07 Elements of groups 16, 17 and 18

Syllabus

+Q.1 Can you recall?

i. How does the valence shell electronic configuration of the elements vary in the p-block of periodic table ?

Ans: The general electronic configuration for the p-block elements is $ns^2\ np^{1-6}$. Hence the electronic configuration of p - block elements varies from $ns^2\ np^1$ to $ns^2\ np^6$.

ii. Name the first element of groups 16, 17 and 18.

Ans: The first element of group 16, 17 and 18 are oxygen (O), Fluorine (F) and Helium (He).

7.1 Introduction

Q.2 Explain : Which groups are present in the modern periodic table.

Ans:

i. The p-block elements the differentiating electron (the last filling electron) enters the p-orbital of the outermost shell.

ii. Since maximum of six electrons can be accommodated in a p-subshell it gives rise to groups 13 to 18, in the p-block.

7.2 Occurance

Q.3 Give the names of elements of group 16.

Ans: The elements oxygen ($_8$O), sulfur ($_{16}$S), selenium ($_{34}$Se), tellurium ($_{52}$Te) and polonium ($_{84}$Po) constitute Group 16, called the oxygen family.

Q.4 Why elements of group 16 are known as chalcogens.

Ans: Large number of metal ores are oxides or sulfides. Hence, group 16 elements are also called chalcogens or ore forming elements.

Q.5 Write a short note on occurance of group 16 elements.

Ans:

i. Oxygen is the most abundant of all the elements on earth. Oxygen forms 20.95 % by volume of air and about 46.6 % by mass of earth's crust.

ii. Sulfur forms 0.034% by mass of the earths crust. It occurs mainly in combined forms as sulfates such as gypsum ($CaSO_4.2H_2O$), epsom salt ($MgSO_4.7H_2O$), baryte ($BaSO_4$) and sulfides such as galena (PbS), zinc blende (ZnS), copper pyrites ($CuFeS_2$).

iii. Selenium and tellurium are also found as metal selenides and tellurides in sulfide ores.

iv. Polonium which is radioactive is a decay product of thorium and uranium.

Q.6 Name the elements of group 17 and why they are known as halogens?

Ans:

i. Fluorine ($_9$F), chlorine ($_{17}$Cl), bromine ($_{35}$Br), iodine ($_{53}$I) and astatine ($_{85}$At) constitute Group

17.

ii. These are collectively known as halogens (Greek halo means salt, gene means born), that is, salt producing element.

Q.7 Why do halogens occur in the form of compounds?

Ans:

i. Halogens are very reactive due to high electronegativities and hence they are not found in free sate.

ii. They occur in the form of compounds.

Q.8 Write a note on occurance of halogens.

Ans:

i. Fluorine occurs mainly as insoluble fluorides (fluorspar CaF_2, cryolite Na_3AlF_6, fluorapatite $3Ca_3(PO_4)_2.CaF_2$) and small quantities are present in soil, fresh water plants, and bones and teeth of animals.

ii. Sea water contains chlorides, bromides and iodides of Na, K, Mg and Ca. However it mainly contains NaCl (2.5 % by mass).

iii. The deposits of dried up sea beds contain sodium chloride and carnallite, $KCl.MgCl_2.6H_2O$.

iv. Marine life also contains iodine in their systems. For example, sea weed contains upto 0.5 % iodine and chile saltpetre contains upto 0.2 % of sodium iodate.

v. Astatine, the last member of halogen family is radioactive and has a half life of 8.1 hours.

Q.9 Name the elements of group 18.

Ans: The elements helium ($_2$He), neon ($_{10}$Ne), argon ($_{18}$Ar), krypton ($_{36}$Kr), xenon ($_{54}$Xe) and radon ($_{86}$Rn) constitute the Group 18.

Q.10 Write a note on the occurance of gruop 18.

Ans:

i. All the noble gases except radon occur in the atmosphere. Their abundance in dry air is a ~1% (by volume) with argon as the major constituent.

ii. The main commercial source of helium is natural gas.

iii. Helium and neon are found in minerals of radioactive origin e.g. pitchblende, monazite, cleveite.

iv. Xenon and radon are the rarest elements of the group. Radon is a decay product of ^{226}Ra.

7.3 Electronic configuration of elements of group 16, 17, and 18

Q.11 Give the general electronic configuration of group 16, 17 and 18.

Ans: :

i. The general electronic configuration of the group 16 elements is ns^2np^4 while that of group 17 elements is $ns^2\ np^5$.

ii. The group 18 elements are shown by $ns^2\ np^6$configuration.

Q.12 Give the condensed electronic configuration of group 16, 17 and 18.

Ans:

Group 16 (Oxygen family)		Group 17 (Halogen family)		Group 18 (Noble gases)	
Element	**Condensed Electronic Configuration**	**Element**	**Condensed Electronic Configuration**	**Element**	**Condensed Electronic Configuration**
				$_2$He	$1s^2$
$_8$O	$[He]2s^22p^4$	$_9$F	$[He]2s^22p^5$	$_{10}$Ne	$[He]2s^22p^6$
$_{16}$S	$[Ne]3s^23p^4$	$_{17}$Cl	$[Ne]3s^23p^5$	$_{18}$Ar	$[Ne]3s^23p^6$
$_{34}$Se	$[Ar]3d^{10}4s^24p^4$	$_{35}$Br	$[Ar]3d^{10}4s^24p^5$	$_{36}$Kr	$[Ar]3d^{10}4s^24p^6$
$_{52}$Te	$[Kr]4d^{10}5s^25p^4$	$_{53}$I	$[Kr]4d^{10}5s^25p^5$	$_{54}$Xe	$[Kr]4d^{10}5s^25p^6$
$_{84}$Po	$[Xe]4f^{14}5d^{10}6s^26p^4$	$_{85}$At	$[Xe]4f^{14}5d^{10}6s^26p^5$	$_{86}$Rn	$[Xe]4f^{14}5d^{10}6s^26p^6$

The elements of groups 16 and 17 repectively have two and one electrons less than the stable electronic configuration of the nearest noble gas.

7.4 Atomic and physical properties of elements of group 16, 17 and 18

Q.13 Explain the trends in atomic and ionic radii of group 16 and 17.

Ans:

i. In group 16 and 17 and atomic and ionic radii increase down the group, as a result of increase in the number of quantum shells.

ii. Across a period atomic or ionic radii decrease with increasing atomic number, consequent to increase in (Z_{eff}) effective nuclear charge.

iii. Group 17 elements (Halogens) have the smallest atomic radii in their respective periods.

+Q.14 Elements of group 16 generally show lower values of first ionisation enthalpy compared to the elements of corresponding period of group 15. Why ?

Ans:

i. Group 15 elements have extra stable, half filled p-orbitals with electronic configuration (ns^2np^3).

ii. Therefore more amount of energy is required to remove an electron compared to that of the partially filled orbitals (ns^2np^4) of group 16 elements of the corresponding period.

Q.15 Explain the trend in following atomic properties of group 16 elements.
i. Atomic radii ii. Ionization enthalpy iii. Electronegativity

Ans:

i. **Atomic radii :**
Atomic radii increases down the group as a result of increase in the number of quantum shells.

ii. **Ionization enthalpy :**
Ionization enthalpy decreses down the group due to increase in atomic size.

iii. **Electronegativity:**
The electronegativity decreases down the group due to increase in atomic size.

Element	Atomic number	Atomic mass g/ mol	Atomic radius (pm)	Ionic radius E^{2-} (pm)	Ionization enthalpy (Δ_iH_1) kJ/mol	Electro-negativity	Electron gain enghalpy kJ/mol	Density g/cm^3	M.P. (K)	B.P. (K)
O	8	16.00	66	140	1314	3.5	-141	1.32	55	90
S	16	32.06	104	184	1000	2.44	-200	2.06	393	718
Se	34	78.96	117	198	941	2.48	-195	4.19	490	958
Te	52	127.60	137	221	869	2.01	-190	6.25	725	1260
Po	84	210.00	146	230	813	1.76	-174	-	520	1235

Atomic and physical properties of group 16 elements.

Q.16 Write a short note on the ionization enthalpy of group 16, 17 and 18.

Ans:

i. The group 16, 17 and 18 elements have high ionization enthalpy. The ionisation enthalpy decreases down the group due to increase in the atomic size.

ii. Across a period ionization enthalpy increases with increase of atomic number. This is due to addition of electrons in the same shell.

iii. However the elements of group 16 have lower ionization enthalpy values compared to those of group 15

in the corresponding periods, owing to extra stable half filled electronic configuration of p-orbitals in elements of group 15.

Try this

+Q.17 Observe the above table and explain the trend in following atomic properties of group 17 elements

i. Atomic size
ii. Ionisation enthalpy
iii. Electronegativity
ii. Electron gain enghalpy

Ans:

i. **Atomic size:** In group 17, atomic size increase down the group, as a result of increase in the number
quantum shells.

ii. **Ionisation enthalpy:** In group 17, the ionisation enthalpy decreases down the group due to uncrease
in atomic size.

iii. **Electronegativity:** In group 17, the electronegativity decreases down the group.

iv. **Electron gain enthalpy:** In group 17, electron gain enthalpy becomes less negative down the group.

