POINTS TO REMEMBER

- Elements of group 15 exhibit two important oxidation states +3 and +5 but +3 oxidation state is formed because of inert pair effect.
- In hydrides of group V:
- Bond angle : $NH_3 > PH_3 > AsH_3 > SbH_3$ Basic character : $NH_3 > PH_3 > AsH_3$
- Boling point : $NH_3 < PH_3 < AsH_3 < SbH_3$ Stability : $NH_3 > PH_3 > AsH_3 > SbH_3$
- Reducing character : $NH_3 < PH_3 < AsH_3$
- Phosphorus exists as P_4 in elemental state and exists in several allotropic forms.
- The oxoacids having P-H bonds are good reducing agents.
- N_2O is called laughing gas and is obtained by heating NH_4NO_3.
- Sulphur exists as S_8 and has plucked ring structure.
- Group 16 elements are called chalcogens. These consists of O, S, Se, Te and Po.
- Allotropic forms of oxygen is O_3, which is highly oxidising agent.
- The highest oxidation state of S is +6 in SF_6.
- In hydrides of group VI
- Bond angle : $H_2O > H_2S > H_2Se > H_2Te$ Acidic character : $H_2O < H_2S < H_2Se$
- Volatility : $H_2O < H_2S > H_2Se > H_2 Te$.
- Halogens are most electronegative elements. Among these iodine has some electropositive character and exists as +1 and +3.
- Reducing Power : $I^- > Br^- > Cl^- > F^-$
- Oxidising power : $F_2 > Cl_2 > Br_2 > I_2$
- Acidic strength in water : HF < HCl < HBr < HI. HF weaker base because of its highest bond dissociation energy
- Acidic character : $HClO_4 > HClO_3 > HClO_2 > HClO$
- HClO > HBrO > HIO.
- Oxidation power : $HClO_4 > HClO_3 > HClO_2 > HClO$
- Fluorine shows only -1 oxidation state while other halogens show variable oxidation states from +1 to +7.

JEE Main/Boards

Exercise 1

Q.1 How is ammonia manufactured industrially?

Q.2 The HNH angle value is higher than HPH, HAsH and HSbH angles. Why?

Q.3 Write main differences between the properties of white phosphorus and red phosphorus.

Q.4 Why does nitrogen show catenation properties less than phosphorus?

Q.5 Justify the placement of O, S, Se, Te and Po in the same group of the periodic table in terms of electronic configuration, oxidation state and hydride formation.

Q.6 Knowing the electron gain enthalpy values for $O \rightarrow O^-$ and $O \rightarrow O_2^-$ as –141 and 702kJ mol^{-1}

respectively, how can you account for the formation of a large number of oxides having O^{2-} species and not O^-?

Q.7 Which aerosols deplete ozone?

Q.8 Describe the manufacture of H_2SO_4 by contact process?

Q.9 Why are halogens strong oxidizing agents?

Q.10 Explain why inspite of nearly the same electronegativity, nitrogen forms hydrogen bonding while chlorine does not.

Q.11 How can you prepare Cl_2 from HCl and HCl from Cl_2? Write reactions only.

Q.12 What are the oxidation states of phosphorus in the following:

(i) H_3PO_3 (ii) PCl_3 (iii) Ca_3P_2

(iv) Na_3PO_4 (v) POF_3

Q.13 Write balanced equation for the following:

(i) NaCl is heated with sulphuric acid in the presence of MnO_2.

(ii) Chlorine gas is passed into a solution of NaI in water.

Q.14 How are xenon fluorides XeF_2, XeF_4 and XeF_6 obtained?

Q.15 With what neutral molecule is ClO-isoelectronic? Is that molecule a Lewis base?

Q.16 How are XeO_3 and $XeOF_4$ prepared?

Q.17 Why do noble gases have comparatively large atomic sizes?

Q.18 List the uses of neon.

Q.19 Discuss the general characteristics of Group 15 elements with reference to their electronic configuration, oxidation state, atomic size, ionization enthalpy and electronegativity.

Q.20 Give the formula and describe the structure of a noble gas species which is isostructural with:

(i) ICl_4^- (ii) IBr_2^- (iii) BrO_3^-

Q.21 Draw the structure of the following molecules:

(i) XeF_4 (ii) BrF_3

Q.22 Account for the following:

(i) H_2S acts only as a reducing agent but SO_2 acts both as a reducing agent as well as an oxidising agent.

(ii) SF_6 is known but SH_6 is not known.

(iii) Compounds of fluorides of oxygen and not the oxides of fluorine.

Q.23 (i) Complete the following reaction equations:

(A) $XeF_2 + PF_5 \rightarrow$

(B) $Cl_2(g) + \underset{(\text{hot and conc.})}{NaOH(aq)} \rightarrow$

(ii) Explain the following observations:

(a) +3 oxidation state becomes more and more stable from As to Bi in the group.

(b) Sulphur in the vapour state exhibits para magnetism

Q.24 (i) Draw the structure of the following:

(a) H_3PO_2 (b) BrF_3

(ii) How would you account for the following observations:

(A) Phosphorus has a greater tendency for catenation than nitrogen.

(B) Bond dissociation energy of fluorine is less than that of chlorine.

(C) No chemical compound of helium is known.

Q.25 Explain the following:

(A) Ammonia has a higher boiling point than phosphine.

(B) Helium does not form any chemical compound.

(C) Bi (V) is a stronger oxidising agent than Sb(V).

Q.26 (i) Complete the following reaction equations.

(a) $PCl_5 + H_2O(\text{excess}) \rightarrow$

(b) $F_2 + H_2O \rightarrow$

(ii) Explain the following observations:

(a) Phosphorus has a greater tendency for catenation than nitrogen.

(b) In solution of H_2SO_4 in water, the second dissociation constant k_{a_2}, is less than first dissociation constant k_{a_1}.

Q.27 (i) Complete the following reaction equations

(a) $P_4 + NaOH + H_2O \rightarrow$ (b) $Cu + HNO_3$(dilute) $\rightarrow$

(ii) Explain why

(a) H_2O is a liquid while, inspite of a higher molecular mass HS_2 is a gas

(b) Helium is used in diving equipment.

Q.28 PCl_5 is well known while PI_5 is unknown. Why?

Q.29 Urea is better nitrogenous fertilizer than ammonium sulphate. Explain.

Q.30 HF is stored in wax coated glass bottles. Why?

Q.31 KHF_2 is well known, whereas $KHCl_2$ or $KHBr_2$ does not exist. Explain

Q.32 Halogens are strong oxidants. Why?

Q.33 Chlorine displaces iodine from aqueous solution of KI. Why?

Q.34 Account for the following observation

(i) Iodine is liberated in the reaction between KI and Cu^{2+} but chlorine is not liberated when KCl is added to Cu^{2+}.

(ii) In the contact process for industrial manufacture of sulphuric acid some amount of sulphuric acid is used as a starting material. Explain briefly. What is catalyst used in the oxidation of SO_2?

Q.35 Explain the following

(i) An orange potassium dichromate paper turns green on exposure to sulphur dioxide.

(ii) Aluminium sulphide gives a foul odour when it becomes damp. Write a balanced chemical equation for the reaction.

Q.36 Explain it with reason: SO_2 can function both as a reducing or oxidizing agent while SO_3 can function only as an oxidizing agent and H_2S can function as reducing agent only

Q.37 Explain why?

(i) Orthophosphoric acid is tribasic but phosphorus acid is dibasic.

(ii) It is advisable to grow a leguminous crop on a soil every three or four years

Q.38 Zinc reacts with dil. H_2SO_4 to give H_2. It also reacts with conc. H_2SO_4 to give SO_2. Make difference between these two reactions.

Exercise 2

Single Correct Choice Type

Q.1 $H_3PO_3 \xrightarrow{\Delta} (x) + PH_3$; is

(A) Dehydration reaction

(B) Oxidation reaction

(C) Disproportionation reaction

(D) Dephosphorylation reaction

Q.2 Which of the following species is not a pseudohalide?

(A) CNO^- (B) $RCOO^-$

(C) OCN^- (D) N_3^-

Q.3 First compound of inert gases was prepared by scientist Neil Barthlete in 1962. This compound is

(A) $XePtF_6$ (B) XeO_3 (C) XeF_6 (D) $XeOF_4$

Q.4 Boron forms BX_3 type of halides. The correct increasing order of Lewis-acid strength of these halides is

(A) $BF_3 > BCl_3 > BBr_3 > BI_3$ (B) $BI_3 > BBr_3 > BCl_3 > BF_3$

(C) $BF_3 > BI_3 > BCl_3 > BBr_3$ (D) $BF_3 > BCl_3 > BI_3 > BBr_3$

Q 5. The compound $(SiH_3)_3N$ is

(A) Pyramidal and more basic than $(CH_3)_3N$

(B) Planar and less basic than $(CH_3)_3N$

(C) Pyramidal and less basic than $(CH_3)_3N$

(D) Planar and more basic than $(CH_3)_3N$

Q 6. In a molecule of phosphorus (V) oxide, there are

(A) 4P-P, 10P-O and 4P=O bonds.

(B) 12P-O and 4P=O bonds

(C) 2P-O and 4P=P bonds

(D) 6P-P, 12P-O and 4P=P bonds

Q 7. When oxalic acid reacts with conc. H_2SO_4, two gases produced are neutral and acidic in nature respectively. Potassium hydroxide absorbs one of the two gases.

The product formed during this absorption and the gas which absorbed are respectively.

(A) K_2CO_3 and CO_2 (B) $KHCO_3$ and CO_2

(C) K_2CO_3 and CO (D) $KHCO_3$ and CO

Q 8. Which of the following is the correct order of acidic strength?

(A) $Cl_2O_7 > SO_2 > P_4O_{10}$ (B) $CO_2 > N_2O_5 > SO_3$

(C) $Na_2O > MgO > Al_2O_3$ (D) $K_2O > CaO > MgO$

Q 9. $Ca + C_2 \longrightarrow CaC_2 \xrightarrow{N_2} A$ Compound (A) is used as a/an

(A) Fertilizer (B) Dehydrating agent

(C) Oxidizing agent (D) Reducing agent

Q 10. A gas which exists in three allotropic forms $\alpha, \beta, \text{and } \gamma$ is

(A) SO_2 (B) SO_3 (C) CO_2 (D) NH_3

Q 11. When an inorganic compound reacts with SO_2 in aqueous medium, produces (A). (A) on reaction with Na_2CO_3, gives compound (B) which with sulphur, gives a substance (C) used in photography. Compound C is

(A) Na_2S (B) $Na_2S_2O_7$ (C) Na_2SO_4 (D) $Na_2S_2O_3$

Q 12. Borax is actually made of two tetrahedral and two triangular units joined together and should be written as: $Na_2[B_4O_5(OH)_4].8H_2O$. Consider the following statements about borax:

(a) Each boron atom has four B-O bonds

(b) Each boron atom has three B-O bonds

(c) Two boron atoms have four B-O bonds while other two have three B-O bonds.

