

INERT GAS FAMILY

1. RARE GASES OR NOBLE GASES ::

They are found on atmosphere to very less extent so named rare gases and

2. IMPORTANT POINT ::

He 2 $1s^2$

Ne 10
Ar 18
Kr 36
Xe 54
Rn 86

} ns^2np^6

All have octet configuration except He having duplet configuration.

- They exist on gaseous state.
- Ra is produced by the disintegration of radium and is radioactive itself.
- Ramsay was the discoverer of these gases.
- First inert gas which was discovered by Ramsay firstly i.e. argon.

3. ISOLATION ::

Except He, non-radioactive noble gases are commercially isolated from air by two methods.

(i) Fractional Distillation of Liquid air (Claude's Method) :

Due to difference in b.p. the various constituents of air are separated from each other.

(ii) Dewar's Coconut Charcoal Adsorption Method :

- O_2 and N_2 are removed by means of compound formation.
- The principle of this method is that the adsorption capacity of these gases at low temperature by coconut charcoal increases with increases in their atomic weights.
- Thus He has the lowest and Xe has the maximum adsorption capacity.

4. GENERAL PROPERTIES ::

(i) Atomic Radii, Melting point and Boiling Point, Density :

- All increases down the group.
- He is the only element having two boiling points i.e. 4.1 K and 2.5 K.
- It is [He] only element which exists in two liquid phases i.e. He and He_2 .

(ii) Ionisation Energy :

- They possess very high ionisation energy.
- Ionisation energy of Xe is nearly equal to that of molecular oxygen.

(iii) Electron Affinity :

Due to complete octet, noble gas atoms are unable to take extra electron.

(iv) Monatomicity :

Due to very high I.E. and nearly zero E.A. noble gas atoms are not capable of combining

and their value of $\gamma = \frac{C_p}{C_v}$ is close to 1.66.

(v) Force of attraction between atoms of Noble Gases :

Vander Waals force between the atoms increases from He to Xe.

(vi) Solubility in Water :

Slightly soluble in water and solubility in water increases with increase in atomic number.

(vii) Chemical Nature :

- Noble gases are almost chemically inert.
- But Kr, Xe and Rn are slightly reactive because of radioactive nature of gases.

(viii) Adsorption of Inert Gases :

- Done on coconut. Gas particles are adsorbed in surface of coconut charcoal.
- Larger the size, more will be the adsorption so maximum adsorption of Xe at highest temp.

(ix) (a) First gas discovered was Argon. (Argus Lazy)

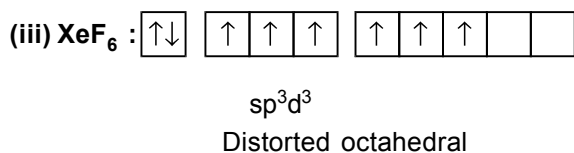
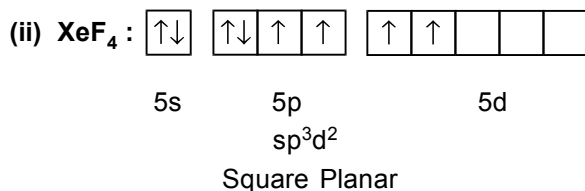
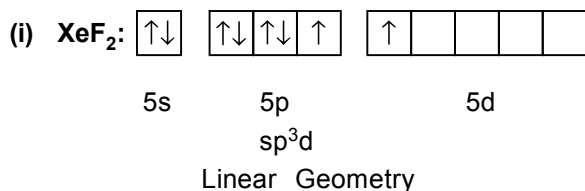
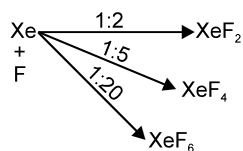
- Other inert gas isolated was Neon.
- Other inert gas remaining hidden gas krypton (Kryptos = Hidden)

- (d) Then Xenon (Xenon = danger)
 (e) Rn emits α , β , γ radiations.
 (f) Discovery of the by Lockyer on sun's atmosphere.

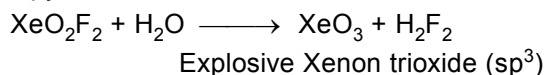
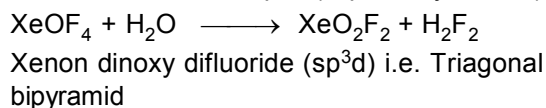
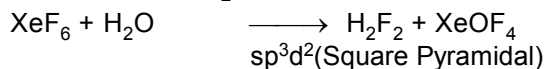
5. FAMILY MEMBERS OF NOBLE GASES ::

5.1 Xenon (Xe) :

It is the only element that forms true compounds and that too with highly reactive elements F_2 .



