CHAPTER 7

p-BLOCK ELEMENTS

Syllabus

- *Group–15 Elements : General introduction, electronic configuration, occurrence, oxidation states, trends in physical and chemical properties; Nitrogen preparation properties and uses; compounds of Nitrogen: preparation and properties of Ammonia and Nitric Acid, Oxides of Nitrogen (Structure only); Phosphorus - allotropic forms, compounds of Phosphorus: Preparation and properties of Phosphine, Halides and Oxoacids (elementary idea only).*
- *Group–16 Elements : General introduction, electronic configuration, oxidation states, occurrence, trends in physical and chemical properties, dioxygen: preparation, properties and uses, classification of Oxides, Ozone, Sulphur -allotropic forms; compounds of Sulphur: preparation properties and uses of Sulphur-dioxide, Sulphuric Acid: industrial process of manufacture, properties and uses; Oxoacids of Sulphur (Structures only).*
- *Group–17 Elements : General introduction, electronic configuration, oxidation states, occurrence, trends in physical and chemical properties; compounds of halogens, Preparation, properties and uses of Chlorine and Hydrochloric acid, interhalogen compounds, Oxoacids of halogens (structures only).*
- *Group–18 Elements : General introduction, electronic configuration, occurrence, trends in physical and chemical properties, uses.*

Trend Analysis

List of Concepts	2018	2019		2020	
	D/OD	D	OD	D	OD
Draw the structure	2Q (2 marks)		2Q (1 mark)	3Q (2 marks)	
What happens when	1Q (2 marks)	2Q (1 mark)			1Q (1 mark)
Give reason	1Q (3 marks)	3Q (1 mark)	1Q (5 marks)		
Complete the reactions	1Q (1 mark)	1Q (2 marks)	1Q (2 marks)		
Arrange the following	1Q (1 mark)/ 1Q (2 marks)	1Q (2 marks)			
Miscellaneous	1Q (3 marks)	1Q (2 marks)			

TOPIC-1

Group-15 Elements, Properties and Some Important Compounds

Revision Notes

- **Elements of *p*-Block :**

Group 13	Boron family	B, Al, Ga, In, Tl
Group 14	Carbon family	C, Si, Ge, Sn, Pb
Group 15	Nitrogen family	N, P, As, Sb, Bi
Group 16	Oxygen family	O, S, Se, Te, Po
Group 17	Halogen family	F, Cl, Br, I, At
Group 18	Noble gases	He, Ne, Ar, Kr, Xe, Rn

- General electronic configuration of *p*-Block elements : $ns^2\, np^{1-6}$

- **Group 15 elements :**
  - **(i)** **Nitrogen family :** $_{7}N$, $_{15}P$, $_{33}As$, $_{51}Sb$, $_{83}Bi$
  - **(ii)** **Atomic radii :** Smaller than the corresponding elements of group 14. Down the group, they increase due to addition of new shells.
  - **(iii)** **Ionisation enthalpy :** Higher than the corresponding elements of group 14. Down the group, it decreases due to increase in atomic size.
  - **(iv)** **Electronegativity :** Decreases down the group with increasing atomic size.
- **Physical properties of Group 15 elements :**
  - **(i)** Except dinitrogen, all are solids.
  - **(ii)** Metallic character increases down the group due to decrease in ionisation enthalpy and increase in the atomic size.
  - **(iii)** Boiling point increases from top the bottom.
  - **(iv)** Melting point increases upto arsenic and decreases upto bismuth.
  - **(v)** **Oxidation states :** –3 to +5.
- **Chemical properties of Group 15 elements :**
  - **(i)** **Towards hydrogen :** All the elements form hydrides of the type EH_3 where E = N, P, As, Sb, Bi. The stability decreases from NH_3 to BiH_3. Reducing character increases down the group. Basic character decreases down the group. Boiling point of NH_3 is greater than PH_3 because of intermolecular hydrogen bonding. Boiling point increases from PH_3 onwards.
  - **(ii)** **Towards oxygen :** Form two types of oxides E_2O_3 and E_2O_5. The acidic character decreases down the group.
  - **(iii)** **Towards halogens :** Directly combine with halogens to form trihalides (EX_3) and pentahalides (EX_5).
  - **(iv)** **Towards metals :** All the elements react with metals to form their binary compounds exhibiting –3 oxidation state.
- **Anomalous properties of nitrogen :** N does not form pentahalides because of non-availability of *d*-orbitals in its valence shell. It has ability to form pπ-pπ multiple bonds with itself and other elements having high electronegativity. N differs from the rest of the members of group due to small size, high electronegativity, high ionisation enthalpy and non-availability of *d*-orbitals.
- **Oxides of Nitrogen: Preparation and Properties:**

S. No.	Formula	Name	Preparation	Properties	O.N.
1.	N_2O	Dinitrogen monoxide	$NH_4NO_3 \xrightarrow{heat} N_2O + 2H_2O$	Colourless gas, rather unreactive.	+1
2.	NO	Nitrogen monoxide	$3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$	Colourless gas, paramagnetic, neutral.	+2
3.	NO_2	Nitrogen dioxide	$2Pb(NO_3)_2 \xrightarrow{673K} 2PbO + 4NO_2 + O_2$	Brown gas, reactive, paramagnetic, neutral.	+4

4.	N_2O_3	Dinitrogen trioxide	$2NO + N_2O_4 \xrightarrow{250\,K} 2N_2O_3$	Dark blue in liquid or solid state, unstable in the gas phase.	+3
5.	N_2O_4	Dinitrogen tetroxide	$2NO_2 \underset{373\,K}{\overset{273\,K}{\rightleftharpoons}} N_2O_4$	Colourless, exists in equilibrium with NO_2 both in the gaseous and liquid state.	+4
6.	N_2O_5	Dinitrogen pentoxide	$2HNO_3 + P_2O_5 \rightarrow 2HPO_3 + N_2O_5$ Metaphosphoric acid	Unstable as gas; in the solid state exists as $[NO_2]^+ [NO_3]^-$.	+5

- **Structures of Oxides of Nitrogen :**

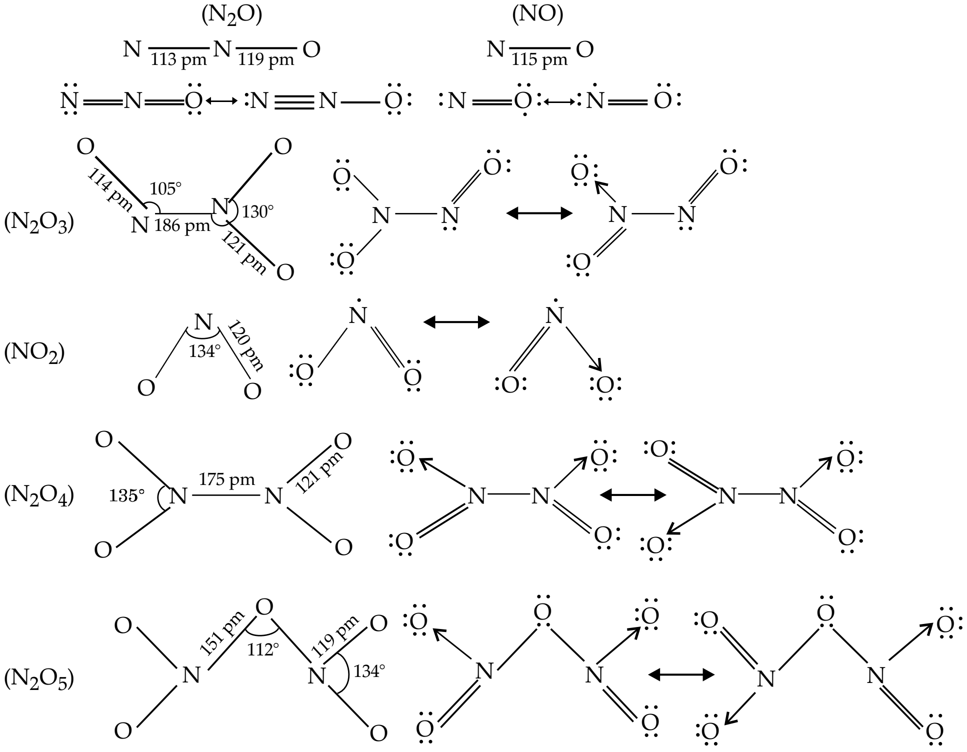


Fig. 1 : The molecular and Lewis dot resonance structure of oxides of nitrogen

- **Dinitrogen (N_2) :**

Preparation :

(i) In laboratory : $NH_4Cl(aq) + NaNO_2(aq) \xrightarrow{heat} N_2(g) + 2H_2O(l) + NaCl(aq)$

(ii) By thermal decomposition :

$$Ba(N_3)_2 \rightarrow Ba + 3N_2$$

Properties :

(i) N_2 has very little reactivity at ordinary temperature.

(ii) Forms nitrides with highly electropositive metals like

$$3Mg + N_2 \rightarrow Mg_3N_2$$
$$6Li + N_2 \rightarrow 2Li_3N$$

- **Ammonia (NH_3) :**

Preparation :

(i) In laboratory : $2NH_4Cl + Ca(OH)_2 \xrightarrow{heat} CaCl_2 + 2NH_3 + 2H_2O$

(ii) By Haber's process :

$$N_{2(g)} + 3H_{2(g)} \underset{773\,K}{\overset{Fe/Mo}{\rightleftharpoons}} 2NH_{3(g)}, \Delta H = -46.1 \text{ kJ mol}^{-1}$$

Properties :

(i) Extremely soluble in water.

(ii) Acts as Lewis base

$$Ag^+ + 2NH_3 \rightleftharpoons [Ag(NH_3)_2]^+$$

$$Cu^{2+} + 4NH_3 \rightleftharpoons \underset{\text{Deep blue}}{[Cu(NH_3)_4]^{2+}}$$

$$Cd^{2+} + 4NH_3 \rightleftharpoons [Cd(NH_3)_4]^{2+}$$

(iii) Forms salts with acids

$$ZnSO_4(aq) + 2NH_4OH(aq) \rightarrow Zn(OH)_2(s) + (NH_4)_2SO_4(aq)$$

$$2FeCl_3(aq) + 3NH_4OH(aq) \rightarrow Fe_2O_3.xH_2O(s) + 3NH_4Cl(aq)$$

(iv) Reaction with Nessler's reagent :

$$2K_2[HgI_4] + NH_3 + 3KOH \rightarrow [OHg_2.NH_2]I + 7KI + 2H_2O$$

- **Nitric Acid (HNO_3) :**

Preparation :

(i) In laboratory :

$$NaNO_3 + \underset{\text{(conc.)}}{H_2SO_4} \rightarrow \underset{\text{(Brown ppt.)}}{NaHSO_4} + HNO_3$$

(ii) By Ostwald's process :

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$$

$$2NO + O_2 \rightleftharpoons 2NO_2$$

$$3NO_2 + H_2O \rightarrow 2HNO_3 + NO$$

Properties :

(i) Colourless liquid.

(ii) Concentrated nitric acid is a strong oxidising agent.

(iii) Reactions :

$$HNO_{3(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + NO^-_{3(aq)}$$

$$3Cu + \underset{\text{(dil)}}{8HNO_3} \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$$

$$Cu + \underset{\text{(conc.)}}{4HNO_3} \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$$

$$4Zn + \underset{\text{(dilute)}}{10HNO_3} \rightarrow 4Zn(NO_3)_2 + 5H_2O + N_2O$$

$$Zn + \underset{\text{(conc.)}}{4HNO_3} \rightarrow Zn(NO_3)_2 + 2H_2O + 2NO_2$$

$$I_2 + 10HNO_3 \rightarrow 2HIO_3 + 10NO_2 + 4H_2O$$

$$S_8 + 48HNO_3 \rightarrow 8H_2SO_4 + 48NO_2 + 16H_2O$$

$$P_4 + 20HNO_3 \rightarrow 4H_3PO_4 + 20NO_2 + 4H_2O$$

Uses :

(i) In the manufacturing of nitrates used in explosives (nitroglycerine, trinitrotoluene etc), fertilisers (ammonium nitrate) etc.

(ii) As a reagent in laboratory.

(iii) In preparing aqua-regia.

- **Allotropes of Phosphorus :**

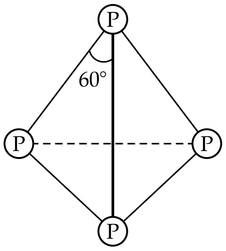
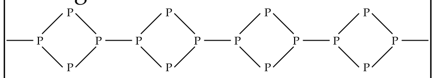
(i) White or yellow phosphorus

(ii) Black phosphorus

(iii) Red phosphorus

- **Differences between White and Red Phosphorus :**

Property	White Phosphorus	Red Phosphorus
State	Translucent white waxy solid	Iron grey lustrous powder
Odour	Garlic	Odourless
Physiological action	Poisonous	Non-poisonous
Stability	Less stable	More stable than white P
Solubility	Insoluble in water but soluble in CS_2.	Insoluble in water as well as CS_2.
Action of air	Readily catches fire to give dense white fumes of P_4H_{10}, Chemiluminescent with greenish glow.	Does not glow in dark.

Effect of heat	Changes to α-black P when heated at 473 K under high pressure and changes to red P when heated at 573 K.	Changes to α-black P when heated at 803 K in a solid form.
Structure	P_4 (tetrahedral) 	Tetrahedral units of P_4 joined together through covalent bond. 

- **Phosphine (PH_3)**

Preparation :

In laboratory :

$$\underset{\text{(white)}}{P_4} + \underset{\text{(conc.)}}{3NaOH} + 3H_2O \xrightleftharpoons[\text{inert atmosphere of } CO_2]{\Delta} PH_3 + \underset{\text{Sodium hypophosphite}}{3NaH_2PO_2}$$

Properties :

(i) Colourless gas with rotten fish smell

(ii) Highly poisonous

(iii) Pure sample is not spontaneously inflammable

(iv) Burns in air or oxygen when heated at 150°C

$$2PH_3 + 4O_2 \rightarrow P_2O_5 + 3H_2O$$
$$3CuSO_4 + 2PH_3 \rightarrow Cu_3P_2 + 3H_2SO_4$$
$$3HgCl_2 + 2PH_3 \rightarrow Hg_3P_2 + 6HCl$$
$$PH_3 + HBr \rightarrow PH_4Br$$

- **Phosphorus trichloride (PCl_3)**

Preparation :

(i) By passing dry chlorine over heated white phosphorus

$$P_4 + 6Cl_2 \rightarrow 4PCl_3$$

(ii) By action of thionyl chloride with white phosphorus

$$P_4 + 8SOCl_2 \rightarrow 4PCl_3 + 4SO_2 + 2S_2Cl_2$$

Properties :

(i) Colourless oily liquid

(ii) Hydrolyses in the presence of moisture

$$PCl_3 + 3H_2O \rightarrow H_3PO_3 + 3HCl$$

(iii) $3CH_3COOH + PCl_3 \rightarrow 3CH_3COCl + H_3PO_3$

Shape : Pyramidal in which phosphorus is sp^3 hybridised.

- **Phosphorus pentachloride (PCl_5)**

Preparation :

(i) Reaction of white phosphorus with excess of dry chlorine.

$$P_4 + 10Cl_2 \rightarrow 4PCl_5$$

(ii) By the action of SO_2Cl_2 on phosphorus.

$$P_4 + 10SO_2Cl_2 \rightarrow 4PCl_5 + 10SO_2$$

Properties :

(i) Yellowish white powder.

(ii) In moist air, it hydrolyses to $POCl_3$ and finally converts to phosphoric acid.

$$PCl_5 + H_2O \rightarrow POCl_3 + 2HCl$$
$$POCl_3 + 3H_2O \rightarrow H_3PO_4 + 3HCl$$

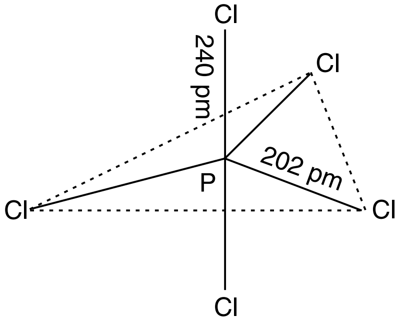
(iii) Decomposes on stronger heating

$$PCl_5 \xrightarrow{\text{heat}} PCl_3 + Cl_2$$

(iv) Gives corresponding halides with transition metals

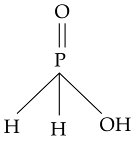
$$2Ag + PCl_5 \rightarrow 2AgCl + PCl_3$$
$$Sn + 2PCl_5 \rightarrow SnCl_4 + 2PCl_3$$

Shape : Trigonal bipyramidal

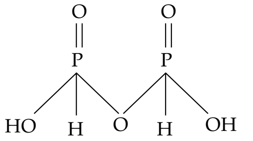


- **Oxoacids of phosphorus with structure :**

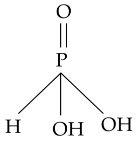
(i) H_3PO_2



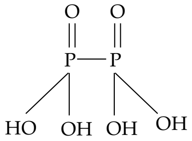
(ii) $H_4P_2O_5$



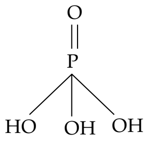
(iii) H_3PO_3



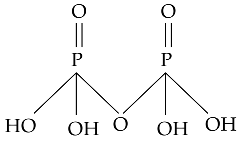
(iv) $H_4P_2O_6$



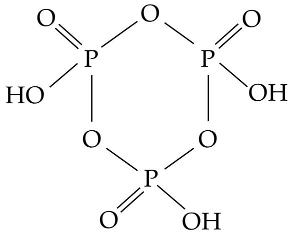
(v) H_3PO_4



(vi) $H_4P_2O_7$



(vii) $(HPO_3)_3$



Trimer or polymer of HPO_3

- The acids which contain P-H bond have reducing characteristics and act as good reducing agent.
  Example : H_3PO_2 reduces $AgNO_3$ to Ag.

$$4AgNO_3 + 2H_2O + H_3PO_2 \rightarrow 4Ag + 4HNO_3 + H_3PO_4$$

- The P-H bonds are not responsible for basicity as they do not ionize to give H^+. Only H attached with oxygen are responsible for basicity and are ionisable.

Know the Terms

- **Pnicogens :** The nitrogen group is group-15 of the periodic table and is also collectively named the pnicogens or pnictogens.
  The word pnicogens is derived from the Greek word pnigein which means 'to choke or stifle' which is a property of nitrogen.
- **Inert pair effect :** The reluctance of the valence *s*-electrons to be available for bonding as compared to the valence *p*-electrons due to their greater penetration in the nucleus.
- **Fuming nitric acid :** Nitric acid containing dissolved NO_2 is known as fuming nitric acid. It can be obtained by distilling concentrated HNO_3 with a little of starch.
- **Phosphazenes :** These are the cyclic compounds which contain both nitrogen and phosphorus atoms in the alternate position along with two substitutes on each phosphorus atom. These are cyclic trimers, tetramers or polymers in nature.
- **Fuming nitric acid :** Nitric acid containing dissolved nitrogen dioxide.
- **Aqua-regia :** Mixture of nitric acid and hydrochloric acid in ratio of 1 : 3.