+Q.18 Oxygen has less nagative electron gain enhalpy than sulfur. Why?

Ans: Oxygen has less negative electron gain enthalpy than sulfur due to its small atomic size.

Q.19 Write a short note on electronegaivity of group 16, 17 and 18.

Ans:

i. In a group (16, 17 and 18) the electronegativity decreases down the group.

ii. Oxygen has the highest electronegativity next to fluorine amongst all the elements.

iii. Halogens have very high electronegativity. Fluorine is the most electronegative element in the periodic table.

Q.20 Write a short note on electron gain enthalpy of group 16, 17 and 18.

Ans:

i. In the groups 16 and 17 electron gain enthalpy becomes less negative down the group.

ii. However in group 16, oxygen has less negative electron gain enthalpy than sulfur due to its small atomic size.

iii. In group 17, fluorine has less negative electron gain enthalpy than that of chlorine. This is due to small size of fluorine atom.

iv. Group 18 elements (noble gases) have no tendency to accept electrons because of their stable electronic configuration (ns^2np^6) and thus have large positive electron gain enthalpy.

+Q.21 Fluorine has less negative electron gain affinity than chlorine. Why ?

Ans:

i. The size of fluorine atom is smaller than chlorine atom. As a result, there are strong inter electronic repulsions in the relatively small 2p orbitals of fluorine and therefore, the incoming electron does not experience much attraction.

ii. Thus fluorine has less negative electron gain affinity than chlorine.

+Q.22 The values of first ionisation enthalpy of S and Cl are 1000 and 1256 kJ mol^{-1}, respectively. Explain the observed trend.

Ans: The elements S and Cl belong to second period of the periodic table.Across a period effective nuclear charge increases and atomic size decreases with increase in atomic number.Therefore the energy required for the removal of electron from the valence shell, I.E. increases in the order S < Cl.

★ Q.23 The first ionization enthalpies of S, Cl and Ar are 1000, 1256 and 1520 kJ/mol, respectively. Explain the observed trend.

Ans:

i. The elements S, Cl and Ar belongs to third period of the periodic table.

ii. As we move left to right across the period the atomic size decreases and effective nuclear charge increases with the increase in atomic number.

iii. Therefore, the energy required for the removal

of electron from the valence shell (Ionization enthalpy) increases in the order: S < Cl < Ar.

Q.24 Write a short note on physical properties of group 16.

Ans:

i. Oxygen is a gas while other elements are solids at room temperature.

ii. Oxygen and sulfur are nonmetals, selenium and tellurium are metalloids, while polonium is a metal.

iii. Polonium is radioactive with its half life of 13.8 days.

iv. Melting and boiling points increase with increasing atomic number.

v. All the elements of group 16 exhibit allotropy.

+Q.25 Why is there a large difference between the melting and boiling points of oxygen and sulfur?

Ans: Oxygen exists as diatomic molecule (O_2) where as sulfur exists as polyatomic molecule (S_8). The van der Waals forces of attraction between O_2 molecules are relatively weak owing to its much smaller size.

The large van der Waals attractive forces in the S_8 molecules can be noticed because of large molecular size. Therefore oxygen has low m.p. and b.p. as compared to sulfur.

Q.26 Write a short note on physical properties of group 17 elements.

Ans:

i. Fluorine, chlorine are gases, bromine is a liquid and iodine is a solid at room temperature.

ii. F_2 is yellow, Cl_2 greenish yellow, Br_2 red and I_2 is violet, in colour.

iii. Fluorine and chlorine react with water.

iv. Bromine and iodine are only sparingly soluble in water and are soluble in various organic solvents such as chloroform, carbon disulfide, carbon tetrachloride, hydrocarbons which give coloured solutions.

Q.27 State the order of bond dissociation enthalpies of halogen molecules.

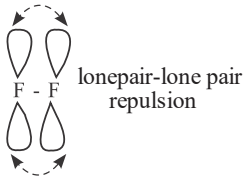
Ans: Bond dissociation enthalpies of halogen molecules follow the order :

Cl – Cl > Br – Br > F – F > I – I.

+Q.28 Bond dissociation enthalpy of F_2 (158.8 KJ mol^{-1}) is lower than that of Cl_2 (242.6 KJ mol^{-1}) Why ?

Ans:

Fluorine has small atomic size than chlorine. The lone pairs on each F atoms in F_2 molecule are so close together that they strongly repel each other, and make the F – F bond weak. Thus it requires less amount of energy to break the F – F bond. In Cl_2 molecule the lone pairs on each Cl atom are at a larger distance and the repulsion is negligible. Thus Cl – Cl bond is comparitively stronger. Therefore bond dissociation enthalpy of F_2 is lower than that of Cl_2.



Q.29 Write a note on physical properties of noble gases.

Ans:

i. Noble gases are monoatomic.

ii. They are sparingly soluble in water.

iii. Noble gases have very low melting and boiling points. Helium has the lowest boiling point (4.2 K) of any known substances.

+Q.30 Noble gases have very low melting and boiling points. Why ?

Ans:

Noble gases are monoatomic, the only type of inter atomic interactions which exist between them are van der Waals forces. Therefore, they can be liquified at very low temperatures and have very low melting or boiling points.

+Q.31 Can you tell?

The first member of a group usually differs in properties from the rest of the members of the group. why?

Ans:

i. The first member of each group 1, 2 and 13-17 exhibit different properties as compared to that of the subsequent members in the group due to their small size. Large charge to radius

ratio and high electronegativity.

ii. The other members of the group can exceed their valency than four.

7.5 Anomalous Behaviour

Q.32 Give the anomalous behaviour of oxygen.

Ans:

Oxygen shows the following anomalous properties compared to other members of group 16 :

i. **Atomicity :**
Oxygen is a diatomic molecule (O_2) while others are polyatomic molecules. For example P_4, S_8.

ii. **Magnetic property :**
Oxygen is paramagnetic while others are diamagnetic.

iii. **Oxidation state :**
Oxygen shows -2, -1, and +2 oxidation states while other elements show, -2, +2, +4, +6 oxidation states. Oxygen can not exhibit higher oxidation state due to absence of vacant d orbitals

iv. **Nature of hydrides :**
Hydride of oxygen (H_2O) is liquid at room temperature while hydrides of other members of the group are gases.

v. Common covalency of oxygen is 2. In rare cases it is four. But for the other members of the group 16 the covalency can exceed four.

Q.33 Why oxygen shows anomalous properties compared to other members of group 16 ?

Ans: The anomalous behaviour of oxygen is due to the following reasons.

i. small atomic size

ii. high electronegativity.

iii. absence of inner d-orbitals.

+Q.34 Use your brain power
Oxygen forms only OF_2 with fluorine while fluorine while sulfur forms SF_6. Explain. Why?

Ans:

i. Oxygen can show oxidation state of – 2, –1 and +2. While other elements in the group shows –2, +2, +4 and +6 oxidation state.

ii. Oxygen cannot show higher oxidation state due to absence of vacant d-orbitals.

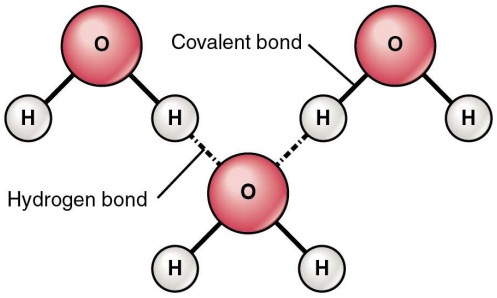
iii. Hence, oxygen forms only OF_2 with fluorine while sulfur forms SF_6.

+Q.35 Use your brain power.
Which of the following possess hydrogen bonding ? H_2S, H_2O, H_2Se, H_2Te.
Show hydrogen bonding in the above molecule with the help of a diagram.

Ans:

i. H_2O possesses hydrogen bonding.

ii. Hydrogen bonding in water (H_2O) is as shown in the diagram below.



Q.36 Give the anomalous behaviour of fluorine.

Ans:

i. Ionisation enthalpy, electronegativity, electrode potential are all higher for fluorine than expected trends shown by other halogens.

ii. Ionic and covalent radii, m.p., b.p. and electron gain enthalpy are quite lower than expected.

iii. Most of the reactions of fluorine are exothermic (due to the short and strong bond formed by it with other elements)

iv. It forms only one oxoacid (HOF) while other halogens form a number of oxoacids.

v. Hydrogen fluoride is a liquid (b.p. 293K) due to strong hydrogen bonding while other hydrogen halides are gases.

Q.37 Why fluorine shows anomalous properties compared to other members of group 17.