(iv) Reaction with H_2O :



5.2 Neon and Argon :

- (i) Gets trapped in the intersitial spaces of H_2O or alcohols and this type of mixture resulted is called as clathrate compound.
 (ii) These compounds are not formed by He.,

6. USES

- (i) Noble gases are widely used to provide inert atmospheres in metallurgical process.
 (ii) He is used as a cooling medium in gas cooled atomic reaction because of its high thermal conductivity, low viscosity and low density.
 (iii) Liquid He is used in gas thermometer required for low temperature measurement.
 (iv) Neon in neon lamps.
 (v) Neon in neon tubes for rectifiers, voltage regulators etc.
 (vi) Argon is in filling in candesent lamps.
 (vii) Xe is used in discharge tube for quick photography.
 (viii) Rn is used in treatment of cancer (Radiotherapy)

SOLVED EXAMPLES

Ex.1 In P_4O_6 and P_4O_{10} , the number of oxygen atoms bonded to each phosphorus atoms are respectively -

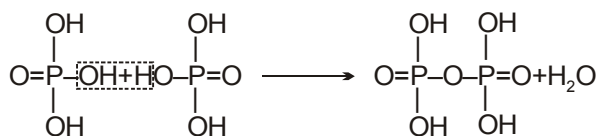
- (A) 3 and 3 (B) 4 and 4
(C) 3 and 4 (D) 4 and 3

Sol.(C) In P_4O_6 each phosphorus is linked to three oxygen atoms; whereas in P_4O_{10} each phosphorus atom is linked to four oxygen atoms.

Ex.2 Pick out out incorrect statement -

- (A) Orthophosphorus acid acn be obtained by reacting P_4O_6 with H_2O
(B) Orthophosphoric acid can be obtained by reacting P_4O_{10} with H_2O
(C) Pyrophosphoric acid can be obtained by heating orthophosphourus acid
(D) Metaphosphoric acid is obtained by the dehydration of orthophosphoric acid at $316^\circ C$.

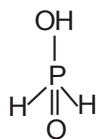
Sol.(C)



Ex.3 Hypophosphorus acid H_3PO_2 is -

- (A) Tribasic acid (B) Dibasic acid
(C) Monobasic acid (D) Not acidic at all

Sol.(C) Structure of Hypophosphorus acid. As it contains only one replaceable H atom. it is mono basic.



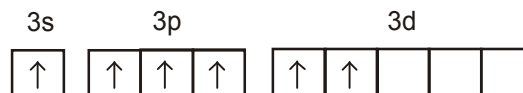
Ex.4 Maximum covalency of sulphur is -

- (A) 2 (B) 4
(C) 6 (D) - 2

Sol.(C) Sulphur atom in ground state



sulphur atom in excited state



Due to presence of six unpaired electrons, it can form maximum of six bonds, so covalency is six.

Ex.5 The formula of sulphur molecule is -

- (A) S_2 (B) S_4
(C) S_6 (D) S_8

Sol.(D) Sulphur atom in S_8 molecule is in sp^3 hybridization state and involves both bonding and non bonding pairs of electrons.

Ex.6 Which of the following is the strongest oxidant -

- (A) F_2 (B) Cl_2
(C) Br_2 (D) I_2

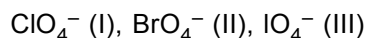
Sol. F_2 is strongest oxidant, because (i) F_2 has exceptionally low dissociation energy of F-F bond, (ii) F^- has high energy of hydration due to small size of the F^- ion.

Ex.7 Which of the following is a false statement-

- (A) Halogens are strong oxidizing agent
(B) Halogens show only (-1) oxidation state
(C) HF molecules form intermolecular H-bonds
(D) Fluorine is highly reactive

Sol.(B) Fluorine, being most electronegative element, always show the oxidation state of -1. Other halogens can show higher positive oxidation state i addition to negative oxidation of -1.

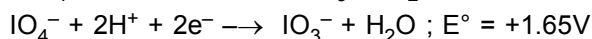
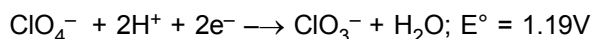
Ex.8 Consider the following perhalate ion in acidic medium



Arrange these in the decreasing order of oxidizing power.