Mnemonics

- Concept: Increasing order of atomic radii and atomic volume (Top to bottom-Group)
- Mnemonic: Nice Phone Assigned to Sub Bidder.
- Interpretation: Nitrogen**(N)**, Phosphorus**(P)**, Arsenic**(As)**, Antimony**(Sb)**, Bismuth**(Bi)**

Objective Type Questions

(1 mark each)

[A] MULTIPLE CHOICE QUESTIONS :

Q. 1. In a cyclotrimetaphosphoric acid molecule, how many single and double bonds are present?

(a) 3 double bonds; 9 single bonds

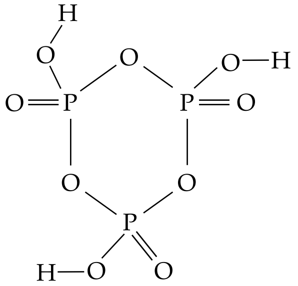
(b) 6 double bonds; 6 single bonds

(c) 3 double bonds; 12 single bonds

(d) Zero double bonds; 12 single bonds A&E

Ans. Correct option : (a)

Explanation : Cyclotrimetaphosphoric acid molecule



Q. 2. Strong reducing behaviour of H_3PO_2 is due to :

(a) low oxidation state of phosphorus

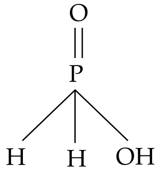
(b) presence of two –OH groups and one P–H bond

(c) presence of one –OH group and two P–H bonds

(d) high electron gain enthalpy of phosphorus U

Ans. Correct option : (c)

Explanation : Strong reducing behaviour of H_3PO_2 is due to presence of one –OH group and two P–H bonds.



H_3PO_2 (Hypophosphoric acid)

Q. 3. Which of the following statements is wrong?

(a) Single N–N bond is stronger than the single P–P bond.

(b) PH_3 can act as a ligand in the formation of coordination compound with transition elements.

(c) NO_2 is paramagnetic in nature.

(d) Covalency of nitrogen in N_2O_5 is four. U

Ans. Correct option : (a)

Explanation : N−N single bond is weaker than P−P bond due to smaller size of N as compared to P. Smaller size of N leads to smaller N−N bond length. Because of larger size of P atom, P−P bond length is more and lone pair-lone pair repulsion between P atoms is less which makes the P−P bond stronger than N−N bond.

[B] ASSERTIONS AND REASONS:

In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

Q. 1. Assertion (A) : N_2 is less reactive than P_4.

Reason (R) : Nitrogen has more electron gain enthalpy than phosphorus. U

Ans. Correct option : (c)

Explanation : Due to high bond dissociation energy of triple bond between the two N atoms, nitrogen (N) is less reactive than P_4 and its electron gain enthalpy is less than phosphorus.

Q. 2. Assertion (A) : HNO_3 makes iron passive.

Reason (R) : HNO_3 forms a protective layer of ferric nitrate on the surface of iron. R

Ans. Correct option : (c)

Explanation : HNO_3 makes iron passive and its passivity is attained by formation of a thin film of oxide on iron.

AI **Q. 3. Assertion (A) : Bismuth forms only one well characterised compound in +5 oxidation state.**

Reason (R) : Elements of group-15 form compounds in +5 oxidation state.

Ans. Correct option : (b)

Explanation : Elements of group-15 form compounds in +5 oxidation state. Bismuth forms only one well characterised compound in +5 oxidation state which is BiF_5. Due to inert pair effect bismuth exhibit +3 oxidation state only and forms trihalides. But due to samll size and high electronegativity of fluorine, Bismuth forms BiF_5.

[C] VERY SHORT ANSWER TYPE QUESTIONS :

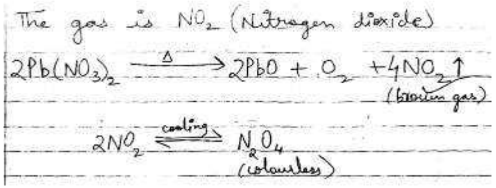
Q. 1. Write the formula of the compound of phosphorus which is obtained when conc. HNO_3 oxidises P_4.

A **[CBSE OD Set-1 2017]**

Ans. H_3PO_4. **[CBSE Marking Scheme 2017]**

Q. 2. On heating $Pb(NO_3)_2$ a brown gas is evolved which undergoes dimerization on cooling. Identify the gas. **A [CBSE OD Set-2/Comptt. OD 2016]**

Ans.



The gas is NO_2 (Nitrogen dioxide)

$2Pb(NO_3)_2 \xrightarrow{\Delta} 2PbO + O_2 + 4NO_2\uparrow$ (brown gas)

$2NO_2 \underset{}{\overset{\text{cooling}}{\rightleftharpoons}} N_2O_4$ (colourless)

[Topper's Answer 2016]

Detailed Answer:

$$2Pb(NO_3)_2 \xrightarrow{\Delta} 2PbO + O_2 + 4NO_2\uparrow$$

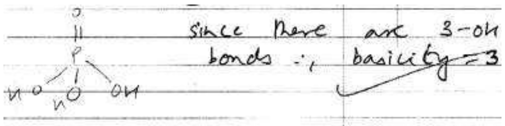
(Brown gas)

Nitrogen dioxide (NO_2) is evolved.

Q. 3.What is the basicity of H_3PO_4 ?

U [CBSE Delhi 2015]

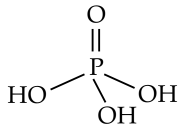
Ans.



since there are 3-OH bonds ∴ basicity = 3

[Topper's Answer 2015]

Detailed Answer:



The basicity of H_3PO_4 is three due to availability of three hydrogen atoms which can be released in aqueous solutions.

Q. 4. On adding NaOH to ammonium sulphate, a colourless gas with pungent odour is evolved which forms a blue coloured complex with Cu^{2+} ion. Identify the gas. **A [CBSE Delhi 2016]**

Ans. Ammonia (NH_3).

$$(NH_4)_2SO_4 + 2NaOH \rightarrow 2NH_3 + 2H_2O + Na_2SO_4$$

$$Cu^{2+}_{(aq)} + 4NH_{3\,(aq)} \rightleftharpoons [Cu(NH_3)_4]^{2+}_{(aq)}$$

Deep blue

Short Answer Type Questions-I

(2 marks each)

Q. 1. Explain the following :

(i) Nitrogen is much less reactive than phosphorus.

(ii) NF_3 is an exothermic compound but NCl_3 is an endothermic compound.

A [CBSE Comptt. OD 2015]

Ans. (i) Due to high bond dissociation enthalpy of $N \equiv N$ **[1]**

(ii) Due to low bond dissociation enthalpy of F_2 than Cl_2 and strong bond formation between N and F. **[1]**

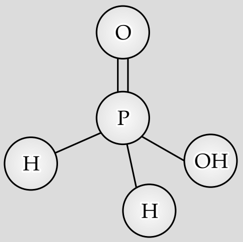
[CBSE Marking Scheme 2015]

Q. 2. Draw the structures of the following :

(i) H_3PO_2 **(ii) XeF_4**

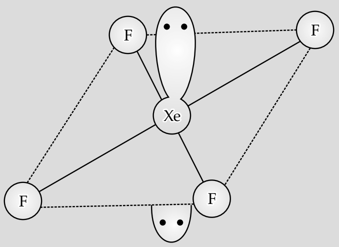
A [CBSE Delhi Set-2 2017]

Ans. (i)



[1]

(ii)



[1]

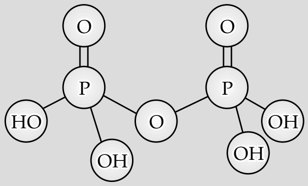
[CBSE Marking Scheme, 2017]

Q. 3. Draw the structures of the following :

(i) $H_4P_2O_7$ **(ii) $XeOF_4$**

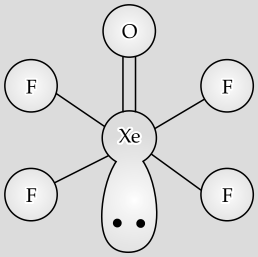
A [CBSE Delhi Set-3 2017]

Ans. (i)



[1]

(ii)



[1]

[CBSE Marking Scheme, 2017]

Q. 4. "Orthophosphoric acid (H_3PO_4) is not a reducing agent whereas hypophosphorus acid (H_3PO_2) is a strong reducing agent." Explain and justify the above statement with the help of a suitable example. A **[CBSE Comptt. OD Set-1, 2, 3 2017]**

Ans. Hypophosphorous acid is a good reducing agent as it contains two P-H bonds. There is no P-H bond in orthophosphoric acid, so it is not a reducing agent. **[1]**

Example : It reduces $AgNO_3$ to metallic silver / chemical equation **[1]**

[CBSE Marking Scheme 2017]

Q. 5. (i) What is the covalence of nitrogen in N_2O_5?

(ii) BiH_3 is a stronger reducing agent than SbH_3, why?

A **[CBSE Comptt. Delhi Set-1, 2, 3 2017]**

Ans. (i) 4 **[1]**

(ii) Due to lower bond dissociation enthalpy of BiH_3 as compared to SbH_3. **[1]**

[CBSE Marking Scheme 2017]

Detailed Answer:

(i) 4

(ii) Because BiH_3 has longer bond length due to larger size of Bi it has lowest bond dissociation energy which makes it less stable than SbH_3.

Q. 6. Among the hydrides of Group-15 elements, NH_3, PH_3, AsH_3, SbH_3 and BiH_3 which have the

(a) lowest boiling point ?

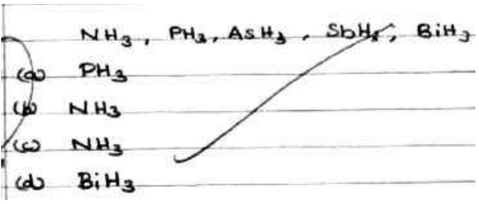
(b) maximum basic character ?

(c) highest bond angle ?

(d) maximum reducing character ?

R **[CBSE Delhi & OD 2018]**

Ans.



NH_3, PH_3, AsH_3, SbH_3, BiH_3

(a) PH_3

(b) NH_3

(c) NH_3

(d) BiH_3

[Topper's Answer 2018]

Short Answer Type Questions-II

(3 marks each)

Q. 1. Give reasons for the following :

(a) Red phosphorus is less reactive than white phosphorus.

(b) Electron gain enthalpies of halogens are largely negative.

(c) N_2O_5 is more acidic than N_2O_3. [3]

Ans. (a) Red phosphorus being polymeric is less reactive than white phosphorus which has discrete tetrahedral structure. **[1]**

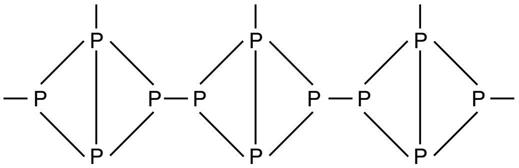
(b) They readily accept an electron to attain noble gas configuration. **[1]**

(c) Because of higher oxidation state (+5) of nitrogen in N_2O_5. **[1]**

[CBSE Marking Scheme, 2017]

Detailed Answer :

(a) In red phosphorus, P_4 molecules are linked in an extended chain structure. So, it is much less reactive.



While white phosphorus contains discrete P_4 molecules in which each phosphorus atom is tetrahedrally bonded to other phosphorus atoms. So, white phosphorus is highly reactive. **[1]**

(b) Electron gain enthalpies of halogens are largely negative due to smaller size and higher nuclear charge. Both these factors increase the force of attraction between the nucleus and the electron being added and hence the atom has a greater tendency to attract the electron towards it self. **[1]**

(c) N_2O_5 dissolves in H_2O with a hissing noise to form nitric acid (HNO_3) which is strong acid while N_2O_3 dissolves in H_2O to form nitrous acid (HNO_2). So, N_2O_5 is more acidic than N_2O_3. **[1]**

$$N_2O_5 + H_2O \rightarrow \underset{\text{Nitric acid (strong acid)}}{2HNO_3}$$

$$N_2O_3 + H_2O \xrightarrow{0°C} \underset{\text{Nitrous acid (weak acid)}}{2HNO_2}$$

Q. 2. (i) Arrange the following in decreasing order of bond dissociation enthalpy

F_2, Cl_2, Br_2, I_2

(ii) Bi does not form pπ-pπ bonds. Give reason for the observation.

(iii) Electron gain enthalpy of oxygen is less negative than sulphur. Justify. A **[CBSE SQP 2021]**

Ans. (i) Decreasing order of bond dissociation enthalpy: **[1]**

$Cl_2 > Br_2 > F_2 > I_2$

(ii) Bi does not form pπ-pπ bonds as its atomic orbitals are large and diffuse so effective overlapping is not possible. **[1]**

(iii) Due to small size of oxygen, it has greater electron electron repulsions. **[1]**

Q. 3. Name three oxoacids of nitrogen. Write the disproportionation reaction of that oxoacid of nitrogen in which nitrogen is in +3 oxidation state. A

Ans. Three oxoacids of nitrogen are :

(i) HNO_2, Nitrous acid **[½]**

(ii) HNO_3, Nitric acid **[½]**

(iii) $H_2N_2O_2$, Hyponitrous acid **[½]**

$$3HNO_2 \xrightarrow{\text{Disproportionation}} HNO_3 + H_2O + 2NO$$

[1.5]

Long Answer Type Questions (5 marks each)

Q.1. On heating lead (II) nitrate gives a brown gas "A". The gas "A" on cooling changes to colourless solid "B". Solid "B" on heating with NO changes to a blue solid 'C'. Identify 'A', 'B' and 'C' and also write reactions involved and draw the structures of 'B' and 'C'. A&E

(Source- Exemplar)

Ans. $Pb(NO_3)_2 \xrightarrow[673\,K]{\Delta} 2PbO + 4NO_2$

(A)

(Brown colour) **[½]**

$$2NO_2 \underset{\text{Heating}}{\overset{\text{on cooling}}{\rightleftharpoons}} N_2O_4$$

(B)

(Colourless solid) **[½]**

$$2NO + N_2O_4 \xrightarrow{\Delta\,250\,K} 2N_2O_3$$

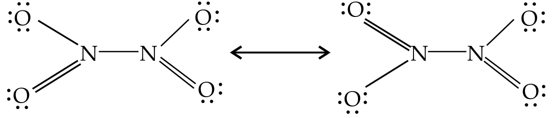
(C)

(Blue solid) **[½]**

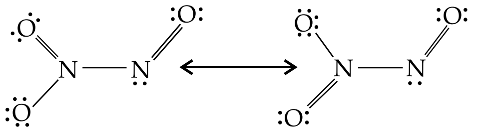
'A' is NO_2. **[½]**

'B' is N_2O_4. **[½]**

'C' is N_2O_3. **[½]**



(Structure of N_2O_4) **[1]**



[1]

(Structure of N_2O_3)

Q.2. On heating compound (A) gives a gas (B) which is a constituent of air. This gas when treated with 3 mol of hydrogen (H2) in the presence of a catalyst gives another gas (C) which is basic in nature. Gas C on further oxidation in moist condition gives a compound (D) which is a part of acid rain. Identify compounds (A) to (D) and also give necessary equations of all the steps involved. A&E

(Source- Exemplar)

Ans. A = NH_4NO_2 B = N_2 C = NH_3 D = HNO_3

(i) $NH_4NO_2 \rightarrow N_2 + 2H_2O$

(ii) $N_2 + 3H_2 \rightarrow 2NH_3$

(iii) $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

$4NO + O_2 \rightarrow 2NO_2$

$3NO_2 + H_2O \rightarrow 2HNO_3 + NO$

[1] mark for each equation.

Q.3. Colorless, oily liquid 'B' is obtained by reaction of Thionyl chloride with compound 'A'. Compound 'B' hydrolyses in presence of moisture to give compound 'C'. Compound 'B' also reacts with organic compounds containing -OH groups to give compound 'C'. Identify compounds 'A','B','C' and write the equations involved in the given reactions. Draw the structure of compound 'B' and identify its hybridization. A&E

(New)

Ans: $P_4 + 8SOCl_2 \rightarrow 4PCl_3 + 4SO_2 + 2S_2Cl_2$ [1]

(A) (B)

(White Phosphorus) (Colorless, oily liquid)

$PCl_3 + 3H_2O \rightarrow H_3PO_3 + 3HCl$ [1]

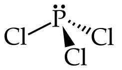
(C)

(Phosphoric acid)

'A' is P_4- White phosphorus **[½]**

'B' is PCl_3- Phosphorus trichloride **[½]**

'C' is H_3PO_3- Phosphoric acid **[½]**



[½]

PCl_3 is Pyramidal in shape. **[½]**

Phosphorus is sp^3 hybridised. **[½]**

TOPIC-2

Group-16 Elements, Properties and Some Important Compounds

Revision Notes

- **Oxygen family : $_{8}O$, $_{16}S$, $_{34}Se$, $_{52}Te$, $_{84}Po$**
- **Physical properties :**

(i) **Atomic and ionic radii :** Smaller than the corresponding elements of group 15 due to increase in nuclear charge. Down the group they increase due to addition of a new shell.

(ii) **Ionisation enthalpy :** I.E.$_1$ is lower than those of corresponding elements of group 15 due to increase in nuclear charge. I.E.$_2$ is higher than those of group 15 due to smaller size of the ions and greater effective nuclear charge. Down the group I.E. decreases.

(iii) **Electron gain enthalpy :** Oxygen has less electron gain enthalpy than sulphur. From sulphur, the value again becomes less negative upto polonium.

(iv) **Electronegativity :** More electronegative than group 15 elements. It decreases down the group due to increase in atomic size.

(v) Oxygen and sulphur are non-metals, selenium and tellurium are metalloids and polonium is a metal.

(vi) **Melting and boiling points :** Increase regularly from O to Te due to increase in size and hence greater van der Waals forces. Po has lesser melting and boiling point than Te due to maximum inert pair effect.

(vii) **Density :** Increases down the group.

(viii) **Oxidation state :** Oxygen shows an oxidation state of –2 only (except OF_2 and H_2O_2). All other elements show +2, +4 and +6 oxidation states.

- **Chemical properties :**

(1) With hydrogen : Form hydrides of type H_2E (E = O, S, Se, Te and Po).

Properties of hydrides :

(i) Thermal stability : Decreases down the group.

(ii) Acidic character : Increases down the group.

(iii) Reducing nature : All are reducing agents except H_2O.

(iv) Boiling point : From H_2O to H_2S there is a sudden drop which increases from H_2S to H_2Te.

(2) With halogens : Form halides of type EX_2, EX_4 and EX_6 where E is an element of group and X is a halogen.

Properties of halides :

(i) Only hexafluorides are the only stable halides.