(d) Each boron atom has one –OH groups

Select correct statement(s)

(A) a, b (B) b, c (C) c, d (D) a, c

Q.13 When a compound X reacts with ozone in aqueous medium, a compound Y is produced. Ozone also reacts with Y and produces compound Z. Z acts as an oxidizing agent, then X, Y and Z will be

(A) X = HI, Y = I_2 and Z = HIO_3

(B) X = KI, Y = I_2 and Z = HIO_3

(C) X = KI, Y = I_2 and Z = HIO_4

(D) X = HI, Y = I_2 and Z = HIO_4

Previous Years' Questions

Q.1 Aluminium chloride exists as dimer, Al_2Cl_6 in solid state as well as in solution of non-polar solvents such as benzene. When dissolved in water, it gives ***(2004)***

(A) $[Al(OH)_6]^{3-} + 3HCl$ (B) $[Al(H_2O)_6]^{3+} + 3Cl^-$

(C) $Al^{3+} + 3Cl^-$ (D) $Al_2O_3 + 6HCl$

Q.2 In the extraction of aluminium the electrolyte is. ***(1989)***

(A) Fused cryolite with feldspar

(B) Fused cryolite with fluorspar

(C) Pure alumina in molten cryolite

(D) Pure alumina with bauxite and molten cryolite

Q.3 Boron cannot form which one of the following anions. ***(2011)***

(A) BF_6^{3-} (B) BH_4^- (C) $B(OH)_4^-$ (D) BO_2^-

Q.4 Heating an aqueous solution of aluminium chloride to dryness will give ***(2005)***

(A) $AlCl_3$ (B) Al_2Cl_6 (C) Al_2O_3 (D) $Al(OH)Cl_2$

Q.5 The structure of diborane (B_2H_6) contains. ***(2009)***

(A) Four 2c-2e bonds and two 3c-2e bonds

(B) Two 2c-2e bonds and four 3c-2e bonds

(C) Two 2c-2e bonds and two 3c-3e bonds

(D) Four 2c-2e bonds and four 3c-2e bonds

Q.6 The stability of dihalides of Si, Ge, Sn and Pb increases steadily in sequence ***(2007)***

(A) $GeX_2 << SiX_2 << SnX_2 << PbX_2$

(B) $SiX_2 << GeX_2 << PbX_2 << SnX_2$

(C) $SiX_2 << GeX_2 << SnX_2 << PbX_2$

(D) $PbX_2 << SnX_2 << GeX_2 << SiX_2$

Q.7 In silicon dioxide, ***(2005)***

(A) Each silicon atom is surrounded by four oxygen atoms and each oxygen atom is bonded to two silicon atoms

(B) Each silicon atom is surrounded by two oxygen atoms and each oxygen atom is bounded to two silicon atoms

(C) Silicon atom is bonded to two oxygen atoms

(D) There are double bonds between silicon and oxygen atoms

Q.8 In which of the following arrangements the sequence is not strictly according to the property written against it. ***(2009)***

(A) $CO_2 < SiO_2 < SnO_2 < PbO_2$: Increasing oxidizing power

(B) HF < HCl < HBr < HI: Increasing acid strength

(C) $NH_3 < PH_3 < AsH_3 < SbH_3$: Increasing basic strength

(D) B < C < O < N: Increasing first ionization enthalpy

Q.9 The percentage of p-character in the orbitals forming P-P bonds in P_4 is ***(2007)***

(A) 25 (B) 33 (C) 50 (D) 75

Q.10 Which of the following statement is wrong ***(2011)***

(A) The stability of hydrides increase from NH_3 to BiH_3 in group 15 of the periodic table

(B) Nitrogen cannot form $d\pi - p\pi$ bond

(C) Single N – N bond is weaker than the single P – P bond

(D) N_2O_4 has two resonance structure

Q.11 What would happen when a solution of potassium chromate is treated with an excess of dilute nitric acid ***(2003)***

(A) Cr^{3+} and $Cr_2O_7^{2-}$ are formed

(B) $Cr_2O_7^{2-}$ and H_2O are formed

(C) CrO_4^{2-} is reduced to +3 state of Cr

(D) CrO_4^{2-} is oxidized to +7 state of Cr

Q.12 In case of nitrogen, NCl_3 is possible but not NCl_5 while in case of phosphorous, PCl_3 as well as PCl_5 are possible. It is due to ***(2004)***

(A) Availability of vacant d-orbital in P but not in N

(B) Lower electronegativity of P than N

(C) Lower tendency of H bond formation in P than N

(D) Occurrence of P in solid while N in gaseous state at room temperature

Q.13 What may be expected to happen when phosphine gas is mixed with chlorine gas ***(2003)***

(A) The mixture only cools down

(B) PCl_3 and HCl are formed and the mixture warms up

(C) PCl_5 and HCl are formed and mixture cools down

(D) PCl_3 and Cl_2 is formed with warming up

Q.14 Which of the following statements regarding sulphur is incorrect? ***(2011)***

(A) S_2 molecule is paramagnetic

(B) The vapour at 200^o C consists mostly of S_8 rings

(C) At 600^o C, the gas mainly consists of S_2 molecules

(D) The oxidation state of sulphur is never less than +4 in its compounds

Q.15 The correct order of the thermal stability of hydrogen halides (H – X) is ***(2010)***

(A) HI > HBr > HCl > HF (B) HF > HCl > HBr > HI

(C) HCl < HF < HBr < HI (D) HI > HCl < HF < HBr

Q.16 Identify the incorrect statement among the following ***(2007)***

(A) Ozone reacts with SO_2 to give SO_3

(B) Silicon reacts with $NaOH_{(aq)}$ in the presence of air to give Na_2SiO_3 and H_2O

(C) Cl_2 reacts with excess of NH_3 to give N_2 and HCl

(D) Br_2 reacts with hot and strong NaOH solution to give NaBr, $NaBrO_4$ and H_2O

Q.17 Which one of the following reactions of Xenon compounds is not feasible? ***(2009)***

(A) $XeO_3 + 6HF \rightarrow XeF_6 + 3H_2O$

(B) $3XeF_4 + 6H_2O \rightarrow 2Xe + XeO_3 + 12HF + 1.50_2$

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

(D) $XeF_6 + RbF \rightarrow Rb[XeF_7]$

Q.18 The number of hydrogen atom(s) attached to phosphorus atom in hypophosphorous acid is ***(2005)***

(A) Zero (B) Two

(C) One (D) Three

Q.19 The decreasing bond angles from NH_3(106°) to SbH_3(101°) down group-15 of the periodic table is due to ***(2006)***

(A) Increasing bp-bp repulsion

(B) Increasing p-orbital character in sp^3

(C) Decreasing lp-bp repulsion

(D) Decreasing electronegativity

Q.20 In XeF_2, XeF_4, XeF_6, the number of lone pairs on Xe is respectively ***(2002)***

(A) 2, 3, 1 (B) 1, 2, 3

(C) 4, 1, 2 (D) 3, 2, 1

Q.21 Which one of the following statements regarding helium is incorrect? ***(2004)***

(A) It is used to produce and sustain powerful superconducting magnets

(B) It is used as a cryogenic agent for carrying out experiments at low temperatures

(C) It is used to fill gas balloons instead of hydrogen because it is lighter and non-inflammable

(D) It is used in gas-cooled nuclear reactors

Q.22 Concentrated hydrochloric acid when kept in open air sometimes produces a cloud of white fumes. The explanation for it is that ***(2003)***

(A) Concentrated hydrochloric acid emits strongly smelling HCl gas all the time

(B) Oxygen in air reacts with the emitted HCl gas to form a cloud of chlorine gas

(C) Strong affinity of HCl gas for moisture in air results in forming of droplets of liquid solution which appears like a cloudy smoke

(D) Due to strong affinity for water, concentrated hydrochloric acid pulls moisture of air towards itself. This moisture forms droplets of water and hence the cloud.

Q.23 Which of the following represents the correct order of increasing first ionization enthalpy for Ca, Ba, S, Se and Ar ? ***(2013)***

(A) Ca < S < Ba < Se < Ar

(B) S < Se < Ca < Ba < Ar

(C) Ba < Ca < Se < S < Ar

(D) Ca < Ba < S < se < Ar

Q.24 Which one of the following properties is **not** shown by NO? ***(2014)***

(A) It combines with oxygen to form nitrogen dioxide

(B) It's bond order is 2.5

(C) It is diamagnetic in gaseous state

(D) It is a neutral oxide

Q.25 Assertion: Nitrogen and Oxygen are the main components in the atmosphere but these do not react to form oxides of nitrogen. ***(2015)***

Reason: The reaction between nitrogen and oxygen requires high temperature.

(A) Both assertion and reason are correct, and the reason is the correct explanation for the assertion

(B) Both assertion and reason are correct, but the reason is not the correct explanation for the assertion

(C) The assertion is incorrect, but the reason is correct

(D) Both the assertion and reason are incorrect

Q.26 The species in which the N atom is in a state of sp hybridization is: ***(2016)***

(A) NO_2^+ (B) NO_2^- (C) NO_3^- (D) NO_2

Q. 27 The pair in which phosphorous atoms have a formal oxidation state of + 3 is : ***(2016)***

(A) Orthophosphorous and pyrophosphorous acids

(B) Pyrophosphorous and hypophosphoric acids

(C) Orthophosphorous and hypophosphoric acids

(D) Pyrophosphorous and pyrophosphoric acids

JEE Advanced/Boards

Exercise 1

Q.1 Arrange the following in the order of property indicated for each set:

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

(ii) HF, HCl, HBr, HI- increasing acid strength.

(iii) NH_3, PH_3, AsH_3, SbH_3, BiH_3 – increasing base strength.

Q.2 Which one of the following does not exists?

(i) $XeOF_4$ (ii) NeF_2 (iii) XeF_2 (iv) XeF_6

Q.3 Complete the following chemical equations:

(i) $Ca_3P_2(s) + H_2O(\ell) \rightarrow .....$

(ii) $Cu^{2+}(aq) + \underset{(excess)}{NH_3(aq)} \rightarrow .....$

Q.4 A solution of ferric chloride acidified with HCl is unaffected when hydrogen is bubbled through it, but gets reduced when zinc is added to some acidified solution. Why?

Q.5 Aqua-regia dissolves noble metals in it. Explain.

Q.6 Pure PH_3 does not burn in air, but impure sample of PH_3 burns in air. Why?

Q.7 Precipitation of second group sulphides in qualitative analysis is carried out with H_2S in presence of HCl and not nitric acid. Why?

Q.8 $KMnO_4$ should not be dissolved in conc. H_2SO_4. Why?

Q.9 Account for the following observations

(i) Bleaching of flowers by Cl_2 is permanent, while by SO_2 it is temporary.

(ii) The brown colour of an acidified dilute solution of iodine in aqueous potassium iodide is intensified by the addition of a nitrite but is discharged by the addition of a sulphite.

Q.10 Explain the following

Silver nitrate solution when treated with a very dilute solution of hypo gives black precipitate but when it is treated with a concentrated solution of hypo it does not form any ppt.

Q.11 Explain it with reason

(i) Concentrated nitric acid turns yellow in sunlight.

(ii) Nitrous oxide supports combustion more vigorously than air.

Q.12 Explain why?

(i) Yellow phosphorous is kept under water but not the red phosphorous.

Q.13 What happens when ....(Give relevant equation)

(i) Hypophosphorous acid is heated.

(ii) Sodium iodate is treated with sodium bisulphite solution.

(iii) Chlorine gas is passed through dry and aqueous SO_2 gas.

(iv) Potassium dichromate and concentrated hydrochloric acid are heated together.

Q.14 Brief it with relevant equation

(i) A few drops of bismuth oxide solution in conc. HCl are added to excess of water.

(ii) Iodine is added to a solution of potassium Iodide.

(iii) Hydriodic acid is added to copper sulphate solution.

(iv) Hydrogen sulphide is bubbled through an aqueous solution of sulphur dioxide.

Q.15 Explain it (Give relevant equation)

(i) Sulphur dioxide is bubbled through aq. Solution of $CuSO_4$ in presence of potassium thiocyanate.

(ii) Ozone is treated with ethylene.

(iiii) Sulphur is boiled with caustic soda solution.

Exercise 2

Single Correct Choice Type

Q.1 Which is incorrectly matched

(A) $CsBr_3 \rightarrow Cs^+ + Br_3^-$

(B) $I_4O_9 \rightarrow I^{3+} + (IO_3^-)_3$

(C) $AgBrO_3 \rightarrow Ag^+ + BrO_3^-$

(D) $I_2O_4 \rightarrow IO_2^- + IO_2^-$

Q.2 An orange solid (X) on heating, gives a colourless gas (Y) and a only green residue (Z). Gas (Y) on treatment with Mg, produces a white solid substance......

(A) Mg_3N_2 (B) MgO (C) Mg_2O_3 (D) $MgCl_2$

Q.3 An inorganic salt (A) is decomposed at about 523 K to give products (B) and (C). Compound (C) is a liquid at room temperature and is neutral to litmus paper while oxide (B) on burning with white phosphorous, given a dehydrating agent (D).

