UNIT – 3 – P-BLOCK ELRMENTS - II

II. Answer the following questions:

1. What is inert pair effect? [QY-19, MAY-22, QY,HY-22, QY-23]

In p-block elements, as we go down the group, two electrons present in the valence s-orbital become inert and are not available for bonding (only p-orbital involves chemical bonding). This is called inert pair effect. This effect is also observed in groups 14, 15 and 16.

2. Chalcogens belongs to p-block. Give reason. [SRT-22]

- Chalcogens are ore forming elements.
- Most of the ores are oxides and sulphides, therefore oxygen, sulphur and other group 16 elements are called Chalcogens.
- In O, S, Se, Te and Po last electron enters to p-orbital.
- Therefore Chalcogens belongs to p-block.
- Chalcogens general electronic configuration is ns^2np^4.

3. Explain why fluorine always exhibit an oxidation state of -1? [FUT-23]

- The electronic configuration of Fluorine is $1s^2$, $2s^2$, $2p_x^2$, $2p_y^2$, $2p_z^1$.
- Fluorine the most electronegative element than other halogens and cannot exhibit any positive oxidation state.
- Fluorine does not have d-orbital while other halogens have d-orbitals.
- Therefore fluorine always exhibit an oxidation state of-1 and others in halogen family shows +1, +3, +5 and +7 oxidation states.

4. Give the oxidation state of halogen in the following.

(i) OF_2 [MAR-23] (ii) O_2F_2 (iii) Cl_2O_3 [SRT-23] (iv) I_2O_4 [SRT,MAR-23]

(i) OF_2	(ii) O_2F_2	(iii) Cl_2O_3	(iv) I_2O_4
$+2 + 2(x) = 0$	$2(+1) + 2x = 0$	$2(x) + 3(-2) = 0$	$2(x) + 4(-2) = 0$
$+2 = -2x$	$2x = -2$	$2x = +6$	$2x = +8$
$2x = -2$ $x = -1$	$x = -1$	$x = +3$	$x = +4$

5. What are interhalogen compounds? Give examples. [GMQ,HY-19, AUG-21, MAY-22, QY-22, QY-23]

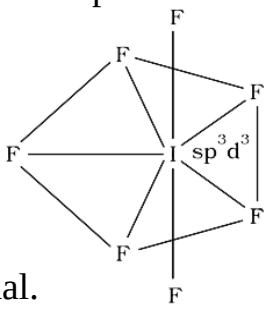
Each halogen combines with other halogens to form a series of compounds called interhalogen compounds. For example, ClF, BrF_3, ClF_3, BrF_5, IF_7.

6. Why fluorine is more reactive than other halogens? [PTA-1&3, QY-19]

Fluorine is the most reactive element among halogen. This is due to the minimum value of F – F bond dissociation energy. Hence fluorine is more reactive than other halogens.

7. Give the uses of helium. [PTA-2, GMQ, QY-19, SEP-20, AUG-21, SRT-22, QY-22, QY,JUN-23, MAR-24]

- Helium and oxygen mixture is used by divers in place of air oxygen mixture. This prevents the painful dangerous condition called bends.
- Helium is used to provide inert atmosphere in electric arc welding of metals
- Helium has lowest boiling point hence used in cryogenics (low temperature science).
- It is much less denser than air and hence used for filling air balloons



8. What is the hybridisation of iodine in IF_7? Give its structure.

Hybridisation of iodine in IF_7 is sp^3d^3 Structure of IF_7 is pentagonal bi-pyramidal.

9. Give the balanced equation for the reaction between chlorine with cold NaOH and hot NaOH. [SEP-20]

- Reaction between chlorine with cold NaOH: $Cl_2 + H_2O \rightarrow HCl + HOCl$

$HCl + NaOH \rightarrow NaCl + H_2O$ $HOCl + NaOH \rightarrow NaOCl + H_2O$

Overall reaction $Cl_2 + 2NaOH \longrightarrow \underset{\text{sodium hypo chlorite}}{NaOCl} + NaCl + H_2O$

Chlorine reacts with cold NaOH to give sodium chloride and sodium hypochlorite.