(ii) All elements except selenium form dichlorides and dibromides. These dihalides are *sp*^{3} hybridised and have tetrahedral structure.

$$2Se_2Cl_2 \rightarrow SeCl_4 + 3Se$$

(a) Preparation of SF_4 and SF_6 :

$$3SCl_2 + 4NaF \rightarrow SF_4 + S_2Cl_2 + 4NaCl$$

$$S + 3F_2 \xrightarrow{\text{Burn}} SF_6$$

(b) Properties of SF_4 : SF_4 is readily hydrolysed.

$$SF_4 + 2H_2O \rightarrow 4HF + SO_2$$

(c) SF_6 is sp^3d^2 hybridised and octahedral whereas SF_4 is sp^3d hybridised and is trigonal bipyramidal with one position occupied by a lone pair of electrons.

(3) With oxygen : Form oxides of EO_2 and EO_3.

- **Dioxygen (O_2)**

Preparation :

In laboratory, $$2KClO_3 \xrightarrow{MnO_2} 2KCl + 3O_2$$

Properties :

(i) Slightly soluble in water and appreciably soluble in alkaline pyrogallol solution.

(ii) Paramagnetic.

(iii) Forms oxides with metals and non-metals.

$$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$$

$$C(s) + O_2(g) \rightarrow CO_2(g)$$

$$4Al + 3O_2 \rightarrow 2Al_2O_3$$

$$P_4 + 5O_2 \rightarrow P_4O_{10}$$

$$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$$

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

$$4HCl + O_2 \rightarrow 2Cl_2 + 2H_2O$$

- **Classification of oxides :** On the basis of chemical nature,
  - **(i) Basic :** Na_2O, CaO, etc. basic oxides.
  - **(ii) Acidic :** CO_2, SO_2, etc. acidic oxides.
  - **(iii) Amphoteric :** SnO_2, Al_2O_3, etc. are amphoteric oxides.
  - **(iv) Neutral :** H_2O, CO, etc. are neutral oxides.
  - **(v) Poly-oxide :** Oxides having oxygen more than required oxygen such as peroxide (Na_2O_2), super oxide (KO_2), dioxide (PbO_2), higher oxide (Mn_2O_7).
  - **(vi) Sub-oxide :** Oxides having oxygen less than required, *e.g.*, C_3O_2.
- **Ozone (O_3)**

  Preparation : By subjecting pure and dry oxygen to silent electric discharge.

$$3O_2(g) \xrightarrow{\text{Discharge}} 2O_3(g), \Delta H = +284 \text{ kJ}$$

Properties :

(i) Poisonous in nature

(ii) Powerful oxidising agent. It is a stronger oxidising agent than O_2.

$$PbS + 4O_3 \rightarrow PbSO_4 + 4O_2$$

$$2I^- + H_2O + O_3 \rightarrow 2OH^- + I_2 + O_2$$

Uses :

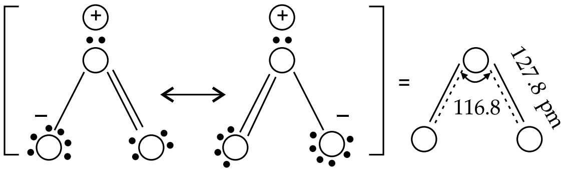
(i) As bleaching agent

(ii) As disinfectant and germicide

(iii) For purification of air in hospitals, railway tunnels, cinema house

(iv) For bleaching oils, ivory flour, starch, etc

Structure :



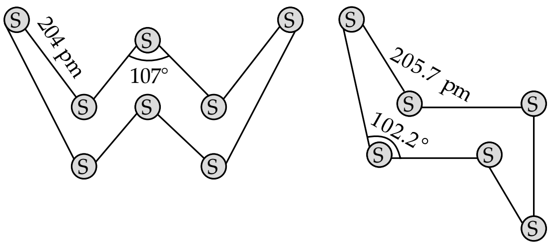
- **Allotropes of Sulphur :**

  (a) Rhombic Sulphur (α-Sulphur) :
  - **(i)** Yellow in colour, melting point 385.8 K and specific gravity 2.06.
  - **(ii)** Formed by evaporating the solution of roll sulphur in CS_2.
  - **(iii)** Insoluble in water but dissolves to some extent in benzene, alcohol and ether.
  - **(iv)** Readily soluble in CS_2.

  (b) Monoclinic Sulphur (β-Sulphur) :
  - **(i)** Melting point is 393 K and specific gravity 1.98.
  - **(ii)** Soluble in CS_2.
  - **(iii)** Prepared by melting rhombic sulphur in a dish and cooling.
  - **(iv)** Stable above 369 K and transforms into α-sulphur below it.

  Both rhombic and monoclinic sulphur have S_8 molecules.

  Shape of S_8 and S_6 molecules :



- **Sulphur dioxide (SO_2) :**

Preparation :

$$\underset{\text{(conc.)}}{S + 2H_2SO_4} \rightarrow 3SO_2 + 2H_2O$$

$$\underset{\text{(conc.)}}{Cu + 2H_2SO_4} \rightarrow CuSO_4 + SO_2 + 2H_2O$$

$$\underset{\text{(dil.)}}{Na_2SO_3 + 2HCl} \rightarrow 2NaCl + SO_2 + H_2O$$

Properties :

(i) Colourless gas with pungent, suffocating odour

(ii) Highly soluble in water

(iii)

$$SO_2 + H_2O \rightleftharpoons \underset{\text{(Sulphurous acid)}}{H_2SO_3}$$

$$2NaOH + SO_2 \rightarrow Na_2SO_3 + H_2O$$

$$Na_2SO_3 + H_2O + SO_2 \rightarrow 2NaHSO_3$$

$$Cl_2 + SO_2 \rightarrow SO_2Cl_2$$

$$O_2 + 2SO_2 \rightarrow 2SO_3$$

(iv) SO_2 acts as reducing agent.

$$2Fe^{3+} + SO_2 + 2H_2O \rightarrow 2Fe^{2+} + SO_4^{2-} + 4H^+$$

$$5SO_2 + 2MnO_4^- + 2H_2O \rightarrow 5SO_4^{2-} + 4H^+ + 2Mn^{2+}$$

Uses :

(i) Used in refining petroleum and sugar.

(ii) As bleaching agent for wool and silk.

(iii) As anti-chlor, disinfectant and preservative.

- **Sulphuric acid (H_2SO_4)**

Preparation : By contact process which involves 3 steps :

(i) Burning of sulphur or sulphide ores in air :

$$S + O_2 \rightarrow SO_2$$

(ii) Conversion of SO_2 to SO_3 with oxygen in the presence of a catalyst V_2O_5.

$$2SO_2 + O_2 \xrightarrow{V_2O_5} 2SO_3$$

(iii) Absorption of SO_3 in H_2SO_4 to give oleum. Oleum is diluted with water to get H_2SO_4 of desired concentration.

$$SO_3 + H_2SO_4 \rightarrow \underset{\text{(Oleum)}}{H_2S_2O_7}$$

$$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$$

Properties :

(i) Colourless, dense, oily liquid with a specific gravity of 1.84 at 298 K

(ii) Low volatility

(iii) Strong acidic character

(iv) Strong affinity for water

(v) Acts as an oxidising agent

$$\underset{\text{(conc.)}}{Cu + 2H_2SO_4} \rightarrow CuSO_4 + SO_2 + 2H_2O$$

$$\underset{\text{(conc.)}}{S + 2H_2SO_4} \rightarrow 3SO_2 + 2H_2O$$

$$\underset{\text{(conc.)}}{C + 2H_2SO_4} \rightarrow CO_2 + 2SO_2 + 2H_2O$$

(vi) Acts as a dehydrating agent.

$$C_{12}H_{22}O_{11} \xrightarrow{H_2SO_4} 12C + 11H_2O$$

Uses :

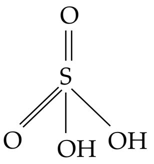
(i) In petroleum refining

(ii) Manufacture of pigments, paints and dye stuff

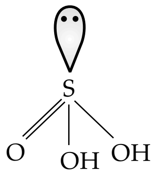
(iii) Detergent industry

(iv) In storage batteries

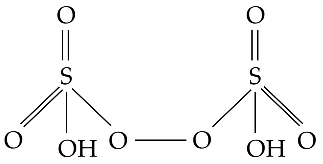
- **Oxoacids of Sulphur :**



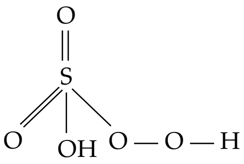
(H_2SO_4)
Sulphuric
acid



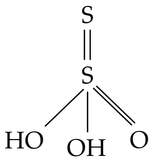
(H_2SO_3)
Sulphurous
acid



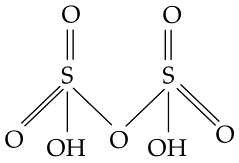
($H_2S_2O_8$)
Marshall's acid
Peroxodisulphuric
acid



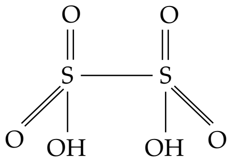
(H_2SO_5)
Caro's acid
Peroxomonosulphuric
acid



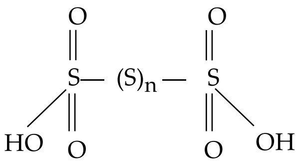
($H_2S_2O_3$)
Thiosulphuric acid



($H_2S_2O_7$)
Pyrosulphuric acid
(Oleum)

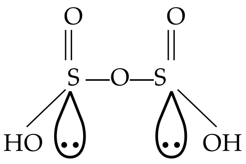


($H_2S_2O_6$)
Dithionic acid



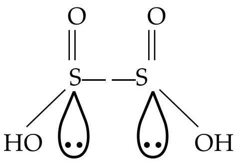
($H_2S_xO_6$)

Polythionic acid



($H_2S_2O_5$)

Disulphurous acid



($H_2S_2O_4$)

Dithionous acid

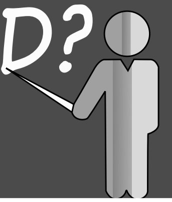
Know the Terms

- **Chalcogens :** Group-16 elements are also known as chalcogens which means ore forming elements.
- **Oil of vitriol :** Pure sulphuric acid is highly viscous due to the presence of intermolecular hydrogen bonding. It is known as oil of vitriol.
- **Oxide :** A binary compound of oxygen with another element.

Mnemonics

- Concept: Increasing order of atomic radii and atomic volume (Top to bottom-Group)
- Mnemonic: Old Sultanpur Seems Terribly Polluted.
- Interpretation: **O**xygen**(O)**, **S**ulphur**(S)**, **S**elenium**(Se)**, **T**ellurium**(Te)**, **P**olonium**(Po)**

How is it done on the GREENBOARD?



Q. Why is SO_2 considered to be an air pollutant?

Solution:

Sulphur dioxide causes harm to the environment in many ways :

STEP-1: When it combines with water vapour, it forms sulphuric acid (H_2SO_4). This causes acid rain. Acid rain damages soil, plants, and buildings, especially those made of marble.

STEP-2: Even in very low concentrations, SO_2 causes irritation in the respiratory tract. It causes throat and eye irritation and can also affect the larynx to cause breathlessness.

STEP-3: It is extremely harmful to plants. Plants exposed to sulphur dioxide for a long time lose colour from their leaves. This condition is known as chlorosis. This happens because the formation of chlorophyll is affected by the presence of sulphur dioxide.

Objective Type Questions

(1 mark each)

[A] MULTIPLE CHOICE QUESTIONS :

Q.1. Hot conc. H_2SO_4 acts as moderately strong oxidising agent. It oxidises both metals and nonmetals. Which of the following element is oxidised by conc. H_2SO_4 into two gaseous products? R

(a) **Cu** **(b)** **S**

(c) C **(d)** Zn

Ans. **Correct option :** (c)

Explanation : $C + 2H_2SO_4 \rightarrow CO_2 + 2SO_2 + 2H_2O$

Reaction Condition

Hot concentrated sulfuric acid should be used to oxidise carbon to carbon dioxide.

Q.2. Which of the following are peroxoacids of sulphur?

(a) H_2SO_5 and $H_2S_2O_8$

(b) H_2SO_5 and $H_2S_2O_7$

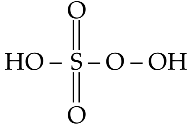
(c) $H_2S_2O_7$ and $H_2S_2O_8$

(d) $H_2S_2O_6$ and $H_2S_2O_7$ R

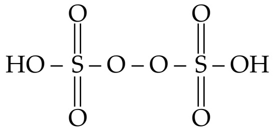
Ans. **Correct option :** (a)

Explanation : H_2SO_5 and $H_2S_2O_8$

Peroxymonosulfuric acid and Peroxydisulfuric acid are peroxoacids of sulphur.



$$HO-\overset{\overset{\displaystyle O}{\|}}{\underset{\underset{\displaystyle O}{\|}}{S}}-O-OH$$



$$HO-\overset{\overset{\displaystyle O}{\|}}{\underset{\underset{\displaystyle O}{\|}}{S}}-O-O-\overset{\overset{\displaystyle O}{\|}}{\underset{\underset{\displaystyle O}{\|}}{S}}-OH$$

AI **Q. 3. Which of the following statements are correct for SO_2 gas?**

(a) It acts as bleaching agent in moist conditions.

(b) Its molecule has linear geometry.

(c) It can be prepared by the reaction of dilute H_2SO_4 with metal sulphide.

(d) All of the above

Ans. **Correct option :** (a)

Explanation : SO_2 acts as a bleaching agent under moist conditions.

$SO_2(g) + 2H_2O \rightarrow H_2SO_4 + 2[H]$

SO_2 is oxidized to sulphuric acid and releases nascent hydrogen which bleaches the material. But this is a temporary as atmospheric oxygen re-oxides the bleached matter after some time.

[B] ASSERTIONS AND REASONS:

In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

Q.1. Assertion (A) : Both rhombic and monoclinic sulphur exist as S_8 but oxygen exists as O_2.

Reason (R) : Oxygen forms pπ–pπ multiple bond due to small size and small bond length but pπ–pπ bonding is not possible in sulphur. R

Ans. Correct option : (a)

Explaination : Sulphur (S) exists as S_8 but oxygen forms pπ–pπ multiple bonds which is not present in S.

Q.2. Assertion (A) : NaCl reacts with concentrated H_2SO_4 to give colourless fumes with pungent smell. But on adding MnO_2 the fumes become greenish yellow.

Reason (R) : MnO_2 oxidises HCl to chlorine gas which is greenish yellow R

Ans. Correct Option : (a)

Explaination : Colourless fumes of hydrochloric acid(HCl) because greenish yellow because MnO_2 oxidises HCl to chlorine gas.

Q.3. Assertion(A) : SF_6 cannot be hydrolysed but SF_4 can be.

Reason (R) : Six atoms in SF_6 prevent the attack of H_2O on sulphur atom of SF_6. U

Ans. Correct Option : (a)

Explaination : SF_6 is sterically protected due to presence of six F atoms around S atom which prevents the attack of H_2O on SF_6.

[C] VERY SHORT ANSWER TYPE QUESTIONS :

Q.1. Write the formula of the compound of sulphur which is obtained when conc. HNO_3 oxidises S_8.

R [CBSE OD Set-2 2017]

Ans. H_2SO_4

[CBSE Marking Scheme, 2017]

OR

H_2SO_4 is obtained when conc. HNO_3 oxidises S_8.

[Topper's Answer, 2017]

Q.2. Write the formulae of any two oxoacids of sulphur.

R [CBSE Comptt. OD 2015]

Ans. H_2SO_3 (Sulphurous acid) and H_2SO_4(Sulphuric acid).

[CBSE Marking Scheme, 2017]

Q.3. Arrange the following hydrides of Group-16 elements in the increasing order of their thermal stability : H_2O, H_2S, H_2Se, H_2Te.

A [CBSE Foreign Set-1,2,3 2017]

Ans. $H_2T < H_2Se < H_2S < H_2O$

[CBSE Marking Scheme, 2017]

Q.4. Write the formula of the compound of iodine which is obtained when conc. HNO_3 oxidises I_2.

R [CBSE OD Set-3 2017]

Ans. HIO_3

[CBSE Marking Scheme, 2017]

Short Answer Type Questions-I (2 marks each)

AI Q. 1. What happens when :

(i) Conc. H_2SO_4 is added to Cu ?

(ii) SO_3 is passed through water ?

Write the equations. R [CBSE Delhi Set-2 2017]

OR

(i) Concentrated H_2SO_4 is added to calcium fluoride ?

(ii) SO_3 is passed through water ?

R [CBSE Comptt. Delhi 2016]

Ans. (i) $Cu + 2H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O$ **[1]**

(ii) $SO_3 + H_2O \rightarrow H_2SO_4$ **[1]**

[CBSE Marking Scheme 2017]

OR

Ans. (i) $\underset{\text{(conc.)}}{H_2SO_4} + CaF_2 \rightarrow 2HF + CaSO_4$ **[1]**

(ii) $SO_3 + H_2O \rightarrow H_2SO_4$ **[1]**

[CBSE Marking Scheme 2016]

Commonly Made Error

- Students often write unbalanced equations for reactions.

Answering Tip

- Give balanced chemical equation.

Q. 2. Write the balanced chemical equations for the following processes :

(i) XeF_2 undergoes hydrolysis.

(ii) MnO_2 is heated with concentrated HCl.

Ans. (i) $2XeF_2 (s) + 2H_2O(l) \rightarrow 2Xe (g) + 4 HF (aq) + O_2(g)$ **[1]**

(ii) $MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$

[CBSE Marking Scheme, 2019] [1]

Detailed Answer :

(i) XeF_2 is soluble in water and undergoes hydrolysis to produce Xe and O_2 gas.

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

(ii) MnO_2 reacts with concentrated HCl to produce manganese chloride, water and chlorine gas.

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

Q. 3. Arrange the following in order of property indicated for each set.

(i) H_2O, H_2S, H_2Se, H_2Te – increasing acidic character.

(ii) HF, HCl, HBr, HI – decreasing bond enthalpy.

R [CBSE Delhi Set-1 2019]

Ans. (i) $H_2O < H_2S < H_2Se < H_2Te$ **[1]**

(ii) $HF > HCl > HBr > HI$

[CBSE Marking Scheme, 2019] [1]

Detailed Answer :

(i) O, S, Se and Te are all in the same group in the periodic table. On moving down the group, the atomic radius increases. In binary acids, the H - Te bond is longest and the H - O bond is shortest. The H - Te bond is therefore weakest and the H - O bond is strongest. Thus H_2O is the weakest acid while H_2Te is the strongest acid.

The order of the given compounds in increasing acidic character is:

$$H_2O < H_2S < H_2Se < H_2Te$$

(ii) On moving down the group, the atomic size increases. Hence, HI is the strongest acid while HF is the weakest acid. Thus, the bond enthalpy is inversely related to the size of the halogen atoms.

The order of the given compounds in decreasing bond enthalpy is:

$HF > HCl > HBr > HI$

Q. 4. Write balanced chemical equations for the following processes :

(a) Cl_2 is passed through slaked lime.

(b) SO_2 gas is passed through an aqueous solution of Fe(III) salt.

