# Chemistry of Xenon

## Important reactions of Xenon for JEE main/Advanced NEET and IISER Aptitude Test

Designed by Dr. Anuradha Mukherjee

**The first compound with noble gas was made by Bartlett with Xenon (Xe)**

**Xenon (Xe) is down the group of periodic table (Period 5) and low ionization energy compare to other noble gas**

**Xenon ionization energy 1170 kJ/mol is almost same to oxygen 1165 kJ/mol**

**Radon (Rn) also has less ionization energy than Xe, but Rn is radioactive and not stable isotope, so much work with Rn is not possible. Only $RnF_2$ is known**

**Ref: J. D. LEE (fifth edition) page no 639**

# Xeon Chemistry

**Xenon reacts directly with fluorine at 400 °C temperature in a sealed nickel vessel and the products depend on the Xe : F ratio**
**All these fluoride compounds are white solid**

$$Xe + F_2 \longrightarrow 2XeF_2$$

**(2:1 mixture)**

$$Xe + 2F_2 \longrightarrow XeF_4$$

**(1:5 mixture)**

$$Xe + 3F_2 \longrightarrow XeF_6$$

**(1:20 mixture)**

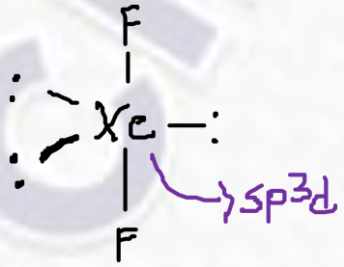
**$XeF_4$ reacts with $F_2O_2$ and produces $XeF_6$ and $O_2$**

$$XeF_4 + F_2O_2 \longrightarrow XeF_6 + O_2$$

**Dioxygen difluoride $F_2O_2$ acts as a powerful fluorinating agent, adding fluorine to xenon tetrafluoride**

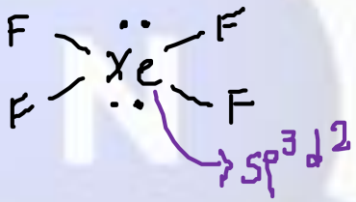
**Ref: J. D. LEE (fifth edition) page no 640**

# Shape of $XeF_2$



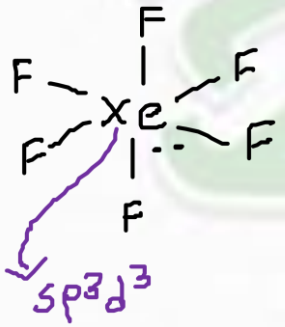

**Three LPs on Xe**
**Molecular geometry: Linear**

# Shape of $XeF_4$




**Two LPs on Xe**
**Molecular geometry: square planar**

# Shape of $XeF_6$




**One LPs on Xe**
**Molecular geometry: distorted octahedral**

| Xenon compounds | Oxidation state of Xe |
|---|---|
| $XeF_2$ | +II |
| $XeF_4$ | +IV |
| $XeF_6$ | +VI |
| $XeO_3$ | +VI |
| $XeO_4$ | +VIII |
| $XeO_2F_2$ | +VI |
| $XeOF_4$ | +VI |
| $XeO_3F_2$ | +VIII |

# Fluorination using $XeF_2/XeF_4/ XeF_6$

**Fluorides are strong oxidizing and fluorinating agent. They react quantitively with hydrogen and produce HF and Xe gas**

$$XeF_2 + H_2 \longrightarrow Xe + 2HF \qquad XeF_4 + 2H_2 \longrightarrow Xe + 4HF$$

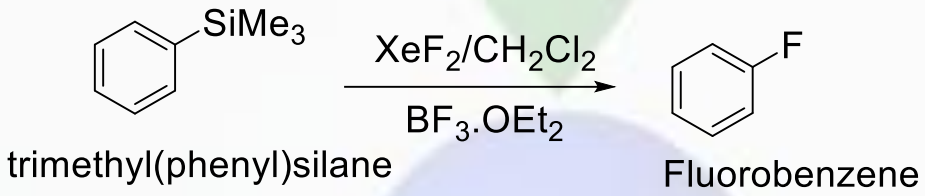
$$XeF_6 + 3H_2 \longrightarrow Xe + 6HF$$