- Reaction between chlorine with hot NaOH: $Cl_2 + H_2O \rightarrow HCl + HOCl$

$HCl + NaOH \rightarrow NaCl + H_2O$ $HOCl + NaOH \rightarrow NaOCl + H_2O$

$3NaOCl \rightarrow NaClO_3 + 2NaCl$

Overall reaction $3Cl_2 + 6NaOH \longrightarrow \underset{\text{sodium chlorate}}{NaClO_3} + 5NaCl + 3H_2O$

Chlorine reacts with hot NaOH to give sodium chlorate and sodium chloride.

10. How will you prepare chlorine in the laboratory? [PTA-2, FUT-23]

- Chlorine is prepared by the action of cone, sulphuric acid on chlorides in presence of manganese dioxide. $4NaCl + MnO_2 + 4H_2SO_4 \rightarrow Cl_2 + MnCl_2 + 4NaHSO_4 + 2H_2O$
- It can also be prepared by oxidising hydrochloric acid using various oxidising agents such as manganese dioxide, lead dioxide, potassium permanganate or dichromate.

$PbO_2 + 4HCl \rightarrow PbCl_2 + 2H_2O + Cl_2$ $MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + Cl_2$

$2KMnO_4 + 16HCl \rightarrow 2KCl + 2MnCl + 8H_2O + 5Cl_2$

$K_2Cr_2O_7 + 14HCl \rightarrow 2KCl + 2CrCl_3 + 7H_2O + 3Cl_2$

- When bleaching powder is treated with mineral acids chlorine is liberated

$CaOCl_2 + 2HCl \rightarrow CaCl_2 + H_2O + Cl_2$ $CaOCl_2 + H_2SO_4 \rightarrow CaSO_4 + H_2O + Cl_2$

11. Give the uses of sulphuric acid.

- Sulphuric acid is used in the manufacture of fertilisers, ammonium sulphate and super phosphates and other chemicals such as hydrochloric acid, nitric acid etc.
- It is used as a drying agent and also used in the preparation of pigments, explosives etc.

12. Prove that sulphuric acid is a dehydrating agent (or) Give a reason to support that sulphuric acid is a dehydrating agent. [PTA1,QY,HY19, HY22, JUN, QY23, MAR24]

- Sulphuric acid is highly soluble in water. It has strong affinity towards water
- Hence it can be used as a dehydrating agent.
- When dissolved in water it forms mono ($H_2SO_4.H_2O$) and di ($H_2SO_4.2H_2O$) hydrates and the reaction is exothermic. The dehydration property can also be illustrated by its reaction with organic compounds such as sugar, oxalic acid and HCOOH.

$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2SO_4 \longrightarrow 12C + H_2SO_4.11H_2O$

$\underset{\text{Formic acid}}{HCOOH} + H_2SO_4 \longrightarrow CO + H_2SO_4.H_2O$

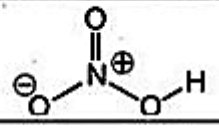
$\underset{\text{Oxalic acid}}{(COOH)_2} + H_2SO_4 \longrightarrow CO + CO_2 + H_2SO_4.H_2O$

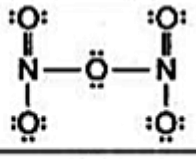
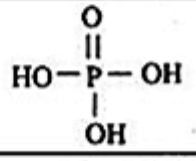
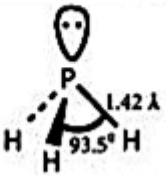
13. Write the reason for the anamolous behaviour of Nitrogen.

- Due to its small size, high electro negativity, high ionisation enthalpy and absence of d-orbitals. Nitrogen exists a diatomic molecule with triple bond between the two atoms whereas other elements form single bond in the elemental state.
- N, has a unique ability to form pπ – pπ multiple bond whereas the heavier members of this group (15) do not form pπ – pπ bond, because their atomic orbitals are so large and diffused that they cannot have effective overlapping.
- N cannot form dπ – pπ bond due to the absence of d – orbitals whereas other elements can.

