The Noble Gases

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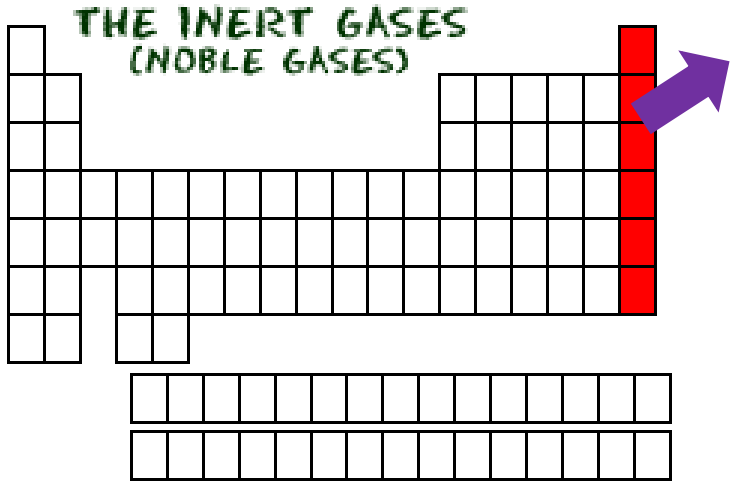
The contents of this presentation is prepared to provide a brief idea about the topics, details will be discussed in the classes.
Contents have been collected from multiple textbooks and internet.

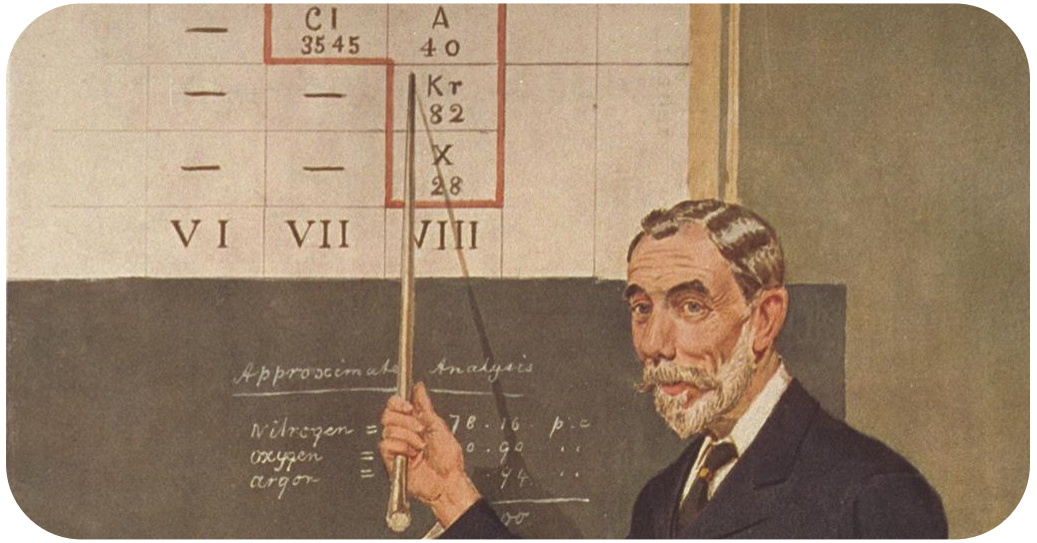
The Noble Gases: Introduction

- ✓ *Also known as the inert gases or rare gases*
- ✓ *Located in Group VIII A (sometimes called Group 0 or 18) of the periodic table*
- ✓ *The elements have a ns^2np^6 electron configuration with a complete octet. (n is the period number) except He.*

He (2)	$1s^2$
Ne (10)	[He] $2s^2$ $2p^6$
Ar (18)	[Ne] $3s^2$ $3p^6$
Kr (36)	[Ar] $4s^2$ $3d^{10}$ $4p^6$
Xe (54)	[Kr] $5s^2$ $4d^{10}$ $5p^6$
Rn (86)	[Xe] $6s^2$ $4f^{14}$ $5d^{10}$ $6p^6$



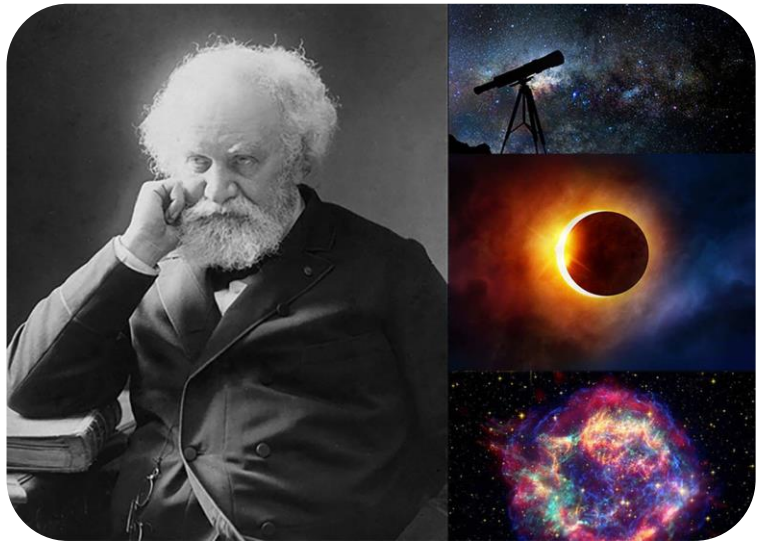
Discovery of The Noble Gases



- ✓ *Cavendish obtained the first experimental evidence for the noble gases in 1766.*
- ✓ *In a series of experiments on air, he was able to sequentially remove nitrogen, oxygen and carbon dioxide from air.*
- ✓ *But a small residue, no more than one part in 120, resisted all attempts at reaction.*
- ✓ *The nature of this unreactive fraction of air remained a mystery for more than a century; it was eventually shown to be a mixture of argon and other noble gases.*

