JEE MAIN · PAPER 1 · CHEMISTRY

10 p-Block Elements

Formula & concept sheet

The p-block group by group, from boron to the noble gases: trends and anomalies of the first member, the inert-pair effect, structures (diborane, allotropes of carbon and phosphorus, silicates), oxides and their nature, the main oxoacids and the reactions JEE asks, with the shapes of the xenon compounds. Each idea is explained first, then the tables, reactions and traps.

INSIDE THIS SHEET

1	Trends across the p-block and the inert-pair effect	2
2	Group 13: boron family	3
3	Group 14: carbon family	4
4	Group 15: nitrogen family	4
5	Group 16: oxygen family	6
6	Group 17: halogens	7
7	Group 18: noble gases	8
8	Worked examples	9
9	Last-minute checklist	9

READ ALONGSIDE NCERT XI · The p-Block Elements (groups 13 and 14)

NCERT XII · The p-Block Elements (groups 15 to 18)

HOW TO USE THIS SHEET

1. **Skim** — Read the Key ideas, then the formula cards.
2. **Memorise** — Learn the formulas and check every Trap box.
3. **Test** — Do the worked examples, then this chapter's PYQs.
4. **Revise** — Use the last-minute checklist before the exam.

Formula memorise · **Key idea** why it works · **Trap** marks lost here · **PYQ** how it is asked

Practise this chapter with real past-paper questions on Prep Vault. Written for revision, not as a first read.

CHAPTER 10

p-Block Elements

NCERT XI · The p-Block Elements (groups 13 and 14) | NCERT XII · The p-Block Elements (groups 15 to 18)

Covers: general trends of groups 13 to 18, anomalous behaviour of the first element · inert-pair effect · boron and aluminium compounds, diborane, borax · allotropes and oxides of carbon, silicones, silicates · hydrides, oxides and oxoacids of nitrogen and phosphorus · oxygen, ozone, sulphur and its oxoacids · halogens, interhalogens, oxoacids · noble gases and xenon compounds.

1 Trends across the p-block and the inert-pair effect

- The p-block has the configuration $ns^2np^{1\text{ to }6}$, groups 13 to 18. The group oxidation state is $+3, +4, +5, +6, +7$ for groups 13 to 17 (the number of valence electrons) and the **lower state, two less**, becomes more stable down a group: this is the **inert-pair effect** (the ns^2 pair resists use, because of poor shielding by d and f electrons).
- The oxide of an element becomes more **acidic** as its oxidation state rises, and the oxides become more **basic** down a group. Non-metal oxides are acidic except CO, NO, N_2O (neutral); amphoteric ones to remember: Al_2O_3, Ga_2O_3, SnO, SnO_2, PbO, PbO_2, ZnO, BeO.
- The **first element** of each group differs from the rest: small size, high electronegativity, no d orbitals (covalency stops at 4), and a strong tendency to form $p\pi$-$p\pi$ multiple bonds ($N{\equiv}N$, $C{=}O$, $O{=}O$).

OXIDES OF GROUPS 13 TO 15 BY OXIDATION STATE

GROUP	ACIDIC	AMPHOTERIC	BASIC	NEUTRAL
13	B_2O_3	Al_2O_3, Ga_2O_3	In_2O_3, Tl_2O_3	–
14	CO_2, SiO_2, GeO_2 (NCERT; often amphoteric elsewhere), GeO	SnO, SnO_2, PbO, PbO_2	–	CO
15	N_2O_3, NO_2, N_2O_5, P_4O_6, P_4O_{10}	Sb_2O_3, As_2O_3	Bi_2O_3	N_2O, NO