**$XeF_4$ also can fluorinate $SF_4$ , Pt metal**

$$XeF_4 + 2SF_4 \longrightarrow Xe + 2SF_6 \qquad XeF_4 + Pt \longrightarrow Xe + PtF_4$$

$$XeF_2 + MoO_3 \xrightarrow{HF} O_2 + Xe + MoF_6 \qquad XeF_2 + S_8 \xrightarrow{HF} Xe + SF_6$$

# $XeF_2$ can replace $SiMe_3$ from an organometallic compound with F. This is the way Fluorine can introduce in benzene ring




$$Mo(CO)_6 + XeF_2 \longrightarrow MoF_6 + Xe + CO$$

Ref: https://www.arkat-usa.org/get-file/49472/

# Hydrolysis of xenon fluoride

**1. $XeF_2$ reacts slowly with water undergoes following reaction**

$$2XeF_2 + H_2O \longrightarrow 2Xe + 4HF + O_2$$

**2. $XeF_4$ reacts violently with water gives xenon trioxide which is highly explosive**

$$3XeF_4 + 6H_2O \longrightarrow 2Xe + XeO_3 + 12HF + 3/2O_2$$

**3a. $XeF_6$ also reacts violently with water. Complete hydrolysis gives highly explosive xenon trioxide**

$$XeF_6 + 6H_2O \longrightarrow XeO_3 + 6HF$$

**3b. $XeF_6$ also undergoes partial hydrolysis and gives colorless liquid xenon oxofluoride $XeOF_4$**

$$XeF_6 + H_2O \longrightarrow XeOF_4 + 2HF$$

# Synthesis of xenon oxofluoride

**1. $XeF_6$ undergoes partial hydrolysis and gives colorless liquid xenon oxofluoride $XeOF_4$**

$$XeF_6 + H_2O \longrightarrow XeOF_4 + 2HF$$

**2. $XeF_6$ also gives xenon oxofluoride $XeOF_4$ after reacting with silica or glass**

**$XeF_6$ is so reactive that it cannot be stored in glass vessels because it readily reacts with the silicon dioxide. That's why XeF6 is stored in Nickel bottle**

$$XeF_6 + SiO_2 \longrightarrow XeOF_4 + SiF_4$$

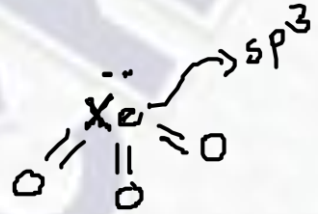
**3. Explosive solid $XeO_3$ reacts with $XeF_6$ and gives xenon oxofluoride $XeOF_4$**