Discovery of The Noble Gases

- ✓ *During a solar eclipse in 1868, a new emission line, matching no known element, was found in the spectrum of the solar corona.*
- ✓ *Pierre Janssen proposed the existence of a new element, helium (Greek, helios, sun).*



- ✓ *The same spectral line was subsequently observed in the gases of Mount Vesuvius.*

Discovery of The Noble Gases

- ✓ *In the early 1890s, Lord Rayleigh and William Ramsay observed a discrepancy in the apparent density of nitrogen isolated from air and from ammonia.*
- ✓ *The two researchers independently performed painstaking experiments to isolate and characterize what seemed to be either a new form of nitrogen (the formula N_3 was one suggestion) or a new element.*
- ✓ *Eventually the two worked cooperatively, with Ramsay apparently the first to suggest that the unknown gas might fit into the periodic table after the element chlorine.*
- ✓ *In 1895, they reported the details of their experiments and evidence for the element they had isolated: argon (Greek, argos, no work, lazy).*

Discovery of The Noble Gases

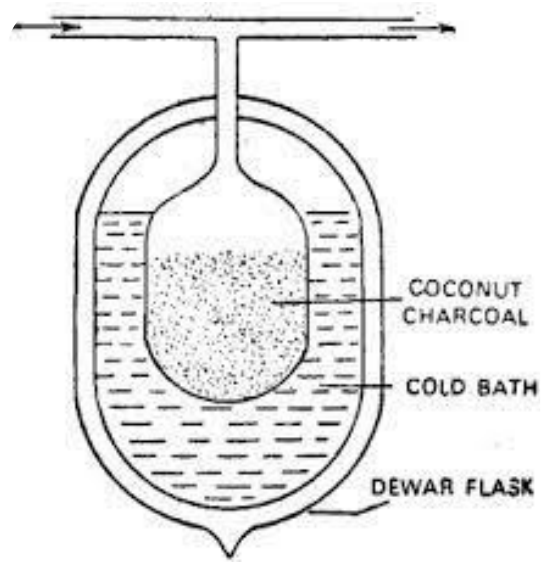
- ✓ *Within three years, Ramsay and Travers had isolated three additional elements by low temperature distillation of liquid air: neon (Greek, neos, new), krypton (Greek, kryptos, concealed), and xenon (Greek, xenos, strange).*
- ✓ *The last of the noble gases, radon, was isolated as a nuclear decay product in 1902.*
- ✓ *Noble gases, except radon, are present in small amounts in air.*

Element	Ionization Energy (kJ mol^{-1})	Melting Point (°C)	Boiling Point (°C)	Enthalpy of Vaporization (kJ mol^{-1})	Electronegativity	Abundance in Dry Air (% by Volume)
He[a]	2372	–	−268.93	0.08	4.160	0.000524
Ne	2081	−248.61	−246.06	1.74	4.787	0.001818
Ar	1521	−189.37	−185.86	6.52	3.242	0.934
Kr	1351	−157.20	−153.35	9.05	2.966	0.000114
Xe	1170	−111.80	−108.13	12.65	2.582	0.0000087
Rn	1037	−71	−62	18.1	2.60[b]	Trace

Discovery of The Noble Gases

Noble gas mixture containing He, Ne, Ar, Kr and Xe brought in contact with coconut charcoal maintained at -100°C.

- Ar .Kr and Xe adsorbed
  - Connected with another coconut charcoal maintained at liquid air temperature
    - Argon diffuses and adsorbed in fresh charcoal
      - heat
      - Argon evolved
    - First coconut charcoal, Kr and Xe in adsorbed state
      - Temperature raised to – 90°C
        - Krypton evolved
        - Xenon remains in adsorbed state
          - heat
          - Xenon evolved
- Unadsorbed He and Ne
  - Brought in contact with charcoal at –180°C.
    - Neon adsorbed
      - heat
      - Neon evolved
    - Unadsorbed Helium



The Noble Gases: Properties

- ✓ *All are nonmetals*
- ✓ *Colorless, odorless gases at room temperature*
- ✓ *Very low melting and boiling points*
- ✓ *The smallest elements in their respective periods, with the highest ionization energies*
- ✓ *Very low electronegativities*
- ✓ *Together they make up 1% (by mass) of the atmosphere*
- ✓ *Argon is the third most abundant gas in the atmosphere after N and O*