14. Write the molecular formula and structural formula for the following molecules.

(a) Nitric acid (b) dinitrogen pentoxide (c) phosphoric acid (d) phosphine

	Molecule	Molecular formula	Structure
a.	Nitric acid	HNO_3	

b.	Dinitorgen pentaoxide	N_2O_5	
c.	Phosphoric acid	H_3PO_4	
d.	Phosphine	PH_3	

15. Give the uses of argon. [PTA-2, JULY-22]

- Mixed with 20.06% nitrogen and it is used in gas filled electric lamps.
- It is also used in radio valves and tubes.
- Argon prevents the oxidation of hot filament and prolongs the life in filament bulbs.

16. Write the valence shell electronic configuration of group-15 elements.

General electronic configuration of group 15 elements are ns^2np^3.

- Nitrogen – [He] $2s^2\ 2p^3$ Phosphorous – [Ne] $3s^2\ 3p^3$ Arsenic – [Ar] $3d^{10}\ 4s^2\ 4p^3$
- Antimony – [Kr] $4d^{10}\ 5s^2\ 5p^3$ Bismuth – [Ne] $4f^{14}\ 5s^{10}\ 6s^2\ 6p^3$

17. Give two equations to illustrate the chemical behaviour of phosphine.

- Phosphine reacts with halogens to give phosphorous penta halides.

$$PH_3 + 4Cl_2 \rightarrow PCl_5 + 3HCl$$

- Phosphine forms coordination compound with lewis acids such as boron trichloride.

$$BCl_3 + PH_3 \rightarrow [Cl_3B \leftarrow :PH_3]$$

- Phosphine precipitates some metal from their salt solutions.

$$3AgNO_3 + PH_3 \rightarrow Ag_3P + 3HNO_3$$

18. Give a reaction between nitric acid and a basic oxide. [FUT-23]

Nitric acid reacts with bases and basic oxides to form salts and water.

$ZnO + 2HNO_3 \rightarrow Zn(NO_3)_2 + H_2O$ $3FeO + 10HNO_3 \rightarrow 3Fe(NO_3)_3 + NO + 5H_2O$

19. What happens when PCl_5 is heated?

On heating phosphorous pentachloride, it decomposes into phosphorus trichloride and chlorine. $PCl_5 \xrightarrow{\Delta} PCl_3 + Cl_2$

20. Suggest a reason why HF is a weak acid, whereas binary acids of the all other halogens are strong acids.

- Fluorine has the greatest affinity for hydrogen, due to the large electro negativity difference between them, forming HF which is associated due to the hydrogen bonding.
- Hydrofluoric acid is a weak acid are strong acids. .....H-F.....H-F.....H-F.....
- Due to hydrogen bonding in HF, it cannot be completely ionised and therefore they are weak acids. But other hydrohalic acids are completely ionised and so are strong acids.

21. Deduce the oxidation number of oxygen in hypofluorous acid – HOF.

- In case of O – F bond is HOF, fluorine is most electronegative element. So its oxidation number is -1.
- Thereby oxidation number of O is +1. Similarly in case of O – H bond is HOF. O is highly electronegative than H. So its oxidation number is -1 and oxidation number of H is +1.
- So, Net oxidation of oxygen is $+1 + x - 1 = 0$. Oxidation number of O in HOF is zero.

22. What type of hybridisation occur in (i) BrF_5 (ii) BrF_3 [SEP-20]

(i) BrF_5 : BrF_5 is a AX_5 type. Therefore is has sp^3d^2 hybridisation. Hence, it has square pyramidal shape.

(ii) BrF_3 : BrF_3 is a AX_3 type. Therefore it has sp^3d hybridisation. Hence, it has T-shape.