Compounds (A), (B), (C) and (D) will be identified as

(A) NH_4NO_3, N_2O, H_2O, P_2O_5

(B) NH_4NO_2, K_2O, P_2O_2

(C) $CaCO_3$, CaO. H_2O, $CaCl_2$

(D) $CaCO_3$, CaO, H_2O, $Ca(OH)_2$

Q.4 An inorganic compound (A) made of two most occurring elements into the earth crust, having a polymeric tetra-headral network structure. With carbon, compound (A) produces a poisonous gas (B) which is the most stable diatomic molecule. Compounds (A) and (B) will be

(A) SiO_2, CO_2 (B) SiO_2,CO

(C) SiC,CO (D)SiO_2,N_2

Q.5 A sulphate of a metal (A) on heating evolves two gases (B) and (C) and an oxide

(D) Gas (B) turns $K_2Cr_2O_7$ paper green while gas (C) forms a trimer in which there is no S-S bond. Compound (D) with HCl, forms a Lewis base (E) which exists as a dimer. Compounds (A), (B), (C), (D) and (E) are respectively

(A) $FeSO_4$, SO_2, SO_3, Fe_2O_3, $FeCl_3$

(B) $Al_2(SO_4)_3$, SO_2, SO_3, Al_2O_3, $FeCl_3$

(C) FeS, SO_2, SO_3, $FeSO_4$, $FeCl_3$

(D) FeS, SO_2, SO_3, $Fe_2(PO_4)_3$, $FeCl_2$

Q.6 A tetra-atomic molecule (A) on reaction with nitrogen (I) oxide, produces two substances (B) and (C). (B) is a dehydrating agent in its monomeric gas which shows almost inert behaviour. The substances (A) and (B) and (C) respectively will be

(A) P_4, P_4O_1, N_2 (B)P_4, N_2O_5, N_2

(C)P_4, P_2O_3, Ar (D)P_4,P_2O_3, H_2

Q.7 Which one of the following compounds on strong heating evolves ammonia gas?

(A) $(NH_4)_2SO_4$ (B) HNO_3

(C) $(NH_4)_2Cr_2O_7$ (D) NH_3NO_3

Q.8 The correct order of acidic strength of oxy-acids of chlorine is

(A) $HClO < HClO_2 < HClO_3 < HClO_4$

(B) $HClO_4 < HClO_3 < HClO_2 < HClO$

(C) $HClO > HClO_4 > HClO_3 > HClO_2$

(D) $HClO_4 < HClO_2 > HClO_3 > HClO_4$

Q.9 Concentrated HNO_3 reacts with iodine to give

(A) HI (B) HOI (C) $HOIO_2$ (D) $HOIO_3$

Q.10 Conc. H_2SO_4 cannot be used to prepare HBr from NaBr because it

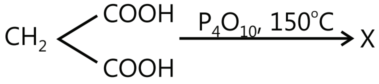
(A) Reacts slowly with NaBr

(B) Oxides HBr

(C) Reduces HBr

(D) Disproportionates HBr

Q.11 Compound (X) is



$CH_2(COOH)_2 \xrightarrow{P_4O_{10},\ 150^\circ C} X$

(A) Malonic acid (B) Carbon suboxide

(C) Tartaric acid (D) Acetic acid

Q.12 Molecular shapes of SF_4, CF_4 and XeF_4 are

(A) The same, with 2, 0 and 1 lone pairs of electrons respectively

(B) The same, with 2, 0 and 1 lone pairs of electrons respectively

(C) The different, with 0, 1 and 2 lone pairs of electrons respectively

(D) The different, with 1, 0 and 2 lone pairs of electrons respectively

Q.13 When $AgNO_3$ is heated strongly, the products formed are

(A) NO and NO_2 (B) NO_2 and O_2

(C) NO_2 and N_2O (D) NO and O_2

Q.14 $HNO_3 + P_4O_{10} \longrightarrow HPO_3 + A$; the product A is

(A) N_2O (B) N_2O_3 (C) NO_2 (D) N_2O_5

Q.15 $B(OH)_3 + NaOH \longrightarrow NaBO_2 + Na[B(OH)_4] + H_2O$

How can these reaction is made to proceed in forward direction?

(A) Addition of cis 1, 2 diol (B) Addition of borax

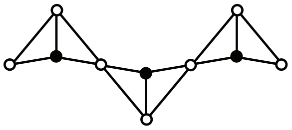
(C) Addition of trans 1, 2 diol (D) Addition of Na_2HPO_4

Comprehension Type

Paragraph 1: Read the following short write-up and answer the questions at the end of it.

The name 'silica' covers an entire group of minerals, which have general formula $SiO_{2,}$ the most common of which is quartz. Quartz is a framework silicate with SiO_4 tetrahedra arranged is spirals. The spirals can turn in a clockwise or anticlockwise direction- a feature that results in there being two mirror images, optically active, varieties of quartz.

Q.16 The following pictures represent various silicate anions. Their formulae are respectively:

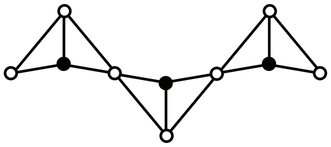


(A) SiO_3^{2-} $Si_3O_7^{2-}$ (B) SiO_4^{4-} $Si_3O_{10}^{8-}$

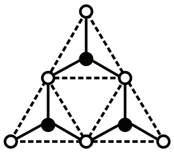
(C) SiO_4^{2-} $Si_3O_9^{2-}$ (D) SiO_3^{4-} $Si_3O_7^{8-}$

Q.17 $Si_3O_9^{6-}$ (having three tetrahedral) is represented as:

(A)



(B)



(C) Both (A) and (B)

(D) None of these

Q.18 The silicate anion in the mineral kinoite is a chain of three SiO_4 tetrahedra that share corners with adjacent tetrahedral. The mineral also contains Ca^{2+} ions, Cu^{2+} ions, and water molecules in 1:1:1 ratio mineral is represented as:

(A) $CaCuSi_3O_{10}$. H_2O (B) $CaCuSi_3O_{10}$. $2H_2O$

(C) $Ca_2Cu_2Si_3O_{10}$.2 H_2O (D) None of these.

Paragraph 2: There are some deposits of nitrates and phosphates in earth's crust. Nitrates are more soluble in water. Nitrates are difficult to reduce under the laboratory conditions but microbes do it easily. Ammonia forms large number of complexes with transition metal ions. Hybridization easily explains the ease of sigma donation capability of NH_3, and PH_3. Phosphine is a flammable gas and is prepared from white phosphorus.

Q.19 Among the following, the correct statement is

(A) Phosphorus have no biological significance in humans.

(B) Between nitrates and phosphates, phosphates are less abundant in earth's crust.

(C) Between nitrates and phosphates, nitrates are less abundant in earth's crust.

(D) Oxidation of nitrates is possible in soil.

Q.20 Among the following, the correct statement is

(A) Between NH_3 and PH_3, NH_3 is a better electron donor because the lone pair of electrons occupies spherical sp^3 orbital and is less directional

(B) Between NH_3 and PH_3, PH_3 is a better electron donor because the lone pair of electrons occupies spherical 's' orbital and is more directional

(C) Between NH_3 and PH_3, NH_3 is a better electron donor because the lone pair of electrons occupies spherical 's' orbital and is more directional

(D) Between NH_3 and PH_3, PH_3 is a better electron donor because the lone pair of electrons occupies spherical sp^3 orbital and is less directional

Q.21 PH_3 as one of the products. This is a

(A) Dimerization reaction.

(B) Disproportionation reaction

(C) Condensation reaction

(D) Precipitation reaction

Assertion Reasoning Type

Questions given below consist of two statements each printed as Assertion (A) and Reason (R); while answering these questions you are required to choose any one of the following responses:

(A) If both (A) and (R) are true and (R) is correct explanation of (A)

(B) If both (A) and (R) are true but (R) is not correct explanation of (A)

(C) If (A) is true but (R) is false

(D) If (A) is false but (R) is true

Q.22 Assertion: Borax bead test is applicable only to coloured salt.

Reason: In borax bead test, coloured salts are decomposed to give coloured metal meta borates.

Q.23 Assertion: Conc. H_2SO_4 cannot be used to prepare pure HBr from NaBr

Reason: It reacts slowly with NaBr.

Q.24 Assertion: Silicones are very inert polymers.

Reason: Both Si-O and Si-C bond energies are very high.

Q.25 Assertion: Chlorine gas disproportionates in hot and conc. NaOH solution.

Reason: NaCl and NaOCl are formed in the above reaction.

Multiple Correct Choice Type

Q.26 The correct statement(s) related to allotropes of carbon is/are

(A) Graphite is the most stable allotropes of carbon and having a two dimensional sheet like structure of hexagonal rings of carbon (sp^2).

(B) Diamond is the hardest allotrope of carbon and having a three dimensional network structure of C (sp^3)

(C) Fullerene (C_{60}) is recently discovered non-crystalline allotrope of carbon having a football like structure.

(D) Vander waal's force of attraction acts between the layers of graphite 6.14 Å away from each other.

Q.27 $Al_2(SO_4)_3 + NH_4OH \longrightarrow X$, then

(A) X is a white coloured compound

(B) X is insoluble in excess of NH4OH

(C) X is soluble in NaOH

(D) X cannot be used as an antacid.

Q.28 Which of the following is/are correct for group 14 elements?

(A) The stability of dihalides are in the order $CX_2 < SiX_2 < GeX_2 < SnX_2 < PbX_2$

(B) The ability to form $p\pi - p\pi$ multiple bonds among themselves increases down the group.

(C) The tendency for catenation decreases down the group.

(D) They all form oxides with the formula MO_2.

Q.29 $2NO_2 \longleftrightarrow N_2O_4$ The dimerization of NO_2 is accompanied with

(A) Decrease in paramagnetism

(B) Change in colour

(C) Increase in temperature

(D) Increase in paramagnetism

Q.30 $C(OH)_4$ is unstable because a carbon atom cannot hold more than one –OH groups but $Si(OH)_4$

is stable compound because

(A) C-O bond energy is low.

(B) C-O bond energy is high.

(C) Si-O bond energy is low.

(D) Si-O bond energy is high.

Q.31 Which of the following statements is/are correct regarding inter-halogen compound ABx types?

(A) x may be 1, 3, 5 and 7

(B) A is more electronegative halogen than B

(C) FBr_3 cannot exists

(D) the structure of ClF_3 and IF_7 show deviation from normal structures and could be explained on the basis of VSEPR theory.

Q.32 Select correct statement(s)

(A) Borax is used as buffer

(B) 1 M borax solution reacts with equal volumes of 2M HCl solution

(C) Titration of borax can be made using methyl orange as the indicator.

(D) Coloured bead obtained in borax-bead test contains metaborate.

Q.33 Select correct statement about B_2H_6

(A) Bridging groups are electron-deficient with 12 valence electrons

(B) It has 2c-2e B-H bonds

(C) It has 3c-2e B-H-B bonds

(D) All above are correct statements.

Match the Columns

Q.34 Match the following

Column I	**Column II**
(A) $Bi^{3+} \to (BiO)^+$	(p) Heat
(B) $[AlO_2]^- \to Al(OH)_3$	(q) Hydrolysis
(C) $SiO_4^{4-} \to Si_2O_7^{6-}$	(r) Acidification
(D) $(B_4O_7^{2-}) \to [B(OH)_3]$	(s) Dilution by water

Previous Years' Questions

Q.1 H_3BO_3 is ***(2003)***

(A) Monobasic acid and weak Lewis acid

(B) Monobasic and weak Bronsted acid

(C) Monobasic and strong Lewis acid

(D) Tribasic and weak Bronsted acid

Q.2 $B(OH)_3 + NaOH \longrightarrow NaBO_2 + Na[B(OH)_4] + H_2O$ How can one proceed this reaction in the forward direction? ***(2006)***

(A) Addition of cis 1, 2 diol

(B) Addition of borax

(C) Addition of trans 1, 2 diol

(D) Addition of Na_2HPO_4

Q.3 In the reaction, $2X + B_2H_6 \longrightarrow [BH_2(X)_2]^+[BH_4]^-$, the amine (s) X is (are) ***(2009)***

(A) NH_3 (B) CH_3NH_2

(C) $(CH_3)_2NH$ (D) $(CH_3)_3N$

Read the following questions and answer as per the direction given below:

(a) Statement-I is true; statement-II is true;statement-II is the correct explanation of statement-I.

(b) Statement-I is true; statement-II is true; statement-II is not the correct explanation of statement-I.

(c) Statement-I is true; statement-II is false.

(d) Statement-I is false; statement-II is true.

Q.4 Statement-I: In water, orthoboric acid behaves as a weak monobasic acid.

