GROUP 18 ELEMENTS (zero group elements)

UNIT : 1

1 General introduction, Electronic configuration, Occurrence, Isolation
2 Trends in Physical and chemical properties ; uses

VERY SHORT ANSWER QUESTIONS :

1. Name the noble gases in the order of their atomic numbers.

A.

Name of the element	**Symbol**	**Atomic number**
Helium	He	2
Neon	Ne	10
Argon	Ar	18
Krypton	Kr	36
Xenon	Xe	54
Radon	Rn	86

2. Why the noble gases are called as inert gas.

A. Due to the stable $ns^2\ np^6$ electronic configuration they are chemically inert and do not involve in the reaction hence they are called as inert gases.

3. Name an inert gas that occurs in the chromosphere of sun. What is the characteristic spectral lines it gives ?

A. Helium exists in the chromosphere of sun.. Helium was discovered by D_3 line in the spectrum

4. Write the names of physical methods by which noble gases can be separated from their mixture ?

A. The physical methods used to separate are

1) Dewar's method

2) Fractional evaporation method

5. Why are the inert gases have very high ionization potential values ?

A. The inert gases have most stable $ns^2\ np^6$ configuration in their outermost shell (Except Helium), to remove an electron from such configuration much energy is needed. Hence their ionization potential is high.

6. How is Nitrogen separated from air by Fisher Ringe's Method?

A. Dry and pure air is passed over a mixture containing 90% calcium carbide and 10%calcium chloride at 1073 K. The Nitrogen present in the air reacts with calcium carbide and is removed in the form of calcium cynamide.

$$CaC_2 + N_2 \xrightarrow{1073K} CaCN_2 + C$$

7. A mixture of inert gases has a trace of O_2 as impurity. How is O_2 removed from the mixture?

A. Traces of O_2 present in the mixture of inert gases is removed by passing the gases through alkaline pyrogallol. O_2 is absorbed .

SHORT ANSWER QUESTIONS :

1. Explain why inert gases have very high IE values.

A. Among all the elements present in the periodic table, noble gases have the highest ionization energy values,due to stable octet electronic configuration $\left(ns^2\, np^6\right)$ except Helium which has doublet $\left(1s^2\right)$ stable configuration. To remove an electron from such configuration more energy is needed. E.g.

Element	He	Ne	Ar
$IE_1\left(KJ/mol\right)$	2372	2080	1520

2. The EA values of inert gases are almost zero. Explain why ?

A They have completed electron shells and so their atoms are highly stable. They cannot expand the octet. They have no tendency to accept additional electron. Hence, have zero EA values.

3. A mono atomic gas has the highest IE value in its period and almost zero electron affinity. Then

a) Assign a possible outer electron configuration

b) Can it form compounds readily ?

c) Assign a group in the periodic table

A. a) Given gas has the highest IE value and almost zero EA value. So, it has completely filled configuration (i.e.) ns^2 (or) $ns^2\, np^6$

b) Because of stable configuration, they are chemically inert. So it cannot form compounds easily

c) Element having above configuration belongs to zero in the periodic table

4. Mention any three uses of He.

A. **Uses of He :**

1) As helium is a light and non – combustible gas, it is used in lifting weather balloons and air ships

2) 'He' mixed with O_2 is also used to help patients suffering from respiratory diseases like asthma

3) 'He' is mixed with 20% oxygen and is supplied to deep sea diver

4) Liquid helium is useful in producing near absolute zero temperature, for cryogenic studies

5. Write the uses of Neon gas.

A. **Uses of Neon gas :**

1) Neon is mainly used in discharge tubes at 2mm of pressure

e.g : Neon signs, Beacon lights

2) Neon is used in safety devices, relays and rectifiers, it has a capacity for carrying high voltage currents

6. Explain why the behaviour of heavier noble gases is different from those of He and Ne.

A. Noble gases have the highest ionization energy and it decreases as we go from 'He' to 'Rn', 'Kr' and 'Xe' has low ionization energy compared to the other elements of the group. He and Ne have high ionization energies, these two elements atomic size is small. No 'd' orbital is present in the outer valency shell of these elements. Hence they are absolutely chemically inert.