23. Complete the following reactions.

1. **$NaCl + MnO_2 + H_2SO_4 \longrightarrow$**

   $4NaCl + MnO_2 + 4H_2SO_4 \longrightarrow Cl_2 + MnCl_2 + 4\,NaHSO_4 + 2H_2O$

2. **$NaNO_2 + HCl \longrightarrow$**

   $NaNO_2 + HCl \longrightarrow NaCl + HNO_2$

3. **$IO_3^- + I^- + H^+ \longrightarrow$**

   $IO_3^- + 5I^- + 6H^+ \longrightarrow 3I_2 + 3H_2O$

4. **$I_2 + S_2O_3^{2-} \longrightarrow$**

   $I_2 + 2S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + 2I^-$

5. **$P_4 + NaOH + H_2O \longrightarrow$ [MAR-23]**

   $P_4 + 3NaOH + 3H_2O \longrightarrow 3NaH_2PO_2 + PH_3\uparrow$

6. **$AgNO_3 + PH_3 \longrightarrow$ [FUT-23]**

   $3AgNO_3 + PH_3 \longrightarrow Ag_3P + 3HNO_3$

7. **$Mg + HNO_3 \longrightarrow$**

   $4Mg + 10HNO_3 \longrightarrow 4\,Mg(NO_3)_2 + NH_4NO_3 + 3H_2O$

8. **$KClO_3 \xrightarrow{\Delta}$ [FUT-23]**

   $2KClO_3 \xrightarrow[MnO_2]{\Delta} 2KCl + 3O_2$

9. **Cu + Hot Conc.$H_2SO_4 \longrightarrow$ [MAR, FUT-23]**

   $Cu + \text{Hot Conc.}2H_2SO_4 \longrightarrow CuSO_4 + 2H_2O + SO_2\uparrow$

10. **$Sb + Cl_2 \longrightarrow$**

    $2Sb + 3Cl_2 \longrightarrow 2SbCl_3$

11. **$HBr + H_2SO_4 \longrightarrow$**

    $2HBr + H_2SO_4 \longrightarrow 2SO_2 + 2H_2O + Br_2$

12. **$XeF_6 + H_2O \longrightarrow$ [MAR-23]**

    $XeF_6 + 3H_2O \longrightarrow XeO_3 + 6HF$

13. **$XeO_6^{4-} + Mn^{2+} + H^+ \longrightarrow$**

    $5XeO_6^{4-} + 2Mn^{2+} + 14H^+ \longrightarrow 2MnO_4^- + 5XeO_3 + 7H_2O$

14. **$XeOF_4 + SiO_2 \longrightarrow$**

    $2XeOF_4 + SiO_2 \longrightarrow 2XeO_2F_2 + SiF_4$

15. **$Xe + F_2 \xrightarrow[400°C]{Ni\ /\ 200\ atm}$**

    $Xe + 3F_2 \xrightarrow[400°C]{Ni\ /\ 200\ atm} XeF_6$

EVALUATE YOURSELF

1. Write the products formed in the reaction of nitric acid (both dilute and concentrated) with zinc.

(*i*) Zinc with Conc. HNO_3:

$4Zn + 10HNO_3 \longrightarrow \underset{\text{(Zinc nitrate)}}{4Zn(NO_3)_2} + \underset{\text{(Ammonium nitrate)}}{NH_4NO_3} + 3H_2O$

(*ii*) **Zinc with Dil. HNO_3:**

$$4Zn + 10HNO_3 \longrightarrow \underset{\text{(Zinc nitrate)}}{4Zn(NO_3)_2} + \underset{\text{(Nitrous oxide)}}{N_2O} + 5H_2O$$

GOVERNMENT EXAM QUESTION PAPER

1. What are the properties of inter halogen compounds? [PTA-2, QY-19, JUL-22]

Properties of inter halogen compounds:

- The central atom will be the larger one.
- It can be formed only between two halogen and not more than two halogens.
- Fluorine can't act as a central metal atom being the smallest one.
- Due to high electronegativity with small size fluorine helps the central atom to attain high coordination number.
- They can undergo the auto ionization.
- They are strong oxidising agents included.

$$2ICl \rightleftharpoons I^+ + ICl_2^- \qquad 2ICl_3 \rightleftharpoons ICl_2^+ + ICl_4^-$$

2. How is pure phosphine prepared from phosphorous acid? [GMQ-19, HY-22]

Phosphine is prepared in pure form by heating phosphorous acid.

$$\underset{\text{Phosphorous acid}}{4H_3PO_3} \xrightarrow{\Delta} \underset{\text{Ortho phosphoric acid}}{3H_3PO_4} + \underset{\text{Phosphine}}{PH_3}\uparrow$$

3. How is bleaching powder prepared? [MAR-20, MAY-22]

Bleaching powder is produced by passing chlorine gas through dry slaked lime (calcium hydroxide). $Ca(OH)_2 + Cl_2 \longrightarrow CaOCl_2 + H_2O$