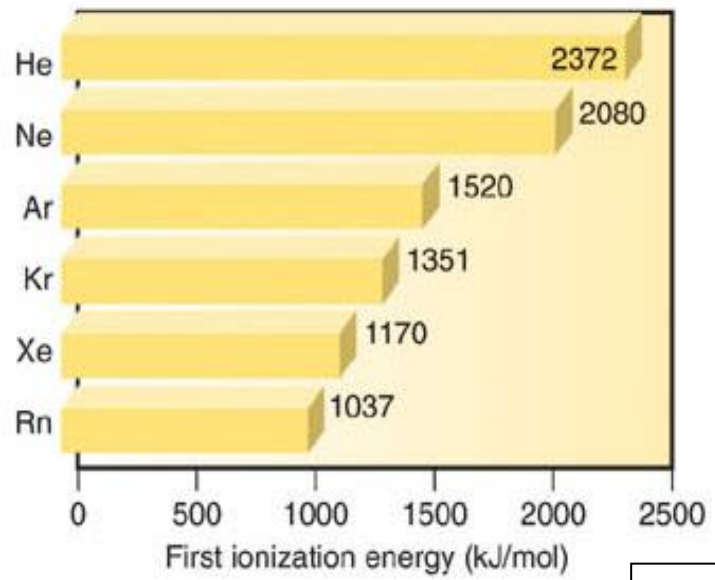
The Noble Gases: Properties

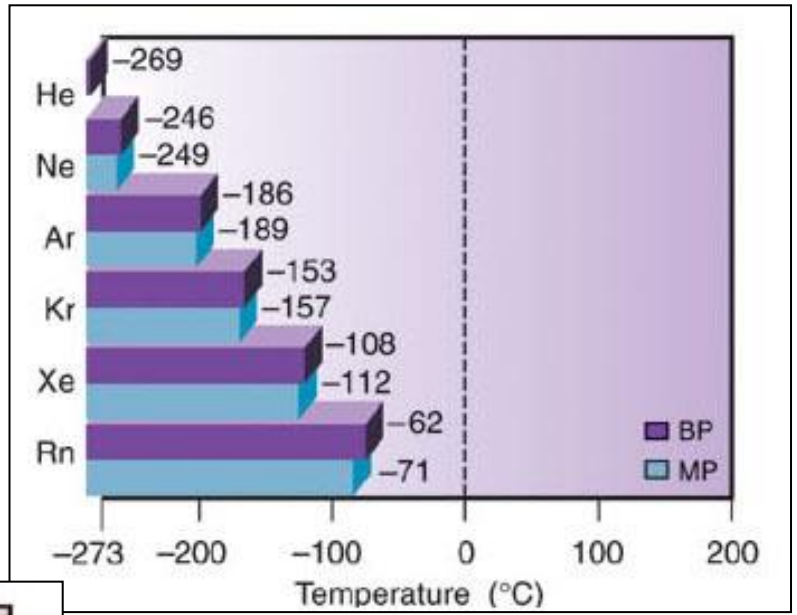
- ✓ *Have a stable valence shell*
- ✓ *VERY unreactive, monatomic gases. Therefore, exist as individual atoms. Most other gases are diatomic*
- ✓ *Only Ar, Kr and Xe are known to form compounds*
- ✓ *Xe is the most reactive noble gas and exhibits all even oxidation states from +2 to +8*

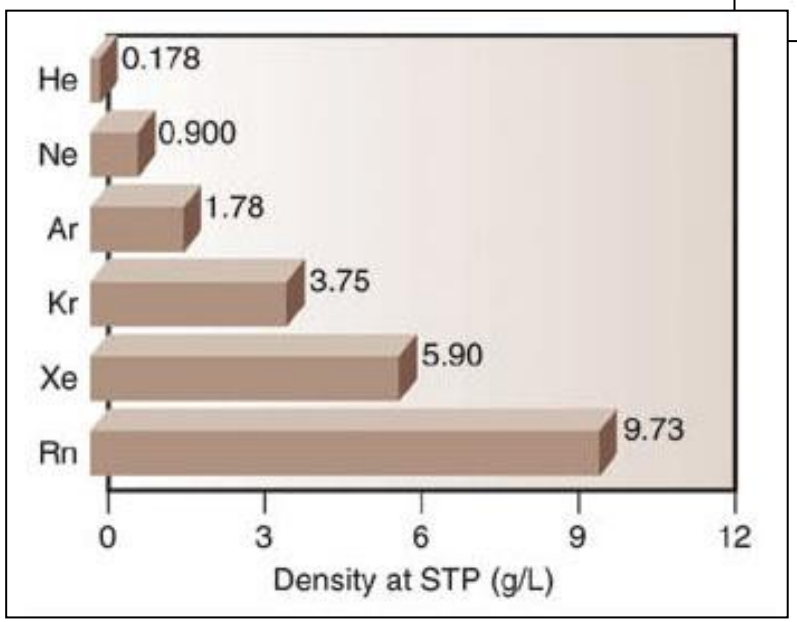
The Noble Gases: Properties along the group

- ✓ *Atomic mass, boiling point, and atomic radii INCREASE down the group in the periodic table*
- ✓ *The first ionization energy DECREASES down the group*
- ✓ *The noble gases have the largest ionization energies, reflecting their chemical inertness*
- ✓ *Down Group 18, atomic radius and interatomic forces INCREASE resulting in an INCREASED melting point, boiling point, energy of vaporization, and solubility*
- ✓ *The INCREASE in density down the group is correlated with the INCREASE in atomic mass*

The Noble Gases: Properties along the group







The Noble Gases: Reactivity and Compounds

- ✓ *He and Ne are chemically inert and they do not form any compounds.*
  - ➢ *due to very high ionization energy, zero electron affinity and the absence of vacant d-orbitals in valence shell.*
- ✓ *Ar, Kr and Xe will show some reactivity*
  - ➢ *due to low ionization potentials and presence of vacant d-orbitals in valence shell.*
- ✓ *Xe is more reactive than Ar and Kr*
  - ➢ *due to it's low ionization energy.*