PATTERN OF THE GROUP TRENDS

PROPERTY	GROUP 13	GROUP 14	GROUP 15
ionisation enthalpy	B > Tl > Ga > Al > In	C > Si > Ge > Pb > Sn	N > P > As > Sb > Bi
stable lower state	$Tl^+ > In^+ > Ga^+$ (+1)	Pb^{2+} stable, Sn^{2+} reducing, Pb^{4+} oxidising	Bi^{3+} stable, $Bi(V)$ oxidising
non-metal → metal	B non-metal, rest metals	C non-metal, Si and Ge metalloids, Sn and Pb metals	N, P non-metals; As, Sb metalloids; Bi metal
first-member anomaly	B: no B^{3+}, covalent	C: catenation, $p\pi$-$p\pi$ bonds	N: $N{\equiv}N$, covalency ≤ 4, weak $N{-}N$

KEY IDEA

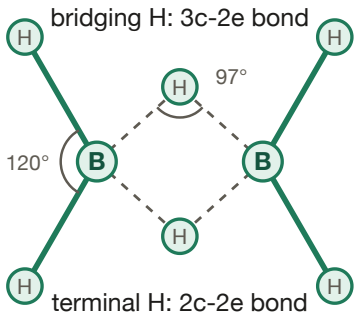
The inert-pair effect explains the reverse of the expected trend: Tl^+ is stable and Tl^{3+} oxidising, Pb^{2+} stable and PbO_2 a strong oxidant, $Bi(V)$ a strong oxidant, and $SnCl_2$ a reducing agent. The first member (B, C, N, O, F) always shows the group's anomalies.

QUICK CHECK

Why is NCl_5 unknown but PCl_5 stable?

Answer: Nitrogen has no d orbitals, so its covalency is limited to 4; phosphorus uses $3d$ orbitals (sp^3d).

2 Group 13: boron family



B is sp^3; 4 terminal 2c-2e bonds and 2 bridging 3c-2e bonds

DIBORANE, B_2H_6 An electron-deficient hydride: boron has too few electrons for 8 two-centre bonds. It has **four terminal** $B-H$ (two-centre two-electron) bonds and **two bridging** $B-H-B$ (three-centre two-electron, "banana") bonds; each B is sp^3. Made by $3\,LiAlH_4 + 4\,BF_3 \longrightarrow 2\,B_2H_6 + 3\,LiF + 3\,AlF_3$.

BORON AND ALUMINIUM COMPOUNDS AND REACTIONS

SPECIES	FACT OR REACTION
BX_3 Lewis acidity	$BF_3 < BCl_3 < BBr_3 < BI_3$: back-bonding ($p\pi$-$p\pi$, filled F orbital into the empty B $2p$) is strongest in BF_3, which lowers its acidity (opposite to the electronegativity expectation)
boric acid	weak monobasic Lewis acid (not a proton donor): $B(OH)_3 + 2\,H_2O \rightleftharpoons [B(OH)_4]^- + H_3O^+$; layered structure held by hydrogen bonds; on heating $H_3BO_3 \longrightarrow HBO_2 + H_2O$ and then $2\,HBO_2 \longrightarrow B_2O_3 + H_2O$
borax	$Na_2B_4O_7 \cdot 10\,H_2O$; $Na_2B_4O_7 \cdot 10\,H_2O + 2\,HCl \longrightarrow 4\,H_3BO_3 + 2\,NaCl + 5\,H_2O$; on heating gives $Na_2B_4O_7 \longrightarrow 2\,NaBO_2 + B_2O_3$, the glassy bead that makes the coloured metaborate (borax-bead test, $CuO + B_2O_3 \longrightarrow Cu(BO_2)_2$, blue)
diborane	$B_2H_6 + 6\,H_2O \longrightarrow 2\,H_3BO_3 + 6\,H_2$; $B_2H_6 + 3\,O_2 \longrightarrow B_2O_3 + 3\,H_2O$ (highly exothermic)
aluminium	amphoteric: $2\,Al + 6\,HCl \longrightarrow 2\,AlCl_3 + 3\,H_2$ and $2\,Al + 2\,NaOH + 6\,H_2O \longrightarrow 2\,Na[Al(OH)_4] + 3\,H_2$; passive in conc. HNO_3 (oxide film)
$AlCl_3$	exists as the dimer Al_2Cl_6 (two bridging Cl, vapour and non-polar solvents); a Lewis acid; hydrolysed by water
Al_2O_3	amphoteric: $Al_2O_3 + 6\,HCl \longrightarrow 2\,AlCl_3 + 3\,H_2O$; $Al_2O_3 + 2\,NaOH + 3\,H_2O \longrightarrow 2\,Na[Al(OH)_4]$