$$2XeF_6 + XeO_3 \longrightarrow 3XeOF_4$$

$$XeOF_4 + XeO_3 \longrightarrow 2XeO_2F_2$$

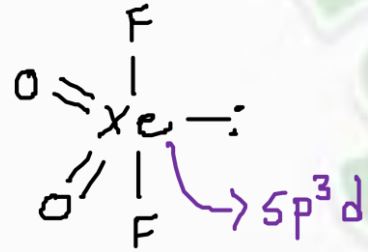
**Xenon oxodifluoride**

# Shape of $XeO_3$



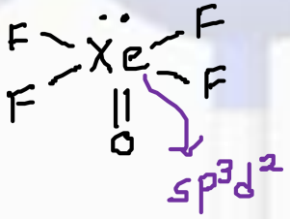

**One LPs on Xe**
**Molecular geometry:**
**Trigonal pyramidal**

# Shape of $XeO_2F_2$



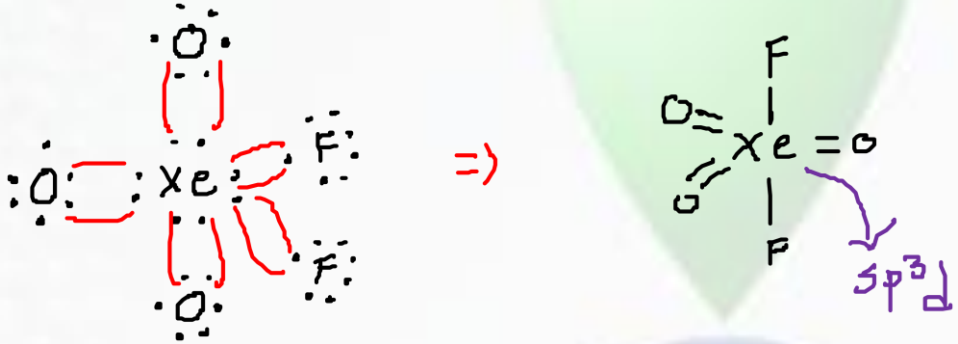

**One LPs on Xe**
**Molecular geometry:**
**See Saw**

# Shape of $XeOF_4$




**One LPs on Xe**
**Molecular geometry:**
**square pyramidal**

# Shape of $XeO_3F_2$




**No LPs on Xe**

**Molecular geometry:**
**Trigonal bipyramidal**

# Reactions of $XeO_3$

**1. Explosive solid $XeO_3$ reacts with $XeF_6$ and gives xenon oxofluoride $XeOF_4$**

$$2XeF_6 + XeO_3 \longrightarrow 3XeOF_4$$

**2. xenon oxofluoride $XeOF_4$ reacts with $XeO_3$ gives $XeO_2F_2$**

$$XeOF_4 + XeO_3 \longrightarrow 2XeO_2F_2$$

**Xenon oxodifluoride**

**3. $XeO_3$ is soluble in water but does not ionize. In alkaline solution it forms xenate ion. Here oxidation state of Xe is +VI**

$$XeO_3 + NaOH \longrightarrow Na^+ [HXeO_4]^-$$

**Sodium xenate**

**4. Xenate (Xe +VI) ion slowly disproportionate in solution and gives perxenate (Xe +VIII) and Xe**

$$2[HXeO_4]^- + 2OH^- \longrightarrow [XeO_6]^{4-} + Xe + O_2 + 2H_2O$$

**perxenate ion**

# Complexes of Xenon fluoride

$XeF_2$ acts as a fluoride donor and forms complexes with covalent compounds like $SbF_5$, $PF_5$, $AsF_5$

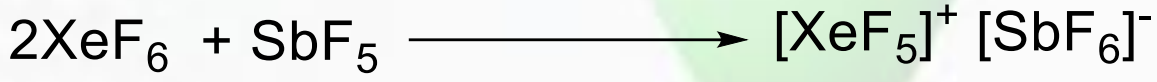
$XeF_2$ also reacts with transition metals like $NbF_5$, $TaF_5$, $RuF_5$

Structures are $XeF_2.MF_5$ or $[XeF]^+ [MF_6]^-$

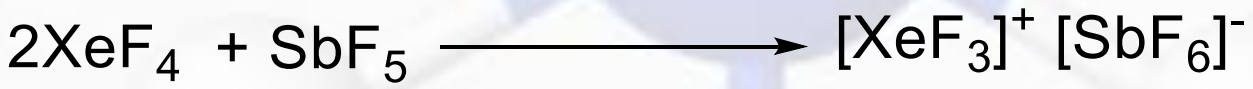
$XeF_6$ also reacts with $SbF_5$, $PF_5$, $AsF_5$ $PF_5$, $AsF_5$, $SbF_5$

Examples $XeF_6.SnF_6$, $XeF_6.AsF_5$

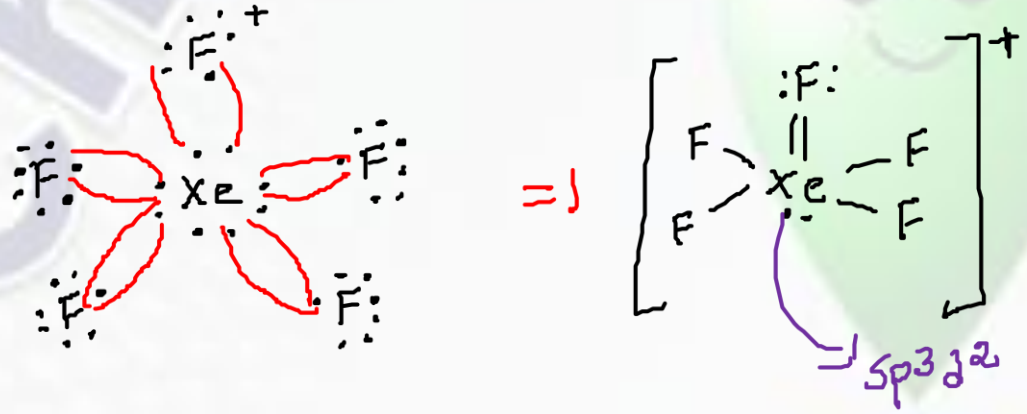
# Write down products when $XeF_6$ reacts with $SbF_5$