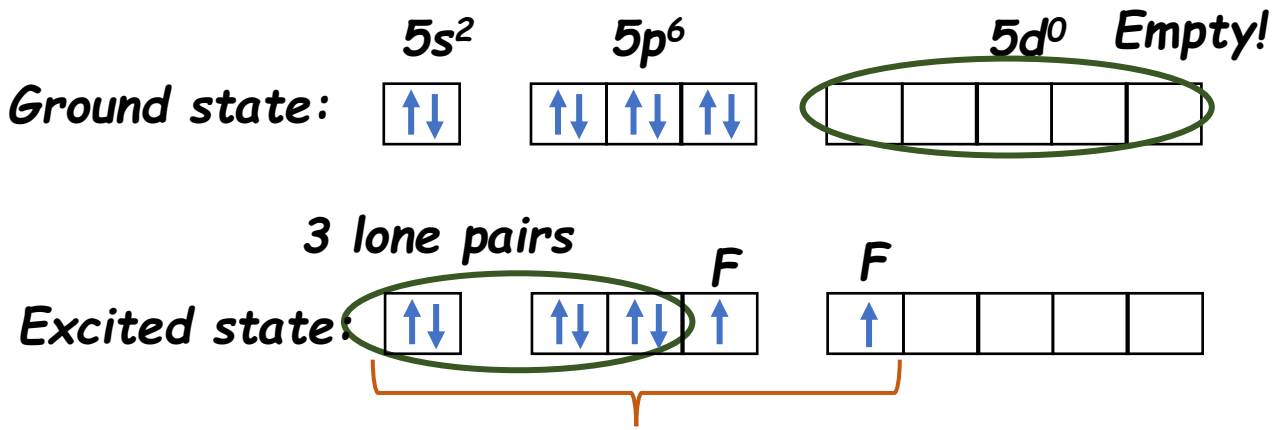
The Noble Gases: Reactivity and Compounds

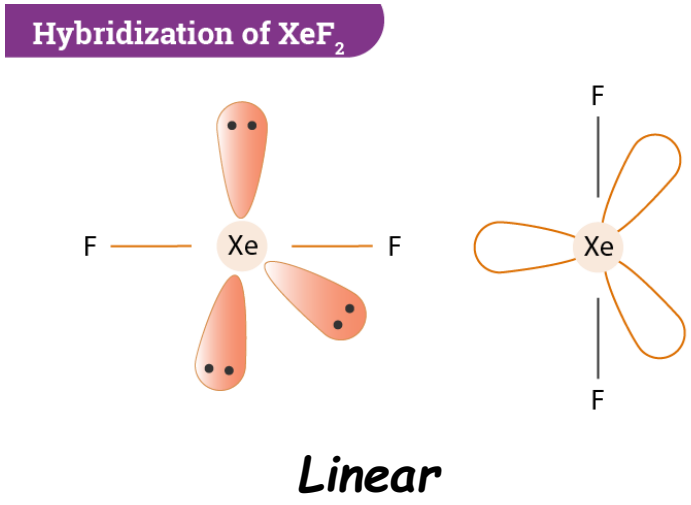
- ✓ *Krypton forms only one known stable neutral molecule KrF_2.*

- ✓ *Xe combines with only strong electronegative elements like F and O or electronegative groups.*