Statement-II: In water, orthoboric acid acts as a proton donor. ***(2007)***

Q.5 Statement-I: Between $SiCl_4$ and CCl_4, only $SiCl_4$ reacts with water.

Statement-II: $SiCl_4$ is ionic and CCl_4 is covalent. ***(2001)***

Q.6 The two types of bonds present in B_2H_6 are covalent and .... ***(1994)***

Q.7 Extra pure N_2 can be obtained by heating ***(2011)***

(A) NH_3 with CuO (B) NH_4NO_3

(C) $(NH_4)_2Cr_2O_7$ (D) $Ba(N_3)_2$

Q.8 The reaction of P_4 with X leads selectively to P_4O_6. The X, is ***(2009)***

(A) Dry O_2

(B) A mixture of O_2 and N_2

(C) Moist O_2

(D) O_2 in the presence of aqueous NaOH

Q.9 The set with correct order of acid strength is ***(2001)***

(A) $HClO < HClO_2 < HClO_3 < HClO_4$

(B) $HClO_4 < HClO_3 < HClO_2 < HClO$

(C) $HClO < HClO_4 < HClO_3 < HClO_2$

(D) $HClO_4 < HClO_2 < HClO_3 < HClO$

Q.10 Nitrogen (I) oxide is produced by ***(1989)***

(A) Thermal decomposition of NH_4NO_3

(B) Disproportionation of N_2O_4

(C) Thermal decomposition of NH_4NO_2

(D) Interaction of hydroxylamine and nitrous acid

Q.11 White phosphorus (P_4) has ***(1998)***

(A) Six P—P single bonds

(B) Four P—P single bonds

(C) Four lone pairs of electrons

(D) PPP angle of 60^o

Paragraph: The noble gases have closed-shell electronic configuration and are monoatomic gases under normal conditions. The low boiling points of the lighter noble gases are due to weak dispersion forces between the atoms and the absence of other interatomic interactions.

The direct reaction of xenon with fluorine leads to a series of compounds with oxidation numbers +2, +4 and +6. XeF_4 reacts violently with water to give XeO_3. The compounds of xenon exhibit rich stereochemistry and their geometries can be deduced considering the total number of electron pairs in the valence shell. ***(2007)***

Q.12 Argon is used in arc welding because of its

(A) Low reactivity with metal

(B) Ability to lower the melting point of metal

(C) Flammability

(D) High calorific value

Q.13 The structure of XeO_3 is

(A) Linear (B) Planer (C) Pyramidal (D) T-shaped

Q.14 XeO_4 and XeO_6 are expected to be

(A) Oxidizing (B) Reducing

(C) Unreactive (D) Strongly basic

Q.15 White phosphourus on reaction with NaOH gives PH_3 as one of the products. This is a ***(2008)***

(A) Dimerisation reaction

(B) Disproportionation reaction

(C) Condensation reaction

(D) Precipitation reaction

Q.16 All the compounds listed in column I react with water. Match the result of the respective with the appropriate option listed in column II. ***(2010)***

Column I	**Column II**
(A) $(CH_3)_2SiCl_2$	(p) Hydrogen halide formation
(B) XeF_4	(q) Redox reaction
(C) Cl_2	(r) Reacts with glass
(D) VCl_2	(s) Polymerization
	(t) O_2 formation

Q.17 The basicity of phosphorus acid (H_3PO_3) is .... ***(1990)***

Q.18 Among the following, the number of compounds than can react with PCl_5 to give $POCl_3$ is $O_2, CO_2, SO_2, H_2SO_4, P_4O_{10}$ ***(2011)***

Q.19 Extra pure N_2 can be obtained by heating ***(2011)***

(A) NH_3 with CuO (B) NH_4NO_3

(C) $(NH_4)Cr_2O_7$ (D) $Ba(N_3)_2$

Q.20 The reaction of white phosphorus with aqueous NaOH gives phosphine along with another phosphorus containing compound. The reaction type ; the oxidation states of phosphorus in phosphine and the other product are respectively ***(2012)***

(A) Redox reaction ; 3 and 5

(B) Redox reaction; +3 and +5

(C) Disproportionation reaction ; –3 and + 5

(D) Disproportionation reaction ; 3 and + 3

Q.21 Bleaching powder contains a salt of an oxoacid as one of its components. The anhydride of that oxoacid is ***(2012)***

(A) Cl_2O (B) Cl_2O_7 (C) ClO_2 (D) Cl_2O_6

Q.22 With respect to graphite and diamond, which of the statement(s) given below is (are) correct? ***(2012)***

(A) Graphite is harder than diamond.

(B) Graphite has higher electrical conductivity than diamond.

(C) Graphite has higher thermal conductivity than diamond.

(D) Graphite has higher C - C bond order than diamond.

Q.23 Which ordering of compounds is according to the decreasing order of the oxidation state of nitrogen ? ***(2012)***

(A) HNO_2, NO, NH_4Cl, N_2 (B) $HNO_3, NO, N_2 NH_4Cl$

(C) HNO_3, NH_4Cl, NO, N_2 (D) NO, HNO_3, NH_4Cl, N_2

Q.24 Concentrated nitric acid, upon long standing, turns yellow − brown due to the formation of ***(2013)***

(A) NO (B) NO_2 (C) N_2O (D) N_2O_4

Q.25 The correct statement(s) about O_3 is(are) ***(2013)***

(A) O−O bond lengths are equal

(B) Thermal decomposition of O_3 is endothermic

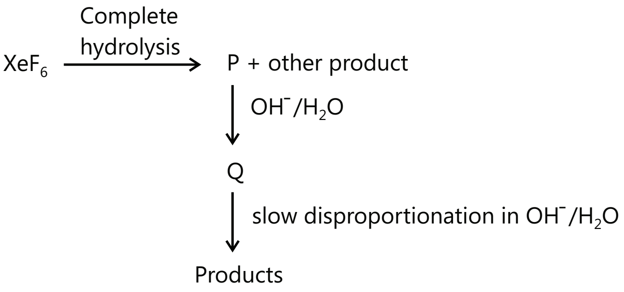
(C) O_3 is diamagnetic in nature

(D) O_3 has a bent structure

Q.26 The product formed in the reaction of $SOCl_2$ with white phosphorous is ***(2014)***

(A) PCl_3 (B) SO_2Cl_2 (C) SCl_2 (D) $POCl_3$

Q.27 Under ambient conditions, the total number of gases released as products in the final step of the reaction scheme shown below is ***(2014)***



(A) 0 (B) 1 (C) 2 (D) 3

Q.28 Three moles of B_2H_6 are completely reacted with methanol. The number of moles of boron containing product formed is ***(2015)***

Q.29 The correct statement(s) regarding, (i) HClO, (ii) $HClO_2$, (iii) $HClO_3$, and (iv) $HClO_4$, is (are) ***(2015)***

(A) The number of $Cl = O$ binds in (ii) and (iii) together is two

(B) The number of lone pairs of electrons on Cl in (ii) and (iii) together is three

(C) The hybridizatiob of Cl in (iv) is sp^3

(D) Amongst (i) to (iv), the strongest acid is (i)

Q.30 Among the triatomic molecules/ions $BeCl_2, N_3^-, N_2O, NO_2^+, O_3, SCl_2, ICl_2^-, I_3^-$ and XeF_2 the total number of linear molecule(s)/ion(s) where the hybridization of the central atom does not have contribution from the d-orbital (s) is

[Atomic number : S = 16, Cl = 17, I = 53 and Xe = 54] ***(2015)***

Q.31 The increasing order of atomic radii of the following Group 13 elements is ***(2016)***

(A) $Al < Ga < In < Tl$ (B) $Ga < Al < In < Tl$

(C) $Al < In < Ga < Tl$ (D) $Al < Ga < Tl < In$

Q.32 The crystalline form of borax has ***(2016)***

(A) Tetranuclear $\left[B_4O_5(OH)_4\right]^{2-}$ unit

(B) All boron atoms in the same plane

(C) Equal number of sp^2 and sp^3 hybridized boron atoms

(D) One terminal hydroxide per boron atom

Q.33 The nitrogen containing compound produced in the reaction of HNO_3 with P_4O_{10} ***(2016)***

(A) Can also be prepared by reaction of P_4 and HNO_3

(B) Is diamagnetic

(C) Contains one N-N bond

(D) Reacts with Na metal producing a brown gas

PlancEssential Questions

JEE Main/Boards

Exercise 1

Q.12 Q.22 Q.23
Q.34 Q.36 Q.37

Exercise 2

Q.7 Q.12

Previous Years' Questions

Q.1 Q.8 Q.12
Q.14 Q.21

JEE Advanced/Boards

Exercise 1

Q.3 Q.9 Q.13
Q.14 Q.16

Exercise 2

Q.1 Q.3 Q.11
Q.15 Q.27 Q.28
Q.29 Q.30 Q.32
Q.33

Previous Years' Questions

Q.3 Q.5 Q.6

Answer Key

JEE Main/Boards

Exercise 2

Single Correct Choice Type

Q.1 C **Q.2** B **Q.3** A **Q.4** B **Q.5** B **Q.6** B
Q.7 A **Q.8** A **Q.9** A **Q.10** B **Q.11** D **Q.12** C
Q.13 A

Previous Years' Questions

Q.1 D **Q.2** C **Q.3** A **Q.4** C **Q.5** A **Q.6** C
Q.7 A **Q.8** C **Q.9** D **Q.10** A **Q.11** B **Q.12** A
Q.13 C **Q.14** D **Q.15** B **Q.16** D **Q.17** A **Q.18** B
Q.19 D **Q.20** D **Q.21** C **Q.22** B **Q. 23** C **Q.24.** C
Q.25 A **Q.26** A **Q.27** A

JEE Advanced/Boards

Exercise 2

Single Correct Choice Type

Q.1 D **Q.2** B **Q.3** A **Q.4** B **Q.5** A **Q.6** A

Q.7 A **Q.8** A **Q.9** C **Q.10** B **Q.11** B **Q.12** D

Q.13 B **Q.14** D **Q.15** A

Comprehension Type

Q.16 B **Q.17** B **Q.18** C **Q.19** C **Q.20** C **Q.21** B

Assertion Reasoning Type

Q.22 A **Q.23** C **Q.24** A **Q.25** C

Multiple Correct Choice Type

Q.26 A, B **Q.27** A, B, C **Q.28** A, C, D **Q.29** A, B **Q.30** A, D **Q.31** A, C

Q.32 A, B, C, D **Q.33** B, C

Match the Columns

Q.34 A → q, s; B → r; C → r; D → q, r

Previous Years' Questions

Q.1 A **Q.2** A **Q.3** A, B, C **Q.4** C **Q.5** C **Q.6** Banana Bond

Q.7 D **Q.8** B **Q.9** A **Q.10** A, D **Q.11** A, C, D **Q.12** A

Q.13 C **Q.14** A **Q.15** B **Q.16** A → p, s; B → p, q, r, t; C → p, q, t: D → p

Q.17 B **Q.18** D **Q.19** D **Q.20** C **Q.21** A **Q.22** B, C, D

Q.23 B **Q.24** B **Q.25** A, C, D **Q.26** A **Q.27** C **Q.28** 6

Q.29 B, C **Q.30** D **Q.31** B **Q.32** A, C, D **Q.33** B, D

Solutions

JEE Main/Boards

Exercise 1

Sol 1: Ammonia is manufactured industrially by using Haber's process.

$$N_2(g) + 3H_2(g) \xrightarrow{Fe/Mo} 2NH_3(g)$$

2. In NH_3, N is sp^3 hybridised and one lone pair of electrons is present on N atom. Due to long pair – bond pair repulsions, the H-atoms are pushed closer and the bond angles decrease from 109° to 107°. In HPH or HAsH or HSbH, the central atom uses only pure p-atomic orbital in the bond formation. As p-atomic orbitals are mutually perpendicular to each other, the bond angle is close to 90°

Sol 2: On moving down the group, size of central atom increases and its electronegativity decreases. As a result, bond pairs lie away from central atom resulting in decreases in bond angle.