Ans. (a) $2Ca(OH)_2 + 2Cl_2 \rightarrow CaCl_2 + Ca(OCl)_2 + 2H_2O$ **[1]**

(b) $SO_2 + 2Fe^{3+} + 2H_2O \rightarrow 2Fe^{2+} + SO_4^{2-} + 4H^+$

[CBSE Marking Scheme, 2019] [1]

Q. 5. (a) Write two poisonous gases prepared from chlorine gas.

(b) Why does Cu^{2+} solution give blue colour on reaction with ammonia?

A&E **[CBSE OD Set-2 2019]**

Ans. (a) Mustard gas, tear gas, phosgene.

(Any two) [½ + ½]

(b) Because it forms blue coloured complex $[Cu(NH_3)_4]^{2+}$ (aq) or Equation.

[CBSE Marking Scheme, 2019] [1]

Detailed Answer :

(a) Phosgene ($COCl_2$), tear gas (CCl_3NO_2), mustard gas $(C_4H_8Cl_2S)$. **(Any two)**

(b) Cu^{2+} ion reacts with ammonia solution to form a deep blue coloured complex because of the property of ammonia to form complex compounds. Ammonia acts as a lewis base due to presence of lone pair of electrons on the nitrogen atom. Hence, it is able to form coordinate bond with electron deficient molecules or a number of transition metal cations.

$$Cu^{2+}(aq) + 4NH_3(aq) \rightarrow \underset{\substack{\text{Tetraammine copper (II)} \\ \text{(blue colour)}}}{[Cu(NH_3)_4]^{2+}}$$

Q. 6. Account for the following:

(i) The two oxygen-oxygen bond lengths in ozone molecule are identical.

(ii) Most of the reactions of fluorine are exothermic.

A&E **[CBSE Comptt. Delhi Set-1 2017]**

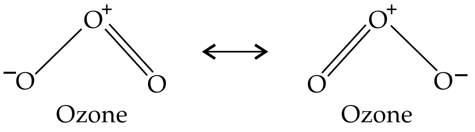
Ans. (i) Due to resonance the two O-O bond lengths are identical. **[1]**

(ii) Due to strong bond formed by it with other elements. **[1]**

[CBSE Marking Scheme 2017]

Detailed Answer:

(i) In ozone, the central oxygen atom forms one single bond with a terminal oxygen atom and double bond with other terminal oxygen atom. The π electrons of double bond are delocalised over the three oxygen atoms. This results into resonance hybrids with the average bond distance of the single and double bond.



[1]

Short Answer Type Questions-II

(3 marks each)

Q. 1. Explain the following giving appropriate reasons:

(i) $(CH_3)_3 P = O$ exists but $(CH_3)_3 N = O$ does not.

(ii) Oxygen has less electron gain enthalpy with negative sign than sulphur.

(iii) H_3PO_2 is a stronger reducing agent than H_3PO_3.

A&E

Ans. (i) Because as N can't form 5 covalent bonds as its maximum covalency is three. The octet cannot be extended as it doesn't have *d* orbital, while P can extend its octet as it has empty *d* orbital. **[1]**

(ii) This is due to very small size of oxygen atom, repulsion between electrons is large in relatively small 2*p* sub-shell. **[1]**

(iii) In H_3PO_2 there are 2P – H bonds, whereas in H_3PO_3 there is 1 P-H bond. **[1]**

Q. 2. Account for the following:

(a) Moist SO_2 decolourises $KMnO_4$ solution.

(b) In general interhalogen compounds are more reactive than halogens (except fluorine).

(c) Ozone acts as a powerful oxidizing agent.

U **[CBSE SQP 2020]**

Ans. (a) Moist sulphur dioxide behaves as a reducing agent, reduces MnO_4^- to Mn^{2+}. **[1]**

(b) X – X′ bond in interhalogens is weaker than X –X bond in halogens except F-F bond. **[1]**

(c) Due to the ease with which it liberates atoms of nascent oxygen. **[1]**

[CBSE SQP Marking Scheme 2020]

Detailed Answer :

(a) The moist SO_2 behaves as a reducing agent and decolourises $KMnO_4$ solution.

$$5SO_2 + 2MnO_4^- + 2H_2O \rightarrow 5SO_4^{2-} + 4H^+ + 2Mn^{2+}$$

Long Answer Type Questions

(5 marks each)

Q.1. (a) Give reasons for the following :

(i) Sulphur in vapour state shows paramagnetic behaviour.

(ii) N-N bond is weaker than P-P bond.

(iii) Ozone is thermodynamically less stable than oxygen.

(b) Write the name of gas released when Cu is added to

(i) dilute HNO_3 and

(ii) conc. HNO_3

Ans. (a) (i) In vapour state sulphur partly exists as S_2 molecule which has two unpaired electrons like O_2. **[1]**

(ii) Due to greater interelectronic repulsion. **[1]**

(iii) Because decomposition of ozone into oxygen results in the liberation of heat (ΔH is negative) and an increase in entropy (ΔS is positive), resulting in large negative Gibbs energy change (ΔG) for its conversion into oxygen. **[1]**

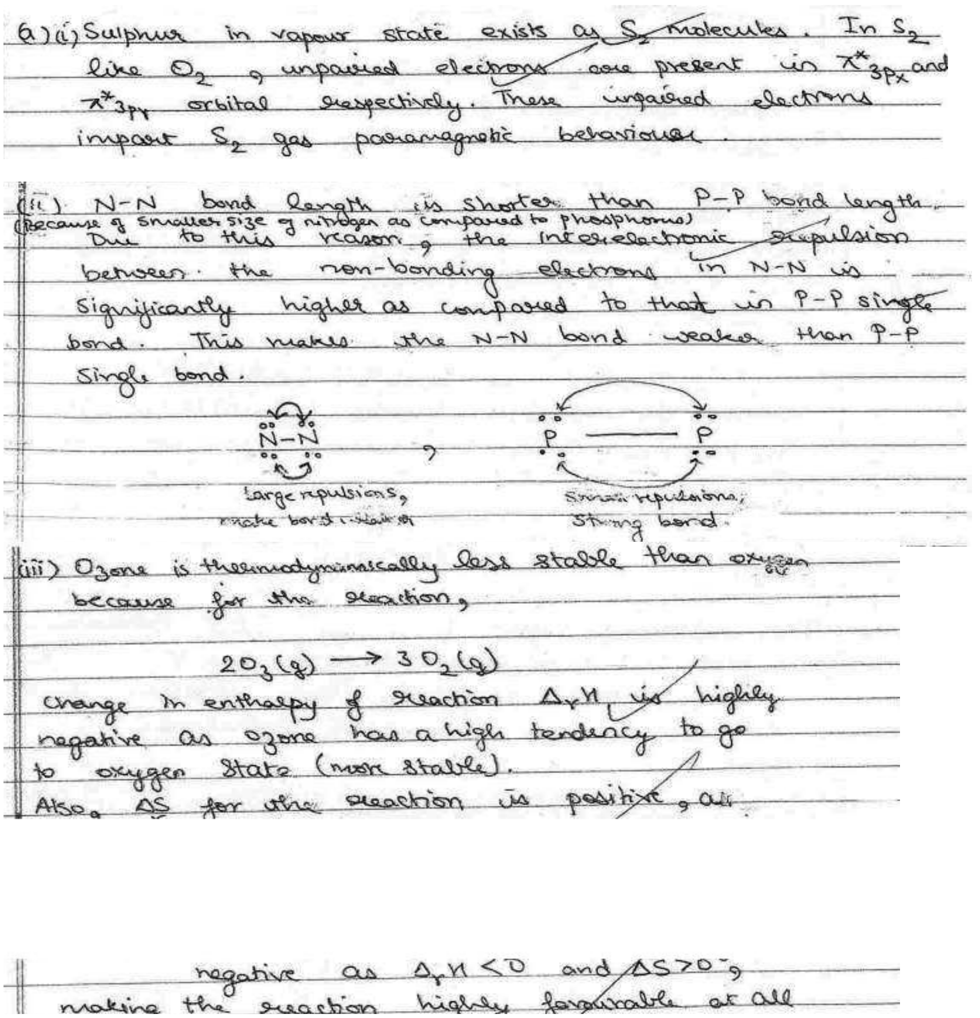
(b) (i) NO gas/ Nitric oxide **[1]**

(ii) NO_2 gas / Nitrogen dioxide

[CBSE Marking Scheme, 2019] [1]

OR

Ans.



(a) (i) Sulphur in vapour state exists as S_2 molecules. In S_2 like O_2, unpaired electrons are present in $\pi^*_{3p_x}$ and $\pi^*_{3p_y}$ orbital respectively. These unpaired electrons impart S_2 gas paramagnetic behaviour.

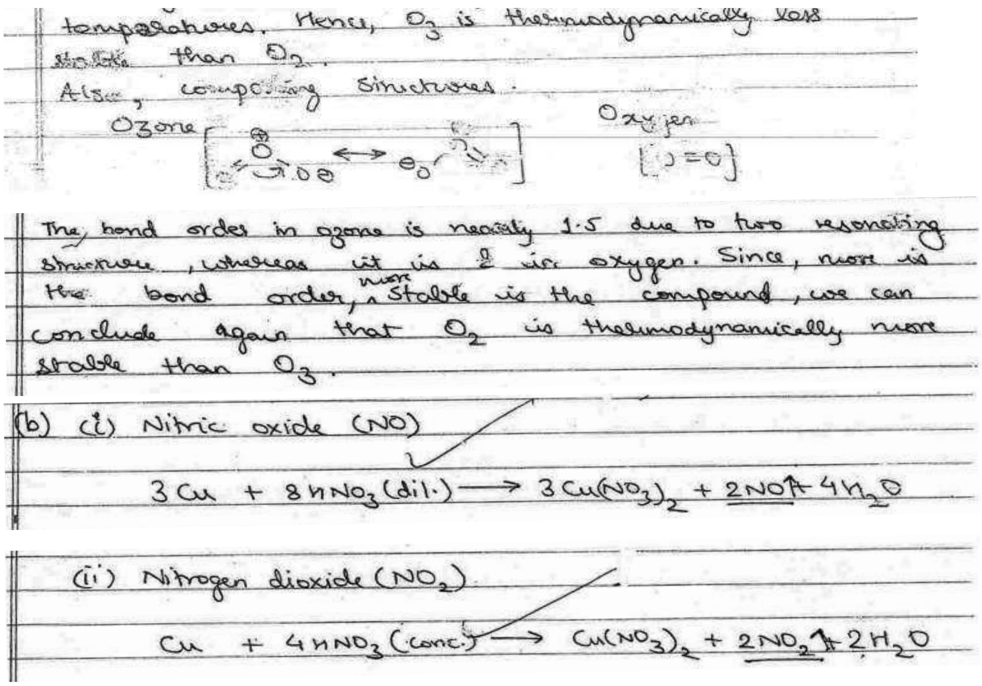
(ii) N-N bond length is shorter than P-P bond length. (Because of smaller size of nitrogen as compared to phosphorus) Due to this reason, the interelectronic repulsion between the non-bonding electrons in N-N is significantly higher as compared to that in P-P single bond. This makes the N-N bond weaker than P-P single bond.

(iii) Ozone is thermodynamically less stable than oxygen because for the reaction,

$$2O_3(g) \longrightarrow 3O_2(g)$$

change in enthalpy of reaction $\Delta_r H$, is highly negative as ozone has a high tendency to go to oxygen state (more stable).
Also, ΔS for the reaction is positive, as

negative as $\Delta_r H < 0$ and $\Delta S > 0$,
making the reaction highly favourable at all



temperatures. Hence, O_3 is thermodynamically less stable than O_2.

Also, comparing structures.

Ozone
Oxygen
[O=O]

The bond order in ozone is nearly 1.5 due to two resonating structures, whereas it is 2 in oxygen. Since, more is the bond order, more stable is the compound, we can conclude again that O_2 is thermodynamically more stable than O_3.

(b) (i) Nitric oxide (NO)

$3Cu + 8HNO_3(dil.) \longrightarrow 3Cu(NO_3)_2 + \underline{2NO} + 4H_2O$

(ii) Nitrogen dioxide (NO_2).

$Cu + 4HNO_3(conc.) \longrightarrow Cu(NO_3)_2 + \underline{2NO_2} + 2H_2O$

[5]

[Topper's Answer 2019]

OR

Detailed Answer :

(a) (i) In gas phase, sulphur exists mostly as diatomic molecule S_2. The bonding in this molecule is similar to that of dioxygen O_2. According to molecular orbital theory it has two unpaired electrons in anti-bonding molecular orbitals.

(ii) The N-N sigma bond length is less than the P-P sigma bond length. The shorter separation means the non-bonding electrons (lone pairs) on the nitrogen atoms repel each other strongly, making its bond weaker than the P-P bond.

(iii) The enthalpy change for decomposition of ozone has a negative value, it results in liberation of heat :

$$2O_3 \rightarrow 3O_2 \quad \ldots \Delta H^o = -142\,\text{kJ / mol}$$

The increase in number of moles of gas means the entropy change for the reaction is positive. This reinforces the effect of negative enthalpy change and results in a large negative value of ΔG^o for the decomposition reaction, making it less stable than oxygen.

(b) (i) Dilute HNO_3: Nitric oxide, NO.

(ii) Conc. HNO_3: Nitrogen dioxide, NO_2.

Q. 2. (a) (i) Write the disproportionation reaction of H_3PO_3.

(ii) Draw the structure of XeF_4.

(b) Account for the following :

(i) Although fluorine has less negative electron gain enthalpy yet F_2 is strong oxidizing agent.

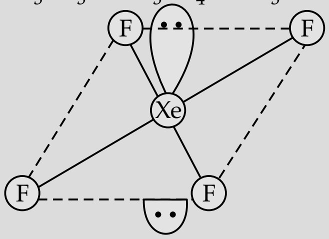
(ii) Acidic character decreases from N_2O_3 to Bi_2O_3 in group 15.

(c) Write a chemical reaction to test sulphur dioxide gas. Write chemical equation involved.

Ⓡ [CBSE Delhi Set - 1, 2019]

Ans. (a) (i) $4H_3PO_3 \rightarrow 3H_3PO_4 + PH_3$ **[1]**

(ii)



[1]

(b) (i) Due to small size and low bond dissociation enthalpy **[1]**

(ii) As the size increases, electronegativity decreases / non-metallic character decreases . **[1]**

(c) $5SO_2 + 2MnO_4^- + 2H_2O \rightarrow 5SO_4^{2-} + 4H^+ + 2Mn^{2+}$

[CBSE Marking Scheme, 2019] [1]

Detailed Answer :

(b) (i) The bond dissociation energy of F_2 is quite low, and the small size of the fluoride ion means that its hydration energy is high. These two compensate for the less negative value of electron gain energy, making F_2 a strong oxidizing agent.

(ii) As we move down a group, the atomic size and metallic character increases while electronegativity decreases. This leads to the acidic character of the oxide decreasing from top to bottom, N_2O_3 to Bi_2O_3.

(c) Sulphur dioxide decolourises acidified potassium permanganate solution.

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

Q. 3. (a) Account for the following :

(i) Tendency to show –3 oxidation state decreases from N to Bi in group 15.

(ii) Acidic character increases from H_2O to H_2Te.

(iii) F_2 is more reactive than ClF_3, whereas ClF_3 is more reactive than Cl_2.

(b) Draw the structure of (i) XeF_2, (ii) $H_4P_2O_7$.

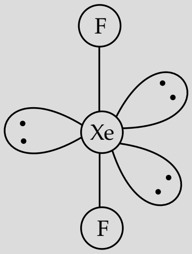
[CBSE OD Set - 2 2019]

Ans. (a) (i) Due to increase in size and metallic character. **[1]**

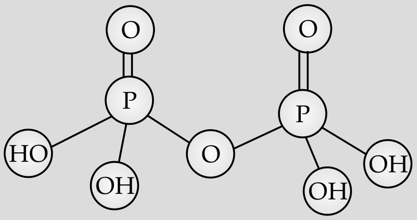
(ii) Due to decrease in bond dissociation enthalpy. **[1]**

(iii) Due to low bond dissociation enthalpy of F-F bond than Cl-F bond whereas Cl-Cl bond has higher bond dissociation enthalpy than Cl-F bond. **[1]**

(b) (i)



(ii)



[CBSE Marking Scheme, 2019] [1 + 1]

Detailed Answer :

(a) (i) Due to increase in the size of the atom and the metallic character.

(ii) Due to increase in size of the central atom as O < S < Se < Te, the distance between central atom and hydrogen atom also increases. This results in increase in bond length, decreasing bond dissociation enthalpy. The bond cleavage becomes easier, increasing the acidic character from H_2O to H_2Te.

(iii) Interhalogen compounds are more reactive than halogen compounds. But in case of fluorine, due to small size of fluorine it has high electronegativity and low bond energy so it is more reactive than ClF_3. Therefore, ClF_3 is more reactive than Cl_2.

Q. 4. (a) Give one example to show the anomalous reaction of fluorine.

(b) What is the structural difference between white phosphorus and red phosphorus?

(c) What happens when XeF_6 reacts with NaF?

(d) Why is H_2S a better reducing agent than H_2O?

(e) Arrange the following acids in the increasing order of their acidic character :
HBr, HI, HCl, HF

R [CBSE OD Set - 2 2019]

Ans. (a) $2F_2(g) + 2H_2O(l) \rightarrow 4H^+(aq) + 4F^-(aq) + O_2(g)$

(b) White phosphorus is discrete tetrahedral whereas red phosphorus is polymeric / or structures drawn.

(c) It forms $Na^+[XeF_7]^-$ / $XeF_6 + NaF \rightarrow Na^+[XeF_7]^-$

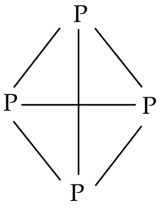
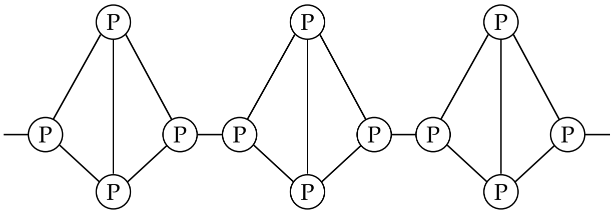
(d) Due to lower bond dissociation enthalpy of H-S bond than H-O bond.

(e) HF < HCl < HBr< HI **[CBSE Marking Scheme, 2019] [1 × 5]**

Detailed Answer :

(a) It forms only one oxoacid as compared to the rest of the halogens that form a number of oxoacids.

(b)

White phosphorus : It exits as discrete to tetrahedral P_4 unit.	**Red phosphorus :** It exits in the form of polymeric chain.
	

(c) $XeF_6 + NaF \longrightarrow Na^+[XeF_7]^-$.

(d) Due to larger size of sulphur and weak S-H bond in comparison to size of oxygen and O-H bond. Therefore, H_2S easily donates electron in comparison to H_2O.

(e) The strength of acidic character in halogen acids increases from HF to HI down the group, due to decrease in bond energy down the group. So, the increasing order of acidic character is:

HF < HCl < HBr < HI.