Ans:

Fluorine, the first member of group 17, differs in properties from the other members of the group. The anomalous behaviour of fluorine is due to the following reasons:

i. small atomic size

ii. high electronegativity
iii. absence of d-orbitals in valence shell
iv. low F-F bond dissociation enthalpy

7.6 Chemical properties of elements of group 16, 17 and 18

Q.38 Explain in brief : The oxidation states of the elements of groups 16.

Ans:

i. The group 16 elements have the valence shell electronic configuration ns^2np^4.
ii. They attain a noble gas configuration either by gaining two electrons, forming E^{2-} ions or by sharing two electrons, forming two covalent bonds.
iii. These elements, thus, show –2 and +2 oxidation states in their compounds.
iv. Oxygen being highly electronegative, shows common oxidation state of –2 except two cases.
v. In the case of OF_2, its oxidation state is +2 and in peroxides, it shows oxidation state –1 (H_2O_2, Na_2O_2).
vi. Other elements of the group exhibit +2, +4, +6 oxidation states with +4 and +6 being more common.
vii. The stability of higher (+6) oxidation state decreases down the group while the stability of the lower oxidation state (+4) increases down the group due to inert pair effect.
viii. Bonding in +4 and +6 oxidation states are primarily covalent.

Q.39 Write a short note on oxidation states of elements in group 17.

Ans:

i. The group 17 elements are represented by their valence shell electronic configuration as ns^2np^5.
ii. They attain noble gas configuration either by gaining one electron forming Eions or by sharing one electron forming one covalent bond.
iii. All halogens exhibit –1 oxidation state. However Cl, Br and I exhibit +1, +3, +5 and +7 oxidation states as well.
iv. This is because they are less electronegative than F and possess empty d-orbitals in the valence shell and therefore, can expand the octet.
v. The oxidation states +4 and +6 occur in the oxides and oxoacids of Cl and Br.
vi. The fluorine atom has no d - orbitals in its valence shell and therefore cannot expand its octet.
vii. Thus fluorine being most electronegative exhibits mostly -1 oxidation state.

★ Q.40 Fluorine a short note on oxidation states of elements in group 17.

Ans:

i. Fluorine element have no vacant d-orbital to expand its octet. Thus fluorine is the most electronegative element exhibiting only -1 oxid iation state.
ii. Cl, Br and I exhibit +1, +3, +5 and +7 oxidation state as well. This is becuase they are less electronegative than F and possess empty d-orbitals in the valence shell and therefore can expand the octet.

+Q.41 Try this

Complete the following tables

Element	O	O	S	F
compound	H_2O	OF	H_2S	HF
Oxidation state	-2	.....	.....	.....
Element	Se	Se	Te	Cl
compound	SeO_2	SeO_3	TeF_6	HOCl
Oxidation state	.....	+6	.....	.....

Ans:

Element	O	O	S	F
compound	H_2O	OF	H_2S	HF
Oxidation state	-2	+2	-2	–1
Element	Se	Se	Te	Cl
compound	SeO_2	SeO_3	TeF_6	HOCl
Oxidation state	+4	+6	+6	+1

Q.42 Explain why noble gases exist as monoatomic gases.

Ans:

i. Group 18 elements (noble gases) have stable valence shell electronic configuration ns^2np^6 with completely filled orbitals.
ii. Thus they have no tendency to gain or lose electrons, that is, they are zero valent and

mostly exist as monoatomic gases.

Q.43 How xenon forms compounds and show higher oxidation state.

Ans:

i. Xenon has large atomic size and lower ionisation enthalpy compared to He, Ne, Ar and Kr.

ii. Hence xenon exhibits higher oxidation states.

iii. Its outermost shell has d-orbitals. The paired electrons of the valence shell can be unpaired and promoted to empty d-orbitals.

iv. The unpaired electrons are shared with fluorine or oxygen atoms and covalent compounds showing higher oxidation state such as XeF_2(+2), XeF_4 (+4), XeF_6(+6), XeO_3(+6) and $XeOF_4$(+6) are formed.

★ **Q.44 What is the oxidation state of xenon in the following compounds? $XeOF_4$, XeO_3, XeF_6, XeF_4, XeF_2.**

Ans:

Compound	Oxidation state of xenon
$XeOF_4$	+6
XeO_3	+6
XeF_6	+6
XeF_4	+4
XeF_2	+2

Q.45 Write a short note on the reactivity of group 16 elements towards hydrogen.

Ans:

i. The elements of group 16 react with hydrogen to form hydrides of the type H_2E. (Where E = O, S, Se, Te, Po).

ii. For example, H_2O, H_2S, H_2Se, H_2Te and H_2Po.

iii. Some properties of hydrides of group 16: H_2O is a colourless, odourless liquid, while H_2S, H_2Se, H_2Te and H_2Po are colourless bad smelling, poisonous gases at ambient conditions.

iv. All hydrides have angular structures which involve sp^3 hybridisation of central atom (E).

★ **Q.46 Acidic Character of hydrides of group 16 elements increases from H_2O to H_2Te. Explain.**

Ans: As we move down the bond dissociation enthalpy of H – E bond decreases. Hence the acidic character of the hydrides increases from H_2O to H_2Te.

★ **Q.47 Write the order of the thermal stability of the hydrides of group 16 elements**

Ans: The decreasing order of thermal stability : $H_2O > H_2S > H_2Se > H_2Te$.

Q.48 Write a short note on reactivity of group 17 elements towards hydrogen.

Ans:

i. The elements of group 17 react with hydrogen to give hydrogen halides.
$H_2 + X_2 \rightarrow 2HX$
(Where X = F, Cl, Br, I)

ii. Acidic strength of halogen acids increases in the order : HF < HCl < HBr < HI

iii. It is due to decreasing bond dissociation enthalpy of H-X bond in the order
HF > HCl > HBr > HI.

iv. Thermal stability of hydrogen halides decreases in the order HF > HC l> HBr > HI. It is due to decrease in bond dissociation enthalpy of H-X bond down the group.

Property	HF	HCl	HBr	HI
m.p (K)	190	159	185	222
b.p (K)	293	189	206	238
Bond length (H-X) pm	91.7	127.4	141.4	160.9
$\Delta_{diss} H^0$ kJ/mol	574	432	363	295
pKa	3.2	-7.0	-9.5	-10.0

Properties of hydrides of group 17 elements.

★ **Q.49 The pKa value of HCl is – 7.0 and that of HI is – 10.0. Which is the stronger acid?**

Ans: Smaller is the pKa value. Greater is the acidity. Therefore HI is stronger acid than HCl.

Q.50 Write a short note on the oxides of group 16 elements.

Ans:

i. All the elements of group 16 form oxides of the type EO_2 and EO_3 where E = S, Se, Te, Po.

ii. EO_2 type oxides, Ozone (O_3) and sulfur dioxide (SO_2) are gases, while selenium dioxide (SeO_2) is solid.

iii. They are acidic in nature and react with water to form acids.

$SO_2 + H_2O \rightarrow H_2SO_3$ (sulfurous acid)

$SeO_2 + H_2O \rightarrow H_2SeO_3$ (Selenious acid)

iv. Reducing property of dioxides decreases from SO_2 to TeO_2. SO_2 is reducing while TeO_2 serves as an oxidising agent.

v. EO_3 type oxides, SO_3, SeO_3, TeO_3 are also acidic in nature. They dissolve in water to form acids.

$SeO_3 + H_2O \rightarrow H_2SeO_4$ (Selenic acid)

$TeO_3 + 3H_2O \rightarrow H_6TeO_6$ (Telluric acid)

★ Q.51 What is the oxidation state of Te in TeO_3?

Ans: Since the net charge of TeO_3 is 0.
(Oxidation state of Te) +
Oxidation state of O) = 0
(Oxidation state of Te) + 3 × (–2) = 0
Oxidation state of Te – 6 = 0
Oxidation state of Te = +6.

Q.52 Write a short notes on oxides of group 17 elements.

Ans:

i. Elements of group 17 (Halogens) form many oxides with oxygen, but most of them are unstable.

ii. Fluorine forms two oxides $OF_2$and O_2F_2 However, only the OF_2 is thermally stable at 298 K.

iii. Both are strong fluorinating agents. O_2F_2 oxidises plutonium to PuF_6 and the reaction is used in removing plutonium as PuF_6 from spent nuclear fuel.

iv. Chlorine oxides, Cl_2O, ClO_2, Cl_2O_6 and Cl_2O_7 are highly reactive oxidising agents and tend to explode.

v. ClO_2 is used as bleaching agent for paper pulp and textiles and in water treatment.

vi. Bromine oxides, Br_2O, BrO_2, BrO_3 are the least stable halogen oxides (middle row anomally). They are very powerful oxidising agents.

vii. Iodine oxides, I_2O_4, I_2O_5 and $I_2O_7$are insoluble solids and decompose on heating. I_2O_5 is a very good oxidising agent and used for the estimation of carbon monoxide.

viii. The higher oxides of halogens are more stable than the lower ones.

★ Q.53 Give two uses of ClO_2.