Krypton and Xenon are chemically active dueto have low ionization energy, large size and empty d – orbitals for the excitation of electrons.

7. Explain the chemical activity of a monoatomic gas with $ns^2\ np^6$ configuration.

A. Noble gases have the outermost orbit electronic configuration of $ns^2\,np^6$ which is complete octet. And hence do not gain or lose elecrons. Thus they are chemically inactive. since they have high ionization energy and zero electron affinity values. they do not participate in chemical reactions.

LONG ANSWER QUESTIONS :

1. Write a brief note on the discovery of noble gase

a) Discovery of Helium :

It was discovered by Janssen and Lockyer in their spectroscopic studies of solar spectrum. Because it is present in the atmosphere of sun, it is named Helium. In the later years it was separated by Ramsay from earth's atmospheric nitrogen gas.

b) Discovery of Argon :

It is observed by Rayleigh that the density of N_2 gas isolated from atmosphere is higher than the density of N_2 gas obtained from chemical compounds. He also predicted that the N_2 gas obtained from atmospheric contained an inert gas with the atomic weight of 40. This gas was named Argon, becaue it is chemically inert.

c) Discovery of Neon, Krypton and Xenon :

These gases were discovered by Ramsay and Travers. They isolated inert gases fraction from the atmospheric nitrogen and subjected it to fractional distillation at different reduced pressures. Then, they separated a new element and named it Neon. Krypton and Xenon were discovered by Ramsay and he separated them by subjecting liquid air to repeated fractional distillation.

Radon was discovered in 1900 by Dorn as the radioactive disintegration product of radium.

2. Write a brief note on the isolation of noble gases.

A. Noble gases are present in the air. Isolation of noble gases mainly occur in two steps

1) Separation of noble gases mixture from air

2) Separation of different inert gases from air

1) Separation of noble gases mixture from air :

The first step involves the separation of noble gaseous mixture from ait. The following chemical methods adopted for this.

1) Ramsay – Rayleigh's first method

2) Ramsay – Rayleigh's second method

3) Fischer – Ringe's method

Fischer – Ringe's method :

Dry and pure air is passed over a mixture containing 90% calcium carbide and 10% $CaCl_2$ at 1073K. O_2 and N_2 gases are removed by the following reaction

$$\underset{\text{Calcium carbide}}{CaC_2} + N_2 \xrightarrow{1073\,K} CaCN_2 + C$$

$$C + O_2 \longrightarrow CO_2$$

$$2C + O_2 \longrightarrow 2CO$$

The carbon monoxide is removed by passing over cupric oxide where it turns to CO_2. The total CO_2 is removed by passing through KOH solution.

$$CuO + CO \longrightarrow CO_2 + Cu$$

$$CO_2 + 2KOH \longrightarrow K_2CO_3 + H_2O$$

The remaining mixture contains all the noble gases

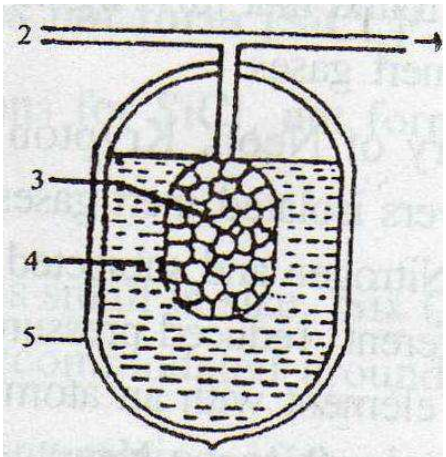
2) Separation of different noble gases from one another :

Dewar's method :

Principle involved in Dewar's method :

i) Activated coconut charcoal absorbs all the noble gases except Helium

ii) The adsorption depends on temperature. Lower the atomic weight of the noble gas, the lower is the temperature needed to adsorb it



Dewar's flask

1. He and Ne 2. Mixture of noble gases 3. Coconut charcoal 4. Liquid air 5. Dewar's flask

Procedure:

The mixture of inert gases is sent into a flask called Dewar's flask. It is a double walled flask containing activated coconut charcoal in the middle. At 173 K, Ar, Kr and Xe gases are adsorbed by the coconut charcoal while He and Ne remain unadsorbed. The mixture of He and Ne is introduced into another Dewar's flask and 93 K temperature is maintained. At 93 K. only Ne gets adsorbed leaving behind Helium (He).The charcoal with Ar, Kr, Xe is cooled to 77 K. Argon comes out. The temperature of the charcoal is raised to 183 k. At this temperature 'Kr' comes out. 'Xe' which remains on the first charcoal is released by warming.