Q. 5. (a) Give reasons :

(i) H_3PO_3 undergoes disproportionation reaction but H_3PO_4 does not.

(ii) When Cl_2 reacts with excess of F_2, ClF_3 is formed and not FCl_3.

(iii) Dioxygen is a gas while Sulphur is a solid at room temperature.

(b) Draw the structures of the following :

(i) XeF_4 (ii) $HClO_3$

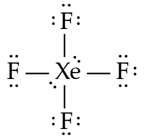
A&E [CBSE Delhi/OD, 2018]

Ans. (a) (i) In H_3PO_3, phosphorus exhibits an oxidation state of +3 hence it tends to undergo disproportionation reaction. However, in H_3PO_4, phosphorus exhibits +5 oxidation state and cannot be oxidised further hence it does not show the disproportionation reaction.

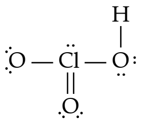
(ii) In interhalogen compounds, the central atom is of larger size and more electropositive than the surrounding atoms. As fluorine is more electronegative and smaller in size than chlorine, ClF_3 is formed.

(iii) Due to its small size and high electronegativity, oxygen forms pπ-pπ bonds and exists as a diatomic molecule. The intermolecular forces are weak van der Waals forces which result in dioxygen to exist as gas at room temperature whereas, sulphur exists as S_8 molecules held together by strong covalent forces and forms puckered ring structures packed in solid crystals.

(b) (i)



(ii)



Q. 6. (a) When concentrated sulphuric acid was added to an unknown salt present in a test tube a brown gas (A) was evolved. This gas intensified when copper turnings were added to this test tube. On cooling, the gas (A) changed into a colourless solid (B).

(i) Identify (A) and (B).

(ii) Write the structures of (A) and (B).

(iii) Why does gas (A) change to solid on cooling ? A&E [CBSE Delhi/OD, 2018]

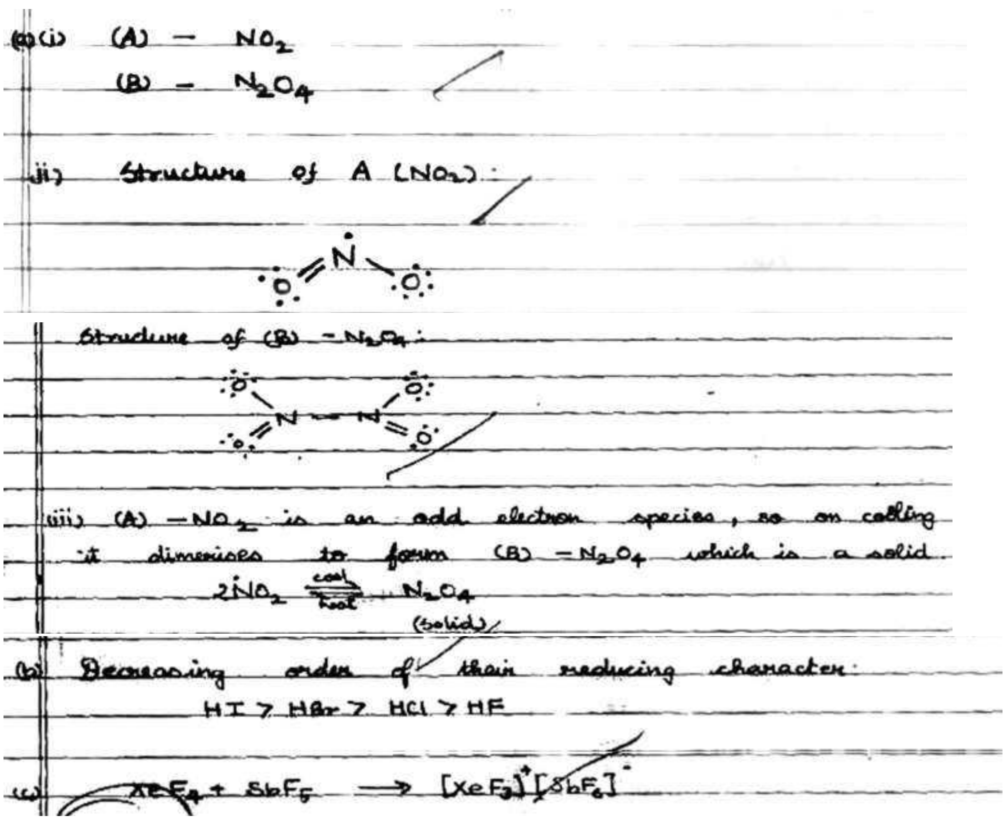
(b) Arrange the following in the decreasing order of their reducing character :

HF, HCl, HBr, HI

(c) Complete the following reaction :

$XeF_4 + SbF_5 \longrightarrow$ AE [CBSE Delhi/OD 2018]

Ans.



(a) (i) (A) – NO_2

(B) – N_2O_4

(ii) Structure of A (NO_2) :

Structure of (B) – N_2O_4 :

(iii) (A) – NO_2 is an odd electron species, so on cooling it dimerises to form (B) – N_2O_4 which is a solid.

$$2\dot{N}O_2 \underset{heat}{\overset{cool}{\rightleftharpoons}} \underset{(solid)}{N_2O_4}$$

(b) Decreasing order of their reducing character :

HI > HBr > HCl > HF

(c) $XeF_4 + SbF_5 \longrightarrow [XeF_3]^+[SbF_6]^-$

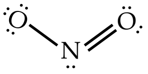
[Topper's Answer 2018]

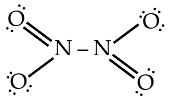
Detailed Answer :

(a) (i) An addition of conc. H_2SO_4 to salt evolves brown gas, which further intensifies brown colour and shows that the salt is a nitrate and the gas evolved is NO_2(A).

On cooling, NO_2 dimerizes to N_2O_4 which is colourless solid (B) is N_2O_4.

(ii)





(iii) Due to dimerization of NO_2.

(b) HI > HBr > HCl > HF

Decrease in bond dissociation enthalpy down the group makes it easier for the halogen to give away proton, thus the reducing property increases.

(c) $XeF_4 + SbF_5 \rightarrow [XeF_3]^+ [SbF_6]^-$

Adduct is formed by XeF_4 with lewis acid SbF_5.

TOPIC-3

Group-17 Elements, Properties and Some Important Compounds

Revision Notes

- **Halogen family :** $_9F$, $_{17}Cl$, $_{35}Br$, $_{53}I$, $_{85}At$.
- **Physical Properties :**
  - **(i) Atomic and ionic radii :** They are the smallest in their respective periods due to increase in nuclear charge. Down the group, they increase.
  - **(ii) Oxidation state :** Fluorine shows –1 oxidation state only. Other elements show oxidation states +1, +3, +5 and +7.
  - **(iii) Ionisation enthalpy :** Higher than the corresponding members of group 16. Down the group, it decreases.
  - **(iv) Electron gain enthalpy :** Have maximum negative electron gain enthalpy in the corresponding periods.
  - **(v) Metallic character** : Due to very high ionisation enthalpies they are non-metals. The last element I, shows some metallic character as it can form I^+ by loss of electrons.
  - **(vi) Electronegativity :** These are the most electronegative elements in their respective periods. Down the group, electronegativity decreases.
  - **(vii)** F_2 and Cl_2 are gases, Br_2 is a liquid while I_2 is solid.
  - **(viii)** All halogens are coloured.
  - **(ix) Melting point and boiling point :** Increase down the group due to increase in size and nuclear charge causing greater van der Waals forces of attraction.
  - **(x) Bond dissociation enthalpy :** Bond dissociation enthalpy decreases from Cl_2 to I_2 *i.e.*, $Cl_2 > Br_2 > F_2 > I_2$.
- **Chemical Properties :**
  - **(a) Highly reactive :** The reactivity decreases down the group. Fluorine is the strongest oxidising halogen. A halogen oxidises halide ions of higher atomic number.

$$F_2 + 2X^- \rightarrow 2F^- + X_2 \qquad (X = Cl, Br\text{ or }I)$$
$$Cl_2 + 2X^- \rightarrow 2Cl^- + X_2 \qquad (X = Br\text{ or }I)$$
$$Br_2 + 2I^- \rightarrow 2Br^- + I_2$$

Fluorine oxidises water to oxygen whereas chlorine and bromine react with water to form corresponding hypohalic and hypohalous acids.

$$2F_2(g) + 2H_2O(l) \rightarrow 4H^+(aq) + 4F^-(aq) + O_2(g)$$
$$X_2(g) + H_2O(l) \rightarrow HX(aq) + HOX(aq) \qquad (X = Cl\text{ or }Br)$$

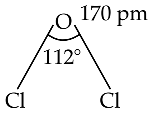
  - **(b) Towards hydrogen :** All elements form hydrides of the type HX (X = F, Cl, Br, I).
    - **(i) Physical state :** Except HF which is a liquid because of H-bonding, all are gases.
    - **(ii) Thermal stability :** It decreases down the group due to increase in bond length.
    - **(iii) Reducing character :** It increases from HF to HI due to decrease of stability.
    - **(iv) Acidic strength :** HF < HCl < HBr < HI.
  - **(c) Towards halogens :** They react with all elements except He, Ne and Ar to form binary halides.
  - **(d) Towards metal :**
    - **(i)** With particular metal, ionic character is M-F > M-Cl > M-Br > M–I.
    - **(ii)** With metals having low I.E., halides are ionic.

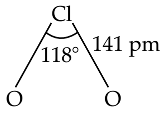
(iii) With metals having high I.E., halides are covalent.

(iv) With metals showing more than one oxidation states, halides with higher oxidation states are more covalent.

(v) Metals show highest oxidation state in fluorides.

(e) Towards oxygen : Halogens form many binary compounds with oxygen, but most of them are unstable. Cl, Br and I form oxides in their oxidation state +1 to +7. Their stability decreases in the order I > Cl > Br.





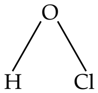
(f) Oxoacids : Because of high electronegativity and small size, fluorine forms only one oxoacid, HOF (hypofluorous acid). The other halogens form acid of the type HOX—hypohalous acid, HOXO–halous acid, $HOXO_2$ – halic acid and $HOXO_3$ – perhalic acid.

Acidic strength : HClO > HBrO > HIO

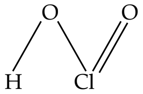
Acidic strength of oxoacids containing the same halogen :

$HOCl > HClO_2 < HClO_3 < HClO_4$

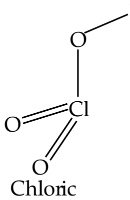
(g) Structure of oxoacids of Chlorine :



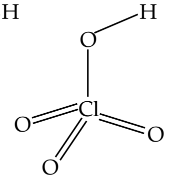
Hypochlorous acid



Chlorous acid



Chloric acid



Perchloric acid

➢ **Chlorine (Cl_2)**

Preparation :

In laboratory,

$$MnO_2 + 4HCl \xrightarrow{\Delta} MnCl_2 + Cl_2 + 2H_2O$$

$$2KMnO_4 + 16HCl \xrightarrow{\Delta} 2KCl + 2MnCl_2 + 8H_2O + 5Cl_2$$

(i) $4HCl + O_2 \xrightarrow{CuCl_2} 2Cl_2 + 2H_2O$ (Deacon's process)

(ii) $4NaCl + MnO_2 + 4H_2SO_4 \rightarrow MnCl_2 + 4NaHSO_4 + 2H_2O + Cl_2$

(iii) Electrolytic process : By electrolysis of brine.

At cathode : $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$; $Na^+ + OH^- \rightarrow NaOH$

At anode : $Cl^- \rightarrow Cl + e^-$; $Cl + Cl \rightarrow Cl_2$

Properties :

(i) It is a greenish yellow gas with a pungent suffocating smell

(ii) It is soluble in water

(iii) About 2.5 times heavier than air

(iv) With metals and non-metals form chlorides

$$2Al + 3Cl_2 \rightarrow 2AlCl_3;\ 2Na + Cl_2 \rightarrow 2NaCl$$
$$2Fe + 3Cl_2 \rightarrow 2FeCl_3;\ S_8 + 4Cl_2 \rightarrow 4S_2Cl_2$$
$$P_4 + 6Cl_2 \rightarrow 4PCl_3;\ H_2 + Cl_2 \rightarrow 2HCl$$

(v) Reacts with compounds containing hydrogen to form HCl

$$H_2S + Cl_2 \rightarrow 2HCl + S;\ C_{10}H_{16} + 8Cl_2 \rightarrow 16HCl + 10C$$
$$\underset{\text{(excess)}}{NH_3} + 3Cl_2 \rightarrow \underset{\text{(explosive)}}{NCl_3} + 3HCl;\ \underset{\text{(excess)}}{8NH_3} + 3Cl_2 \rightarrow 6NH_4Cl + N_2$$

(vi) With cold and dilute alkalies

$$\underset{\text{(cold and dilute)}}{2NaOH} + Cl_2 \rightarrow NaCl + NaOCl + H_2O$$

(vii) With hot and concentrated alkalies

$$\underset{\text{(hot and conc.)}}{6NaOH} + 3Cl_2 \rightarrow 5NaCl + NaClO_3 + 3H_2O$$

(viii) With dry slaked lime, it gives bleaching powder.

$$2Ca(OH)_2 + 2Cl_2 \rightarrow Ca(OCl)_2 + CaCl_2 + 2H_2O$$

(ix) Chlorine water on standing loses its yellow colour. HOCl formed gives nascent oxygen.

$$Cl_2 + H_2O \rightarrow HCl + HOCl$$
$$HOCl \rightarrow HCl + O$$

(x) It oxidises ferrous to ferric, sulphite to sulphate, sulphur dioxide to sulphuric acid and iodine to iodic acid.

$$2FeSO_4 + H_2SO_4 + Cl_2 \rightarrow Fe_2(SO_4)_3 + 2HCl$$
$$Na_2SO_3 + Cl_2 + H_2O \rightarrow Na_2SO_4 + 2HCl$$
$$SO_2 + 2H_2O + Cl_2 \rightarrow H_2SO_4 + 2HCl$$
$$I_2 + 6H_2O + 5Cl_2 \rightarrow 2HIO_3 + 10HCl$$

Uses :

(i) For bleaching cotton and textiles.

(ii) In sterilising drinking water.

(iii) In the extraction of gold and platinum.

(iv) Manufacture of dyes, drugs, refrigerant and other organic compounds like $CHCl_3$, DDT, CCl_4, etc.

- **Hydrogen chloride (HCl) :**

Preparation : In laboratory

$$NaCl + H_2SO_4 \xrightarrow{420\ K} NaHSO_4 + HCl$$
$$NaHSO_4 + NaCl \xrightarrow{823\ K} Na_2SO_4 + HCl$$

HCl gas can be dried by passing conc. H_2SO_4 through it.

Properties :

(i) Colourless and pungent smelling gas.

(ii) Extremely soluble in water.

(iii) When three parts of conc. HCl and one part of conc. HNO_3 are mixed, aqua-regia is formed which is used for dissolving noble metals *e.g.*, gold, platinum.

$$Au + 4H^+ + NO_3^- + 4Cl^- \rightarrow AuCl_4^- + NO + 2H_2O$$
$$3Pt + 16H^+ + 4NO_3^- + 18Cl^- \rightarrow 3PtCl_6^{2-} + 4NO + 8H_2O$$

(iv) Reacts with NH_3 giving white fumes of NH_4Cl

$$NH_3 + HCl \rightarrow NH_4Cl$$

(v) Decomposes salts of weaker acids.

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$$
$$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$$
$$Na_2SO_3 + 2HCl \rightarrow 2NaCl + H_2O + SO_2$$

Uses :

(i) In the manufacture of chlorine, glucose and NH_4Cl.

(ii) For extracting glue from bones and purifying bone black.

- **Interhalogen Compounds :** Halogen combines amongst themselves to form a number of compounds known as interhalogen compounds. Their general formulae are XX', XX_3', XX_5' and XX_7' where X is halogen of larger size and higher electropositivity and X' of smaller size.

Preparation :

$$\underset{\text{(Equal volume)}}{Cl_2 + F_2} \xrightarrow{437\ K} 2ClF; \qquad \underset{\text{(excess)}}{I_2 + 3Cl_2} \rightarrow 2ICl_3$$

$$\underset{\text{(excess)}}{Cl_2 + 3F_2} \xrightarrow{573\ K} 2ClF_3; \qquad \underset{\text{(Diluted with water)}}{Br_2 + 3F_2} \rightarrow 2BrF_3$$

$$\underset{\text{(Equimolar)}}{I_2 + Cl_2} \rightarrow 2ICl; \qquad \underset{\text{(excess)}}{Br_2 + 5F_2} \rightarrow 2BrF_5$$

Properties :

(i) Covalent compounds.

(ii) Diamagnetic in nature.

(iii) More reactive than halogens.

(iv) Undergo hydrolysis.

$$XX' + H_2O \rightarrow HX' + HOX$$

- **Structure :** On the basis of VSEPR theory, XX_3' compounds have bent 'T' shape, XX_5' compounds have square pyramidal and IF_7 has pentagonal bipyramidal shape.

  Uses :

  (i) As non-aqueous solvents.

  (ii) As fluorinating agents.

  (iii) ClF_3 and BrF_3 are used for the production of UF_6 in the enrichment of ^{235}U.

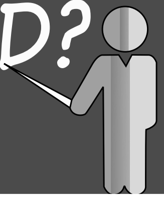
Know the Terms

- **Pseudohalide ions :** CN^-, SCN^- and OCN^- ions are called pseudohalide ions while $(CN)_2$, $(SCN)_2$ and $(OCN)_2$ are known as pseudohalogens.
- **Bleaching powder :** $Ca(OH)_2 + Cl_2 \rightarrow \underset{\text{Bleaching Powder}}{CaOCl_2} + H_2O$

Mnemonics

- **Concept:** Increasing order of atomic radii and atomic volume (Top to bottom-Group)
- **Mnemonic:** First Class Biryani In Australia.
- **Interpretation:** **F**luorine**(F)**, **C**hlorine**(Cl)**, **B**romine**(Br)**, **I**odine**(I)**, **A**statine**(At)**

How is it done on the GREENBOARD?



Q. (a) Account for the following :

(i) Tendency to show –2 oxidation state decreases from oxygen to tellurium.

(ii) Acidic character increases from HF to HI.

(iii) Moist SO_2 gas acts as a reducing agent.

(b) Draw the structure of an oxoacid of sulphur containing S–O–S linkage.

(c) Complete the following equation :

$$XeF_2 + H_2O \rightarrow$$

Solution:

STEP-1: (a) (i) –2 oxidation state decreases from oxygen to tellurium because of the presence and filling of d-orbitals. As we move from O to Te, nuclear size increases and electronegativity decreases.

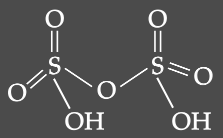
STEP-2: Acidic strength increases from HF to HI because HF has maximum polarity and bond dissociation enthalpy. HF also has intermolecular hydrogen bonding so hydrogen atoms get trapped in the hydrogen bond.