Sol 3:

White phosphorus	Red phosphorus
(i) It consist of discrete P_4 tetrahedral.	(i) It consists of polymer of P_4 tetrahedral units
(ii) It glows in dark and is soluble in CS_2	(ii) It does not glow in the dark and is insoluble in CS_2
(iii) It is highly reactive due to strained P_4 tetrahedral	(iii) It is much less reactive due to polymerization
(iv) It dissolves in NaOH to give PH_3	(iv) It is insoluble in NaOH

Sol 4: The bond dissociation energy of N-N bond is less than that of P-P due to strong lone pair-lone pair repulsions.

Sol 5: (i) Electronic configuration:

$${}_8O = [He]2s^2 2p^4;\ {}_{16}DS = [Ne]3s^2 3p^4;$$

$${}_{34}Se = [Ar]3d^{10}\, 4s^2 2p^4$$

$${}_{52}Te = [Kr]4d^{10}\, 5s^2 2p^4 \text{ and}$$

$${}_{84}Po = [Xe]4f^{14} 5d^{10}\, 6s^2 6p^4$$

All these elements have same $ns^2\, np^4$ (n =2 to 6) valence shell electronic configuration and hence are justified to be placed in group 16 of the periodic table.

(ii) Oxidation states: They need two more electrons to form dinegative ions by acquiring the nearest noble gas configuration. So, the minimum oxidation state of these elements should be -2. Oxygen predominantly and sulphur to some extent being electronegative show an oxidation state of -2. Since these elements have six electrons in the valence shell, therefore, at the maximum they can show an oxidation state + 6. Other positive oxidation states shown by these elements are +2 and + 4. Although, oxygen due to the absence of d-orbitals does not show oxidation state of +4 and + 6. Thus, on the basis of minimum and maximum oxidation states, these elements are justified to be placed in the same group i.e. , group 16 of the periodic table.

(iii) Formation of hydrides: All the elements complete their respective octets by sharing two of their valence electrons with 1s-orbital of hydrogen to form hybrids of the general formula EH_2 i.e., H_2O, H_2S, H_2Se, H_2Te and H_2Po. Therefore, on the basis of formation of hydride of the general formula, EH_2, these elements are justified to be placed in group 16 of the periodic table.

Sol 6: Although the formation of O^{2-} from O is endothermic but still almost all elements form oxides and this is due to high lattice energy of the oxides. This is due to small size and high charge of O^{2-} .

Sol 7: Aerosols such as chlorofluorocarbons (CFCs), i.e., feron (CCl_2F_2) depletes the O_3 layer by supplying Cl free radicals which convert O_3 to O_2 as shown below:

$$\underset{\text{Feron}}{Cl_2CF_2(g)} \xrightarrow{hv} \bullet Cl(g) + \bullet CClF_2(g)$$

$$\bullet Cl(g) + O_3(g) \longrightarrow ClO\bullet(g) + O_2(g)$$

$$ClO\bullet(g) + \bullet O(g) \longrightarrow \bullet Cl(g) + O_2(g)$$

Sol 8: Sulphuric acid is manufactured by the Contact Process which involves three steps:

(i) Burning of sulphur or sulphide ores in air to produce SO_2.

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

(iii) absorption of SO_3 in H_2SO_4 to give oleum ($H_2S_2O_7$).

The SO_2 produced is purified by removing dust and other impurities such as arsenic compounds.

The key step in the manufacture of H_2SO_4 is the catalytic oxidation of SO_2 with O_2 to give SO_3 in the presence of V_2O_5 (catalyst).

$$2SO_2(g)+O_2(g)\longrightarrow 2SO_3(g);\Delta_rH^\circ=-196.6\ \text{kJ mol}^{-1}$$

The reaction is exothermic, reversible and the forward reaction leads to a decrease in volume. Therefore, low temperature and high pressure are the favourable conditions for maximum yield. But the temperature should not be very low otherwise the rate of reaction will become slow.

In practice, the plant is operated at a pressure of 2 bar and a temperature of 720 K. The SO_3 gas oleum with water gives H_2SO_4 of the desired concentration.

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

The sulphuric acid obtained by contact process is 96-98% pure.

Sol 9: Due to low bond dissociation enthalpy, high electronegativity and large negative electron gain enthalpy, halogens have a strong tendency to accept electrons and thus get reduced.

$$X+e^-\longrightarrow X^-$$

Thus, halogens act as strong oxidising agents. Their oxidising power, however, decreases from F_2 to I_2.

Sol 10: Although O and Cl have about the same electronegativity, yet their atomic size (covalent radii) are much different : O = 66 pm and Cl =99 pm. Thus, electron density per unit volume on oxygen atom is much higher than that on chlorine atom. Hence, oxygen forms hydrogen bonds while chlorine does not though both have approx. The same electronegativity.

Sol 11: HCl can be oxidized to Cl_2 by a number of oxidising agents like MnO_2, $KMnO_4$ and K_2CrO_7

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

Cl_2 can be reduced to HCl by reaction of H_2 in the presence of diffused sunlight.

$$H_2+Cl_2\xrightarrow{\text{Diffused sunlight}}2HCl$$

Sol 12: Let the oxidation state of P be x.

(i) $\overset{+1}{H_3}\ \overset{x}{P}\ \overset{-2}{O_3}\ \therefore 3(+1)+x+3(-2)=0$ or $x=+3$

(ii) $\overset{x}{P}\ \overset{-1}{Cl_3}\ \therefore x+3(-1)=0$ or $x=+3$

(iii) $\overset{+2}{Ca_3}\ \overset{x}{P_2}\ \therefore 3(+2)+2\times x=0$ or $x=-3$

(iv) $\overset{+1}{Na_3}\ \overset{x}{P}\ \overset{-2}{O_4}\ \therefore 3(+1)+x+4(-2)=0$ or $x=+5$

(v) $\overset{x}{P}\ \overset{-2}{O}\ \overset{-1}{F_3}\ \therefore x+1(-2)+3(-1)=0$ or $x=+5$.

Sol 13: Cl_2 is produced

$$\begin{array}{c}
[NaCl+H_2SO_4\longrightarrow NaHSO_4+HCl]\times 4\\
4HCl+MnO_2\longrightarrow MNCl_2+Cl_2+2H_2O\\
\hline
4NaCl+MnO_2+4H_2SO_4\longrightarrow MnCl_2+4NaHSO_4+Cl_2+2H_2O
\end{array}$$

(ii) Cl_2 being an oxidising agent oxidises NaI to I_2.

$$Cl_2(g)+2NaI(aq)\longrightarrow 2NaCl(aq)+I_2(s)$$

Sol 14: These xenon fluorides are prepared by direct reaction between Xe and F_2 under different conditions as shown below:

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

$$\underset{\text{(1:5 ration)}}{Xe(g)+2F_2(g)}\xrightarrow{873K,7\ \text{bar}}XeF_4(s)$$

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

Sol 15: Replace O^-(9 electrons) in ClO^- by F (9 electrons). The resulting neutral molecule is ClF. Since ClF can combine further with F to form ClF_3, so, ClF is a Lewis base.

Sol 16: Hydrolysis of XeF_4 and XeF_6 with water gives XeO_3.

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

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

In contrast, partial hydrolysis of XeF_6 gives $XeOF_4$

$$XeF_6+H_2O\longrightarrow XeOF_4+2HF$$

Sol 17: Noble gases have only van der Waals' radii while others have covalent radii. Van der Waals' radii are larger than covalent radii. Hence, noble gases have comparatively large atomic sizes.

Sol 18: Uses of Neon:

(i) Neon is used in discharge tubes and fluorescent bulbs for advertisement display purposes.

(ii) Neon bulbs are used in botanical gardens and in green houses.

(iii) Neon is used in voltage regulators and indicators.

Sol 19: Electronic configuration: The valence shell electronic configuration of these elements are $ns^2\ np^3$. The s-orbital in these elements is completely filled and p-orbitals are half-filled, making their electronic configuration extra stable.

Oxidation states: The common oxidation states of these elements are -3 , +3, and + 5. The tendency to exhibit -3 oxidation, state decreases down the group due to increase in size and metallic character. In fact last member of the group, bismuth hardly forms any compounds in -3 oxidation state. The stability of +5 oxidation state decreases down the group. The only well characterized Bi (v) compound is BiF_3 The stability of +5 oxidation state decreases and that of +3 oxidation state increases (due to inert pair effect) down the group. Nitrogen exhibits +1, +2, +4 oxidation states also when it reacts with oxygen.

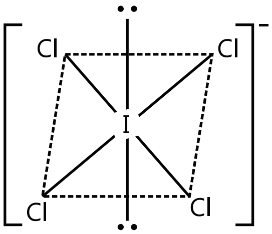
Phosphorus also shows +1 and +4 oxidation states in some oxoacids.

Atomic size: Covalent and ionic (in a particular state) radii increases in size down the group. There is a considerable increase in covalent radius from N to P. However, from As to Bi only a small increase in covalent radius is observed. This is due to the presence of completely filled d and /or f orbitals in heavier members.

Ionization Enthalpy: Ionization enthalpy decreases down the group due to gradual increases in atomic size. Because of the extra stable half-filled p-orbitals electronic configuration and smaller size, the ionization enthalpy of the group 15 elements is much greater than that of group 14 elements in the corresponding periods. The order of successive ionization enthalpies as expected is $\Delta_i H_1 < \Delta_i H_2 < \Delta_i H_3$.

Electronegativity: The electronegativity value, in general, decreases down the group with increasing atomic size. However, amongst the heavier elements, the difference is not that pronounced.

Sol 20: (i) Structure of ICl^-_4:

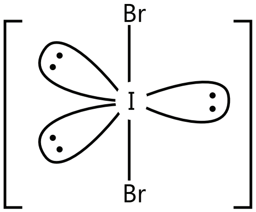


Square planar

I in ICl^-_4 has four bond pairs and two lone pairs. Therefore, according to VSEPR theory, it should be square planar as shown.

Here, ICl^-_4 has $(7+4\times7+1)=36$ valence electrons. A noble gas species having 36 valence electrons is XeF_4 $(8+4\times7=36)$. Therefore, like ICl^-_4, XeF_4 is also square planar.

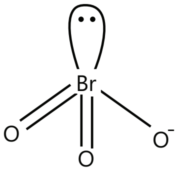
(ii) Structure of IBr^-_2:



Linear

I in IBr^-_2 has two bond pairs and three lone pairs. SO, according to VSEPR theory, it should be linear. Here, IBr_2 has $22(7+2\times7+1)$ valence electrons. A noble gas species having 22 valence electrons is XeF_2 $(8+2\times7=22)$. Thus, like IBr^-_2, XeF_2 is also linear:

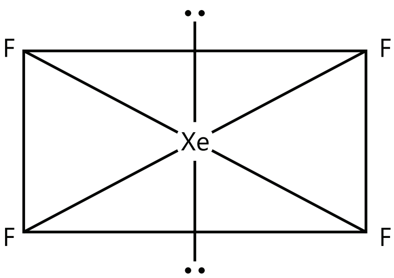
(iii) Structure of BrO^-_3:



Pyramidal

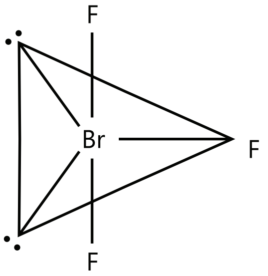
The central atom Br has seven electrons. Four of these electrons form two double bonds or coordinate bonds with two oxygen atoms while the fifth electron forms a single bond with O^- ion. The remaining two electrons form one lone pair. Hence, in all there are three bond pairs and one lone pair around Br atom in BrO^-_3 Therefore, according to VSEPR theory, BrO^-_3 should be pyramidal. Here, BrO^-_3 has $26(7+3\times6+1=26)$ valence electrons. A noble gas species having 26 valence electrons is XeO_3 $(8+3\times6+1=26)$. Thus, like BrO^-_3, XeO_3 is also pyramidal.

Sol 21: XeF_4



Square planar

BrF_3



T-Shaped

Sol 22: (i) The minimum oxidation number (O.N.) of S is -2 while its maximum O.N. is +6 In SO_2, the O. N. is +4, here, it can not only increase its O.N. by losing electrons but also reduce its O.N. by gaining electrons. Thus, it acts both as a reducing agent as well as an oxidising agent. In contrast, in H_2S, S has an O.N. of -2. Thus, it can only increase its O.N by losing electrons and hence acts only as a reducing agent.