Ans: ClO_2 is used as bleaching agent for paper pulp and textiles and in water treatment.

Note-

Noble gas elements are chemically inert and do not directly react with oxygen.

Q.54 Write a short note on reactivity of group 16 elements towards halogens.

Ans:

i. Elements of group 16 react with halogens to give a large number of halides of the types EX_6 , EX_4 and EX_2.
(Where E = S, Se, Te)

ii. Hexahalides, SF_6, SeF_6 and TeF_6 are formed by direct combination. They are colourless gases. They have sp^3d^2 hybridisation and possess octahedral structure.

iii. SF_6 is exceptionally stable halide for steric reasons.

iv. Stability of halides decreases in the order fluorides > chlorides > bromides > iodides

v. Tetrahalides, SF_4, SeF_4, TeF_4, $TeCl_4$ have sp^3 hybridisation and thus trigonal bipyramidal geometry with one equatorial position occupied by a lone pair.

vi. Dihalides, SCl_2, $SeCl_2$, $TeCl_2$ have sp^3 hybridisation and thus possess tetrahedral structure with two equatorial positions occupied by lone pairs.

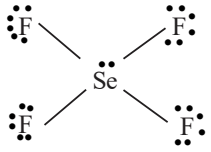
vii. Monohalides are dimeric in nature. For example, S_2F_2, S_2Cl_2, Se_2Cl_2 and $SeBr_2$.

viii. These dimeric halides undergo disproportionation.

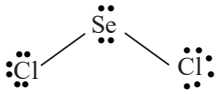
$2\ Se_2Cl_2 \rightarrow SeCl_4 + 3Se$

+Q.55 Internet my friend
Find and draw the structures of SeF_4 and SCl_2.

Ans:



SeF_4 structure



Q.56 Explain intrhalogen componds.

Ans:

i. Halogens (Group 17 elements) combine amongst themselves to form a number of compounds known as interhalogen compounds.

ii. These are of following types : XX', XX'_3, XX'_5, XX'_7, where X is the halogen atom with larger size and X', is the halogen atom with smaller size.

Q.57 Explain reactivity of group 18 elements towards halogen.

Ans:

i. Group 18 elements (Noble gases) are chemically inert. Krypton and xenon, however react directly with fluorine to give their fluorides.

ii. For example,

$$Xe_{(g)} + F_{2(g)} \xrightarrow[1atm]{673K} XeF_{2(s)}$$

iii. Xenon fluorides XeF_2, XeF_4 and XeF_6 are crystalline and colourless which sublime readily at 298 K.

iv. They are powerful fluorinating agents.

Q.58 Explain reactivity of group 16 and 17 towards metals.

Ans:

i. Group 16 elements:

a. Elements of group 16 react with metals to form corresponding compounds.

b. For example,

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

$$Cu + S \rightarrow CuS$$

$$Mg + Se \rightarrow MgSe$$

magnesium selenide

ii. Group 17 elements :

a. Elements of group 17 (Halogens) react with metals instantly to give metal halides.

b. For example,

$$2Na_{(s)} + Cl_{2(l)} \rightarrow 2NaCl_{(s)}$$

$$Mg_{(s)} + Br_{(l)} \rightarrow MgBr_{2\,(s)}$$

magnesium bromide

c. Ionic character of halides decreases in the order MF > MCl > MBr > MI, where M is a monovalent metal.

d. The metal halides having metals in their higher oxidation states are more covalent than the ones having metals in lower oxidation state.

e. For example, $SnCl_4$, $PbCl_4$, $SbCl_5$ and UF_6 are more covalent than $SnCl_2$, $PbCl_2$, $SbCl_3$ and UF_4 respectively.

Do you know:

Tellurium has the unusal property of combining with gold metal to form telluride

$$2Au + 3Te \rightarrow Au_2Te_3$$

gold telluride

Note-

Noble gases do not directly react with metals.

★Q.59 What is the action of bromine on magnesium metal?

Ans: Bomine reacts with magnesium to form magnesium bromide.

$$\underset{\text{Magnesium}}{Mg_{(s)}} + \underset{\text{Bromine}}{Br_2} \rightarrow \underset{\text{Magnesium bromide}}{MgBr_2}$$

7.7 Allotropy

+Q.60 Can you tell?

i. What is allotropy?

Ans: A phenomenon in which an element exists in different crystallilne forms with different physical properties, the phenomenon is called allotropy.

ii. What is the difference between allotropy and polymorphism?

Ans:

i. Polymorphism means single substance exhibiting two or more crystalline structures.

ii. Polymorphism can be found in compound. While allotropy occures in elements only.

Q.61 Name the allotropes of group 16 elements.

Ans:

i. Tellurium exists in two allotropic forms (i) crystalline and (ii) amorphous.

ii. Polonium reveals two allotropic forms α and β (both metallic).

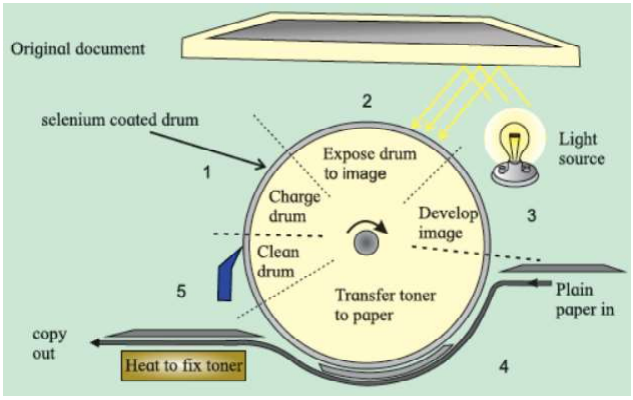
iii. Allotropes of Selenium: Red and grey selenium

Q.62 Explain photocopying process.

Ans:

i. Grey selenium allotrope of is a photoconductor used in photocells.

ii. The photocopying process. A selenium-coated rotating drum is given a uniform positive charge (step 1) and is then exposed to an image (step 2). Negatively charged toner particles are attracted to the charged area of the drum (step 3) and the image is transferred from the drum to a sheet of paper (step 4). Heating the fixes the image and the drum is flooded with light and cleaned to ready the machine for another cycle (step 5). Figure of photocopying process using Se is as shown below:



+Q.63 Which form of sulfur shows paramagnetic behaviour ?

Ans:

In vapour state, sulfur partly exists as S_2 molecule, which has two unpaired electrons in the antibonding π^* orbitals like O_2. Hence it exhibits paramagnetism.

★Q.64 Distnguish between rhombic sulfur and monoclinic sulfur.

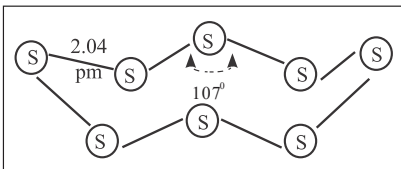
Ans:

	Rohmbic Sulfur (α-Sulfur)	Monoclinic Sulfur (β-Sulfur)
Colour	Pale Yellow	Bright yellow solid
Shape	Orthorhombic crystals	Needle shaped monoclinic crystals
M. P.	385.8 K	393 K
Density	2.069 /cm^3	1.989 / cm^3
Solubilit	Insoluble in water and soluble in CS_2	Soluble in CS_2
Stability	Stable below 369 K and transforms to β-Sulphur above this temperature	Stable above 369K and transforms into α-Sulphur below this temperature.
Structure	S_8 molecules having puckered ring structure	S_8 molecules with puckered ring structure
Method of preparation	It is prepared by evaporation of roll sulphur in CS_2.	Rhomic sulphur melted in a dish and cooled till crust is formed. Two holes are made in the crust and remaining liquid is poured out to give needle shaped crystals of β- Sulphur

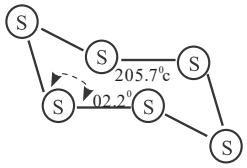
Q.65 Explain the structure of S_8 and S_6 molecules.

Ans:

Several modifications of sulfur containing 6-20 sulfur atoms per ring, have been synsthesised. In the S_8 molecule the ring is puckered and has a crown shape. In cyclo – S_6, the ring adopts the chair form. At elevated temperature (~ 1000 K), S_2 is the dominant species which like O_2 is paramagnetic.



Structure of S_8 ring in rhombic sulfur



Chair form of S_6

7.8 Oxoacids

Q.66 Give the oxoacids of sulfur.

Ans:

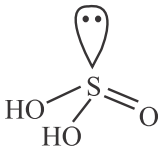
i. Sulfur forms a number of oxoacids.

ii. Some of them are unstable and cannot be isolated.

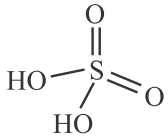
iii. They are known to exist in aqueous solutions or in the form of their salts.

iv. Some important oxoacids of sulfur and their structures are given below.