3. How is the mixture of noble gases separated from the air ? Give any one method.

A. Noble gas mixture can be separated from air by Fischer – Ringe's method

Procedure :

Dry and pure air is passed over a mixture containing 90% calcium carbide and 10% $CaCl_2$ at 1073K. O_2 and N_2 gases are removed by the following reaction

$$\underset{\text{Calcium carbide}}{CaC_2} + N_2 \xrightarrow{1073\,K} CaCN_2 + C$$

$$C + O_2 \longrightarrow CO_2$$

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$$CuO + CO \longrightarrow CO_2 + Cu$$

$$CO_2 + 2KOH \longrightarrow K_2CO_3 + H_2O$$

The remaining mixture contains all the noble gases

4. Write about Dewar's method for the separation of Noble gases from their mixture.

A. Separation of different inert gases from one another:

Dewars method:

Principle :

i)Activated coconut charcoal adsorbs all the Noble gases except Helium

ii) The Adsorption depends on temperature, Lower the atomic weight of the Noble gas, lower is the temperature needed to adsorb it

Procedure:

The mixture of inert gases is sent into a flask called Dewar's flask. It is a double.

Walled flask containing activated coconut charcoal in the middle. At 173 K, Ar, Kr and Xe gases are adsorbed by the coconut charcoal while He and Ne remain unadsorbed. The mixture of He and Ne is introduced into another Dewar's flask and 93 K temperature is maintained. At 93 K. only Ne gets adsorbed leaving behind Helium (He).The charcoal with Ar, Kr, Xe is cooled to 77 K. Argon comes out. The temperature of the charcoal is raised to 183 k. At this temperature 'Kr' comes out. 'Xe' which remains on the first charcoal is released by warming.

5. Describe the separation of noble gases from liquid air.

A. Various constituents present in the liquid air differ in their boiling points. So, they can be separated by Fractional Evaporation method.

Gas	He	Ne	N_2	Ar	O_2	Kr	Xe
Boiling point K	4	27	77	87.6	90.1	121.3	165.0

Claude's apparatus :

Fractional distillation of liquid air is carried out in Claude's apparatus. Cold and compressed air is sent from the bottom through the tubes which are surrounded by liquid oxygen. Both nitrogen and oxygen are condensed and are collected in separate vessels.

The fractions collected in the Claude's process are given below

Fraction – 1 : Gaseous mixture consisting of He, Ne and a small amount of N_2 go out. This mixture is passed through spiral tubes cooled in the liquid N_2. Most of N_2 condenses. The out going gases contain traces of N_2 and He, Ne gases.

The traces of N_2 are removed by passing the gas over calcium carbide (1075 – 1275K) N_2 is absorbed. When He and Ne mixture is passed through pipes surrounded by liquid H_2. Ne condenses to a liquid. He gas escapes