4. SO_2 – is a reducing agent. Prove it. [SRT-22]

- SO_2 – It can readily be oxidised, it acts as a reducing agent. It reduces chlorine into hydrochloric acid. $SO_2 + 2H_2O + Cl_2 \rightarrow H_2SO_4 + 2HCl$
- It also reduces potassium permanganate and dichromate to Mn^{2+}

$$2KMnO_4 + 5SO_2 + 2H_2O \rightarrow K_2SO_4 + 2MnSO_4 + 2H_2SO_4$$

5. What is the reaction of ammonia on Cu^{2+} solution? [SRT-22]

Ammonia reacts with metallic salts to forming complexes

$$Cu^{2+} + 4NH_3 \longrightarrow \underset{\text{Tetraamminecopper(II)ion (a coordination complex)}}{[Cu(NH_3)_4]^{2+}}$$

6. What are the uses of oxygen? [MAY-22]

- Oxygen is used up by living beings in respiration process.
- It is used for burning of fuels.
- In industry it is used for cutting, welding and melting metals.
- It is used in water treatment and chemical combustion.

7. Explain the bleaching action of Chlorine? [QY-19]

Oxidising and bleaching action: Chlorine is a strong oxidising and bleaching agent because of the nascent oxygen.

$$H_2O + Cl_2 \longrightarrow HCl + \underset{\text{Hypo chlorous acid}}{HOCl}$$

$$HOCl \longrightarrow HCl + (O)$$

Colouring matter + Nascent oxygen → Colourless oxidation product

The bleaching of chlorine is permanent. It oxidises ferrous salts to ferric, sulphites to sulphates and hydrogen sulphide to sulphur.

$$2FeCl_2 + Cl_2 \longrightarrow 2FeCl_3$$

$$Cl_2 + H_2O \longrightarrow HCl + HOCl$$

$$2FeSO_4 + H_2SO_4 + HOCl \longrightarrow Fe_2(SO_4)_3 + HCl + H_2O$$

overall reaction $2FeSO_4 + H_2SO_4 + Cl_2 \longrightarrow Fe_2(SO_4)_3 + 2HCl$

$Cl_2 + H_2O \longrightarrow HCl + HOCl$

$Na_2SO_3 + HOCl \longrightarrow Na_2SO_4 + HCl$

overall reaction $Na_2SO_3 + H_2O + Cl_2 \longrightarrow Na_2SO_4 + 2HCl$

$Cl_2 + H_2S \longrightarrow 2HCl + S$

8. Why HF cannot be stores in glass bottles? [MAR-20]

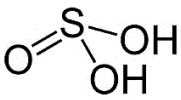
Moist hydrofluoric acid (not dry) rapidly react with silica and glass.

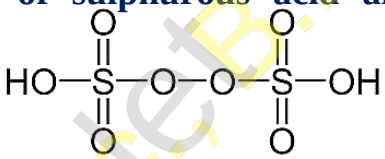
$$SiO_2 + 4HF \rightarrow SiF_4 + 2H_2O$$

$$Na_2SiO_3 + 6HF \rightarrow Na_2SiF_6 + 3H_2O$$

9. Write the molecular formula and draw the structure of sulphurous acid and Marshall's acid. [MAR-20]

(i) Sulphurous acid (H_2SO_3)





(ii) Marshall's acid or Peroxodisulphuric acid ($H_2S_2O_8$)

10. Write a short note on Holmes Signal. [SEP-20, HY-22]

- In a ship, a pierced container with a mixture of calcium carbide and calcium phosphide, liberates phosphine and acetylene when thrown into sea.
- The liberated phosphine catches fire and ignites acetylene.
- These burning gases serves as a signal to the approaching ships.
- This is known as **Holmes signal**.

11. Explain the bleaching action of Sulphur dioxide. [AUG-21, JUN-23]

In presence of water, sulphur dioxide bleaches coloured wool, silk, sponges and straw into colourless due to its reducing property. $SO_2 + 2H_2O \longrightarrow H_2SO_4 + 2(H)$

$$\underset{\text{Coloured}}{X} + 2(H) \longrightarrow \underset{\text{Colourless}}{XH_2}$$

However, the bleached product (colourless) is allowed to stand in air, it is reoxidised by atmospheric oxygen to its original colour. Hence bleaching action of sulphur dioxide is temporary.