STEP-III: In the presence of moisture SO_2 is oxidised to H_2SO_4 liberating hydrogen.

$$SO_2 + 2H_2O \rightarrow H_2SO_4 + 2\,[H]$$

Coloured substance + 2[H] → colourless

(b) $H_2S_2O_7$



(c) $2XeF_2 + 2H_2O \rightarrow 2Xe + 4HF + O_2$

[3 + 1 + 1 = 5]

Objective Type Questions

(1 mark each)

[A] MULTIPLE CHOICE QUESTIONS :

Q.1. Affinity for hydrogen decreases in the group from fluorine to iodine. Which of the halogen acids should have highest bond dissociation enthalpy?

(a) H-F **(b) HCl**

(c) HBr **(d) HI**

U

Ans. Correct option : (a)

Explanation : F being smallest has the shortest H-F bond and therefore HF has the highest bond dissociation energy.

Q. 2. Reduction potentials of some ions are given below. Arrange them in decreasing order of oxidising power.

Ion	ClO_4^-	IO_4^-	BrO_4^-
Reduction potential $E^{\ominus}/V$	$E^{\ominus}=1.19V$	$E^{\ominus}=1.65V$	$E^{\ominus}=1.74V$

(a) $ClO_4^- > IO_4^- > BrO_4^-$ **(b) $IO_4^- > BrO_4^- > ClO_4^-$**

(c) $BrO_4^- > IO_4^- > ClO_4^-$ **(d) $BrO_4^- > ClO_4^- > IO_4^-$**

A

Ans. Correct option : (c)

Explanation : The higher the reduction potential, the higher is its tendency to get reduced. Hence, the order of oxidising power is :

$BrO_4^- > IO_4^- > ClO_4^-$

Q. 3. Which of the following is iso-electronic pair?

(a) ICl_2, ClO_2 **(b) BrO_2^-, BrF_2^+**

(c) ClO_2, BrF **(d) CN^-, O_3** A

Ans. Correct option : (b)

Explanation :

(a) $ICl_2 = 53 + 2 \times 17 = 87$

$ClO_2 = 17 + 16 = 33$

(b) $BrO_2^- = 35 + 2 \times 8 + 1 = 52$

$BrF_2^+ = 35 + 9 \times 2 - 1 = 52$

(c) $ClO_2 = 17 + 16 = 33$

$BrF = 35 + 9 = 44$

(d) $CN^- = 6 + 7 + 1 = 14$

$O_3 = 8 \times 3 = 24$

Q. 4. A black compound of manganese reacts with a halogen acid to give greenish yellow gas. When excess of this gas reacts with NH_3 an unstable tri-halide is formed. In this process the oxidation state of nitrogen changes from :

(a) – 3 to +3. (b) **– 3 to 0.**

(c) – 3 to +5. (d) **0 to – 3.** A&E

Ans. Correct option : (a)

Explanation :

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

(Greenish yellow gas)

$NH_3 + 3Cl_2 \rightarrow NCl_3 + 3HCl$

When excess of chlorine reacts with ammonia then NCl_3 and HCl will form. In this reaction on left-hand side chlorine has (−3) oxidation state and on the right-hand chlorine has (+3) oxidation state.

[B] ASSERTION AND REASON TYPE QUESTIONS :

In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

Q.1. Assertion (A) : HI cannot be prepared by the reaction of KI with concentrated H_2SO_4.

Reason (R) : HI has lowest H–X bond strength among halogen acids. R

Ans. Correct option : (b)

Explanation : Both statements are correct but are independent of each other.

HI cannot be prepared by the reaction of KI with concentrated H_2SO_4 as it results in the formation of HI which further oxidizes to I_2 as H_2SO_4 is a strong oxidizing agent.

Q.2. Assertion (A) : F_2 is a strong oxidizing agent.

Reason (R) : Electron gain enthalpy of fluorine is less negative. **[CBSE OD Set-1 2020]**

Ans. Correct option : (b)

Explanation : Fluorine is the best oxidising agent because it has more reduction potential (more ability to lose the electrons) which is attributed to its high electronegativity.

Q.3. Assertion (A) : F_2 has lower bond dissociation energy than Cl_2.

Reason (R) : Flourine is more electronegative than chlorine. **[CBSE OD Set-2 2020]**

Ans. Correct option : (d)

Explanation : F_2 has higher bond dissociation enthalpy than Cl_2.

Q.4. Assertion (A) : F_2 has lower reactivity.

Reason (R) : F-F bond has low $\Delta_{bond} H^o$.

Ans. Correct option : (d)

Explanation : Fluorine is the maximum reactive because of low bond dissociation enthalpy.

[C] VERY SHORT ANSWER TYPE QUESTIONS :

Q.1. Write the formula of the compound of iodine which is obtained when conc. HNO_3 oxidises I_2.

R **[CBSE OD Set-3 2017]**

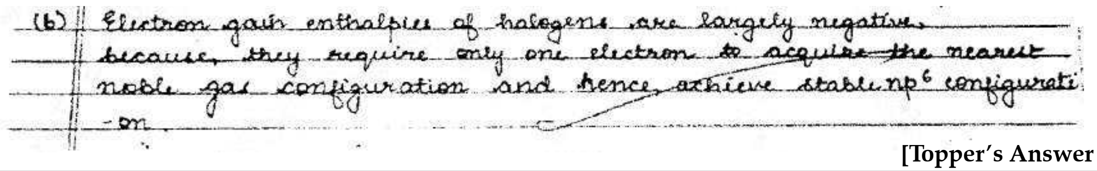
Ans. HIO_3.

[CBSE Marking Scheme 2017]

Q.2. Give reason for the following:

Electron gain enthalpies of halogens are largely negative. A&E **[CBSE O.D. Set-2, 2017]**

Ans.



(b) Electron gain enthalpies of halogens are largely negative because, they require only one electron to acquire the nearest noble gas configuration and hence, achieve stable np^6 configuration.

[Topper's Answer 2017]

Detailed Answer:

Halogens are smallest in size in their respective periods resulting in high effective nuclear charge. They accept one electron to attain noble gas electronic configuration. Hence, they have negative electron gain enthalpy.

Q. 3. Give reason: Fluoride ion has higher hydration enthalpy than chloride ion.

A&E **[CBSE Delhi Set-1, 2, 3, 2017]**

Ans. Due to small size of fluoride ion/high charge density of fluoride ion/high charge size ratio of fluoride ion. **[1]**

[CBSE Marking Scheme 2017]

Detailed Answer :

The size of fluoride ion is smaller to that of chloride ion. So, on dissolving in water, the hydration energy released in the case of fluoride ion is higher than chloride ion because of stronger interactions between the water and fluoride ion.

Q. 4. Assign reason for the following: Reducing character increases from HF to HI.

A&E **[CBSE O.D. Set-2, 2016]**

Ans. As we move from HF to HI, the thermal stability of these hydrides decreases as bond dissociation enthalpy of HX bond decreases. So, on moving from HF to HI, the hydrogen is available for reduction. Therefore, reducing character increases. **[1]**

Commonly Made Error

- Students often state the facts but do not explain the reason properly.

Answering Tip

- While stating the reason, write the cause and the consequence.

Q. 5. Give reason: ICl is more reactive than I_2.

A&E **[CBSE OD (Central) 2016]**

Ans. Inter halogen compound ICl is more reactive than Cl_2 because I–Cl bond in inter halogen is weaker than Cl–Cl bond in halogens except F–F bond. **[1]**

Short Answer Type Questions

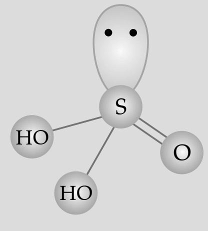
(2 marks each)

AI **Q. 1. Draw the structures of the following:**

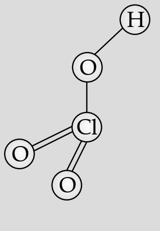
(i) H_2SO_3

(ii) $HClO_3$ R **[CBSE OD Set-1 2017]**

Ans. (i)



(ii)



[1+1]

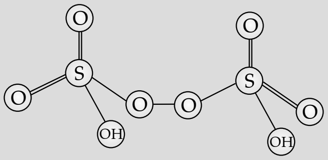
[CBSE Marking Scheme 2017]

AI **Q. 2. Draw the structures of the following:**

(i) $H_2S_2O_8$

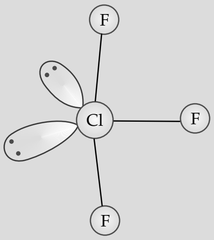
(ii) ClF_3 R **[CBSE OD Set-2 2017]**

Ans. (i)



[1]

(ii)

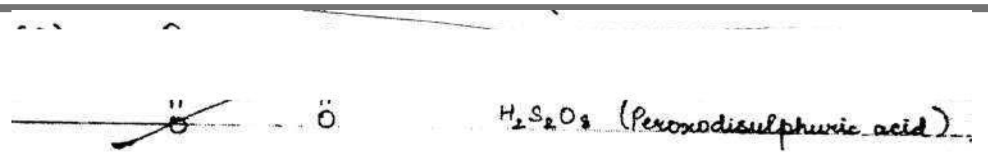


[1]

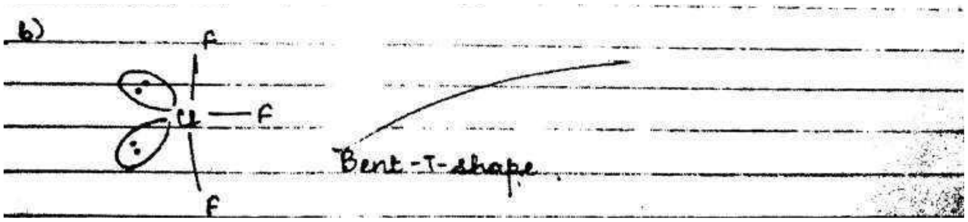
[CBSE Marking Scheme 2017]

OR

Ans.



$H_2S_2O_8$ (Peroxodisulphuric acid).



[Topper's Answer 2017] [2]

Commonly Made Error

- Students often do not follow the convention and draw inaccurate structures.

Answering Tip

- Draw the structures with lone pair of electrons (if present). Avoid over-writing.

AI **Q. 3. Arrange the following in order of property indicated for each set :**

(i) F_2, Cl_2, Br_2, I_2 – increasing bond dissociation enthalpy.

(ii) PH_3, AsH_3, BiH_3, SbH_3, NH_3 – increasing basic strength. U **[CBSE SQP 2016; DDE]**

Ans. (i) $I_2 < F_2 < Br_2 < Cl_2$ **[1]**

(ii) $BiH_3 < SbH_3 < AsH_3 < PH_3 < NH_3$ **[1]**

Q. 4. Account for the following:

(i) Two S-O bond lengths in SO_2 are equal.

(ii) Fluorine shows only –1 oxidation state in its compounds. A&E **[CBSE Comptt. Delhi Set-2 2017]**

Ans. (i) Due to resonance the two S-O bond lengths are identical. **[1]**

(ii) Absence of d-orbitals and most electronegative element. **[1]**

[CBSE Marking Scheme 2017]

AI **Q. 5. Account for the following:**

(i) Bond angle in NH_4^+ is higher than that in NH_3.

(ii) ICl is more reactive than I_2.

A&E **[CBSE Comptt. Delhi Set-3 2017]**

Ans. (i) In NH_4^+, all are bond pairs whereas in ammonia the lone pair of electron on nitrogen repels the bond pairs and reduces the bond angle. **[1]**

(ii) I-Cl bond is weaker than I-I bond / low bond dissociation enthalpy in I-Cl. **[1]**

[CBSE Marking Scheme 2017]

Q. 6. Arrange the following in the order of property indicated against each set:

(a) F_2, Cl_2, Br_2, I_2 (increasing bond dissociation enthalpy)

(b) H_2O, H_2S, H_2Se, H_2Te (increasing acidic character) U

OR

Answer the following questions :

(i) Write the formula of the neutral molecule which is isoelectronic with ClO.

(ii) Draw the shape of $H_2S_2O_7$.

U + R **[CBSE SQP 2017]**

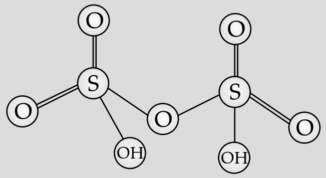
Ans. (a) $I_2 < F_2 < Br_2 < Cl_2$

(b) $H_2O < H_2S < H_2Se < H_2Te$

OR

(i) ClF **[1]**

(ii)



[1]

Pyrosulphuric acid (Oleum)
($H_2S_2O_7$)

Q. 7. Give reasons :

(i) When Cl_2 reacts with excess of F_2, ClF_3 is formed and not FCl_3.

(ii) Dioxygen is a gas while Sulphur is a solid at room temperature. A&E **[CBSE Delhi OD 2018]**

Ans. (i) F cannot show positive oxidation state as it has highest electronegativity/Because Fluorine cannot expand its covalency / As Fluorine is a small sized atom, it cannot pack three large sized Cl atoms around it. **[1]**

(ii) Oxygen has multiple bonding whereas sulphur shows catenation / Due to pπ-pπ bonding in oxygen whereas sulphur does not / Oxygen is diatomic therefore held by weak intermolecular force while sulphur is polyatomic held by strong intermolecular forces. **[1]**

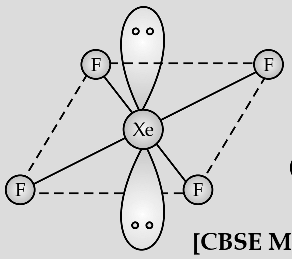
[CBSE Marking Scheme 2018]

Q. 8. Draw the structures of the following :

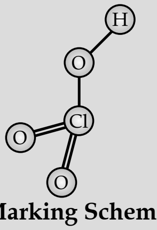
(i) XeF_4

(ii) $HClO_3$ R **[CBSE Delhi OD 2018]**

Ans. **(i)**



(ii)



[1+1]

[CBSE Marking Scheme 2018]

Q. 9. Write balanced chemical equations for the following processes :

(i) XeF_2 undergoes hydrolysis.

(ii) MnO_2 is heated with conc HCl. **[2]**

OR

Arrange the following in order of property indicated for each set :

(i) H_2O, H_2S, H_2Se, H_2Te – **increasing acidic character**

(ii) HF, HCl, HBr, HI – decreasing bond enthalpy

Ans. (i) $2XeF_2(s) + 2H_2O\ (l) \rightarrow 2Xe(g) + 4\ HF(aq) + O_2(g)$ **[1]**

(ii) $MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$ **[1]**

[CBSE Marking Scheme, 2019]

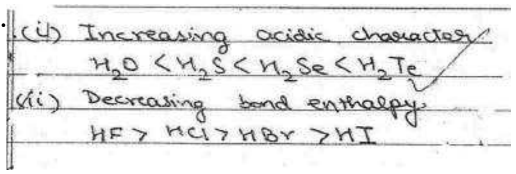
OR

Ans. (i) $H_2O < H_2S < H_2Se < H_2Te$ **[1]**

(ii) HF > HCl > HBr > HI **[1]**

[CBSE Marking Scheme, 2019]

Ans.



(i) Increasing acidic character

$H_2O < H_2S < H_2Se < H_2Te$

(ii) Decreasing bond enthalpy.

HF > HCl > HBr > HI

[Topper's Answer 2019]

Detailed Answer :

(i) O, S, Se and Te are all in the same group in the periodic table. As we move down the group, the atomic radius increases. In binary acids, the H - Te bond is longest and the H - O bonds is shortest. The H - Te bond is therefore weakest and the H - O bond is strongest. Thus H_2O is the weakest acid while H_2Te is the strongest acid.

The order of the given compounds in increasing acidic character is:

$H_2O < H_2S < H_2Se < H_2Te$

(ii) As we move down the group, the atomic size increases. Hence, HI is the strongest acid while HF is the weakest acid. Thus, the bond enthalpy is inversely related to the size of the halogen atoms.

The order of the given compounds in decreasing bond enthalpy is:

HF > HCl > HBr > HI **[2]**

Short Answer Type Questions-II

(3 marks each)

Q. 1. What is the reason behind the anomalous behaviour of fluorine in Group 16? R

Ans: Fluorine's anomalous behaviour is due to the following-

(a) Its small size

(b) Its high electronegativity

(c) Its low F-F bond dissociation enthalpy

(d) Non-availability of d-orbitals in valence shell

(Any three correct reasons) **[3]**

Q. 2. A greenish yellow gas 'Y' is obtained by oxidation of 'X' in the presence of CuCl2 as catalyst. 'Y' reacts with gas 'Z' to give HCl. Identify 'X', 'Y', 'Z' and write the equations involved. A&E

Ans: $4HCl + O2\text{----}CuCl_2\text{---}\ 2Cl_2 + 2H_2O$

(X) (Y)

(Greenish yellow gas)

$H_2 + Cl_2\ \text{---}\ 2HCl$

(Z) **[3]**

Q. 3. Give any three characteristics of Interhalogen compounds. R

Ans: Characteristics of Interhalogen compounds-

(a) All are covalent compounds.

(b) Diamagnetic in nature.

(c) Volatile solids or liquids except ClF which is a gas.

(d) Physical properties are intermediate between those of constituent halogens but m.p and b.p are a little higher than expected.

(Any three correct properties) **[3]**

Long Answer Type Questions

(5 marks each)

Q. 1. (i) Answer the following questions : (2+3)

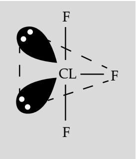
(a) Write the balanced chemical reaction for reaction of Cu with dilute HNO_3**.**

(b) Draw the shape of ClF_3**.**

(ii) 'X' has a boiling point of 4.2K, lowest for any known substance. It is used as a diluent for oxygen in modern diving apparatus. Identify the gas 'X'. Which property of this gas makes it usable as diluent? Why is the boiling point of the gas 'X' so low? A **[CBSE SQP 2021]**

Ans. (i) (a) $3Cu + 8HNO_3(\text{dilute}) \longrightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$ **[1]**

(b)



[1]

(ii) 'X' is Helium **[1]**

It is used as a diluent for oxygen in modern diving apparatus because of its very low solubility in blood. **[1]**

It is monoatomic having no interatomic forces except weak dispersion forces and has second lowest mass therefore boiling point is lowest. **[1]**

Q. 2. (a) Account for the following :

(i) Ozone is thermodynamically unstable.

(ii) Solid PCl_5 is ionic in nature.

(iii) Fluorine forms only one oxoacid HOF.

(b) Draw the structure of

(i) BrF_5

(ii) XeF_4 **[5]**

OR

(i) Compare the oxidising action of F_2 and Cl_2 by considering parameters such as bond dissociation enthalpy, electron gain enthalpy and hydration enthalpy.

(ii) Write the conditions to maximize the yield of H_2SO_4 by contact process.

(iii) Arrange the following in the increasing order of property mentioned :

(a) H_3PO_3, H_3PO_4, H_3PO_2 (Reducing character).