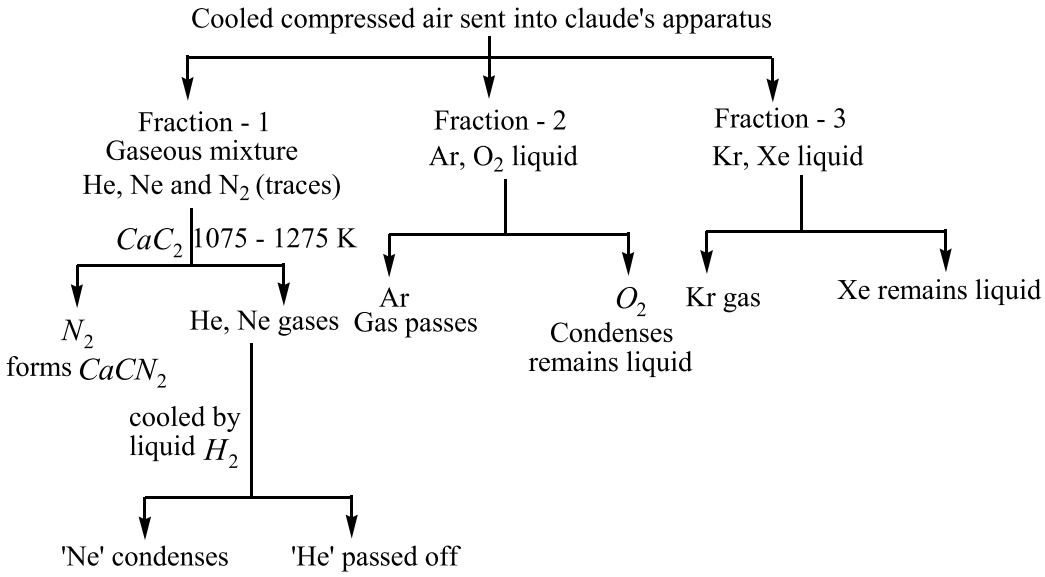
Fraction – 2 :

'Ar' is always associated with O_2 cooling the mixture in liquid N_2, oxygen condenses and leaves 'Ar' gas.

Fraction – 3 :

Krypton and Xenon are separated by passing the gas mixture through pipes cooled by liquid air. The isolation of the noble gases by fractional distillation is represented in the chart given below :

FLOW CHART



GROUP 18 ELEMENTS (zero group elements)

UNIT: 2

1. Compounds of Xenon oxides and halides (structures only)

VERY SHORT ANSWER QUESTIONS:

1. Name the first compound of inert gas?

A. Xenon hexa fluoro platinate (IV) Xe [pt F_6] was the first chemical compound of inert gases prepared.

2. What are shapes of XeO_3 and XeO_4?

A. Shape of XeO_3 molecule is pyramidal due to the presence of one lone pair electrons. Shape of XeO_4 molecule is tetrahedral

3. In what respect do the structures of XeO_3 and XeO_4 resemble.

A. In both Xe are linked to oxygen atoms through double bonds and in both Xe undergoes sp^3 hybridization.

4. Xe forms fluorides with F_2. Predict the formulas of one of these compounds.

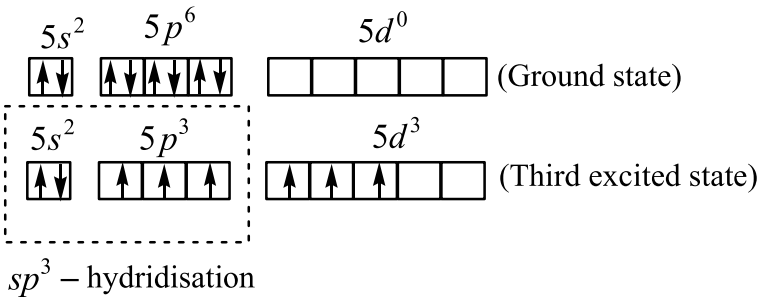
A. Xenon combines with fluorine to form xenon difluoride (XeF_2), Xenon tetrafluoride (XeF_4) and Xenon hexafluoride (XeF_6)

SHORT ANSWER QUESTIONS:

1. Deduce the structure of XeO_3 on the basis of VBT.

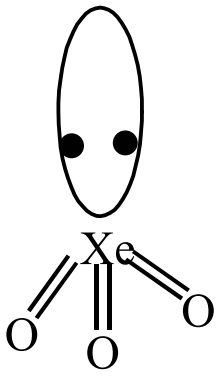
A. **Structure of XeO_3 :** Xenon atom undergo sp^3 hybridization for the formation of XeO_3.