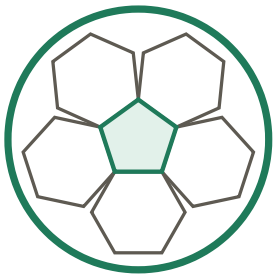
GROUP 13 SUMMARY

- Boron: a non-metal, forms only covalent compounds, maximum covalency 4 (BF_4^-); no B^{3+} ion (very high sum of the first three IE).
- Down the group: metallic character rises; the $+1$ state grows more stable ($Ga < In < Tl$); Ga is smaller than Al because of the $3d$ electrons.
- Tl^+ resembles alkali metal ions; Tl^{3+} is oxidising.

TRAP

BF_3 is the **weakest** Lewis acid of the boron halides; H_3BO_3 is **monobasic** and acts by accepting OH^- (a Lewis acid), not by losing a proton. Al dissolves in alkali as well as acid, but is passive in conc. HNO_3.

3 Group 14: carbon family



60 C, all sp²
12 pentagons, 20 hexagons

$V - E + F = 60 - 90 + 32 = 2$

ALLOTROPES OF CARBON

- **Diamond**: sp^3, rigid three-dimensional network, hardest, insulator, high melting point.
- **Graphite**: sp^2 layers, free π electrons, conducts, soft, a lubricant; the stable form of carbon.
- **Fullerene** C_{60}: sp^2 soccer ball, 60 C, 12 pentagons, 20 hexagons, 90 edges.

CATENATION AND STRUCTURE

- C−C 348 > Si−Si 297 kJ mol^{-1}: catenation $C \gg Si > Ge \approx Sn$; Pb almost none.
- Si and Ge are semiconductors; diamond an insulator.
- CO_2 is a molecule, SiO_2 a network solid (high melting).

COMPOUNDS AND REACTIONS

SPECIES	FACT OR REACTION
CO	neutral, toxic (binds haemoglobin), reducing agent; $HCOOH \longrightarrow CO + H_2O$ (conc. H_2SO_4); water gas $C + H_2O \longrightarrow CO + H_2$
CO_2	acidic, linear, sp; dry ice; greenhouse gas
SiO_2	acidic network oxide: $SiO_2 + 4\,HF \longrightarrow SiF_4 + 2\,H_2O$ (etches glass); $SiO_2 + 2\,NaOH \longrightarrow Na_2SiO_3 + H_2O$
halides	CCl_4 is not hydrolysed (no vacant low-energy orbital on C); $SiCl_4 + 4\,H_2O \longrightarrow Si(OH)_4 + 4\,HCl$
silicones	polymers $(R_2SiO)_n$: $Si + 2\,CH_3Cl \longrightarrow (CH_3)_2SiCl_2$ (Cu, 573 K), then hydrolysis and condensation; water-repellent, heat resistant, inert
silicates	building unit SiO_4^{4-} tetrahedron; sharing corners gives chains (asbestos), sheets (mica, talc), 3D frameworks (quartz, feldspar, zeolites)
zeolites	aluminosilicates with channels; ZSM-5 converts alcohols to petrol; used as catalysts and molecular sieves
lower oxidation state	Sn^{2+} reduces; PbO_2 oxidises (lead storage battery); Pb^{2+} is the stable state

WHY IT WORKS

CCl_4 resists hydrolysis because carbon has no d orbitals to accept the lone pair of water, while $SiCl_4$ hydrolyses at once. Carbon also forms $p\pi$-$p\pi$ double and triple bonds; silicon, being large, forms Si−O chains instead.