(ii) Fluorine being the strongest oxidising agent oxidises sulphur to its maximum oxidation state of +6 and thus forms SF_6 In contrast H_2 being a very weak oxidising agent cannot oxidise S to its maximum oxidation state of +6 and hence does not form $SH_{6.}$

(iii) This is because fluorine is more electronegative than oxygen.

Sol 23: (i) (a) $XeF_2 + PF_5 \longrightarrow [XeF]^+[PF_6]^-$:

(b) $2AgNO_3 \xrightarrow{\Delta} 2Ag + 2NO_2 + O_2$

(ii) (a) +3 oxidation state becomes more stable from As to Bi in the group due to inert pair effect. The reluctance of the s electrons to take part in the chemical bonding due to which the lower oxidation state become more stable on descending down the group of p-block elements is known as inert pair effect.

(b) Sulphur in vapour state exhibits paramagnetic behaviour because it forms S_2 molecules like O_2 which contains two unpaired electrons.

Sol 24: (ii) (a) Because P-P bond is stronger than N-N bond.

(b) $p\pi - p\pi$ bonding is available in case of fluorine whereas in case of chlorine, $d\pi - p\pi$ is seen.

(c) Ionization energy is quite high.

Sol 25: (ii) a Hydrogen bonding in NH_3

(b) same as 24(c).

(c) Due to Due to the inert pair effect, Sb and Bi are more stable in +3 oxidation state as compared to the +5 state. But due to the presence of f orbital electrons in Bi, its +3 is more stable than Sb(+3). That is why, Bi(V) tends to achieve Bi(III) state (i.e. reduction of Bi) for greater stability easily as compared to the Sb. since Bi (V) is undergoing self reduction, hence it is a stronger oxidising agent then Sb(V).

Sol 26:

(i) (a) $PCl_5 + H_2OH \rightarrow Cl + H_3PO_4$

(b) $F_2 + H_2O \rightarrow HF + O_2$

(ii) (a) Presence of d-orbitals in P.

(b) Formation of bisulfate anion $\left(HSO_4^-\right)$ by loss of one proton gives a bigger Ka_1.

Sol 27: (i) (a) $P_4 + 4NaOH + 2H_2O \rightarrow 2PH_3 + 2Na_2HPO_3$

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

(ii)(a) Oxygen has small size and more electronegativity in comparison to sulphur and thus H_2O molecules exists as associated molecule to form liquid state because of H-bonding. H_2S doesnt not show H-bonding and thus exists as unassociated molecules to have gaseous state.

ii) (b) Deep sea divers can remain at depth only for controlled periods and must come up slowly and even remain at specified depths to avoid the bends. When ordinary air is used for diving the oxygen in the air is used up by the body but the nitrogen builds up to a new equilibrium state at the higher pressure required at great depths. The excess nitrogen would then come out of tissues and form bubbles (like the fizz in a opened can of soda) in the blood causing the bends and great pain with possible death. During controlled decompression the helium would also diffuse out of tissues and the lungs more easily than nitrogen avoiding the bends.

Sol 28: In PCl_5, due to small size and high electronegativity of Cl, hybridisation is possible. But in PI_5, hybridisation is restricted due to large size and less electronegativity.

Sol 29: Urea releases nitrogen readily as compared to ammonium sulphate and moreover, urea contains the highest percentage of nitrogen.

Sol 30: HF has a corrosive action on glass.

Sol 31: H_2F_2 exists as dimeric molecule due to H-bonding and thus shows dibasic nature. Hence it gives two series of salts KHF_2 as $\left[K^+ and F^- .....H-F^-\right]$ and $KF\left[K^+ and F^-\right]$ whereas HCl and HBr do not show hydrogen bonding and thus formation of $KHCl_2$ or $KHBr_2$ is not possible.

Sol 32: Halogens have variable oxidation states, +1, +3, +5 and +7.

Sol 33: Chlorine can displace iodine sinc its above I in the group.

Sol 34: (i) Ionization energy of Cl is greater than Iodine. Thus I_2 can be readily displaced.

ii) SO_2 is obtained by burning sulphur in air.

$S + O_2 \rightarrow SO_2$

The SO_2 so obtained is impure. Dust present in sulphur is removed by allowing the gas to expand, when some dust settles, as well as by passing through electrostatic precipitators and finally washing with water. The moistened gas is now treated with conc.H_2SO_4 to dry SO_2 and H_2SO_4 is kept in use until its concentration falls to 94%.

The SO_2 so obtained then catalytically converted to SO_3

$$2SO_2 + O_2 \xrightarrow[\substack{\text{finely divided Pt deposited on } MgSO_4 \\ \text{or } Fe_2O_3 \text{ \& } CuO \\ \text{or Pt–silica gel}}]{\text{Pt asbestos or}} 2SO_3$$

Sol 35: (i)

SO_2 reduces $K_2Cr_2O_7$ to green chromium sulphate.

$3SO_2 + K_2Cr_2O_7 + H_2SO_4 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + H_2O$

ii) $Al_2S_3 + 6H_2O \rightarrow 2Al(OH)_3 + \underset{\text{foul odour}}{3H_2S\uparrow}$

Sol 36: The oxidation number of sulphur in sulphur dioxide is +4 which lies between its maximum value (+6) and minimum value (-2). Hence sulphur dioxide can both be oxidized and reduced and SO_2 can act both as a reducer and oxidizer respectively

As oxidizer

$2H_2S^{-2} + \overset{+4}{S}O_2 = 3\overset{0}{S} + 2H_2O$

AS reducer-

$I_2^0 + \overset{+4}{S}O_2 + 2H_2O = 2H\overset{-1}{I} + H_2\overset{+6}{S}O_4$

$2K\overset{+5}{S}O_3 + 5\overset{+4}{S}O_2 + 4H_2O \rightarrow \overset{0}{I_2} + 4H_2\overset{+6}{S}O_4 + K_2SO_4$

Sulphur is placed below oxygen in the same group in the periodic table.

Thus H_2S acts as a reducing agent only.

Sol 37: (i) H_3PO_4 ,orthophosphoric acid, can be written $O=P(OH)_3$. It has three acidic protons (attached to oxygen) and is therefore tribasic. But Phosphorus acid, H_3PO_3,is diprotic (readily ionizes two protons), not triprotic as might be suggested by the formula.

ii) to restore the fertility of the soil. These plants have the ability to fix atmospheric nitrogen to form nitrogen compounds through the help of certain bacteria present in their root. These nitrogen compounds go into the soil and make it more fertile.

Sol 38: $Zn + H_2SO_4(dil) \longrightarrow ZnSO_4 + H_2$

$Zn + \text{conc. } H_2SO_4 \longrightarrow ZnSO_4 + SO_2 + 2H_2O$

Exercise 2

Single Correct Choice Type

Sol 1: (C) $H_3PO_2 \xrightarrow{\Delta} (X) + PH_3$;

Disproportionation reaction

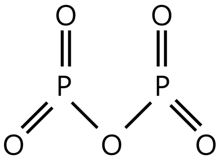
Sol 2: (B) (b) **Pseudohalogen molecules:** (meaning"fake" halogens) are inorganic molecules of the general forms Ps–Ps or Ps–X, where Ps is a **pseudohalogen group** such as cyanide, cyanate, thiocyanate and others, and X is a "true" halogen.

Sol 3: (A) Fact.

Sol 4: (B) (b) Depends on the sizes of the halogens

Sol 5: (B) (b) It has a lone pair in 2p orbital which is transferred to the empty d-orbital of Si atom resulting dπ-pπ bonding.

Sol 6: (B)



Sol 7: (A)

$$H_2C_2O_4 + H_2SO_4 \rightarrow H_2O + CO + CO_2$$
$$KOH + CO_2 \rightarrow K_2CO_3 + H_2O$$

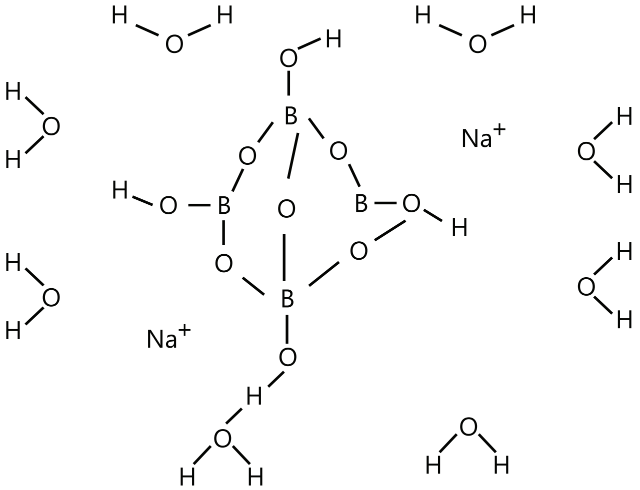
Sol 8: (A) Acidic strengths increases as electronegativity of atom increases So, $Cl_2O_7 > SO_2 > P_4O_{10}$

Sol 9: (A) $CaC_2 + N_2 \rightarrow \underbrace{CaN_2}_{\text{Calcium cyanamide}} + C$

Sol 10: (B) Fact.

Sol 11: (D) Self explanatory

Sol 12: (C)



Sol 13: (A) $KI + O_3 + H_2O \rightarrow I_2 + KOH + O_2$

Previous Years' Questions

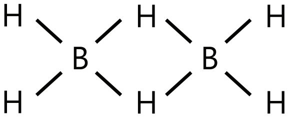
Sol 1: (D) $Al_2Cl_6 + 12H_2O \rightleftharpoons 2[Al(H_2O)_6]^{3+} + 6Cl^-$

Sol 2: (C) Fact.

Sol 3: (A) Boron does not have d orbitals in its valence shell and so, maximum covalency of Boron cannot exceed 4. So, its cannot form BF_6^{-3}.

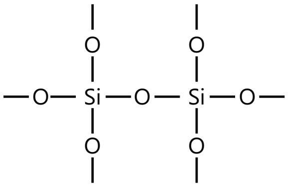
Sol 4: (C) $Al_2Cl_6 6H_2O \longrightarrow Al_2O_3 + 6HCl + 3H_2O$

Sol 5: (A)



Sol 6: (C) Stability of dihalides increases down the group.

Sol 7: (A)



Sol 8: (C) Down the group, acidic character increases.

Sol 9: (D) In P_4, P – P bond is sp^3 hybridised

$\therefore$ % p character = 75

Sol 10: (A) Down the group, stability of hydrides decreases.

Sol 11: (B) $K_2Cr_2O_7 + \underset{\text{excess}}{HNO_3}(dil) \rightarrow Cr_2O_7^{-2} + 2k^+ + 2H_2O$

$Cr_2O_7^{-2}$ & H_2O are formed.

Sol 12: (A) Nitrogen does not have vacant d-orbitals.

Sol 13: (C) $PH_3 + 4Cl_2 \rightarrow PCl_5 + 3HCl$

Sol 14: (D) a) $S \rightarrow 1s^2 2s^2 2p^6 3s^2 3p^4$

S_2 = total 32 e^-

$$\sigma(2s)^2\ \sigma^*(2s)^2 \ldots\ldots\ldots \left[\pi(3p_x)^2\right]\left[x(3p_y)^2\right]$$

$$\left[\pi(3p_2)^2\right]\left[x^*(3p_x)^1\right]\left[\pi^*(3p_y)^1\right]$$

b) Vapour at 200 - S_8

c) Vapour at 600 - S_2

d) Oxidation state of S in S_2 is O.

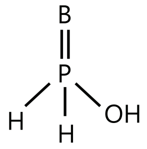
Sol 15: (B) HF > HCl > HBr > HI (Thermal stability).

Sol 16: (D) $Br_2 + NaOH(\text{not}) \rightarrow NaBr + NaBrO_4 + H_2O$

Sol 17: (A) $XeF_6 + H_2O \rightarrow XeO_3 + 6HF$

Reaction is not reversible.

Sol 18: (B)

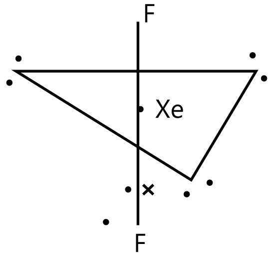


Sol 19: (D) Decrease in Electronegativity down the group causes decreases in bond angles.