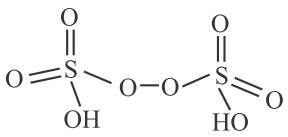
v. Sulfurous acid, H_2SO_3



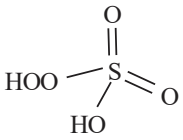
vi. Sulfuric acid, H_2SO_4



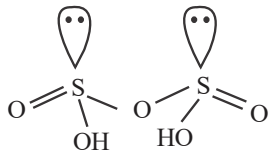
vii. Di or pyrosulfuric acid, $H_2S_2O_7$



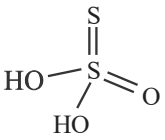
viii. Peroxy monosulfuric acid, H_2SO_5



ix. Peroxy disulfuric acid, $H_2S_2O_8$



x. Thisulfuric acid, $H_2S_2O_3$



★ Q.67 What is the oxidation state of 'S' in H_2SO_4

Ans:

2(oxidation number of H) + (Oxidation number of S) + 4 (Oxidation number of O) = 0

$2 \times (+1)$ + (oxidation number of S) $+ 4(-2) = 0$

2 + (oxidation number S) – 8 = 0

(Oxidation number of S) – 6 = 0

Oxidation number of S = +6.

Q.68 Name the four oxoacids that have been isolated in pure form.

Ans:

i. hypofluorous acid (HOF),

ii. perchloric acid ($HClO_4$),

iii. iodic acid (HIO_3),

iv. metaperiodic acid (H_2IO_6).

Q.69 Give reason : HClO is a weak acid whereas $HClO_4$ is a very strong acid.

Ans:

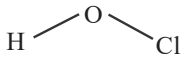
i. The acid strength of the halogen oxoacids increases with the increasing oxidation state of halogen.

ii. For example, acid strength increases from HClO, a weak acid (K_a = 3.5 u 10^{-8}), to $HClO_4$, a very strong acid (K_a >>1).

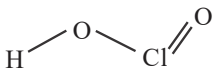
Q.70 Write the names and structural formulae of oxoacids of chlorine.

Ans: Sturcutres of oxoacids of chlorine:

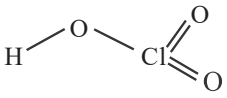
i. Hypochlorous acid, HOCl



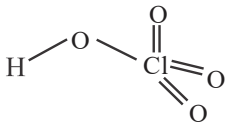
ii. Chlorous acid, HOClO or $HClO_2$



iii. Chloric acid, $HClO_3$



iv. Perchloric acid, $HClO_4$



Note-

oxidation state of X	Generic name	Oxoacids of fluorine	Oxoacids of chlorine	Oxoacids of bromine	Oxoacids of iodine
+1	Hypohalous acid (HXO)	HOF	HOCl	HOBr	HOI
+3	Halous acid (HXO_2)	-	HOClO	-	-
+5	Halic acid (HXO_4)	-	$HOClO_2$	$HOBrO_2$	$HOIO_2$
+7	Perhalic acid (HXO_4)	-	$HOClO_3$	$HOBrO_3$	$HOIO_3$

7.9 Oxygen and compounds of oxygen

Q.71 How is dioxygen prepared by laboratory methods?

Ans:

i. By heating oxygen containing salts such as chlorates, nitrates and permanganates.

$$2KClO_{3(s)} \xrightarrow[MnO_2]{Heat} 2KCl_{(s)} + 3O_{2(g)}$$

ii. By thermal decomposition of oxides of metals.

$$2Ag_2O_{(s)} \xrightarrow{\Delta} 4Ag_{(s)} + O_{2(g)}$$

$$2HgO_{(s)} \xrightarrow{\Delta} 2Hg_{(l)} + O_{2(g)}$$

$$2PbO_{2(s)} \xrightarrow{\Delta} 2PbO_{(s)} + O_{2(g)}$$

iii. By decomposition of hydrogen peroxide in presence of catalyst such as finely divided metals and manganese dioxide.

$$2H_2O_{2(aq)} \xrightarrow[MnO_2]{\Delta} 2H_2O_{(l)} + O_{2(g)}$$

Q.72 How is oxygen macufactured from electrolysis & industrial process?

Ans:

i. **Electrolysis:**
Dioxygen can be prepared on large scale by electrolysis of water, when hydrogen is liberated at cathode and oxygen at anode.

$$2H_2O \xrightarrow{Electrolysis} 2H_2 + O_2$$

ii. **Industrial method :**
a. Dioxygen is obtained from air, by first removing carbon dioxide and water vapour.
b. The remaining gases are liquified subsequently. This is followed by fractional distillation which gives dinitrogen and dioxygen.

Q.73 State the pysical properties of dioxygen.

Ans:

i. Dioxygen is colourless and odourless gas.
ii. Dioxygen is sparingly soluble in water, 30.8 cm^3 of O_2 dissolves in 1000 cm^3 of water at 293 K. A small amount of dissolved dioxygen is sufficient to sustain marine and aquatic life.
iii. It liquifies at 90 K and freezes at 55 K.
iv. Oxygen has three stable isotopes ^{16}O, ^{17}O and ^{18}O.
v. Molecular oxygen, O_2 exhibits paramagnetism.

+Q.74 Dioxygen is paramagnetic inspite of having even number of electrons. Explain.

Ans:

Dioxygen is a covalently bonded molecule.

:Ö::Ö: or :Ö=Ö:

Paramagnetic behaviour of O_2 can be explained with the help of molecular orbital theory .

Electronic configuration of O_2

$KK\sigma(2s)^2\ \sigma^*(2s)^2\ \sigma(2p_z)^2\ \pi(2p_x)^2\pi(2p_y)^2\ \pi^*(2p_x)^1\ \pi(2p_y)^1$. Presence of two unpaired electrons explains paramagnetic nature of dioxygen.

Q.75 Explain the reaction of dioxygen with metals and non metals

Ans:

i. **Reaction with metals :**

a. Dioxygen directly reacts with almost all metals except Au, Pt to form their oxides.

b. $2Ca + O_2 \rightarrow 2CaO$

$4Al + 3O_2 \rightarrow 2Al_2O_3$

ii. **Reaction with nonmetals :**

a. Dioxygen reacts with nonmetals (except noble gases) to form their oxides.

b. $C + O_2 \rightarrow CO_2$

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

Q.76 Give the reactions of dioxygen with the following compounds

i. ZnS **ii. CH_4**

iii. SO_2 **iv. HCl.**

Ans:

i. ZnS

$2ZnS + 3O_2 \xrightarrow{\Delta} 2ZnO + 2SO_2$

ii. CH_4

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

iii. **SO_2**

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

iv. HCl

$4HCl + O_2 \xrightarrow[\Delta]{CuCl_2} 2Cl_2 + 2H_2O$

Q.77 Give the uses of dioxygen.

Ans:

i. Dioxygen is important for respiration to sustain animal and aquatic life.

ii. It is used in the manufacture of steel.

iii. It is used in oxyacetylene flame for welding and cutting of metals.

iv. Oxygen cylinders are widely used in hospitals, high altitude flying and mountaineering.

v. It is used in combustion of fuels; for example, hydrazine in liquid oxygen provides tremendous thrust (energy) in rockets.

+Q.78 Try this

Why water in the fish pot needs to be changed time to time.

Ans: Fish waste is filled with ammonia, which can be harmful to the fish. Over a period of time starts blooming which reduce dissolved oxygen. Hence, water in the fish pot needs to be changed time to time.

Q.79 What are the different types of oxides? How are they classified?

Ans:

A binary compound of oxygen with another element is called an oxide.

Oxides can be classified into

i. **Acidic oxides :**

a. An oxide which dissolves in water to give an acid or reacts with a base to give a salt is called acidic oxide.

b. For example, SO_2, SO_3, CO_2, N_2O_5, Cl_2O_7 etc.

$SO_2 + H_2O \rightarrow H_2SO_3$

$SO_3 + 2NaOH \rightarrow Na_2SO_4 + H_2O$

c. Generally, oxides of nonmetals are acidic oxides.

ii. **Basic oxides:**

a. An oxide which dissolves in water to give a base or reacts with an acid to give salt is called basic oxide.

b. For example, Na_2O, CaO, BaO etc.

$CaO + H_2O \rightarrow Ca(OH)_2$

$BaO + 2HCl \rightarrow BaCl_2 + H_2O$

iii. **Amphoteric oxides:**

a. The oxide which reacts with a base as well as with an acid to give salt is called an amphoteric oxide.

b. For example, Al_2O_3

$Al_2O_3 + 6NaOH_{(aq)} + 3H_2O_{(l)} \rightarrow 2Na_3[Al(OH)_6]$

(Acidic)

$Al_2O_{3(s)} + 6HCl_{(aq)} + 9H_2O_{(l)} \rightarrow 2[Al(H_2O)_6]^{3+} + 6Cl^-_{(aq)}$

(Basic)

iv. Neutral oxides:

a. The oxides which are neither acidic nor basic, are called as neutral oxides.
b. For example, CO, NO, N_2O etc.

Q.80 Explain how ozone is prepared in the atmosphere.