QUICK CHECK

Count the faces and bonds of P_4 and C_{60} ($V - E + F = 2$ check for C60).

Answer: P_4: 4 triangular faces, 6 P−P bonds, 60° angle. C_{60}: $60 - 90 + 32 = 2$ (12 pentagons +20 hexagons = 32 faces).

4 Group 15: nitrogen family

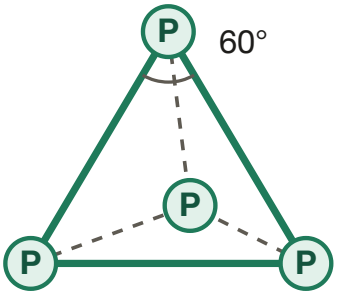
- **Nitrogen** is anomalous: small, very electronegative, no d orbitals (covalency ≤ 4), forms the strong N≡N triple bond (so N_2 is inert), and its N−N single bond is **weaker** than P−P (lone-pair repulsion on small atoms). Phosphorus and heavier members have d orbitals and show $+3$ and $+5$.
- Hydrides EH_3: bond angle NH_3 (107.8°) > PH_3 (93.6°) > AsH_3 > SbH_3 (about 92°); basicity and thermal stability fall down the group; reducing power rises (BiH_3 strongest); boiling point $PH_3 < AsH_3 < NH_3 < SbH_3 < BiH_3$ (NH_3 is raised by hydrogen bonding).

OXIDES OF NITROGEN

OXIDE	OXIDATION STATE	NATURE	FACTS
N_2O	$+1$	neutral	laughing gas; $NH_4NO_3 \longrightarrow N_2O + 2\,H_2O$
NO	$+2$	neutral	paramagnetic; $2\,NO + O_2 \longrightarrow 2\,NO_2$
N_2O_3	$+3$	acidic	blue solid, anhydride of nitrous acid
NO_2	$+4$	acidic	brown, paramagnetic, dimerises: $2\,NO_2 \rightleftharpoons N_2O_4$ (colourless)
N_2O_5	$+5$	acidic	anhydride of HNO_3

NITRIC ACID AND PHOSPHORUS

REACTION	EQUATION
Ostwald process	$4\,NH_3 + 5\,O_2 \longrightarrow 4\,NO + 6\,H_2O$ (Pt-Rh, 1100 K); $2\,NO + O_2 \longrightarrow 2\,NO_2$; $3\,NO_2 + H_2O \longrightarrow 2\,HNO_3 + NO$
Cu with conc. HNO_3	$Cu + 4\,HNO_3 \longrightarrow Cu(NO_3)_2 + 2\,NO_2 + 2\,H_2O$
Cu with dilute HNO_3	$3\,Cu + 8\,HNO_3 \longrightarrow 3\,Cu(NO_3)_2 + 2\,NO + 4\,H_2O$
Zn with dilute / very dilute	$4\,Zn + 10\,HNO_3 \longrightarrow 4\,Zn(NO_3)_2 + N_2O + 5\,H_2O$; $4\,Zn + 10\,HNO_3 \longrightarrow 4\,Zn(NO_3)_2 + NH_4NO_3 + 3\,H_2O$
PbS with dilute HNO_3	$3\,PbS + 8\,HNO_3 \longrightarrow 3\,Pb(NO_3)_2 + 3\,S + 2\,NO + 4\,H_2O$ (S is not taken to SO_2)
ammonia in the lab	$2\,NH_4Cl + Ca(OH)_2 \longrightarrow 2\,NH_3 + 2\,H_2O + CaCl_2$
phosphine	$P_4 + 3\,NaOH + 3\,H_2O \longrightarrow PH_3 + 3\,NaH_2PO_2$
PCl_3, PCl_5	$PCl_3 + 3\,H_2O \longrightarrow H_3PO_3 + 3\,HCl$; $PCl_5 + H_2O \longrightarrow POCl_3 + 2\,HCl$ (partial); $PCl_5 + 4\,H_2O \longrightarrow H_3PO_4 + 5\,HCl$ (excess); solid PCl_5 is $[PCl_4]^+[PCl_6]^-$
H_3PO_3 on heating	$4\,H_3PO_3 \longrightarrow 3\,H_3PO_4 + PH_3$ (disproportionation)