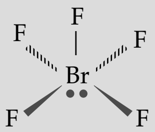
(b) NH_3, PH_3, AsH_3, SbH_3, BiH_3 (Base strength). **A [CBSE Delhi Set-1 2016]**

Ans. (a) (i) Endothermic compound / decomposition of ozone is exothermic in nature and ΔG is negative / decomposition of ozone is spontaneous. **[1]**

(ii) Exists as $[PCl_4]^+$ and $[PCl_6]^-$. **[1]**

(iii) Shows only -1 oxidation state / most electronegative element/ absence of *d*-orbitals. **[1]**

(b) (i)



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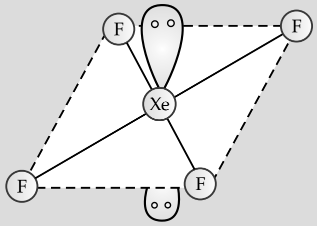


[1 + 1]

OR

(i) F_2 is the stronger oxidising agent than chlorine

(a) low enthalpy of dissociation of F-F bond

(b) less negative electron gain enthalpy of F

(c) high hydration enthalpy of F^- ion

[½ × 4 = 2]

(ii) low temperature, high pressure and presence of catalyst **[1]**

(iii) (a) $H_3PO_4 < H_3PO_3 < H_3PO_2$ **[1]**

(b) $BiH_3 < SbH_3 < AsH_3 < PH_3 < NH_3$ **[1]**

[CBSE Marking Scheme, 2016]

TOPIC-4

Group-18 Elements, Properties and Some Important Compounds

Revision Notes

- **Noble gases :** ${}_2He$, ${}_{10}Ne$, ${}_{18}Ar$, ${}_{36}Kr$, ${}_{54}Xe$, ${}_{86}Ra$.
- Also known as rare gases as they are present in very small amounts in the air or as inert gases as they were considered chemically unreactive.
- **Electronic configuration :** ns^2np^6 (except He which has $1s^2$)
- **Physical Properties :**
  - **(i)** Gases
  - **(ii)** Atomic radii increase down the group and highest in their respective periods.
  - **(iii)** Highest ionisation enthalpy in their respective periods. Down the group, it decreases due to increase in atomic size.
  - **(iv)** Large positive values of electron gain enthalpy as noble gases have stable electronic configuration and no tendency to accept electron.
  - **(v)** Low melting points and boiling points due to weak dispersion forces. Down the group they increase because of increase in van der Waals forces.
  - **(vi) Liquefaction :** They are difficult to liquify. Down the group, the ease of liquefaction increases.
- In 1962, Bartlett studied the given reaction :

$$O_2 + PtF_6 \rightarrow \underset{\text{Dioxygenyl hexafluoro platinate}}{O_2^+[PtF_6]^-}$$

As ionisation enthalpy of molecular oxygen was almost similar to xenon, following reaction was also found to occur :

$$Xe + PtF_6 \xrightarrow{289\text{ K}} Xe^+[PtF_6]^-$$

- **Preparation of Xenon fluorides :** Xenon forms three binary fluorides, XeF_2, XeF_4 and XeF_6.

$$\underset{\text{(excess)}}{Xe(g) + F_2(g)} \xrightarrow{673\text{ K, 1 bar}} XeF_2(s)$$

$$Xe(g) + 2F_2(g) \xrightarrow{873\text{ K, 7 bar}} XeF_4(s)$$

$$\underset{\text{(1 : 20 ratio)}}{Xe(g) + 3F_2(g)} \xrightarrow{573\text{ K, 60-70 bar}} XeF_6(s)$$

$$XeF_4 + O_2F_2 \xrightarrow{143\text{ K}} XeF_6 + O_2$$

- **Preparation of Xenon trioxide (XeO_3) :**

$$6XeF_4 + 12H_2O \rightarrow 2XeO_3 + 4Xe + 3O_2 + 24HF$$
$$XeF_6 + 3H_2O \rightarrow XeO_3 + 6HF$$

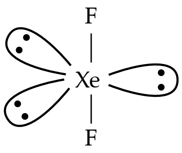
- **Preparation of Xenon oxyfluorides :**

$$XeF_4 + H_2O \rightarrow \underset{\substack{\text{Xenon}\\ \text{oxydifluoride}}}{XeOF_2} + 2HF$$

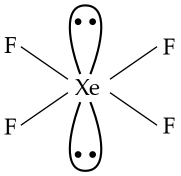
$$XeF_6 + H_2O \xrightarrow[\text{Hydrolysis}]{\text{Partial}} \underset{\substack{\text{Xenon}\\ \text{oxytetrafluoride}}}{XeOF_4} + 2HF$$

$$XeF_6 + 2H_2O \xrightarrow[\text{Hydrolysis}]{\text{Complete}} \underset{\substack{\text{Xenon}\\ \text{dioxydifluoride}}}{XeO_2F_2} + 4HF$$

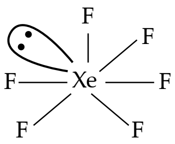
- **Structures of Xenon-fluorine compounds :**



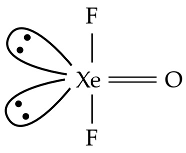
XeF_2(sp^3d)
[Linear]



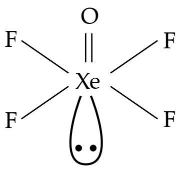
XeF_4 (sp^3d^2)
[Square Planar]



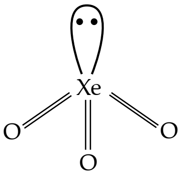
XeF_6 (sp^3d^3)
[Distorted Octahedral]



$XeOF_2$ (sp^3d)
[T-Shaped]



$XeOF_4$ (sp^3d^2)
[Square Pyramidal]



XeO_3 (sp^3)
[Trigonal Pyramidal]

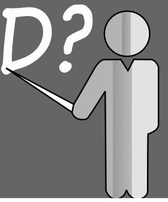
- **Uses :**

Helium	Neon	Argon	Krypton	Xenon
(i) To lift weather balloons and air ships.	For advertising.	To create an inert atmosphere.	For runway and approach lights in airports.	In electric flash bulbs for high speed photography.
(ii) As breathing mixture.	For filling sodium vapour lamps.	In geiger counters.	In high efficiency miner's cap lamps.	In gas filled lamps.
(iii) For inflating the tyres of aeroplanes.	In beacon light.	To date the age of rocks.		

Mnemonics

- Concept: Increasing order of atomic radii and atomic volume (Top to bottom-Group)
- Mnemonic: Help Needy And Krippled (Crippled) on X-mas Religiously.
- Interpretation: **H**elium**(He)**, **N**eon**(Ne)**, **A**rgon**(Ar)**, **K**rypton**(Kr)**, **X**enon**(Xe)**, **R**adon**(Rn)**

How is it done on the GREENBOARD?



Q. (a) Compare the oxidizing action of F_2 and Cl_2 by considering parameters such as bond dissociation enthalpy, electron gain enthalpy and hydration enthalpy.

(b) Write the conditions to maximize the yield of H_2SO_4 by contact process.

(c) F_2 is the stronger oxidising agent than chlorine :

Solutions:

STEP-1: Low enthalpy of dissociation of F-F bond.

STEP-2: Less negative electron gain enthalpy of F.

STEP-3: High hydration enthalpy of F– ion.

STEP-1: The main reaction in contact process is $2SO_2 + O_2 \rightarrow 2SO_3 \uparrow$

STEP-2: This reaction is reversible and conditions to increase the yield of SO_3 are :

- **(a)** High pressure
- **(b)** Low temperature (optimum temperture 720 K) should be maintained and
- **(c)** V_2O_5 as catalyst.

Objective Type Questions

(1 mark each)

[A] MULTIPLE CHOICE QUESTIONS :

Q.1. Which one of the following does not exist?

(a) $XeOF_4$	**(b) NeF_2**
(c) XeF_2	**(d) XeF_6** R

Ans. Correct option : (b)

Explanation : Xe has least ionisation energy among the noble gases and hence it forms chemical compounds with oxygen and fluorine, however, Ne cannot form compounds with oxygen and fluorine so NeF_2 does not exist.

Q.2. In the preparation of compounds of Xe, Bartlett had taken $O_2^+PtF_6^-$ as a base compound. This is because

- **(a) both O_2 and Xe have same size.**
- **(b) both O_2 and Xe have same electron gain enthalpy.**
- **(c) both O_2 and Xe have same ionisation enthalpy.**
- **(d) both Xe and O_2 are gases.**

Ans. Correct option : (c)

Explanation : In the preparation of compounds of Xe, Bartelett had taken $O_2^+PtF_6^-$ as a base compound. This is because both O_2 and Xe have almost same ionisation enthalpy.

Q.3. Which of the following statements are true?

- **(a) Only types of interactions between particles of noble gases are due to weak dispersion forces.**
- **(b) Hydrolysis of XeF_6 is a redox reaction.**
- **(c) Xenon fluorides are not reactive.**
- **(d) None of the above**

Ans. Correct option : (a)

Explanation : Only types of interactions between particles of noble gases are due to weak dispersion forces.

[B] ASSERTIONS AND REASONS:

In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

- **(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.**
- **(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.**
- **(c) Assertion is correct statement but reason is wrong statement.**
- **(d) Assertion is wrong statement but reason is correct statement.**

AI **Q. 1. Assertion(A) : Group 18 gases exhibit very high ionisation enthalpy.**

Reason (R) : They have a stable electronic configuration. U

Ans. Correct option : (a)

Explanation : Group 18 gases exhibit very high ionisation enthalpy because they have a stable electronic configuration.

AI **Q. 2. Assertion(A) : The noble gases are inactive.**

Reason(R) : These gases have a closed shell structure. U

Ans. Correct option : (a)

Explanation : The noble gases are inactive as they have a closed shell structure.

Q. 3. Assertion(A) : Helium diffuses through most commonly used laboratory materials.

Reason(R) : This gas has a very low melting point. U

Ans. Correct option : (c)

Explanation : Helium diffuses through most commonly used laboratory materials which is an unusual property of this gas.

[C] VERY SHORT ANSWER TYPE QUESTIONS :

Q. 1. Why do noble gases have large positive electron gain enthalpies? U

Ans. Since noble gases have filled shells and stable electronic configurations, they do not accept electrons. Hence they have high positive electron gain enthalpies. **[1]**

Q.2. What is the structure of $XeOF_4$? R

Ans. $XeOF_4$ is square pyramidal.

Q. 3. Complete the following hydrolysis equation and balance it. A

$$XeF_6 + H_2O \rightarrow HF + \_\_\_\_\_\_\_\_$$

Ans. $XeF_6 + 3H_2O \rightarrow 6HF + XeO_3$

Short Answer Type Questions - I

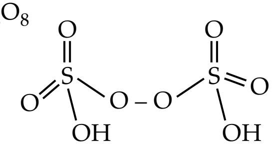
(2 marks each)

Q.1. Draw the structures of the following :

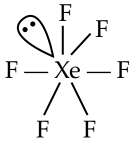
(i) $H_2S_2O_8$

(ii) XeF_6 **[CBSE Delhi Set - I, 2020]**

Ans. (i) $H_2S_2O_8$



(ii) XeF_6

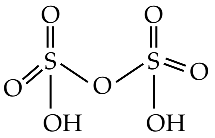


Q.2. Draw the structures of the following :

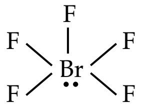
(i) $H_2S_2O_7$

(ii) BrF_5 **[CBSE Delhi Set - 2, 2020]**

Ans. (i) $H_2S_2O_7$



(ii) BrF_5

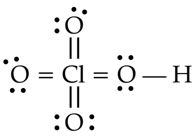


Q.3. Draw the structures of the following : **[1+1]**

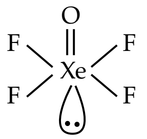
(i) $HClO_4$

(ii) $XeOF_4$ **[CBSE Delhi Set - 3, 2020]**

Ans. (i) $HClO_4$



(ii) $XeOF_4$

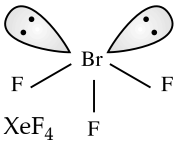


[1+1]

Q. 4. Write the structures of the following :

(i) BrF_3 **(ii) XeF_4** R

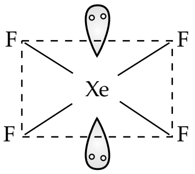
Ans. (i) BrF_3



Trigonal bipyramidal or Bent T-shaped

[1]

(ii) XeF_4



Square planar

[1]

Commonly Made Error

- Students often draw rough structural diagrams without showing the lone pair.

Answering Tip

- Draw the structures with lone pair of electrons (if present). Avoid over-writing.

Q. 5. What happens when :

(i) SO_2 gas is passed through an aqueous solution of Fe^{3+} salt ?

(ii) XeF_4 reacts with SbF_5 ?

R **[CBSE OD 2016]**

Ans. (i) When SO_2 gas is passed through an aqueous solution of Fe^{3+} salt, SO_2 acts as a reducing agent and reduces Fe^{3+} to Fe^{2+}. The brown colour of iron (III) solution turns into green. **[1]**

$$2Fe^{3+} + SO_2 + 2H_2O \rightarrow 2Fe^{2+} + SO_4^{2-} + 4H^+$$

(ii) When XeF_4 reacts with strong Lewis acids like SbF_5, it forms complexes (addition compounds).

$$XeF_4 + SbF_5 \rightarrow [XeF_3]^+[SbF_6]^- \quad [1]$$

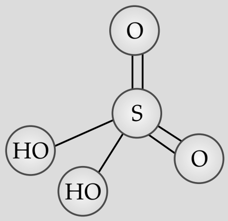
[CBSE Marking Scheme 2016]

Q. 6. Draw the structures of the following :

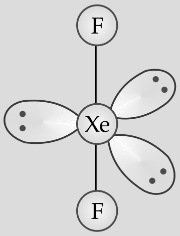
(i) H_2SO_4 **(ii) XeF_2** R **[CBSE Delhi 2015]**

Ans.

(i)



(ii)



[1 + 1]

[CBSE Marking Scheme 2015]

Q. 7. Complete the following reactions:

(i) $NH_3 + 3Cl_2$ (excess) $\rightarrow$

(ii) $XeF_6 + 2H_2O \rightarrow$ R **[CBSE Delhi Set-1 2017]**

Ans. (i) $NH_3 + 3Cl_2$ (excess) $\rightarrow NCl_3 + 3HCl$ **[1]**

(ii) $XeF_6 + 2H_2O \rightarrow XeO_2F_2$ **[1]**

[CBSE Marking Scheme 2017]

Q. 8. What happens when

(i) $(NH_4)_2Cr_2O_7$ is heated ?

(ii) H_3PO_3 is heated ?

Write the equation.

Ans. (i) $(NH_4)_2Cr_2O_7 \rightarrow N_2 + 4H_2O + Cr_2O_3$

(ii) $4H_3PO_3 \rightarrow 3H_3PO_4 + PH_3$

[CBSE Marking Scheme, 2017]

Detailed Answer :

(i) $(NH_4)_2Cr_2O_7$ decomposes on heating to produce Cr_2O_3, H_2O and N_2. The reaction that takes place is :

$(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} Cr_2O_3 + 4H_2O + N_2$ **[1]**

(ii) H_3PO_3 disproportionates on heating to produce orthophosphoric acid or phosphoric acid and phosphine. The reaction that takes place is :

$4H_3PO_3 \xrightarrow{\Delta} 3H_3PO_4 + PH_3$ **[1]**

Q. 9. Complete the following reactions:

(i) $Cl_2 + H_2O \rightarrow$

(ii) $XeF_6 + 3H_2O \rightarrow$ R **[CBSE Delhi Set-2 2017]**

Ans. (i) $Cl_2 + H_2O \rightarrow 2HCl + [O] / HCl + HOCl$ **[1]**

(ii) $XeF_6 + 3H_2O \rightarrow XeO_3 + 6HF$ **[1]**

[CBSE Marking Scheme 2017]

Commonly Made Error

- Students often write wrong products, do not write all the correct products, write only the main product thus leading to error in balancing or do not balance the equations at all.

Answering Tip

- Write correct, complete and balanced equations for all reactions mentioning all reactants and products.

Q. 10. Complete the following chemical equation :

(i) $F_2 + 2Cl^- \rightarrow$

(ii) $2XeF_2 + 2H_2O \rightarrow$ R **[CBSE Delhi Set-3 2017]**

Ans. (i) $F_2 + 2Cl^- \rightarrow 2F^- + Cl_2$ **[1]**

(ii) $2XeF_2 + 2H_2O \rightarrow 2Xe + 4HF + O_2$ **[1]**

[CBSE Marking Scheme 2017]

Q. 11. What happens when

(i) HCl is added to MnO_2 ?

(ii) PCl_5 is heated ?

Write the equations involved.

(i) $MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$ **[1]**

(ii) $PCl_5 \xrightarrow{\Delta} PCl_3 + Cl_2$ **[1]**

[CBSE Marking Scheme, 2017]

Detailed Answer :

(i) When HCl is added to MnO_2, chlorine gas is formed along with other products.

$MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + Cl_2$ **[1]**

(ii) When heated, PCl_5 sublimes but decomposes on strong heating.

$PCl_5 \xrightarrow{\Delta} PCl_3 + Cl_2$ **[1]**

AI **Q. 12. Account for the following :**

(i) Acidic character increases from HF to HI.

(ii) There is a large difference between the melting and boiling points of oxygen and sulphur.

A&E **[CBSE Delhi 2015]**

Ans. (i) Acidic character increases from HF to HI due to increase in size as a result attraction force decreases and acidity increases.

$$\xrightarrow[\text{Increasing order of acidity size increase}]{HF < HCl < HBr < HI}$$

(ii) There is large difference between the melting point and boiling point of oxygen and sulphur due to small size and high electronegativity of oxygen. **2**

Q. 13. Account for the following :

(a) Cl_2 acts as a bleaching agent.

(b) Noble gases have very low boiling points. A&E

Ans. (a) Because Cl_2 in presence of moisture liberates nascent oxygen. **[1]**

(b) Interatomic interactions are weak. **[1]**

Commonly Made Error

- Students often lose time in writing long answers to 1 mark questions.

Answering Tip

- While stating the reason, be specific. Avoid unnecessary explanations.

Q. 14. (a) What happens when F_2 reacts with water ?

(b) Write the formula of a noble gas species which is isostructural with IBr_2.

U **[CBSE Foreign Set-1 2017]**

Ans. (a) $2F_2 + 2H_2O \rightarrow 4HF + O_2$

HF and O_2 are produced. **[1]**

(b) XeF_2 **[1]**

[CBSE Marking Scheme 2017]

Short Answer Type Questions-II (3 marks each)

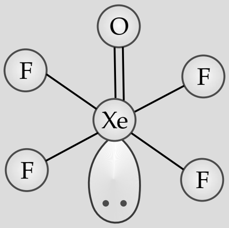
AI **Q. 1. (i) Arrange the hydrides of group 16 in increasing order of their acidic character. Justify your answer.**

(ii) Draw structure of $XeOF_4$.