- (A) I > II > III (B) I > III > II
(C) II > I > III (D) II > III > I

Sol.(D) Standard reduction potential (in volts) of the perhalate ions are gives as below -



more the standard reduction potential, the more is tendency of perhalite ion to undergo reduction and more stronger it will be an oxidizing agent.

Ex.9 Which of the following reactions will give bleaching powder –

- (A) $\text{CaCl}_2 + \text{H}_2\text{O}$ (B) $\text{CaO} + \text{HCl}$
 (C) $\text{Ca(OH)}_2 + \text{Cl}_2$ (D) $\text{ClO}_2 + \text{Ca(OH)}_2$

Sol.(C) $\text{Ca(OH)}_2 + \text{Cl}_2 \rightarrow \text{CaOCl}_2 + \text{H}_2\text{O}$
 Slaked lime

Ex.10 The boiling point and melting point of inert gases are –

- (A) Low (B) High
 (C) Very high (D) Very low

Sol.(D) Very weak, Vander Waals forces.

Ex.11 The ease of liquefaction of noble gases increases in the order –

- (A) $\text{He} < \text{Ne} < \text{Ar} < \text{Kr} < \text{Xe}$
 (B) $\text{Xe} < \text{Kr} < \text{Ne} < \text{Ar} < \text{He}$
 (C) $\text{Kr} < \text{Xe} < \text{He} < \text{Ne} < \text{Ar}$
 (D) $\text{Ar} < \text{Kr} < \text{Xe} < \text{Ne} < \text{He}$

Sol.(A) As size increases, Vander Waals forces also increases.

Ex.12 Noble gases can be separated by –

- (A) Passing them through some solution
 (B) Electrolysis of their compounds
 (C) Adsorption and desorption on coconut charcoal
 (D) None

Sol.(C) Coconut charcoal possess characteristic property for adsorbing different noble gases at different temperatures.

Ex.13 The statement, which prompted Neil Bartlett to prepare the first noble gas compound was –

- (A) Xe-F bond has high bond energy
 (B) F_2 has exceptionally low bond energy
 (C) PtF_6 is a strong oxidant
 (D) O_2 molecule and Xe atom have very similar ionization energies.

Sol. Both Xe and O_2 have comparable ionisation energies.

$\text{Xe} \rightarrow \text{Xe}^+ + \text{e}^-$ ionisation energy = 1,170 kJ/mol

$\text{O}_2 \rightarrow \text{O}_2^+ + \text{e}^-$ ionisation energy = 1,175 kJ/mol

Ex.14 Which of the following halides is most acidic ?
 (A) PCl_3 (B) SbCl_3 (C) BiCl_3 (D) CCl_4

Sol.(A) In CCl_4 , carbon atom does not have d-orbitals to accommodate a lone pair of electrons and hence is not a Lewis acid. In PCl_3 , SbCl_3 , BiCl_3 central atom has empty d-orbitals and hence is a Lewis acid in each case but electronegativity of p is maximum, hence PCl_3 is strongest acid. In PCl_3 , SbCl_3 and BiCl_3 central atom has maximum, hence PCl_3 is strongest acid.

Ex.15 Compounds A and B are treated with dilute HCl separately. The gases liberated are Y and Z respectively. Y turns acidified $\text{K}_2\text{Cr}_2\text{O}_7$ paper green while Z turns lead acetate paper black. The compounds A and B are respectively –

- (A) Na_2S and Na_2SO_3
 (B) Na_2SO_3 and Na_2S
 (C) NaCl and Na_2CO_3
 (D) Na_2SO_3 and Na_2SO_4

Sol. SO_2 turns acidified $\text{K}_2\text{Cr}_2\text{O}_7$ paper green.
 $\text{Na}_2\text{SO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + \text{SO}_2 + \text{H}_2\text{O}$
 (Y)

$\text{K}_2\text{Cr}_2\text{O}_7 + \text{H}_2\text{SO}_4 + 3\text{SO}_2 \rightarrow \text{Cr}_2(\text{SO}_4)_3 + \text{K}_2\text{SO}_4 + \text{H}_2\text{O}$
 Green

H_2S turns lead acetate paper black.