6 P-P bonds, 4 faces

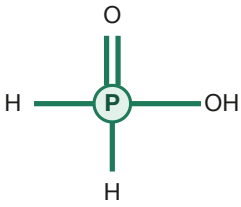
P_4: 6 P-P bonds, 60° angle, each P has one lone pair

ALLOTROPES OF PHOSPHORUS

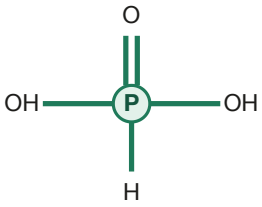
- **White** P_4: tetrahedral, 60° strain, reactive, glows in the dark, kept under water, poisonous.
- **Red**: polymeric chains, stable, not poisonous.
- **Black**: layered, the most stable form.

COUNTING

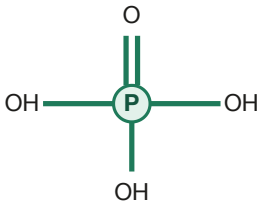
- P_4 has $6\,P{-}P$ bonds and 4 lone pairs.
- Basicity of a P oxoacid = number of $P{-}OH$ groups.



H_3PO_2
1 P-OH: monobasic
2 P-H: reducing



H_3PO_3
2 P-OH: dibasic
1 P-H



H_3PO_4
3 P-OH: tribasic

only P-OH hydrogens are acidic; P-H bonds are not

TRAP

H_3PO_3 is **dibasic** and H_3PO_2 **monobasic**: only $P-OH$ hydrogens ionise. Both are reducing agents (they have $P-H$ bonds). Conc. HNO_3 gives NO_2 and dilute gives NO with copper; Fe and Al are passive in conc. HNO_3.

QUICK CHECK

Basicity of H_3PO_2, H_3PO_3, $H_4P_2O_7$?

Answer: $1,\ 2,\ 4$ (count $P-OH$ groups: pyrophosphoric acid has four).

5 Group 16: oxygen family

- **Oxygen** is anomalous because of small size and high electronegativity: hydrogen bonding in H_2O (high b.p.), no d orbitals (covalency 2, at most 4), $O=O$ double bond (O_2 is paramagnetic), and the oxidation state -2 (also -1 in peroxides, $+2$ in OF_2). Sulphur has the more negative electron gain enthalpy and a far greater tendency to catenate (S_8 crown ring).
- Hydrides H_2E: thermal stability $H_2O > H_2S > H_2Se > H_2Te$; acidity $H_2O < H_2S < H_2Se < H_2Te$ (weaker E−H bond); bond angle H_2O $104.5^\circ > H_2S$ about 92°.

OXYGEN, OZONE, SULPHUR COMPOUNDS

SPECIES	FACT OR REACTION
O_3	bent (117°), diamagnetic, a strong oxidant: $O_3 + 2\,I^- + H_2O \longrightarrow O_2 + I_2 + 2\,OH^-$; $2\,O_3 \longrightarrow 3\,O_2$; $NO + O_3 \longrightarrow NO_2 + O_2$ (ozone-layer depletion)
SO_2	reducing agent: $5\,SO_2 + 2\,MnO_4^- + 2\,H_2O \longrightarrow 5\,SO_4^{2-} + 2\,Mn^{2+} + 4\,H^+$ (decolourises acidified $KMnO_4$); bent, sp^2, acidic
contact process	$2\,SO_2 + O_2 \rightleftharpoons 2\,SO_3$ (V_2O_5, about 720 K, 2 bar); $SO_3 + H_2SO_4 \longrightarrow H_2S_2O_7$ (oleum); $H_2S_2O_7 + H_2O \longrightarrow 2\,H_2SO_4$
oleum	$H_2S_2O_7$ has 7 oxygen atoms
conc. H_2SO_4	dehydrating and oxidising: $C + 2\,H_2SO_4 \longrightarrow CO_2 + 2\,SO_2 + 2\,H_2O$; $Cu + 2\,H_2SO_4 \longrightarrow CuSO_4 + SO_2 + 2\,H_2O$
sulphur allotropes	rhombic (α, stable below 369 K) and monoclinic (β), both S_8; transition temperature 369 K
H_2S	reducing agent, weak diprotic acid, rotten-egg smell; precipitates metal sulphides