Ans:

i. Ozone (O_3) is an allotrope of oxygen.

ii. Oxygen in the upper atmosphere absorbs energy in the form of ultra-violet light and changes to atomic oxygen, which combines with molecular oxygen to form O_3.

iii. $O_2 \xrightarrow{\text{U.V.light}} O + O$

$O_2 + O \rightarrow O_3$

Q.81 What is 'ozone' umbrella?

Ans: The layer of ozone protects the earth's surface from harmful ultraviolet (U.V) radiations. Hence, it is called as 'ozone umbrella'.

Q.82 Explain the preparation of ozone in laboratory.

Ans:

i. Ozone is prepared in the laboratory by passing silent electric discharge through pure and dry oxygen in an apparatus called ozoniser.

ii. As the conversion of oxygen to ozone is only 10%, the product is known as ozonised oxygen.

iii. It is an endothermic process.

$3O_{2(g)} \rightleftharpoons 2O_3 \quad \Delta H = +142 kJ / mol$

Q.83 State the physical properties of ozone.

Ans:

i. Pure Ozone is a pale - blue gas, dark blue liquid and violet - black solid.

ii. Ozone has a characteristic smell. When inhaled in concerntration above 100 ppm, it causes nausea and headache.

iii. It is diamagnetic in nature.

Q.84 High concerntration of ozone can be dangerously explosive. Explain.

Ans:

Ozone is thermodynamically unstable than oxygen and decomposes into O_2. The decomposition is exothermic and results in the liberation of heat (ΔH is – ve) and an increase in entropy (ΔS is positive). This results in large negative Gibbs energy change (ΔG). Therefore high concerntration of ozone can be dangerously explosive.

Eq. $O_3 \rightarrow O_2 + O$

Q.85 Write a short note on oxidizing property of ozone.

Ans:

i. Ozone is a powerful oxidising agents as it easily decomposes to liberate nascent oxygen.

$(O_3 \rightarrow O_2 + O)$

ii. Ozone oxidises lead sulfide to lead sulfate and iodide ions to iodine.

$PbS_{(s)} + 4O_{3(g)} \rightarrow PbSO_{4(s)} + 4O_{2(g)}$

$2KI_{(aq)} + H_2O_{(l)} + O_{3(g)} \rightarrow 2KOH_{(aq)} + I_{2(g)} + O_{2(g)}$

iii. Ozone oxidises nitrogen oxide and gives nitrogen dioxide.

$NO_{(g)} + O_{3(g)} \rightarrow NO_{2(g)} + O_{2(g)}$

iv. Hence the nitrogen oxide emmited from the exhaust systems of supersonic jet aeroplanes can bringforth depletion of ozone layer in the upper atmosphere.

★ Q.86 What happens when

i. Lead sulfide reacts with ozone (O_3)?

ii. Nitirc oxide reacts with ozone?

Ans:

i. Ozone oxidezes lead sulfide to lead sulfate.

$\underset{\text{Lead sulfied}}{PbS_{(s)}} + 4O_{3(g)} \rightarrow \underset{\text{Lead sulfate}}{PbSO_{4(s)}} + 4O_{2(g)}$

ii. Ozone xoidizes nitric oxide and gives nitrogen dioxide.

$\underset{\text{Nitric oxide}}{NO_{(g)}} + \underset{\text{Ozone}}{O_{3(g)}} \rightarrow \underset{\text{Nitrogen dioxide}}{NO_{2(g)}} + \underset{\text{Dioxygen}}{O_{2(g)}}$

Q.87 Explain why ozone is used a a bleaching agent?

Ans:

i. Ozone acts as a good bleaching agent due to its oxidising nature.

$O_3 \rightarrow O + O_2$

Q.88 What is dry bleach?

Ans: Ozone bleaches in absence of moisture so it

is also known as dry bleach.

★Q.89 Give one example showing reducing property of ozone.

Ans: Ozone reduces peroxides as oxides

$$\underset{\text{Hydrogen peroxide}}{H_2O_2} + O_3 \rightarrow H_2O + \underset{\text{Dioxygen}}{3O_2}$$

Q.90 Give the reaction of barium peroxide with ozone.

Ans: Ozone reduces peroxides to oxides.

$$\underset{\text{Barium peroxide}}{BaO_2} + O_3 \rightarrow BaO + \underset{\text{Dioxygen}}{2O_2}$$

+Q.91 Try this

i. Ozone is used as bleaching agent explain.

Ans: *Refer Q.87*

ii. Why does ozone act as a powerful oxidising agent?

Ans: Ozone is a powerful oxidizing agent it decomposes to produce nascent oxygent.

$$\underset{\text{ozone}}{O_3} \rightarrow \underset{\text{Dioxygen}}{O_2} + \underset{\text{Nascent oxygen}}{[O]}$$

Q.92 Write a short note on ozone depletion.

Ans:

i. Thinning of ozone layer in upper atmosphere is called ozone depletion.

ii. The ozone (O_3) layer in the upper atmosphere, absorbs harmful UV radiations from the sun, thus protecting people on the earth.

iii. Depletion of ozone layer in the upper atmosphere is caused by nitrogen oxide released from exhausts system of car or supersonic jet aeroplanes.

$$NO_{(g)} + O_{3(g)} \rightarrow NO_{2(g)} + O_{2(g)}$$

iv. Depletion (thining) of ozone layer can also be caused by chlorofluoro carbons (freons) used in aerosol and refrigerators and their subsequent escape into the atmosphere.

v. The depletion of ozone layer has been most pronounced in polar regions, especially over Antarctica.

vi. Ozone depletion is a major environmental problem because it increases the amount of ultraviolet (UV) radiation that reaches earth's surface, thus causing an increase in rate of skin cancer, eye cataracts and genetic as well as immune system damage among people.

★Q.93 Name two gases which deplete ozone layer.

Ans: Depletion of ozone is caused by Nitrogen dioxide (NO_2) and chlorofluoro carbon (freons).

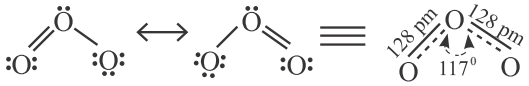
★Q.94 Describe the structure of ozone.

Ans:

i. Ozone (O_3) is an angular molecule.

ii. The two O – O bond lengths in the ozone molecule are identical, 128 pm and the O – O – O bond angle of about 117^0.

iii. It is a resonance hybrid of two canonical forms.



Q.95 State the uses of ozone.

Ans:

i. Ozone is used for air purification at crowded places like cinema halls, tunnels, railways, etc.

ii. In sterilizing drinking water by oxidising all germs and bacteria.

iii. For bleaching ivory, oils, starch, wax and delicate fabrics such as silk.

iv. In the manufacture of synthetic camphor, potassium permanganate, etc.

7.10 Compounds of sulfur

Q.96 How is sulfur dioxide prepared from sulfur?

Ans: Sulfur dioxide gas can be prepared by burning of sulfur in air.

$$S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$$

★Q.97 How is SO_2 prepared in laboratory from sodium sulfite?

Ans: In the laboratory sulfur dioxide is prepared by treating sodium sulfite with dilute sulfuric acid.

$$Na_2SO_3 + H_2SO_{4(aq)} \rightarrow Na_2SO_4 + H_2O_{(l)} + SO_{2(g)}$$

Q.98 How is sulfur dioxide prepared from industrial method?

Ans: Sulfur dioxide can be prepared by roasting zinc sulfide and iron pyrites.

$$2ZnS_{(s)} + 3O_{2(g)} \xrightarrow{\Delta} 2ZnO_{(s)} + 2SO_{2(s)}$$

$$4FeS_{2(s)} + 11O_{2(g)} \xrightarrow{\Delta} 2Fe_2O_{3(s)} + 8SO_{2(g)}$$

Q.99 State the properties of SO_2.

Ans:

i. Sulfur dioxide is a colourless gas with a pungent smell.

ii. It is poisonous in nature.

iii. SO_2 is highly soluble in water and its solution in water is called sulfurous acid.

iv. It liquifies at room temperature under a pressure of 2 atm and boils at 263 K.

Q.100 Write the action of SO_2 on the following compounds.

i. Cl_2 **ii. O_2**

iii. NaOH **iv. Na_2SO_3**

Ans:

i. Reaction with Cl_2

Sulfur dioxide reacts with chlorine in the presence of charcoal (catalyst) to form sulfuryl chloride.

$$SO_{2(g)} + Cl_{2(g)} \xrightarrow{\text{Charcoal}} SO_2Cl_{2(l)}$$

ii. Reaction with O_2:

Sulfur dioxide is oxidised by dioxygen in presence of vanadium (V) oxide to sulfur trioxide.

$$SO_{2(g)} + O_{2(g)} \xrightarrow{V_2O_5} 2SO_{3(g)}$$

iii. Reaction with NaOH :

Sulfur dioxide readily reacts with sodium hydroxide solution to form sodium sulfite.