- ✓ *Xe does not combine with less electronegative elements like Cl or N.*

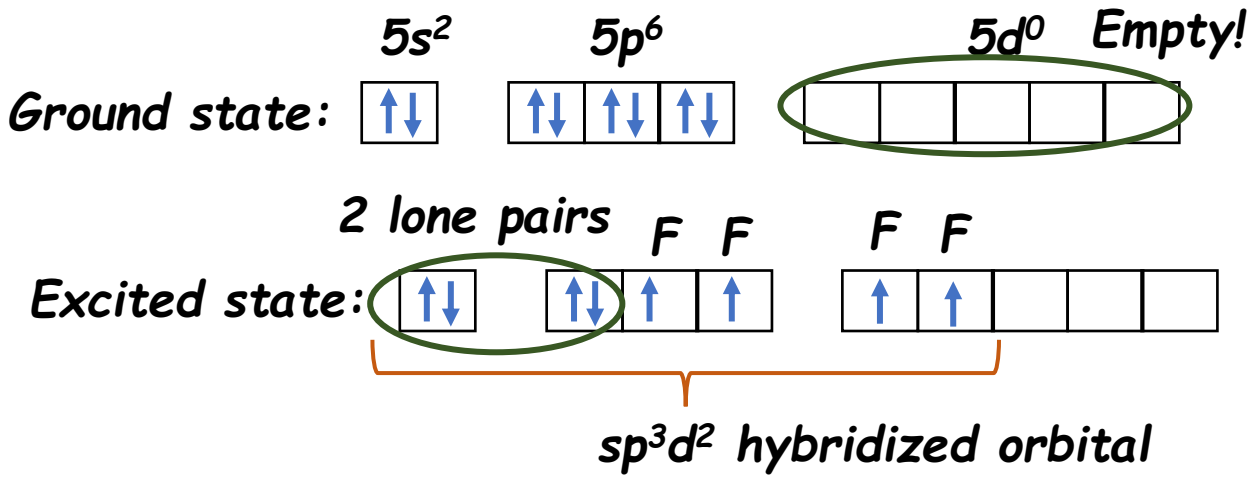
Compounds of Xenon: XeF_2



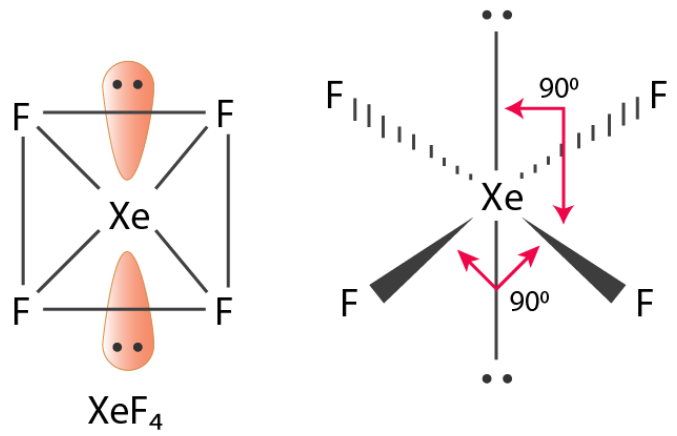


Linear

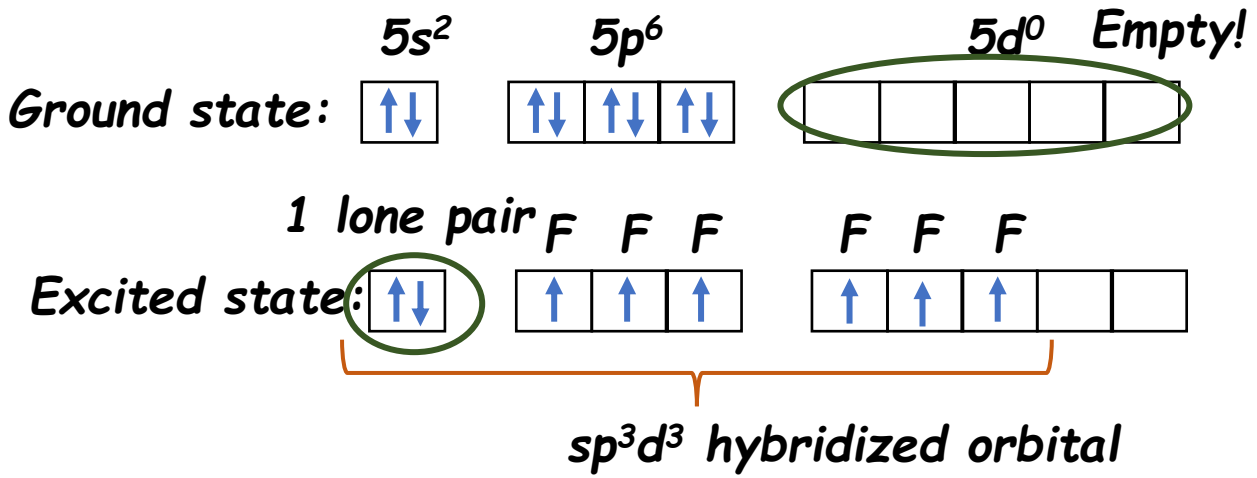
Compounds of Xenon: XeF_4

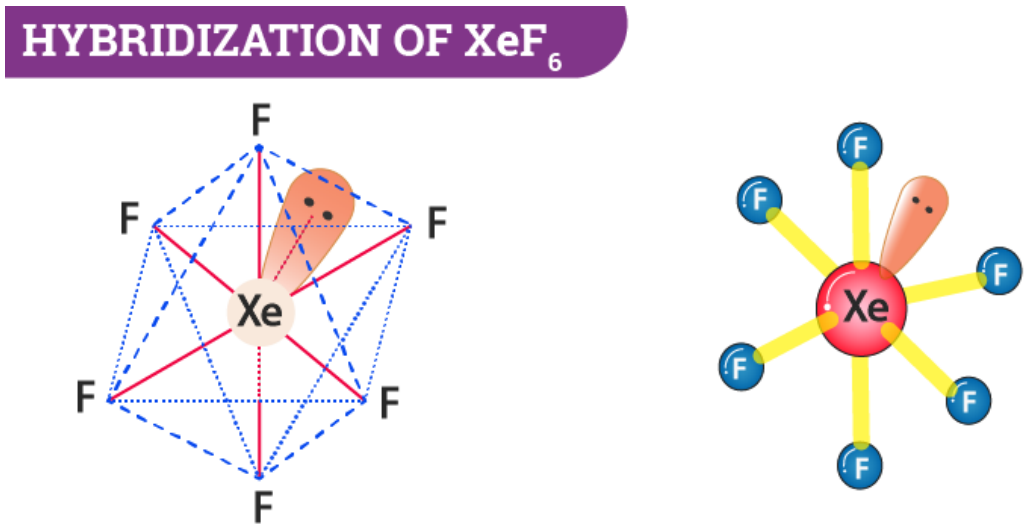


Hybridization of XeF_4

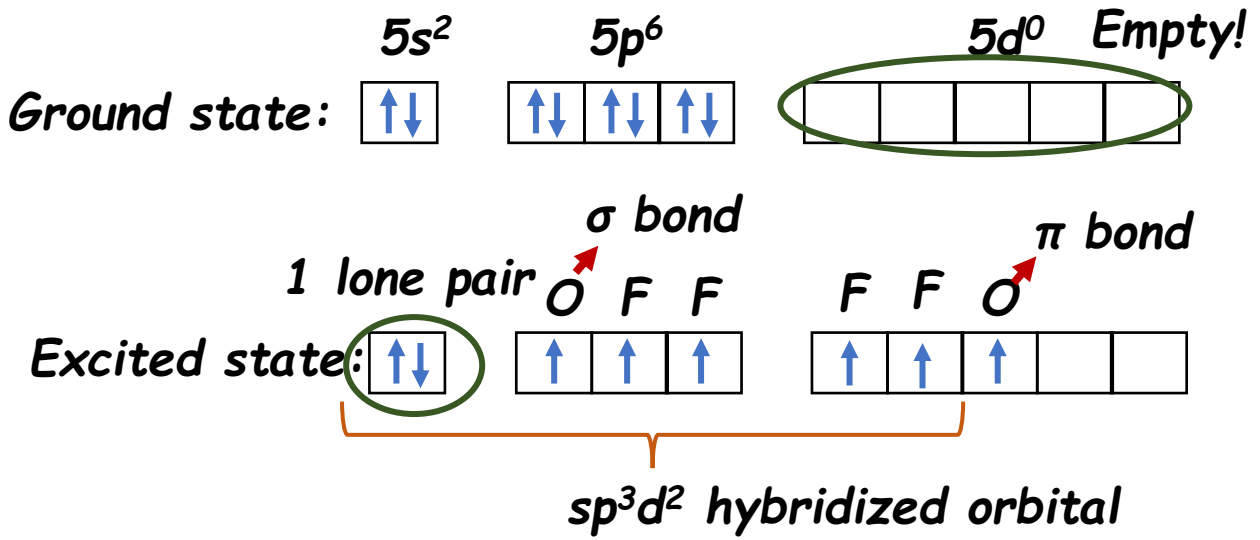


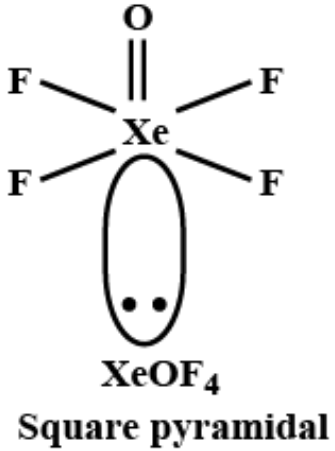
Compounds of Xenon: XeF_6





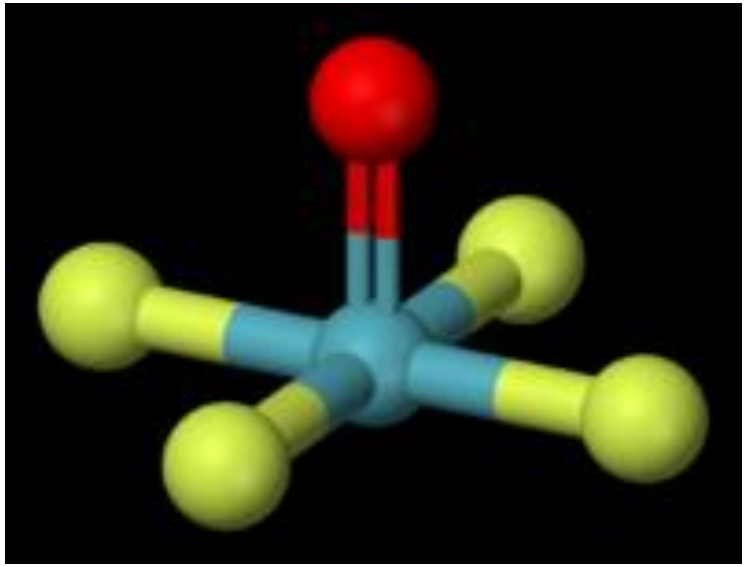
Compounds of Xenon: $XeOF_4$



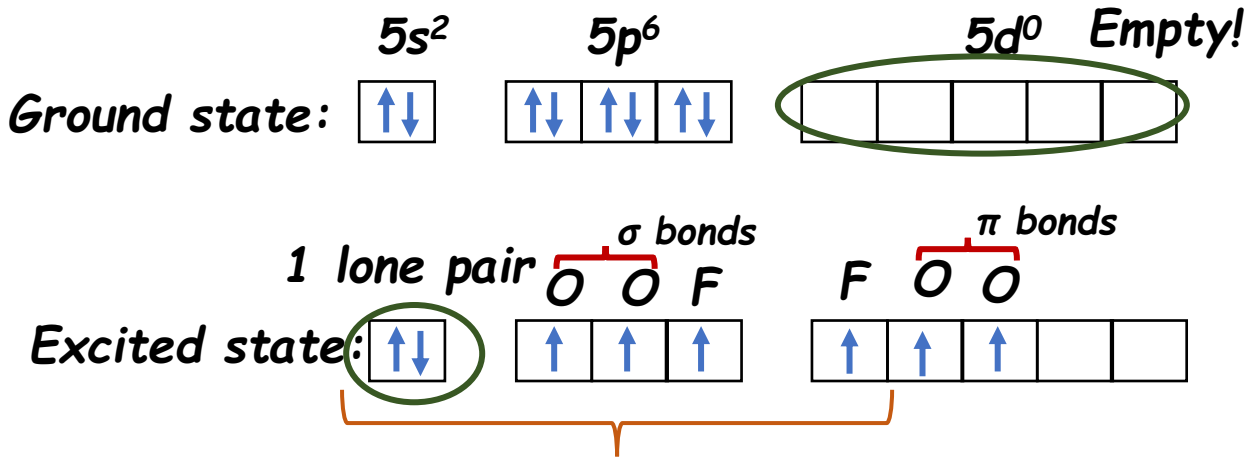


$XeOF_4$

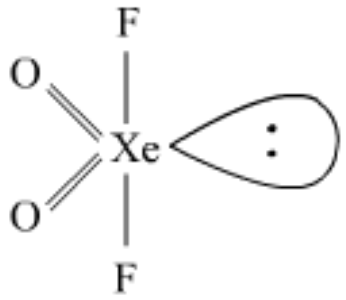