HYDRIDES AND OXOACIDS TO KNOW

- ✓ H_2SO_4: strong dibasic acid, sp^3 S with two S=O and two S−OH.
- ✓ H_2SO_3 and $H_2S_2O_3$ are unstable; thiosulphate $S_2O_3^{2-}$ is a reducing agent used in iodometry.
- ✓ H_2O_2 is both oxidising and reducing; it disproportionates: $2\,H_2O_2 \longrightarrow 2\,H_2O + O_2$.

TRAP

Electron gain enthalpy of S (-200) is more negative than that of O (-141); but H_2O is the most thermally stable hydride and the weakest acid. SO_2 reduces $KMnO_4$ and $K_2Cr_2O_7$; it does not oxidise them.

6 Group 17: halogens

TRENDS IN THE HALOGENS

PROPERTY	ORDER
electronegativity	F > Cl > Br > I
electron gain enthalpy (most negative first)	Cl > F > Br > I ($-349, -328, -325, -295$ kJ mol^{-1})
bond dissociation enthalpy	$Cl_2 > Br_2 > F_2 > I_2$ (F_2 is weak because of lone-pair repulsion in the short bond)
oxidising power (aqueous)	$F_2 > Cl_2 > Br_2 > I_2$ (low bond energy and high hydration enthalpy of F^-)
HX acid strength	HF < HCl < HBr < HI (bond enthalpy falls HF > HCl > HBr > HI)
HX boiling point	HCl < HBr < HI < HF (hydrogen bonding in HF)
oxoacid acidity	$HClO_4 > HClO_3 > HClO_2 > HOCl$; $HOCl > HOBr > HOI$
oxidation states	F only -1; the others $-1, +1, +3, +5, +7$

REACTIONS AND COMPOUNDS

ITEM	FACT OR REACTION
chlorine, lab	$MnO_2 + 4\,HCl \longrightarrow MnCl_2 + Cl_2 + 2\,H_2O$; $2\,KMnO_4 + 16\,HCl \longrightarrow 2\,KCl + 2\,MnCl_2 + 8\,H_2O + 5\,Cl_2$
with alkali	cold dilute: $Cl_2 + 2\,NaOH \longrightarrow NaCl + NaOCl + H_2O$; hot conc.: $3\,Cl_2 + 6\,NaOH \longrightarrow 5\,NaCl + NaClO_3 + 3\,H_2O$ (disproportionations)
bleaching powder	$Ca(OH)_2 + Cl_2 \longrightarrow CaOCl_2 + H_2O$; bleaching by oxidation (nascent oxygen from HOCl)
HF	weak acid in water (strong H−F bond, HF_2^- formation); etches glass: $SiO_2 + 4\,HF \longrightarrow SiF_4 + 2\,H_2O$
interhalogens XX'_n	$n = 1, 3, 5, 7$; ClF_3 T-shaped (sp^3d), BrF_5 square pyramidal (sp^3d^2), IF_7 pentagonal bipyramidal (sp^3d^3); more reactive than the halogens (weak X−X′ bond), except F_2; the larger atom is central
polyhalide	$I_2 + I^- \rightleftharpoons I_3^-$ (linear, I_3^- has sp^3d and 3 lone pairs on I)

TRAP

Cl has a more negative electron gain enthalpy than F, but F_2 is the stronger oxidant. F_2 is weaker (lower bond energy) than Cl_2 and Br_2. F never shows a positive oxidation state, so there are no fluorine oxoacids.