Uses: Sulphur dioxide is used in bleaching hair, silk, wool etc...

- It can be used for disinfecting crops and plants in agriculture.

Structure of sulphur dioxide: In sulphur dioxide, sulphur atom undergoes sp2 hybridisation. A double bond arises between S and O is due pπ – dπ overlapping.

12. Complete the following reactions. [SRT-22]

(i) NH_3 (excess) + Cl_2 → ?

(ii) NH_3 + Cl_2 (excess) → ?

(i) With excess ammonia $2\,NH_3 + 3\,Cl_2 \longrightarrow N_2 + 6\,HCl$

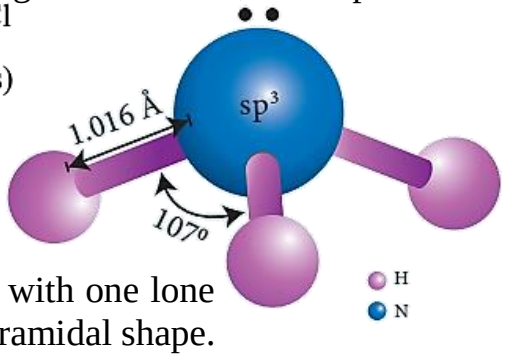
$6\,HCl + 6\,NH_3 \longrightarrow 6\,NH_4Cl$

(ii) With excess of chlorine ammonia reacts to give nitrogen trichloride, an explosive substance. $2NH_3 + 6Cl_2 \longrightarrow 2NCl_3 + 6\,HCl$

$2NH_3(g) + HCl(g) \longrightarrow NH_4Cl\,(s)$

13. Explain the structure of ammonia. [SRT-22]

- Ammonia molecule is pyramidal in shape N-H bond distance is 1.016 Å and H-H bond distance is 1.645 Å with a bond angle 107°.
- The structure of ammonia may be regarded as a tetrahedral with one lone pair of electrons in one tetrahedral position hence it has a pyramidal shape.



14.Show that phosphine act as a reducing agent. [QY-23]

Phosphine shows reducing agent in the reaction with some metal compounds. For example, Phosphine reacts with $AgNO_3$ to reduce and produce precipitates of Ag_3P (silver phosphide).

$$3AgNO_3 + PH_3 \longrightarrow Ag_3P + 3HNO_3$$

15.Powdered $CaCO_3$ reacts much faster with dilute HCl than with the same mass of $CaCO_3$ as marble. Give reason. [SEP-20]

For a given mass of react and when a particle decrease, surface are increases, Increase in surface area of the reactant leads to more collisions per litre per second and hence the rate of reaction also increases. $CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2$

16.Explain the Deacons's process for manufacture of chlorine [SEP-20]

In this process a mixture of air and hydrochloric acid is passed up a chamber containing a number of shelves, pumice stones soaked in cuprous chloride are placed. Hot gases at about 723K are passed through a jacket that surrounds the chamber.

$$4HCl + O_2 \xrightarrow[Cu_2Cl_2]{400^0C} 2H_2O + 2Cl_2\uparrow$$

The chlorine obtained by this method is dilute and is employed for the manufacture of bleaching powder. The catalysed reaction is given below

$$2Cu_2Cl_2 + O_2 \longrightarrow \underset{\text{Cuprous oxy chloride}}{2Cu_2OCl_2} \qquad Cu_2OCl_2 + 2HCl \longrightarrow \underset{\text{Cupric chloride}}{2CuCl_2} + H_2O$$

$$2CuCl_2 \longrightarrow \underset{\text{Cuprous chloride}}{Cu_2Cl_2} + Cl_2$$

17.Sulphuric acid dibasic acid prove it [SEP-20]

It is a strong dibasic acid. Heance it forms two types of salts sulphates and bisulphates.

$$H_2SO_4 + NaOH \longrightarrow \underset{\text{sodium bisulphate}}{NaHSO_4} + H_2O \qquad H_2SO_4 + 2NaOH \longrightarrow \underset{\text{sodium sulphate}}{Na_2SO_4} + 2H_2O$$

$$H_2SO_4 + 2NH_3 \longrightarrow \underset{\text{Ammonium sulphate}}{(NH_4)_2SO_4}$$