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

iv. Reaction with Na_2SO_3:

Sulfur dioxide reacts with sodium sulfite solution to form sodium hydrogen sulfite.

$$Na_2SO_3 + H_2O_{(l)} + SO \rightarrow 2NaHSO_3$$

Q.101 Give the reactions showing reducing property of SO_2.

Ans:

i. Sulfur dioxide acts as a reducing agent in the presence of moisture.

ii. Moist sulfur dioxide reduces ferric salts into ferrous salts.

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

iii. Moist sulfur dioxide decolourises acidified potassium permangnate (VII) solution.

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

iv. Moist sulfur dioxide reduces halogens to halogen acids.

$$I_2 + SO_2 + 2H_2O \rightarrow 2H_2SO_4 + 2HI$$

★ Q.102 Discuss the struture of sulfur dioxide.

Ans: Sulfur dioxide is angular with O – S – O bond angle of 119.5^0.

The S – O double bond arises from dπ - pπ bonding. It is a resonance hybrid of two canonical forms.

Q.103 Give the uses of sulfur dioxide.

Ans: Sulfur dioxide is used

i In refining of petroleum and sugar.

ii. In bleaching wool and silk.

iii As an anti-chlor, disinfectant.

iv. As a preservative.

v. In the manufacture of H_2SO_4, $NaHSO_3$.

vi. Liquid SO_2 is used as a solvent to dissolve a number of organic and inorganic chemicals.

Q.104 Describe the manufacturing of H_2SO_4 by contact process.

Ans:

i. Sulfuric acid is manaufactured by Contact process, which involves the following three steps.

ii. Sulfur or sulfide ore (iron pyrites) on burning or roasting in air produces sulfur dioxide.

$$S_{(s)} + O_{2(g)} \xrightarrow{\Delta} SO_{2(g)}$$

$$4FeS_{2(s)} + 110_{2(s)} \xrightarrow{\Delta} 2Fe_2O_{3(s)} + 8SO_{2(g)}$$

iii. Sulfur dioxide is oxidised catalytically with oxygen to sulfur trioxide, in the presence of V_2O_5 catalyst.

$$2SO_{2(g)} + O_2 \xrightarrow{V_2O_5} 2SO_{3(g)}$$

The reaction is exothermic and reversible and the forward reaction leads to decrease in volume. Therefore low temperature (720K) and high pressure (2 bar) are favourable conditions for maximum yield of SO_3.

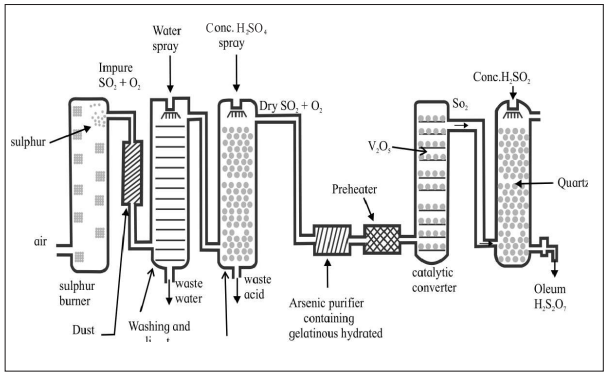
iv. Sulfur trioxide gas (from the catalytic converter) is absorbed in concentrated H_2SO_4 to produce oleum. Dilution of oleum with water gives sulfuric acid of desired

concentration.

$$SO_{3(g)} + H_2SO_4 \rightarrow \underset{\text{Oleum}}{H_2S_2O_7}$$

$$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$$

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



Q.104 State the physical properties of sulfuric acid.

Ans:

i. Sulfuric acid is a colourless, dense, oily liquid.

ii. It has a density (specific gravity) of 1.84 g/ cm^3 at 298 K.

iii. It freezes at 283 K and boils at 611 K.

iv. It is highly corrosive and produces severe burns on the skin.

Q.105 Concentrated H_2SO_4 must be added slowly to water with constant stirring by keeping the beaker in water bath. Give reason.

Ans:

Sulfuric acid dissolves in water with the evolution of a large quantity of heat. Hence care must be taken while preparing solution of sulfuric acid from concentrated sulfuric acid. Concentrated H_2SO_4 must be added slowly to water with constant stirring by keeping the beaker in water bath.

Q.106 Write a short note on acidic property of H_2SO_4.

Ans:

i. Sulfuric acid ionises in aqueous solution in two steps.

$$H_2SO_{4(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + HSO^-_{4(aq)} \qquad K_a > 10$$

$$HSO^-_{4(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + SO^{2-}_{4\,(aq)} \qquad K_a = 1.2 \times 10^{-2}$$

ii. The greater value of K_a (K_a >10) means that H_2SO_4 is largely dissociated into H^+ and HSO_4 ions. Thus H_2SO_4 is a strong acid.

Q.107 Write a note on dehydrating property of sulphuric acid.

Ans: The reaction is.

$$\underset{\text{Carbon}}{C} + 2\underset{\substack{\text{Sulfuric}\\ \text{acid}\\ \text{(Conc)}}}{H_2SO_4} \rightarrow CO_2 + 2SO_2 + 2H_2O$$

Q.108 Hot, concentrated H_2SO_4 is a better oxidizing agent than the dilute, cold acid. Explain.

Ans:

Oxidizing properties of sulfuric acid depend on its concentration and temperature. In dilute solutions, at room temperature, H_2SO_4 behaves like HCl, oxidizing metals that stand above hydrogen in the e.m.f. series.

$$Fe_{(s)} + 2H^+_{(aq)} \rightarrow Fe^{2+}_{(aq)} + H_{2(g)}$$

Hot, concentrated H_2SO_4 is a better oxidizing agent than the dilute, cold acid. It oxidises metals like copper.

★ Q.109 Write a note on dehydrating property of sulphuric acid.

Ans:

i. Concentrated sulfuric acid is a strong dehydrating agent.

ii. Sulfuric acid removes water from sugar and carbohydrates. Carbon left behind is called sugar charcoal and the process is called charring.

iii. $C_{12}H_{22}O_{11} \xrightarrow{\text{conc.}H_2SO_4} 12C + 11H_2O$

Q.110 Give the reactions of concentrated H_2SO_4 with salt.

Ans:

i. Concentrated sulfuric acid decomposes the salts of more volatile acids to the corresponding acid.

ii. e.g.

$$NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$$

$$KNO_3 + H_2SO_4 \rightarrow KHSO_4 + HNO_3$$

$$CaF_2 + H_2SO_4 \rightarrow CaSO_4 + 2HF$$

+Q.111 What is the action of concentrated H_2SO_4 on: (a) HBr (b) HI

Solution :

Concerntrated sulfuric acid oxidises hydrobromic acid to bromine.

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

It oxidises hydroiodic acid to iodine.

$2HI + H_2SO_4 \rightarrow I_2 + SO_2 + 2H_2O$

Q.112 State the uses of sulfuric acid.

Ans: Sulfuric acid is a very important industrial chemical. It is used

i. In the manufacture of fertilizers. For example, ammonium sulfate, superphosphate, etc.
ii. In the manufacture of pigments, paints and dyestuff intermediates.
iii. In petroleum refining.
iv. In detergent industry.
v. In metallurgy, for cleaning of metals electroplating and galvanising.
vi. In storage batteries.
vii. As a laboratory reagent.
viii. In the manufacture of nitrocellulose products.

7.11 Chlorine and compounds of chlorine

Q.113 How will you prepare chlorine from the following compounds?

i. MnO_2 and HCl
ii. $KMnO_4$ and HCl
iii. $KMnO_4$ and conc. H_2SO_4

Ans:

i. Chlorine can be prepared by the action of concentrated sulfuric acid on manganese dioxide.

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

ii. Chlorine can be prepared by the action of concentrated sulfuric acid on $KMnO_4$.

$2KMnO_4 + 16HCl \rightarrow 2KCl + 2MnCl_2 + 8H_2O + 5Cl_2$

iii. Chlorine can be prepared by the action of concentrated sulfuric acid on a mixture of sodium chloride (common salt) and manganese dioxide. The reaction takes place in two steps.

$$4NaCl + 4H_2SO_4 \rightarrow 4NaHSO_4 + 4HCl$$
$$MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + Cl_2$$
$$4NaCl + MnO_2 + 4H_2SO_4 \rightarrow 4NaHSO_4 + MnCl_2 + 2H_2O + Cl_2$$

Q.114 How is chlorine manufactured by

i. Deacon process
ii. Electrolytic process

Ans:

i. **Deacon's process :**

a. Chlorine is manufactured by the oxidation of hydrogen chloride gas by atmospheric oxygen in the presence of $CuCl_2$ as catalyst at 723 K.

b. $4HCl + O_2 \xrightarrow{CuCl_2} 2Cl_2 + 2H_2O$

ii. **Electrolytic process :**

a. By the electrolysis of brine (concentrated NaCl solution), chlorine is liberated at the anode.

b. $NaCl \rightleftharpoons Na^+ + Cl^-$

c. Cathode: $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$
$Na^+ + OH^- \rightarrow NaOH$

Anode: $Cl^- \rightarrow Cl + e^-$
$Cl + Cl \rightarrow Cl_2$

Q.115 State the physical properties of chlorine.