U + R **[CBSE Comptt. Delhi Set-1, 2, 3 2017]**

Ans. (i) $H_2O < H_2S < H_2Se < H_2Te$, because of decrease in bond dissociation enthalpy.**[1+1]**

(ii)



[1]

Square pyramidal **[CBSE Marking Scheme 2017]**

Q. 2. (i) F_2 has lower bond dissociation enthalpy than Cl_2. Why ?

(ii) Which noble gas is used in filling balloons for meteorological observations ?

(ii) Complete the following equation :

$XeF_2 + PF_5 \rightarrow$ A&E **[CBSE Delhi 2015]**

Ans. (i) F_2 has lower bond dissociation energy than Cl_2 because the size of F_2 is much smaller than Cl_2 as a result interelectronic repulsion works and make F_2 weak. **[1]**

(ii) Helium is used in filling balloons for meteorological observations. **[1]**

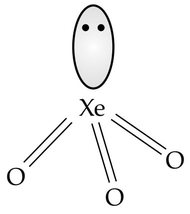
(iii) $XeF_2 + PF_5 \rightarrow [XeF_2]^+ [PF_6]^-$ **[1]**

Q. 3. (i) Draw the structure of a noble gas species which is isostructural with BrO_3^-.

(ii) Considering the parameters such as bond dissociation enthalpy, electron gain enthalpy and hydration enthalpy, compare the oxidising power of F_2 and Cl_2.

(iii) Why is $Ka_2 << Ka_1$ for H_2SO_4 in water ?

Ans. (i) XeO_3 is isostructural with BrO_3^-. (pyramidal structure)



XeO_3

Pyramidal **[1]**

(ii) The bond dissociation enthalpy of F—F bond is lower than that of Cl—Cl bond and hydration enthalpy of F^- ion is much higher than that of Cl^- ion.

These two factors more than compensate the less negative electron gain enthalpy of F_2. Thus, F_2 is a stronger oxidizing agent than Cl_2. **[1]**

(iii) H_2SO_4 ionises in two stages and hence has two dissociation constants $Ka_2 << Ka_1$.

This is because the negatively charged HSO_4^- ion resonance stabilized which has much less tendency to donate a proton to H_2O as compared to neutral H_2SO_4. **[1]**

Q. 4. Explain the following :

(i) Hydrogen fluoride is a weaker acid than hydrogen chloride in aqueous solution.

(ii) SF_6 is inert towards hydrolysis.

(iii) Out of noble gases only Xenon is known to form established chemical compounds.

A&E **[CBSE SQP 2016]**

Ans. (i) Due to stronger H-F bond than HCl bond, HF ionises less readily than HCl in aqueous solution to give H^+ ions. Therefore, HF is a weaker acid than HCl. **[1]**

(ii) In SF_6, S is sterically protected by six F atoms and hence does not allow H_2O molecules to attack the S molecule. Also, F does not have d-orbitals to accept the electrons donated by H_2O molecules. **[1]**

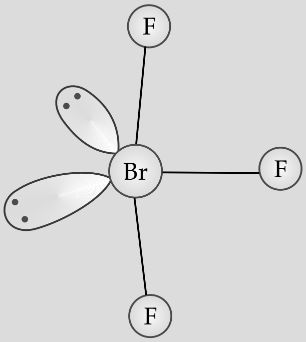
(iii) Except radon which is radioactive, Xenon has least ionisation energy among noble gases and hence it readily forms chemical compounds particularly with O_2 and F_2. **[1]**

Q. 5. Draw the structure of the following

(a) BrF_3 **(b) XeO_3**

(c) $XeOF_4$ R **[CBSE Delhi Set-1 2015]**

Ans. (a)



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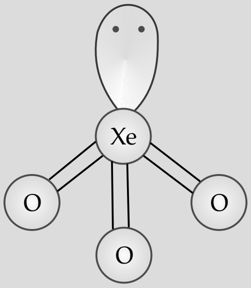
(b)



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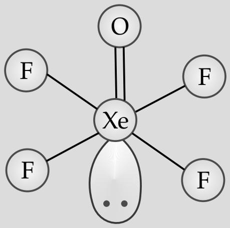
(c)



[1]

[CBSE Marking Scheme 2015]

Q. 6. (i) What happens when :

(a) Chlorine gas reacts with cold and dilute solution of NaOH ?

(b) XeF_2 undergoes hydrolysis ?

(ii) Assign suitable reason for the following :

Out of noble gases only Xenon is known to form established chemical compounds.

U + A & E **[CBSE Comptt. Delhi/OD 2018]**

Ans. (i) (a) $2NaOH + Cl_2 \rightarrow NaCl + NaOCl + H_2O$ **[1]**

(b) $2XeF_2(s) + 2H_2O(l) \rightarrow 2Xe(g) + 4HF(aq) + O_2(g)$ **[1]**

(ii) Xe has least ionization energy among the noble gases and hence it forms chemical compounds particularly with O_2 and F_2. **[1]**

[CBSE Marking Scheme 2018]

Long Answer Type Questions (5 marks each)

Q. 1. (i) Write balanced equations for the following reactions :

(a) Chlorine reacts with dry slaked lime.

(b) Carbon reacts with concentrated H_2SO_4.

(ii) Describe the contact process for the manufacture of sulphuric acid with special reference to the reaction conditions, catalysts used and the yield in the process. R + U **[CBSE Comptt. Delhi 2015]**

Ans. (i) (a) $2Ca(OH)_2 + 2Cl_2 \rightarrow Ca(OCl)_2 + CaCl_2 + 2H_2O$ **[1]**

(b) $C + 2H_2SO_4(conc.) \rightarrow CO_2 + 2SO_2 + 2H_2O$ **[1]**

(ii) It is manufactured by contact process which involves following steps :

(a) burning of sulphur or sulphide ores in air to generate SO_2.

(b) conversion of SO_2 to SO_3 by the reaction with oxygen in the presence of a catalyst (V_2O_5).

(c) absorption of SO_3 in H_2SO_4 to give oleum ($H_2S_2O_7$). The oleum obtained is diluted to give sulphuric acid. **[1]**

$2SO_2(g) + O_2(g) \xrightarrow{V_2O_5} 2SO_3(g)$ **[1]**

Reaction condition – pressure of 2 bar and temperature of 720 K.

Catalyst used is V_2O_5.

Yield – 96 – 98% pure. **[1]**

[CBSE Marking Scheme 2015]

Q. 2. (i) Account for the following:

(a) Reducing character decreases from SO_2 to TeO_2.

(b) $HClO_3$ is a stronger acid than HClO.

(c) Xenon forms compounds with fluorine and oxygen only.

(ii) Complete the following equations:

(a) $4NaCl + MnO_2 + 4H_2SO_4 \rightarrow$

(b) $6XeF_4 + 12H_2O \rightarrow$

A & E + R **[CBSE Comptt. OD Set-1, 2, 3 2017]**

Ans. (i) (a) Stability of higher oxidation state decreases down the group from S to Te/Stability of lower oxidation state increases down the group from S to Te. **[1]**

(b) ClO_3 is more stable than ClO^-/ClO_3^- is a weak conjugate base than ClO^-/Due to higher oxidation state of chlorine in $HClO_3$ **[1]**

(c) Fluorine and oxygen are most electronegative and very reactive. **[1]**

(ii) (a) $4NaCl + MnO_2 + 4H_2SO_4 \rightarrow MnCl_2 + 4NaHSO_4 + 2H_2O + Cl_2$ **[1]**

(b) $6XeF_4 + 12H_2O \rightarrow 4Xe + 2XeO_3 + 24HF + 3O_2$ **[1]**

[CBSE Marking Scheme 2017]

Visual Case-based Questions (4 marks each)

Q.1. Read the passage given below and answer the following questions:

In spite of the predictions of stable noble gas compounds since at least 1902, unsuccessful attempts at their synthesis gave rise to the widely held opinion that noble gases are not only noble but also inert. It was not until 1962 that this dogma was shattered when Bartlett in Canada published the first stable noble gas compound XePtF6 . This discovery triggered a worldwide frenzy in this area, and within a short time span many new xenon, radon, and krypton compounds were prepared and characterized. The recent discoveries show the ability of xenon to act as a ligand . The discovery by Seppelt's group that more than one xenon atom can attach itself to a metal center which in the case of gold leads to surprisingly stable Au- Xe bonds. The bonding in $[AuXe4]^{2+}$ involves 4 Xe ligands attached by relatively strong bonds to a single Au(II) center in a square planar arrangement with a Xe-Au bond length of about 274 pm This discovery provides not only the first example of multiple xenon ligands but also represents the first strong metal - xenon bond.

(Source: Christe, K. O. (2001). A renaissance in noble gas chemistry. *Angewandte Chemie International Edition, 40(8), 1419-1421.*) **(CBSE QB 2021)**

1. In the complex ion [AuXe4]2+ , Xe acts as :
   a. central atom
   b. ligand
   c. chelating agent
   d. electrophile
2. Hybridisation shown by Au in [AuXe4]2+ is :
   a. sp3
   b. sp3d
   c. sp3d2
   d. sp2
3. Compounds of noble gases except _______ are known.
   a. Krypton
   b. Radon

c. Helium
d. Xenon

4. Xe is a ___________ ligand
a. ambidentate
b. bidantate
c. unidentate
d. hexadentate

Ans. : 1a, 2 b 3 c 4 c

Q.2. In the last 10 years much has been learned about the molecular structure of elemental sulfur. lt is now known that many different types of rings are sufficiently metastable to exist at room temperature for several days. It is known that at high temperature, the equilibrium composition allows for a variety of rings and chains to exist in comparable concentration, and it is known that at the boiling point and above, the vapor as well as the liquid contains small species with three, four, and five atoms.

The sulfur atom has the same number of valence electrons as oxygen. Thus, sulfur atoms S_2 and S_3 have physical and chemical properties analogous to those of oxygen and ozone. S2 has a ground state of 38 $\sigma 3s^2\sigma^* 3s^2\sigma 3pz^2\pi 3px\ 2 = \pi 3py^2\pi^* 3px^1 = \pi^* 3py^1$. S3 , thiozone has a wellknown uv spectrum, and has a bent structure, analogous to its isovalent molecules 03, SO2, and S20. The chemistry of the two elements, sulphur and oxygen, differs because sulfur has a pronounced tendency for catenation. The most frequently quoted explanation is based on the electron structure of the atom. Sulfur has low-lying unoccupied 3d orbitals, and it is widely believed that the 4s and 3d orbitals of sulfur participate in bonding in a manner similar to the participation of 2s and 2p orbitals in carbon.

(CBSE QB 2021)

(source: Meyer, B. (1976). *Elemental sulfur. Chemical Reviews, 76(3), 367– 388*. doi:10.1021/cr60301a003)

In the following questions, a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices on the basis of the above passage.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

(i) Assertion: Sulphur belongs to same group in the periodic table as oxygen.
Reason: S2 has properties analogous to O2.

(ii) Assertion: Thiozone has bent structure like ozone.
Reason: Ozone has a lone pair which makes the molecule bent.

(iii) Assertion: S2 is paramagnetic in nature
Reason: The electrons in π^*3px and π^*3py orbitals in S_2 are unpaired.

(iv) Assertion: Sulphur has a greater tendency for catenation than oxygen.
Reason: 3d and 4s orbitals of Sulphur have same energy.

Ans. : 1B,2B, 3A,4C

Q.3. Read the given passage and answer the questions (i) to (iv) that follow :

The halogens have the smallest atomic radii in their respective periods. The atomic radius of fluorine is extremely small. All halogens exhibit –1 oxidation state. They are strong oxidising agents and have maximum negative electron gain enthalpy. Among halogens, fluorine shows anomalous behaviour in many properties. For example electronegativity and ionisation enthalpy are higher for fluorine than expected whereas bond dissociation enthalpy, m.p. and b.p. and electron gain enthalpy are quite lower than expected. Halogens react with hydrogen to give hydrogen halides (HX) and combine amongst themselves to form a number of compounds of the type XX′, XX'_3, XX'_5 and XX'_7 called inter-halogens.

(i) Why halogens have maximum negative electron gain enthalpy?

Ans. Halogens have only seven electrons in their valence shell. So they require only one electron to attain a noble gas configuration. Hence they have maximum electron gain enthalpy. **[1]**

(ii) Why fluorine shows anomalous behaviour as compared to other halogens?

Ans. (i) It has smallest in size.
(ii) Very high electronegativity.
(iii) Absence of d-orbitals.
(iv) dissociation enthalpy in molecular form is least.
(Any one) **[1]**

(iii) Arrange the hydrogen halides (HF to HI) in the decreasing order of their reducing character.

Ans. HI > HBr > HCl > HF **[1]**

(iv) Why fluorine is a stronger oxidizing agent than chlorine?

Ans. Because fluorine has greater E° value (2.87V) than chlorine (1.36V). **[1]**

(v) What are the sizes of X and X′ in the interhalogen compounds?

Ans. Size of X is greater than X′.

❑❑

Self Assessment PaperTest - 7

Time : 1 Hour **Max. Marks : 25**

[A] OBJECTIVE TYPE QUESTIONS : (1 mark each)

1. Read the passage given below and answer the following questions : ($1 \times 4 = 4$)

Interhalogen compounds are in the form of XYn where X and Y are halogens and n is one, three, five, or seven. Interhalogen compounds contain at most two different halogens. Large interhalogens, such as ClF_3 can be produced by a reaction of a pure halogen with a smaller interhalogen such as ClF. All interhalogens except IF_7 can be produced by directly combining pure halogens in various conditions.

Interhalogens are typically more reactive than all diatomic halogen molecules except F_2 because interhalogen bonds are weaker. However, the chemical properties of interhalogens are still roughly the same as those of diatomic halogens. Many interhalogens consist of one or more atoms of fluorine bonding to a heavier halogen. Chlorine can bond with up to 3 fluorine atoms, bromine can bond with up to five fluorine atoms, and iodine can bond with up to seven fluorine atoms. Most interhalogen compounds are covalent gases. However, some interhalogens are liquids, such as BrF_3, and many iodine-containing interhalogens are solids.

(i) Reduction potentials of some ions are given below:

Arrange them in decreasing order of oxidising power.

Ion	**ClO_4^-**	**IO_4^-**	**BrO_4^-**
Reduction potential E^o/V	**E^o=1.19V**	**E^o=1.65V**	**E^o=1.74V**

(a) $ClO_4^- > IO_4^- > BrO_4^-$
(b) $IO_4^- > BrO_4^- > ClO_4^-$
(c) $BrO_4^- > IO_4^- > ClO_4^-$
(d) $BrO_4^- > ClO_4^- > IO_4^-$

(ii) Which of the following is isoelectronic pair?

(a) ICl_2, ClO_2
(b) BrO_2^-, BrF_2^+
(c) ClO_2, BrF
(d) CN^-, O_3

(iii) Which of the following options are not in accordance with the property mentioned against them.

(a) $F_2 > Cl_2 > Br_2 > I_2$	**Oxidising power**
(b) MI > MBr > MCl > MF	**Ionic character of metal halide**
(c) $F_2 > Cl_2 > Br_2 > I_2$	**Bond dissociation enthalpy.**
(d) HI < HBr < HCl < HF	**Hydrogen-halogen bond strength.**

(iv) Which of the following statements are correct?

(a) Among halogens, radius ratio between iodine and fluorine is maximum.
(b) Leaving F – F bond, all halogens have weaker X – X bond than X – X′ bond in inter-halogens.
(c) Among inter-halogen compounds maximum number of atoms ate present in iodine fluoride.
(d) Inter-halogen compounds are more reactive than halogen compounds.

OR

Chlorine water on standing loses its yellow colour due to _________

(a) Formation of chlorine gas
(b) Formation of HCl
(c) Formation of HCl and HOCl.
(d) Formation of HOCl.

Following questions (No. 2 to 5) are Multiple Choice Questions carrying 1 mark each.

2. Which of the following statements are correct?

(a) All the three N – O bond lengths in HNO_3 are equal.
(b) All P – Cl bond lengths in PCl_5 molecule in gaseous state are equal.
(c) P_4 molecules in white phosphorus have angular strain, therefore white phosphorus is very reactive.
(d) PCl_5 is ionic in solid state in which cation is tetrahedral and anion is octahedral. U

3. The oxidation state of central atom in the anion of compound NaH_2PO_2 will be __________

(a) +3 **(b) +5**
(c) +1 **(d) –3** **[A&E]**

4. Which of the following elements does not show allotropy?

(a) Nitrogen **(b) Bisumth**
(c) Antimony **(d) Arsenic**

R **[Exemplar page 92]**

5. In solid state PCl_5 is a ________

(a) Covalent solid.
(b) Octahedral structure
(c) Ionic solid with $[PCl_6]^+$ octahedral and $[PCl_4]^-$ tetrahedral
(d) Ionic solid with $[PCl_4]^+$ tetrahedral and $[PCl_6]^-$ octahedra R

The following questions (Q. no. 6 & 7), a statement of assertion followed by a statement of reason given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.
(b) Assertion and reason both are correct statements but reason is not the correct explanation for assertion.
(c) Assertion is correct statement but reason is wrong statement.
(d) Assertion is wrong statement but reason is correct statement.

6. Assertion (A) : XeF_6 has distorted octahedral structure.
Reason (R) : The orbitals of Xenon are sp^3d^3 hybridised. U

7. Assertion (A) : The sp^3d^2 hybrid orbitals are responsible for square pyramidal structure of $XeOF_4$.

Reason (R) : The hybridization in Xenon is sp^3d^2 because there is a migration of two electrons of p to d orbital which results in the formation of sigma bond with F. U

The following questions (Q.No. 8 & 9), are Short Answer Type-I and carry 2 marks each.

8. Mention two conditions which maximise the yield of H_2SO_4 during contact process. U

9. Complete the following equations :

(i) $Ag + PCl_5 \rightarrow$

(ii) $CaF_2 + H_2SO_4 \rightarrow$ A

Q.No. 10 & 11 are Short Answer Type-II carrying 3 marks each.

10. Give reasons for the following :

(i) $(CH_3)_3 P = O$ exists but $(CH_3)_3 N = O$ does not.

(ii) Oxygen has less electron gain enthalpy with negative sign than sulphur.

(iii) H_3PO_2 is a stronger reducing agent than H_3PO_3. A&E

AI 11. Draw the structures of the following compounds.

(i) ClF_3

(ii) $HClO_3$

(iii) $H_2S_2O_7$ A

Q.No 12 is Long Answer Type Carrying 5 marks.

12. (i) Draw the structure of a noble gas species which is isostructural with BrO_3^-.

(ii) Considering the parameters such as bond dissociation enthalpy, electron gain enthalpy and hydration enthalpy, compare the oxidising power of F_2 and Cl_2.

(iii) Why is $Ka_2 << Ka_1$ for H_2SO_4 in water ?

OR

Explain the following :

(i) Hydrogen fluoride is a weaker acid than hydrogen chloride in aqueous solution.

(ii) SF_6 is inert towards hydrolysis.

(iii) Out of noble gases only Xenon is known to form established chemical compounds.

[1]