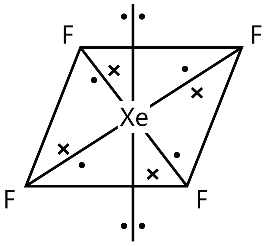
Sol 20: (D) $XeF_2 \rightarrow 3\ell p, 2BP$

$XeF_4 \rightarrow 2\ell p, 4BP$

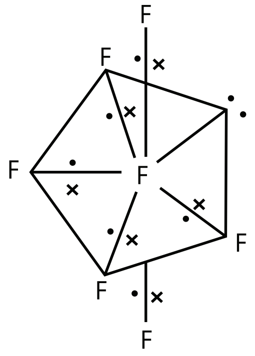
$XeF_6 \rightarrow 1\ell p, 6BP$



sp^3 hybridization



sp^3d^2 hybridization



sp^3d^2 hybridization

Sol 21: (C) Helium is twice as heavy as hydrogen, its lifting power is 92% of that of hydrogen. Helium has the lowest melting and boiling point of any element which makes liquid helium an ideal coolant for many extremely low temperature application such as super conducting magnet and cryogenic research where temperature close to absolute zero are needed.

Sol 22: (B) HCl is a gas.

Sol 23: (C) Factual.

Sol 24: (C) NO is paramagnetic in gaseous state and diamagnetic in solid state.

Sol 25: (A) $N_2 + O_2 \longrightarrow 2NO$

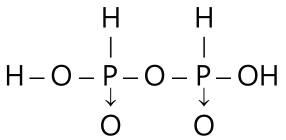
$\Delta G = \Delta H - T\Delta S$

ΔH & ΔS As are positive.

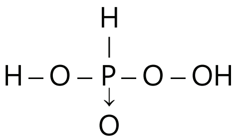
So reaction is thermodynamically favourable at high temperature.

Sol 26: (A) $O = \underset{\text{sp hybridisation}}{\overset{\oplus}{N}} = O$

Sol 27: (A) Phosphorus acid series contain phosphorus in the oxidation state (+ III).



Pyrophosphorus acid



orthophosphorus acid

JEE Advanced/Boards

Exercise 1

Sol 1: (i) $I_2 < F_2 < Br_2 < Cl_2$

(ii) HF < HCl < HBr < H –I

(iii) $BiH_3 < SbH_3 < AsH_3 < PH_3 < NH_3$

Sol 2: NeF_2 does not exist.

Sol 3: (i) $Ca_3P_2 + H_2O \rightarrow Ca(OH)_2 + PH_3$

(ii) $Cu^{2+}(aq) + \underset{\text{excess}}{NH_3(aq)} \rightarrow \underset{\substack{\text{Deep blue} \\ \text{complex ion}}}{Cu(NH_3)_4^{+2}}$

Sol 4: Reaction of Zinc and HCl produces nascent hydrogen which is more reactive than molecular hydrogen.

Sol 5: Aquaregia is a mixture of 1 part conc. HNO_3 and 3 part conc. HCl. The mixture liberate nascent chlorine which dissolves noble metals.

Sol 6: The impurity in PH_3 is P_2H_4, the liquid hydride present in phosphine catches fire as soon as it contact with air and forms vortex rings of smoke.

Sol 7: The chlorides, nitrates and sulphates are soluble while the sulfides are insoluble.

Sol 8: Mn_2O_7 is formed in the reaction between $KMnO_4$ and H_2SO_4. Mn_2O_7 is unstable and explosive in nature.

Sol 9: (i) Bleaching by SO_2 takes place du to reduction, since SO_2 liberates nascent hydrogen. The colours are restored by the oxidation of colourless substance by air.

$$SO_2 + 2H_2O \longrightarrow H_2SO_4 + 2[H]$$

$$\text{Colour} + 2[H] \underset{\text{Air}}{\rightleftharpoons} \text{Colourless}$$

On the other hand Cl_2 acts as bleaching agent due to oxidation and permanent.

$$Cl_2 + H_2O \longrightarrow 2HCl + [O]$$

(ii) Nitrite oxidizes iodide ion to iodine and thus liberated iodine gets dissolved in KI

solution to intensity its colour. On the other hand, sulphites are themselves oxidized by I_2 of solution and thus, reducing I_2 to discharge the colour of solution.

Sol 10: (i) $2Ag^+ + SO_3^{2-} \rightarrow Ag_2SO_3 \downarrow$

$$Ag_2SO_3 + SO_3^{2-}(\text{excess}) \rightarrow 2\left[Ag(SO_3)\right]^- (\text{soluble})$$

Sol 11: (i) Nitric acid in its pure form is colorless. The color changes to brownish-yellow due to the presence of nitrogen dioxide (NO_2). This nitrogen dioxide usually forms when bottles containing nitric acid reacts with oxygen in the air to form nitrogen dioxide which remains dissolved in the acid to give this particular colour.

(ii) N_2O is better source of oxygen than air because air has oxygen about 1/5 of its volume. While N_2O on decomposition produces oxygen about 1/3 volume.

Sol 12: (i) Yellow phosphorus is quite reactive in air and very unstable burns in air whereas Red Phosphorus is very stable and less reactive.

Sol 13: (i)

$$3H_3PO_2 = PH_3 + 2H_3PO_3;$$
$$4H_3PO_3 = PH_3 + 3H_3PO_4$$

(ii) $IO_3^- + 3HSO_3^- \rightarrow I^- + 3HSO_4^-$

(iii) $SO_2 + Cl_2 \rightarrow SO_2Cl_2$

(iv) $K_2Cr_2O_7 + 14\underset{\text{conc.}}{HCl} \rightarrow$

$$\underset{(aq.)}{2K^+} + \underset{(aq.)}{2Cr^{3+}} + \underset{(aq)}{8Cl^-} + 7H_2O(l) + 3Cl_2(g)$$

Sol 14: (i)

Bismuth oxide + HCl + excess water → ppt / turbidity

$$Bi^{3+}(aq.) + Cl^-(aq.) + 3H_2O(l) \rightleftharpoons \underset{(s)\,ppt}{BiOCl}\downarrow + 2H_3O^{\oplus}(aq).$$

(ii) $\underset{(aq.)}{KI} + \underset{(s)}{I_2} \rightarrow KI_3(aq.)$

Through this reaction, iodine is used in redox titrations.

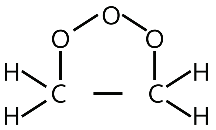
(iii) $4HI + \underset{(aq.)}{CuSO_4} \rightarrow \underset{\text{copper tetraiodate complex}}{CuI_4^{2-}}$

(iv) $2H_2S + \underset{(aq.)}{SO_2} \rightarrow 3S + 2H_2O$

Used in Calus's process.

Sol 15: (i) $CuSO_4 + KSCN \rightarrow CuSCN + K_2SO_4$

(ii) $O_3 + CH_2 = CH_2 \rightarrow$



(iii) $6NaOH + 4S \rightarrow Na_2S_2O_3 + Na_2S + Na_2SO_3$

Exercise 2

Single Correct Choice Type

Sol 1: (D) $I_2O_4 \longrightarrow IO^+ + IO_3^-$

Sol 2: (B)

$$\underset{\substack{\text{orange solid}\\(X)}}{4K_2Cr_2O_7} \rightarrow 4K_2CrO_4 + \underset{\substack{\text{green residue}\\(Z)}}{2Cr_2O_3} + 3O_2\uparrow$$

$$\xrightarrow{Mg} \underset{\text{White solid}}{MgO}$$

Sol 3: (A)

$$NH_4NO_3 \xrightarrow[523\,K]{A} \underset{(B)}{N_2O} + \underset{(C)}{2H_2O}(\text{Neutral to litmus paper})$$

$$\underset{(B)}{N_2O} \xrightarrow{\text{White phosphorous}} P_2O_5$$

Sol 4: (B) SiO_2 has tetrahedral network structure.

$$SiO_2 + 3C \longrightarrow 2CO + SiC$$

Sol 5: (A)

$$FeSO_4 \xrightarrow{\Delta} \overset{+4}{SO_2} + SO_3 + Fe_2O_3$$
$$\overset{+4}{SO_2} \xrightarrow{K_2Cr_2O_7} Cr^{+3}\left(\text{Green}\right)$$
$$SO_3 \longrightarrow S_3O_9$$
$$Fe_2O_3 \xrightarrow{HCl} FeCl_3$$

Sol 6: (A) $P_4 + 10NO \longrightarrow \underset{\text{Dehydrating agent}}{P_4O_{10}} + 5N_2$

Sol 7: (A) $\left(NH_4\right)_2 SO_4 \xrightarrow{\Delta} NH_3 + H_2O + SO_3$

Sol 8: (A) More the no.of oxygen atoms increase, acidic strength increases.

Sol 9: (C) $I_2 + 10HNO_3 \rightarrow 2HIO_3 + 10NO_2 + 4H_2O$

Sol 10: (B) $2HBr + H_2SO_4\left(\text{conc.}\right) \longrightarrow Br_2 + SO_2 + 2H_2O$

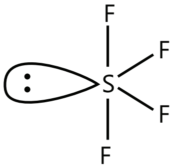
HBr gets oxidised to Br_2

Sol 11: (B)

$$\underset{\text{Malonic acid}}{HOOC - CH_2 - COOH} \xrightarrow[P_4O_{10}]{150^\circ C} \underset{\substack{\text{Carbon suboxide} \\ \text{Tricarbon dioxide}}}{O = C = C = C = O} + 2H_2O$$

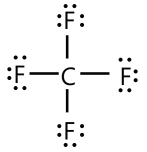
Sol 12: (D)

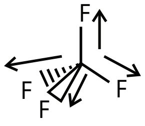
SF_4

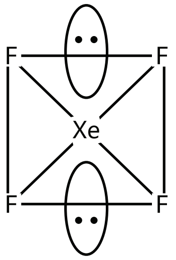


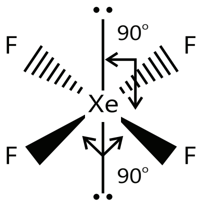
See-saw shape

CF_4









Sol 13: (B) When $AgNO_3$ is heated strongly it decomposes to give metallic silver.

$$2AgNO_3 \xrightarrow{\Delta} 2Ag + 2NO_2 + O_2$$

Sol 14: (D) $4HNO_3 + P_4O_{10} \longrightarrow 4HPO_3 + 2N_2O_5$

Sol 15: (A) Addition of Cis-1,2-diol converts boric acid into a strong complex, so as to prevent hydrolysis of complex & make it strong enough to be titrated with NaOH.

Comprehension Type

Sol 16: (B) $4O^-$ atoms with 1 Si atom So, SiO_4^{-4} $2O^-$ atoms are shared between 3 tetrahedral 3 Si atoms with 10 oxygen atoms $Si_3O_{10}^{-8}$.

Sol 17: (B) (B) will be the structure.

Sol 18: (C) Anion will be $Si_3O_{10}^{-8}$.

So compound will be $Ca_2\,Cu_2\,Si_3O_{10}.2H_2O$

Sol 19: (C) Due to greater solubility and nature to be prone to microbial action, nitrates are less abundant is earth's crust.

Sol 20: (C) NH_3 is better electron donor because the lone pair of electrons occupies sp^3-orbital and is more directional.

Sol 21: (B) White phosphorus on reaction with NaOH gives PH_3 as one of the product in disproportionation reaction.

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

Assertion Reasoning Type

Sol 22: (A) Reason is correct explanation of assertion. Coloured salts decompose to give. Coloured meta borates. So borax bead fast is applicable to coloured salt.

Sol 23: (C) H_2SO_4 is a stronger oxidizing agent than both Br_2 & I_2.

Sol 24: (A) Reason is correct explanation of Assertion. Bond energy of Si-O & Si-C are very high which make then inert.

Sol 25: (C)

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

Multiple Correct Choice Type

Sol 26: (A, B) Fact.

Sol 27: (A, B, C)

$$Al_2(SO_4)_3 + NH_4OH \longrightarrow Al(OH)_3 \downarrow$$

(a) White coloured

(b) Insoluble in NH_4OH

(c) Soluble in NaOH

Sol 28: (A, C, D) Stability of dihalides increase down the group.

Ability of forming $p\pi - p\pi$ multiple bonds decreases down the group.

They all form oxides (MO_2).

Sol 29: (A, B) NO_2 is paramagnetic, but N_2O_4 is diamagnetic.