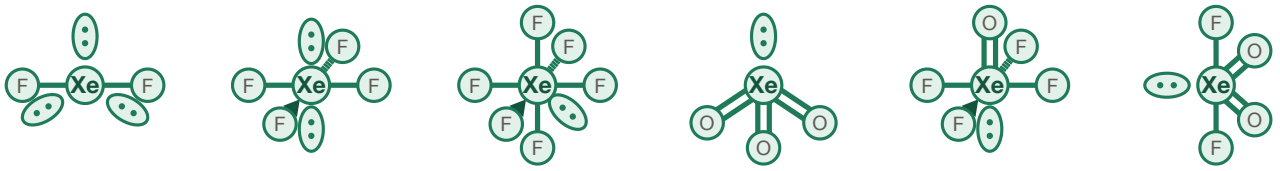
QUICK CHECK

Shape of ClF_3 and IF_7?

Answer: ClF_3: $SN = 5$ (3 bp + 2 lp), T-shaped. IF_7: $SN = 7$, pentagonal bipyramid.

7 Group 18: noble gases

- Noble gases have closed shells (ns^2np^6, He $1s^2$), the highest ionisation enthalpies, and positive electron gain enthalpy. Neil Bartlett made the first compound, $O_2^+[PtF_6]^-$ (IE of O_2 1175 kJ mol^{-1}), then $Xe^+[PtF_6]^-$ because $IE(Xe) = 1170$ is nearly the same. Only Xe (and Kr, Rn) form compounds, with F and O.
- Preparation: $Xe + F_2 \longrightarrow XeF_2$ (673 K, high pressure), $Xe + 2\,F_2 \longrightarrow XeF_4$ (873 K, 7 bar), $Xe + 3\,F_2 \longrightarrow XeF_6$ (573 K, 60 to 70 bar). Hydrolysis gives the oxides and oxyfluorides.



XeF_2
linear
SN 5, 3 lp

XeF_4
square planar
SN 6, 2 lp

XeF_6
distorted octahedral
SN 7, 1 lp

XeO_3
trigonal pyramidal
SN 4, 1 lp

$XeOF_4$
square pyramidal
SN 6, 1 lp

XeO_2F_2
see-saw
SN 5, 1 lp

lone pairs sit equatorial in a trigonal bipyramid and trans in an octahedron

XENON COMPOUNDS AND THEIR SHAPES

COMPOUND	SN	LONE PAIRS	SHAPE	HYDROLYSIS
XeF_2	5	3	linear	$2\,XeF_2 + 2\,H_2O \longrightarrow 2\,Xe + 4\,HF + O_2$
XeF_4	6	2	square planar	$6\,XeF_4 + 12\,H_2O \longrightarrow 4\,Xe + 2\,XeO_3 + 24\,HF + 3\,O_2$
XeF_6	7	1	distorted octahedral	$XeF_6 + 3\,H_2O \longrightarrow XeO_3 + 6\,HF$; partial: $XeF_6 + H_2O \longrightarrow XeOF_4 + 2\,HF$
XeO_3	4	1	trigonal pyramidal	explosive, acidic
$XeOF_4$	6	1	square pyramidal	
XeO_2F_2	5	1	see-saw (F axial, F−Xe−F close to 180°; O equatorial, O−Xe−O about 105°)	
XeO_4	4	0	tetrahedral	

WHY IT WORKS

Lone pairs on Xe $= (8 -$ electrons used in bonding$)/2$, with each F using 1 and each $=$ O using 2. XeO_2F_2: $(8-6)/2 = 1$, so $SN = 4 + 1 = 5$, a trigonal bipyramid with the lone pair equatorial (see-saw).

TRAP

In XeO_2F_2 the angle near 180° is F−Xe−F, not O−Xe−O (that is about 105°). XeF_2 is linear because the three lone pairs sit in the equatorial plane. Argon and helium form no compounds.