Xe :



In the third excited state of xenon atom, it has six unpaired electrons. One's' orbital and three 'p' orbitals undergo sp^3 hybridisation and form four sp^3 hybrid orbitals. One sp^3 hybrid orbital contains lone pair of electrons; hence, it does not participate in bonding. Remaining three sp^3 hybrid orbitals form three σ bonds with three different oxygen atoms. Three 'π' bonds also formed with the oxygen atoms by the unpaired electrons.

The bond angle is reduced to 103^0 in XeO_3 due to the presence of a lone pair . Hence, the shape of the molecules is pyramidal.



2. Explain why Xe and Kr only can form compounds with F_2 and O_2

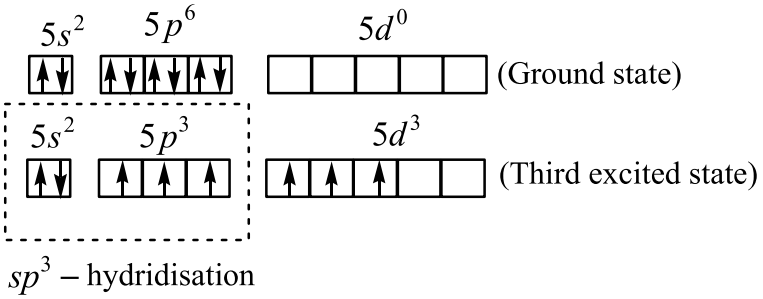
A. In many compounds, Xe and Kr shows a tendency to lose an electron and exist in a positive oxidation state. Therefore, it reacts with highly electronegative elements like F_2 (or) O_2

LONG ANSWER QUESTIONS

1. Explain the structures of XeO_3 and XeO_4 on the basis of Valence bond theory

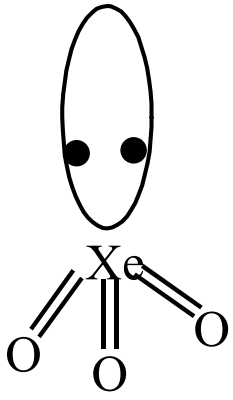
A. **Structure of XeO_3**: Xenon atom undergo sp^3 hybridization in the formation of XeO_3.

Xe :



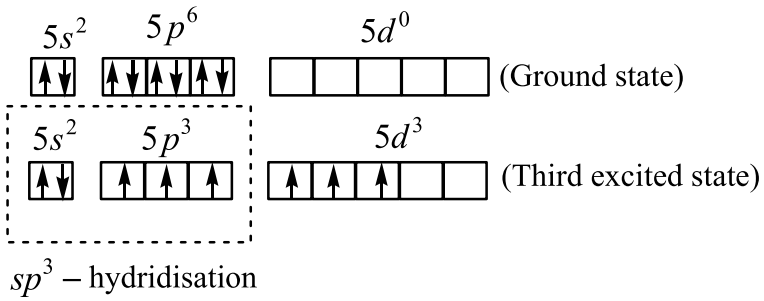
In the third excited state of xenon atom, it has six unpaired electrons. One 's' orbital and three 'p' orbitals undergo sp^3 hybridisation and form four sp^3 hybrid orbitals.Among them one sp^3 hybrid orbital contains lone pair of electrons, hence it does not participate in bonding. Remaining three sp^3 hybrid orbitals form three σ bonds with three different oxygen atoms. Three 'π' bonds also formed with the oxygen atoms by the unpaired electrons.

The bond angle is reduced to 103^0 instead of $109^0 28'$ in XeO_3 due to the presence of a lone pair . thus, the shape of the molecules is pyramidal.



<u>Structure of XeO_4</u>

Xenon undergoes SP^3 hybridization in the fourth excited in the formation of XeO_4



In the fourth excited xenon atom, has 8 unpaired electrons. One “s” and three “p” – orbitals undergo sp^3 hybridization. Four sp^3 hybrid orbitals form four σ bonds with oxygen atoms. They are $\sigma sp^3 - p$. Four π - bonds are also formed with oxygen atoms by the unpaired electrons

Since it has no lone pair of electrons, the shape of XeO_4 is tetrahedral with the bond angle of 109^0. It has four sigma and four π bonds.