NO_2 is brown and N_2O_4 is colourless.

Sol 30: (A, D) C – O bond energy is less than SiO bond energy.

Sol 31: (A, C) IF_3, IF_5, IF_7, BrCl

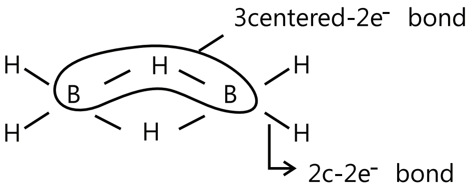
B is more Electronegative than A

FBr_3 does not exist.

There is no deviation in structure of ClF_3 and IF_7.

Sol 32: (A, B, C, D) Fact.

Sol 33: (B, C)



Match the Columns

Sol 34: A → q, s; B → r; C → r; D → q, r

A. $Bi^{3+} + H_2O \longrightarrow BiO^+ + 2H^+$ thus (q) and (s)

B. $AlO_2^- + H_3O^+ \longrightarrow Al(OH)_3 \downarrow$ thus (r)

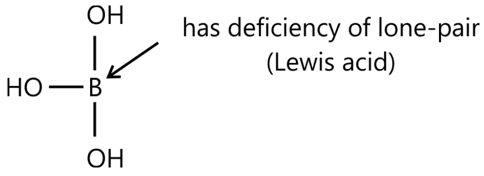
C. $2SiO_4^{4-} + 2H^+ \longrightarrow Si_2O_7^{6-}$ thus (r)

D. $B_4O_7^{2-} \xrightarrow{H^+} B(OH)_3$

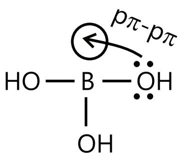
$B_4O_7^{2-} \xrightarrow{H_2O} B(OH)_3$. Thus, (q) are (r)

Previous Years' Questions

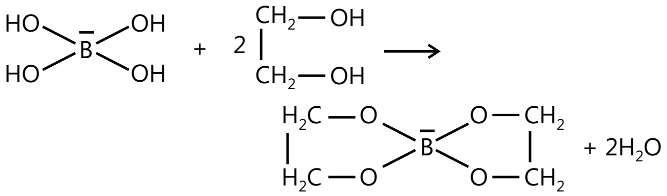
Sol 1: (A) Orthoboric acid is a weak, monobasic, Lewis acid.



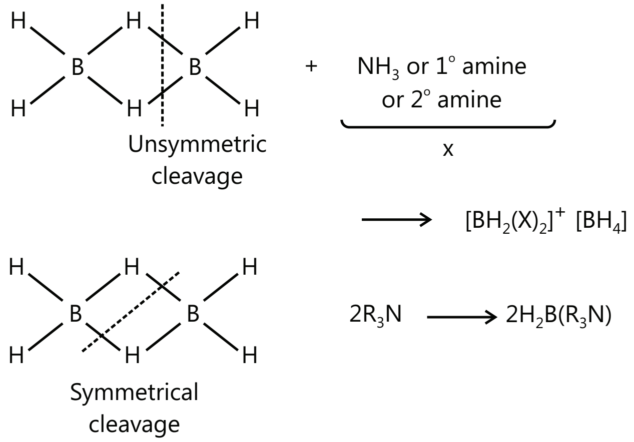
$p\pi$-$p\pi$ back-bonding between 'B' and 'O' decreases acid strength greatly:



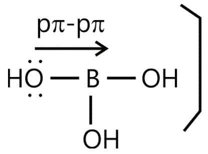
Sol 2: (A) Orthoboric acid is a very weak acid, direct neutralization does not complete. However, addition of cis-diol allow the reaction to go to completion by forming a stable complex with $[B(OH)_4]^-$ as:



Sol 3: (A, B, C) Diborane (B_2H_6) undergo unsymmetric cleavage with NH_3, primary and secondary amine while tertiary amine brings about symmetrical cleavage of B_2H_6 as:

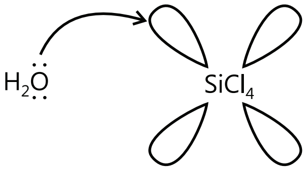


Sol 4: (C) Orthoboric acid is a weak, monobasic, Lewis acid and the poor acidic character is due to $p\pi$-$p\pi$ back bondings as



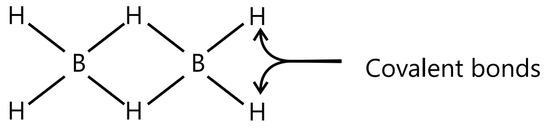
Back bonding decreases electron deficiency decreases electron its Lewis acid strength.

Sol 5: (C) $SiCl_4$ reacts with water due to vacant d-orbitals available with Si as:



No such vacant d-orbitals are available with carbon, hence CCl_4 does not react with water. Otherwise, both $SiCl_4$ and CCl_4 are covalent.

Sol 6: Three centred two electron bonds.



Three centred two electron bridged B—H—B bonds

Sol 7: (D) $Ba(N_3)_2 \xrightarrow{\text{Heat}} Ba(s) + 3N_2(g)$

Azide salt of barium can be obtained in purest form as well as the decomposition product contain solid Ba as by product along with gaseous nitrogen, hence no additional step of separation is required.

Other reactions are:

$$NH_4NO_3 \xrightarrow{\text{Heat}} N_2O + 2H_2O$$

$$2NH_3 + 3CuO \xrightarrow{\text{Heat}} 3Cu + 3H_2O + N_2$$

$$(NH_4)_2Cr_2O_7 \xrightarrow{\text{Heat}} Cr_2O_3 + 4H_2O + N_2$$

Sol 8: (B) In limited supply of oxygen, phosphorus is oxidized to its lower oxide P_4O_6 while excess of oxygen gives P_4O_{10} A mixture of O_2 and N_2 is used for controlled oxidation of phosphorus into $P_4O_{6.}$

Sol 9: (A) Amongst oxyacids of a given halogen, higher the oxidation number of halogen, stronger the acid. Hence,

$HOCl < HClO_2 < HClO_3 < HClO_4$.

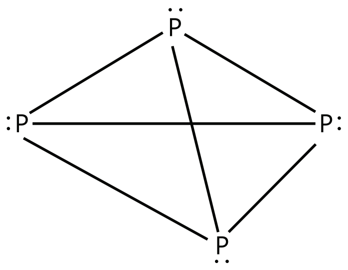
Sol 10: (A, D)

$$NH_4NO_3 \xrightarrow{\text{Heat}} N_2O + 2H_2O$$

$$NH_2OH.HCl + NaNO_2 \longrightarrow NaCl + 2H_2O + N_2O$$

However, NH_4NO_2 on heating gives N_2.

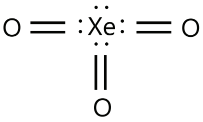
Sol 11: (A, C, D) The structure of P_4 is



It has six P-P single bonds. There are four lone pairs of electrons on four phosphorus. P-P-P bond angle are 60.

Sol 12: (A) Ar, being inert, provide inert atmosphere in arc welding, and prevent from undesired oxidation.

Sol 13: (C) Xe is sp^3 hybridised with one lone pair. Hence, molecule of XeO_3 has pyramidal shape.

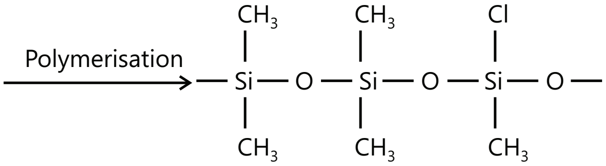


Sol 14: (A) Both XeF_4 and XeF_6 are strong oxidising agent.

Sol 15: (B) White phosphorus undergo disproportionation in alkaline medium.

$$P_4 + NaOH \longrightarrow PH_3 + NaH_2PO_2$$

Sol 16: A → p, s; B → p, q, r, t; C → p, q, t; D → p



Silicone

$$3XeF_4 + 6H_2O \rightarrow XeO_3 + 2Xe + 12HF + Cl\,\frac{3}{2}O_2$$

$$Cl_2 + H_2O \rightarrow HCl + HOCl \rightarrow HCl + \frac{1}{2}O_2$$

$$VCl_5 + H_2O \rightarrow VOVCl_3 + 2HCl$$

Sol 17: (B) $H_3PO_3\,[\,O = PH\,(\,OH)_2]$ is a dibasic acid.

Sol 18: (D) $PCl_5 + SO_2 \rightarrow POCl_3 + SOCl_2$

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

$$6PCl_5 + P_4O_{10} \rightarrow 10POCl_3$$

Sol 19: (D) $(NH_4)_2Cr_2O_7 \rightarrow N_2 + 4H_2O + Cr_2O_3$

$$NH_4NO_3 \rightarrow N_2O + H_2O$$

$$3CuO + 2NH_3 \rightarrow 3Cu + N_2 + 3H_2O$$

$$Ba(N_3)_2 \rightarrow 3N_2 + Ba \text{ (pure nitrogen)}$$

Sol 20: (C) P_4 (white) $+ NaOH + 3H_2O \rightarrow PH_3 + 3NaH_2PO_2$

PH_3 has -3 and NaH_2PO_3 has $+5$.

Sol 21: (A) Bleaching powder contains salt HCl

It is obtained by adding H_2O to Cl_2O

Sol 22: (B, C, D) Graphite is sp^2 hybridized and contains Vander Wall Force. While diamond is sp^3 hybridized.

Sol 23: (B) $HNO_3 \rightarrow +5$

$$NO \rightarrow +2, N_2 = 0$$

$$NH_4Cl \rightarrow -3$$

Sol 24: (B) $4HNO_3 \xrightarrow{\text{Sunlight}} 4NO_2 + 2H_2O + O_2$

Sol 25: (A, C, D) Exothermic.

Sol 26: (A) $SOCl_2 + P_4 \longrightarrow PCl_3 + SO_2 + S_2Cl_2$

Sol 27: (C) $XeF_6 + 3H_2O \rightarrow XeO_3 + 3H_2F_2$

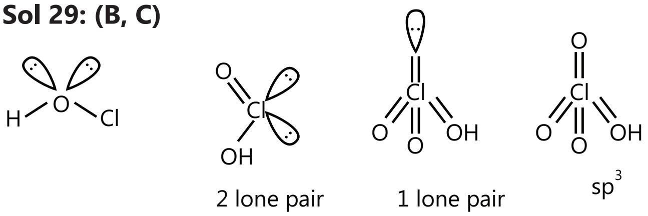
$$XeO_3 + OH^- \rightarrow HXeO_4^-$$

$$2HXeO_4^- + 2OH^- \rightarrow XeO_6^{-4} + Xe + 2H_2O + O_2$$

Sol 28: $B_2H_6 + 6MeOH \rightarrow 2B(OMe)_3 + 6H_2$

Diborane reacts with methanol to give hydrogen and trimethoxyborate ester.

Sol 29: (B, C)



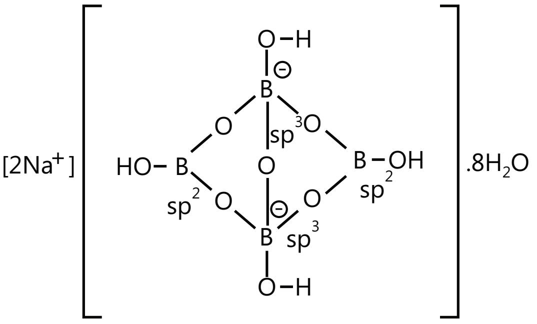
Sol 30: (D)

$$\underbrace{Cl-Be-Cl \quad \underset{N=N=N}{-1+1-1} \quad N\equiv N\rightarrow O \quad O=\overset{+}{N}=0}_{\text{Linear(sphybridisation)}}$$

Sol 31: (B) $Ga < Al < In < Tl$

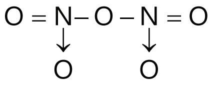
On moving down the group, atomic radii increases except Ga to poor screening effect.

Sol 32: (A, C, D)



Sol 33: (B, D) $4HNO_3 + P_4O_{10} \rightarrow 2N_2O_5 + 4HPO_3$

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



$O = \underset{\substack{\downarrow \\ O}}{N} - O - \underset{\substack{\downarrow \\ O}}{N} = O$ is diamagnetic

$$N_2O_5 + Na \longrightarrow NaNO_3 + NO_2\uparrow$$