Square pyramidal



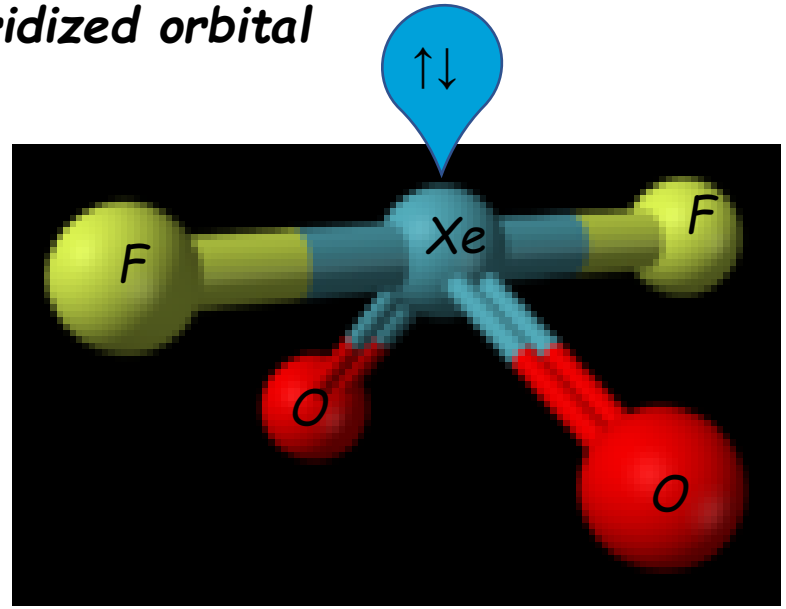
Compounds of Xenon: XeO_2F_2



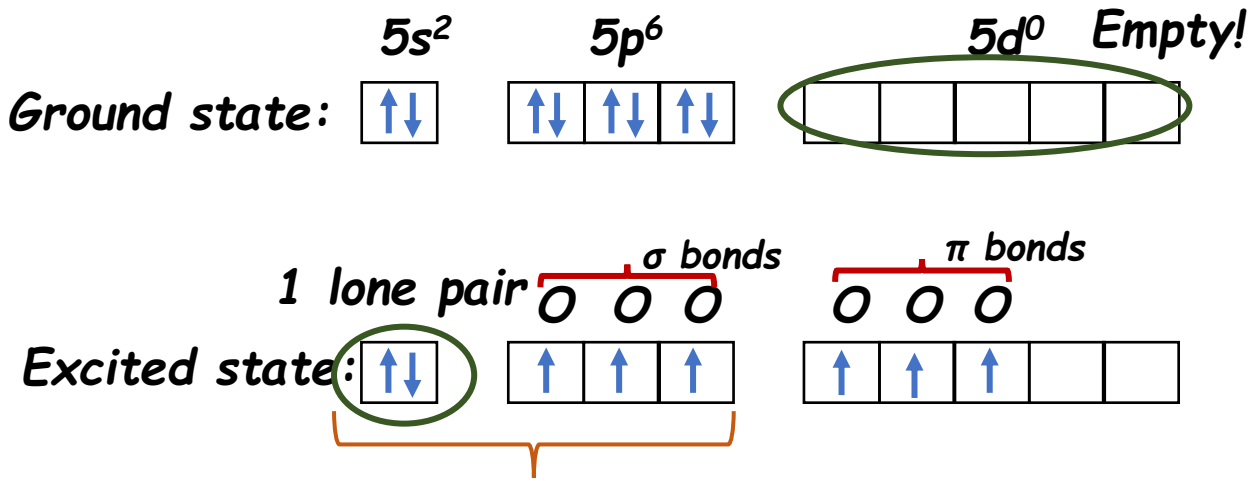
Xenon dioxy difluoride

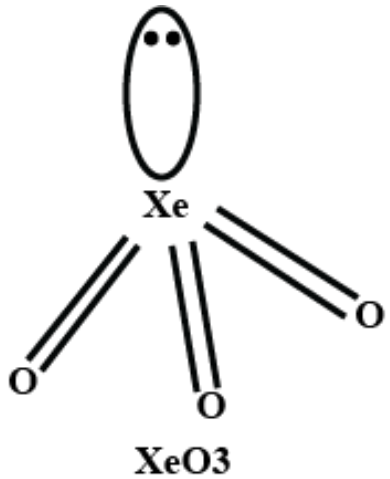


See saw structure

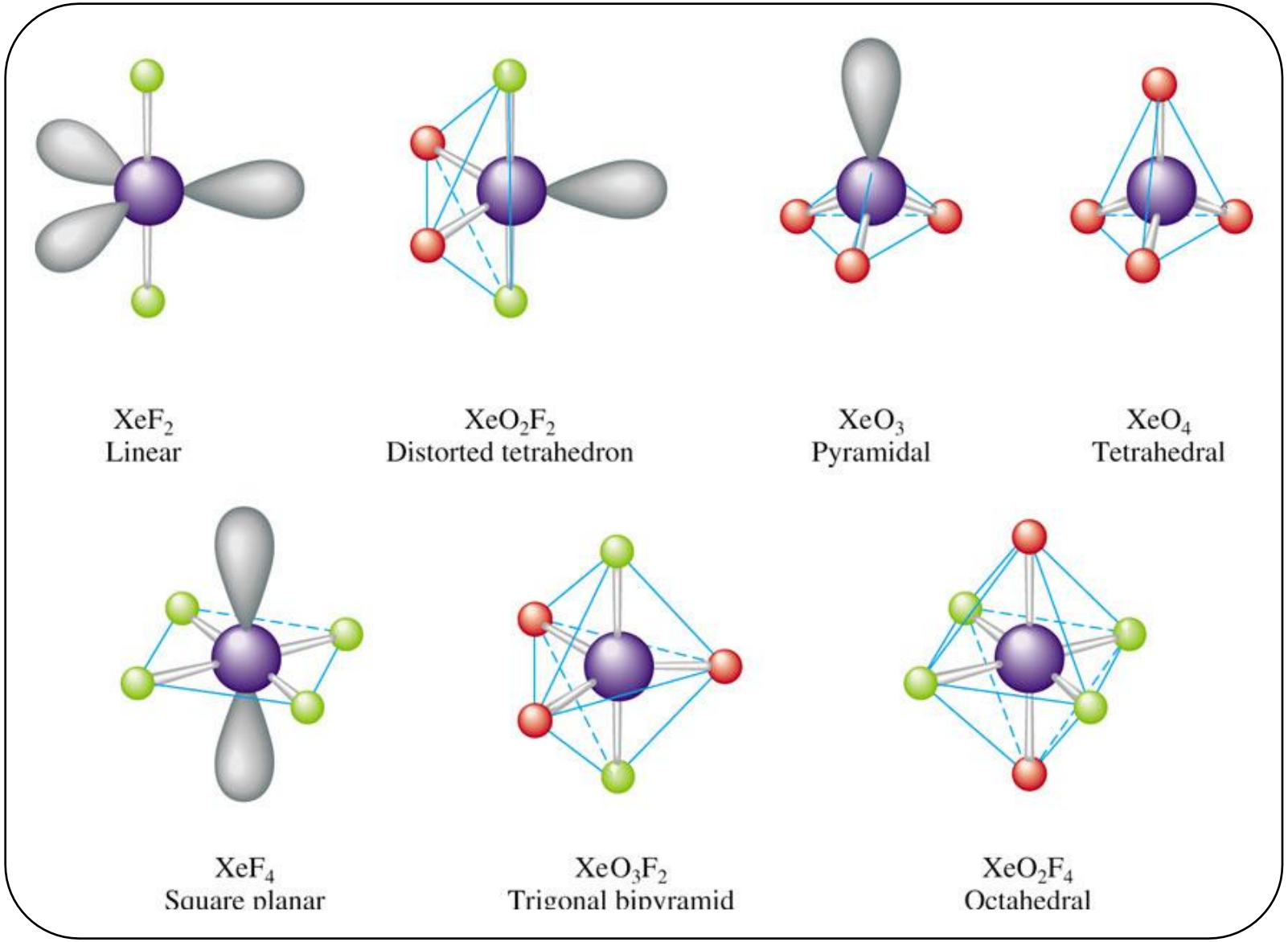


Compounds of Xenon: XeO_3





Structure of few common Xe compounds



Uses of Helium

- ✓ *It is a non-inflammable and light gas. Hence, used in filling balloons.*
- ✓ *It is also used in gas-cooled nuclear reactors, and used as cryogenic agent for carrying out various experiments at low temperatures.*
- ✓ *It is used as a diluent for oxygen in modern diving apparatus because of its very low solubility in blood.*

Uses of Neon

- ✓ *It is used in discharge tubes and fluorescent bulbs for advertisement display purposes.*
- ✓ *Neon bulbs are used in botanical gardens and in green houses.*

Uses of Argon

- ✓ *It is used mainly to provide an inert atmosphere in high temperature metallurgical processes (arc welding of metals or alloys) and for filling electric bulbs.*
- ✓ *It is also used in the laboratory for handling substances that are air-sensitive.*

Uses of Krypton

- ✓ *Used in various kinds of lights, from small bright flashlight bulbs to special strobe lights for airport runways.*
- ✓ *Due to it's large number of spectral lines, it's ionized gas is white, which is why light bulbs that are krypton based are used in photography and studio lighting in the film industry.*
- ✓ *The most significant uses of Krypton is in the krypton-fluoride laser which is used in nuclear fusion energy research.*

Uses of Xenon

- ✓ *This element is most notable for its bright luminescence in light bulbs.*
- ✓ *HID Xenon headlights in cars are brighter, stable and more economy friendly than regular halogen light bulbs.*

Thank You