)**, not triprotic.

Example 2: Oxidation States

Q: Why does BiH_3 not exist while NH_3 is very stable?

Solution: Due to the **inert pair effect**, the $6s^2$ electrons of Bi are reluctant to participate in bonding. The Bi–H bond is very weak (large size difference), making BiH_3 extremely unstable. NH_3 is stable because of strong N–H bonds (small size, good overlap).

Example 3: Halogen Reactivity

Q: Why is F_2 the strongest oxidising agent among halogens?

Solution: Three factors favour F_2:
1. Low F–F bond dissociation energy (easy to break)
2. High electronegativity (strong tendency to gain electrons)
3. Very high hydration enthalpy of F^- (small size → strong hydration)
All three factors make the overall ΔG very negative for reduction, making F_2 the strongest oxidising agent.

Example 4: Xenon Compound Geometry

Q: Predict the shape and hybridisation of XeF_4.

Solution: Xe has 8 valence electrons. In XeF_4, 4 bond pairs + 2 lone pairs = 6 electron pairs → **sp^3d^2 hybridisation**. The 2 lone pairs occupy opposite positions (axial) to minimise repulsion → shape is **square planar**.

Important Questions for Board Exams

1 Mark Questions

1. Why is N_2 less reactive at room temperature?
2. What is the basicity of H_3PO_4?
3. Why does fluorine not show positive oxidation states?
4. What is the shape of XeF_2?
5. Why is HF a weak acid despite F being most electronegative?

2 Mark Questions

1. Draw the structures of (a) H_2SO_4 (b) HNO_3.
2. Explain why Bi^{3+} is more stable than Bi^{5+}.
3. Why is SO_2 an air pollutant?

4. What is the structure of ozone? Is it a resonance hybrid?

3 Mark Questions

1. Explain the Contact process for manufacturing H_2SO_4 with equations.
2. Discuss the preparation and properties of ammonia.
3. What are interhalogen compounds? Give their types, examples, and shapes.
4. How does HNO_3 react with (a) copper (b) zinc (c) iron?

5 Mark Questions

1. Discuss the chemistry of Group 16 elements. Explain the preparation of H_2SO_4 by Contact process. What are its properties as (a) dehydrating agent (b) oxidising agent?
2. Describe the preparation and properties of XeF_2, XeF_4 and XeF_6. Write their structures.

Quick Revision Points

- Group 15: ns^2np^3; NH_3 (Haber), HNO_3 (Ostwald); inert pair effect → Bi^{3+} stable
- Group 16: ns^2np^4; O_3 (angular), H_2SO_4 (Contact process — "King of Chemicals")
- Group 17: ns^2np^5; strongest oxidisers; F_2 never +ve; interhalogen compounds
- Group 18: noble gases; Xe forms compounds (XeF_2 linear, XeF_4 sq. planar, XeF_6 distorted oct.)
- Aqua Regia = 3HCl : 1HNO_3 (dissolves Au, Pt)
- H_3PO_3 is dibasic (not tribasic) — one P–H bond
- HF is a weak acid due to high H–F bond strength despite F's electronegativity
- F_2 bond energy < Cl_2 bond energy (lone pair repulsion in small F_2)

← Previous: Isolation of Elements

Next: d- and f-Block Elements →

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