8 Worked examples

SHAPES FROM LONE PAIRS

Lone pairs on Xe in XeF_4, $XeOF_4$, XeO_3 and their shapes?

XeF_4: $\frac{8-4}{2} = 2$, $SN = 6$, square planar. $XeOF_4$: $\frac{8-(2+4)}{2} = 1$, $SN = 6$, square pyramidal. XeO_3: $\frac{8-6}{2} = 1$, $SN = 4$, pyramidal

OXYGEN ATOMS

Number of oxygen atoms in oleum ($H_2S_2O_7$)?

$H_2S_2O_7$: 7 (formed from $SO_3 + H_2SO_4$: $3 + 4 = 7$)

OXIDE TYPES

How many of CO, N_2O, Al_2O_3, SnO_2, B_2O_3 are amphoteric?

Al_2O_3 and SnO_2: 2 (CO, N_2O neutral; B_2O_3 acidic)

BALANCING

Balance and name the oxidation states:
$Cu + HNO_3(\text{conc}\cdot) \longrightarrow Cu(NO_3)_2 + NO_2 + H_2O$.

$Cu + 4\,HNO_3 \longrightarrow Cu(NO_3)_2 + 2\,NO_2 + 2\,H_2O$; Cu $0 \to +2$, N $+5 \to +4$

ORDER OF HYDRIDES

Arrange NH_3, PH_3, AsH_3, SbH_3 by boiling point and by bond angle.

b.p.: $PH_3 < AsH_3 < NH_3 < SbH_3$; angle: $NH_3 > PH_3 > AsH_3 > SbH_3$

ACID STRENGTH

Order $HClO$, $HClO_2$, $HClO_3$, $HClO_4$ and $HOBr$, HOI, $HOCl$ by acidity.

$HClO_4 > HClO_3 > HClO_2 > HClO$; $HOCl > HOBr > HOI$

9 Last-minute checklist

BEFORE YOU ANSWER

Group trend first, then the first-member anomaly (B, C, N, O, F), then the inert-pair exception. Is the oxide acidic, amphoteric, basic or neutral? Count $P-OH$ for basicity; count lone pairs for shapes.

- Inert pair: Tl^+, Pb^{2+}, Bi^{3+} stable; Tl^{3+}, PbO_2, $Bi(V)$ oxidising. Neutral oxides: CO, NO, N_2O. Amphoteric: Al_2O_3, Ga_2O_3, SnO, SnO_2, PbO, PbO_2, ZnO, BeO.
- Boron: $BF_3 < BCl_3 < BBr_3$ (Lewis acidity); B_2H_6: 4 terminal $2c$-$2e$, 2 bridging $3c$-$2e$; H_3BO_3 monobasic Lewis acid; $AlCl_3$ dimer.
- Carbon: diamond sp^3, graphite sp^2, C_{60} 12 pentagons and 20 hexagons; CCl_4 not hydrolysed; SiO_4 tetrahedra in silicates; silicones $(R_2SiO)_n$.
- Nitrogen: N_2O $+1$ to N_2O_5 $+5$; conc. HNO_3 gives NO_2, dilute NO; H_3PO_2 monobasic, H_3PO_3 dibasic, H_3PO_4 tribasic; P_4: 6 bonds.
- Oxygen/sulphur: $H_2O > H_2S$ in stability, reverse in acidity; contact process V_2O_5; oleum $H_2S_2O_7$ (7 O); O_3 bent 117°; halogens: EGE $Cl > F$, oxidant F_2, HF highest b.p., HI strongest acid.
- Xe: XeF_2 linear, XeF_4 square planar, XeF_6 distorted octahedral, XeO_3 pyramidal, $XeOF_4$ square pyramidal, XeO_2F_2 see-saw, XeO_4 tetrahedral.

Now test it. Practise this chapter with past-paper and bank questions on Prep Vault. **Practice this chapter →**