# Write down products when $XeF_4$ reacts with $SbF_5$

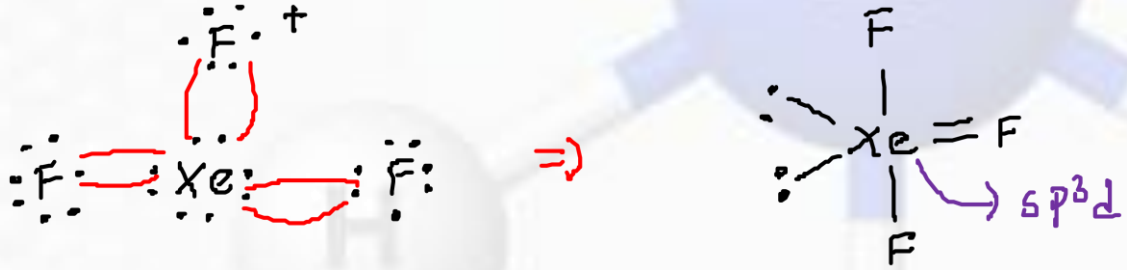


# Shape of $XeF_5^+$



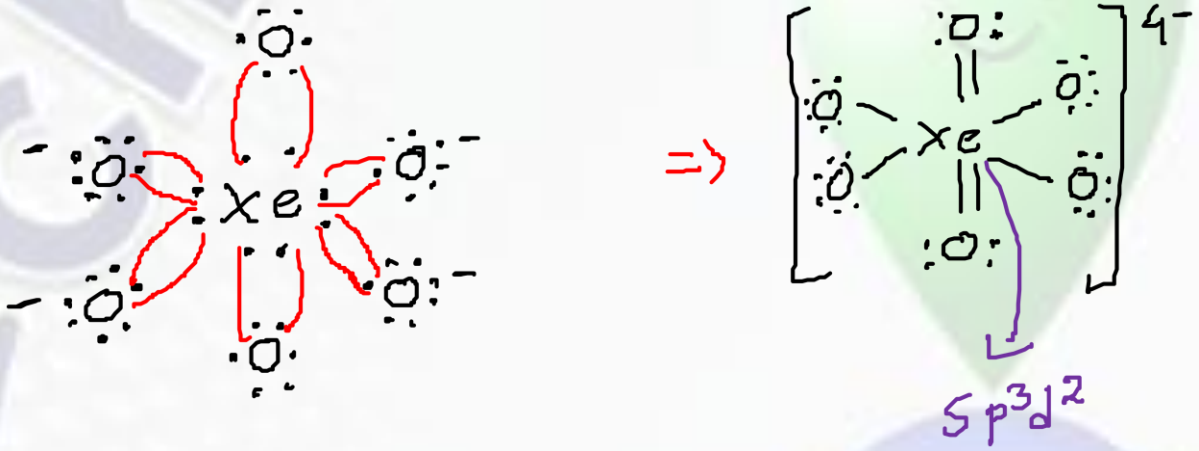

**One LPs on Xe**
**Molecular geometry: square pyramidal**

# Shape of $XeF_3^+$



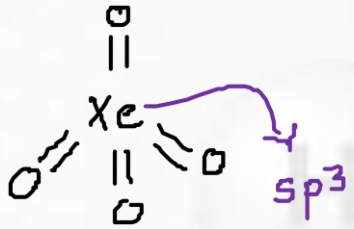

**Two LPs on Xe**
**Molecular geometry: T shaped**

# Shape of $XeO_6^{4-}$




**No LPs on Xe**
**Molecular geometry:**
**Octahedral**

# Shape of $XeO_4$




**No LPs on Xe**
**Molecular geometry:**
**Tetrahedral**

# Key Points

**Noble gases like He, Ne, Ar, Kr are inert. They don't form any compounds**

**Xe is down the group and has lower ionization energy, thus make compound with highly electronegative elements like fluorine and oxygen only**

**Xe has d orbital, so Xe can form $sp^3d$, $sp^3d^2$ orbitals and form high coordination number with elements with high electronegative elements**

# All the best for the preparation of inorganic chemistry