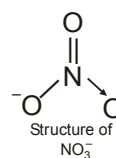
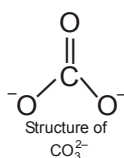
$\text{Na}_2\text{S} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + \text{H}_2\text{S}$
 (Z)

$\text{H}_2\text{S} + \text{Pb}(\text{CH}_3\text{COO})_2 \rightarrow \text{PbS} + 2\text{CH}_3\text{COOH}$

Ex.16 Which of the following are isoelectronic and isostructural ?

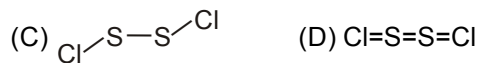
- (A) NO_3^- , CO_3^{2-} , (B) SO_3 , NO_3^-
 (C) ClO_3^- , CO_3^{2-} (D) CO_3^{2-} , SO_3

Sol. NO_3^- and CO_3^{2-} both have same number of electrons (32 electrons) and central atom in each being sp^2 hybridized.



$\text{SO}_3 = 40$ electrons
 $\text{ClO}_3^- = 42$ electrons

Ex.17 Which of the following is correct structure of S_2Cl_2 -

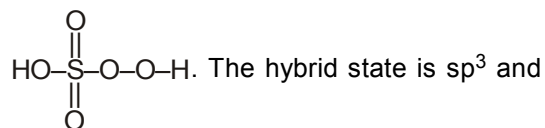


Sol.(C)

Ex.18 What is the hybrid state and oxidation state of sulphur in Caro's acid ?

- (A) sp^2 , +10 (B) sp^3 , +10
(C) sp^2 , +6 (D) sp^3 , +6

Sol.(D) The structure of Caro's acid is



its O.N. is +6.]

Ex.19 Identify the correct sequence of increasing number of π -bonds in structures of the following molecules -

- (i) $H_2S_2O_6$ (ii) H_2SO_3
(iii) $H_2S_2O_5$
(A) I, II, III (B) II, III, I
(C) II, I, III (D) I, III, II

Sol.(B) $H_2S_2O_6$, $H-O-S(=O)_2-S(=O)_2-OH$ - 4 π -bonds;

H_2SO_3 , $HO-S(=O)-OH$ - one π -bond;

$H_2S_2O_5$, $H-O-S(=O)_2-S(=O)-OH$ - 3 π -bonds;

Ex.20 I_4O_9 is an -

- (A) covalent bond
(B) coordinate compound
(C) ionic compound
(D) double salt

Sol.(C) I_4O_9 is actually $I(IO_3)_3$ which gets ionised.



Ex.21 $Cl_2 \begin{cases} \xrightarrow{\text{Cold and dilute NaOH}} (A) + NaCl + H_2O \\ \xrightarrow{\text{Hot and conc. NaOH}} (B) + NaCl + H_2O \end{cases}$

Compounds (A) and (B) are -

- (A) $NaClO_3$, $NaClO$
(B) $NaOCl_2$, $NaOCl$
(C) $NaClO_4$, $NaClO_3$
(D) $NaOCl$, $NaClO_3$

Sol.(D) $Cl_2 + 2NaOH \rightarrow NaCl + NaOCl + H_2O$

Cold and dil. (A)

$3Cl_2 + 6NaOH \rightarrow 5NaCl + NaOCl + 3H_2O$

Hot and conc. (B)

Ex.22 When chlorine water is added to an aqueous solution of sodium iodide in the presence of chloroform, a violet colouration is obtained. On adding more of chlorine water and vigorous shaking, the violet colour disappears. This shows the conversion of.....into.....

- (A) I_2 , HIO_3 (B) I_2 , HI
(C) HI , HIO_3 (D) I_2 , HIO

Sol.(A) $Cl_2 + 2NaI \rightarrow 2NaCl + I_2$

(Violet colouration in chloroform)

$5Cl_2 + 6H_2O + I_2 \rightarrow 2HIO_3 + 10HCl$

colourless

Ex.23 A greenish yellow gas reacts with an alkali hydroxide to form a halate which can be used in fireworks and safety matches. The gas and the halate are -

- (A) Br_2 , $KBrO_3$ (B) Cl_2 , $KClO_3$
(C) I_2 , $NaIO_3$ (D) I_2 , KIO_3

Sol.(B) The halate used in fireworks and safety matches is $KClO_3$. Thus, the gas is Cl_2 .

$3Cl_2 + 6KOH \rightarrow KClO_3 + 5KCl + 3H_2O$

greenish

yellow gas