Ans:

i. Chlorine is a greenish-yellow gas having pungent and suffocating odour.
ii. It is poisonous in nature.
iii. It can be easily liquified into a greenish yellow liquid, which boils at 293 K.
iv. It dissolves in water to give chlorine water.
v. It is 2-5 times heavier than air.

Q.116 Give the action of chlorine on metals.

Ans: Chlorine reacts with metals to form chlorides.

$2Al + 3Cl_2 \rightarrow 2AlCl_3$
$2Na + Cl_2 \rightarrow 2NaCl$
$2Fe + 3Cl_2 \rightarrow 2FeCl_3$

Q.117 Give the action of chlorine on nonmetals.

Ans: Chlorine reacts with nonmetals to form their chlorides.

$P_4 + 6Cl_2 \rightarrow 4PCl_3$
$S_8 + 4Cl_2 \rightarrow 4S_2Cl_2$

Q.118 Write a note on affinity of chlorine for hydrogen.

Ans: Chlorine has great affinity for hydrogen. It reacts with hydrogen and compounds containing hydrogen to form HCl.

$H_2 + Cl_2 \rightarrow 2HCl$
$H_2S + Cl_2 \rightarrow 2HCl + S$

Q.119 Give the reaction of ammonia with

chlorine.

Ans:

i. Chlorine when reacted with excess of ammonia gives ammonium chloride and nitrogen.

$$8NH_3 + 3Cl_2 \rightarrow 6NH_4Cl + N_2$$
(Excess)

ii. Excess of chlorine reacts with ammonia to give nitrogen trichloride (explosive).

$$NH_3 + 3Cl_2 \rightarrow NCl_3 + 3HCl$$
(Excess)

★ Q.120 What is the action of chlorine on the following?
i. Fe ii. Excess of NH_3

Ans:

i. Chlorine reacts with Fe to form ferric chloride.

$$2Fe + 3Cl_2 \rightarrow 2FeCl_3$$
Ferric chloride

ii. Chlorine when reacted with excess of ammonia gives ammonium chloride and nitrogen.

$$8NH_3 + 3Cl_2 \rightarrow 6NH_4Cl + N_2$$
Excess

Q.121 Give the reactions of alkali with chlorine.

Ans:

i. Chlorine reacts with cold and dilute alkali to produce a mixture of chloride and hypochlorite. When reacted with hot concentrated alkali, chloride and chlorate are produced.

ii. $$2NaOH + Cl_2 \rightarrow NaCl + NaOCl + H_2O$$
(Cold and dilute)

$$NaOH + 3Cl_2 \rightarrow 5NaCl + NaClO_3 + 3H_2O$$
(Hot and conc.)

iii. Chlorine when reacted with dry slaked lime gives bleaching powder.

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

Q.122 Explain the reaction of chlorine with hydrocarbons.

Ans:

i. Chlorine reacts with saturated hydrocarbons to give substitution products and with unsaturated hydrocarbons gives addition products.

ii. $$CH_4 + Cl_2 \xrightarrow{U.V} CH_3Cl + HCl$$
Methane — Methylchloride

iii. $$H_2C = H_2C + Cl_2 \rightarrow \underset{\text{Cl}}{\overset{|}{CH_2}} - \underset{\text{Cl}}{\overset{|}{CH_2}}$$
Ethene — 1,2 – Dichloroethane

Q.123 Explain the oxidising property of clorine.

Ans:

i. Chlorine oxidises ferrous salts to ferrric salts and sulfites to sulfates.

$$2FeSO_4 + H_2SO_4 + Cl \rightarrow Fe_2(SO_4)_3 + 2HCl$$

$$Na_2SO_3 + Cl_2 + H_2O \rightarrow Na_2SO_4 + 2HCl$$

ii. It oxidises sulfur dioxide to sulfur trioxide and iodine to iodate. In presence of water they form sulfuric acid and iodic acid respectively.

$$SO_2 + 2H_2O + Cl_2 \rightarrow H_2SO_4 + 2HCl$$

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

Q.124 Write a note on bleaching property of chlorine.

Ans:

i. Chlorine requires the presence of moisture (water) for bleaching. It liberates nascent oxygen from water which is responsible for its oxidising and bleaching property

ii. $$Cl_2 + H_2O \rightarrow HCl + HOCl$$
$$HOCl \rightarrow HCl + [O]$$

iii. Chlorine bleaches vegetable matter or coloured organic matter in the presence of moisture to colourless matter.

iv. Coloured organic matter + [O] → Colourless organic matter.

Q.125 Bleaching by chlorine is permanent. Explain.

Ans: Bleaching by chlorine is permanent. It bleaches cotton fabrics, wood pulp, litmus, etc. However chlorine is not used to bleach delicate materials such as silk, wool etc. as it is a strong bleaching and oxidising agent. This dual action will damage the base material.

Q.126 State the uses of chlorine.

Ans: Chlorine is used:

i. For purification (sterilizing) of drinking water.

ii. For bleaching wood pulp required for manufacture of paper and rayon, bleaching

cotton and textiles.

iii. For extraction of metals like gold and platinum.

iv. In the manufacture of dyes, drugs and organic compounds such as CCl_4, $CHCl_3$, DDT, refrigerants, etc.

v. In the preparation of poisonous gases such as phosgene ($COCl_2$), tear gas (CCl_3NO_2), mustard gas ($ClCH_2CH_2SCH_2CH_2Cl$).

Q.127 Name the two gases used in war.

Ans: Phosgene ($COCl_2$)
Mustard gas ($ClCH_2CH_2SCH_2CH_2Cl$)

★Q.128 How is hydrogen chloride prepared from sodium chloride?

Ans:

i. In the laboratory, hydrogen chloride is prepared by heating sodium chloride (common salt) with concentrated sulfuric acid.

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

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

iii. HCl gas can be dried by passing it through concentrated sulfuric acid.

Q.129 State the physical properties of HCl.

Ans:

i. Hydrogen chloride is a colourless and pungent smelling gas.

ii. It can be easily liquified to a colourless liquid (b.p. 189 K) which freezes to a white crystalline solid (m.p. 159 K)

iii. It is highly soluble in water.

Q.130 Explain: HCl is a strong acid in water.

Ans:

i. Hydrogen chloride is highly soluble in water and ionises as follows

$$HCl_{(g)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + Cl^-_{(aq)} \qquad K_a = 10^7$$

ii. The aqueous solution of HCl gas is called hydrochloric acid. High value of dissociation constant (K_a) indicates that it is a strong acid in water.

★Q.131 What is the action of hydrochloric acid on the following

i. NH_3 **ii. Na_2CO_3**

Ans:

i. Hydrochloric acid reacts with ammonia and gives white fumes of ammonium chloride.

$$NH_3 + HCl \rightarrow NH_4Cl$$

ii. Hydrochloric acid reacts with sodium corbonate and gives sodium chloride, water and releases CO_2 gas.

$$\underset{\text{Sodium Carbonate}}{Na_2CO_3} + \underset{\text{Hydrochloric acid}}{2HCl} \rightarrow \underset{\text{Sodium Chloride}}{2NaCl} + \underset{\text{Water}}{H_2O} + \underset{\text{Carbon dioxide}}{CO_2}$$

Q.132 What is aquaregia? Give the reactions of aquaregia with noble metals.

Ans:

i. When three parts of concentrated HCl and one part of concentrated HNO_3 are mixed, aqua regia is formed.

ii. Noble metals like gold, platinum get dissolved in aqua regia.

iii. $$Au + 4H^+ + NO_3^- + 4Cl \rightarrow AuCl_4^- + NO + 2H_2O$$

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

★Q.133 Give two uses of HCl.

Ans:

i. It is used in the manufacture of ammonium chloride.

ii. It is used in the preparation of aquaregia which is used to dissolve to dissolve noble metals like gold and platinum.

+Q.134 Can you recall?

i. Which type of bonds do halogens form with other elements?

ii. Does BrF_5 obey the octet rule?

iii. What is the oxidation state of Br in BrF_5?

iv. How many electrons do halogens required to complete their octet?

v. What is the shape of ClF_3?

Ans:

i. Halogen forms ionic bonds with metals and covalaent bonds with nonemtals.

ii. No, BrF_5 dies not obey octet rule.

iii. Oxidation state of Br in BrF_5 = +5

iv. Halogens contain 7 electrons in their covalence shell. Hence, they require only one electron to complete their octet.

v. Shape of ClF_3: T-Shape

★Q.135 What are interhalogen compounds? Give two examples.

Ans:

i An interhalogen compound is a compound formed by combination of atoms of different halogens. For examples: ClF and BrF_3.

ii. The interhalogen compound is regarded as the halide of the more electropositive halogen.

iii. A given halogen forms an interhalogen compound only with the halogen having lesser electronegativity.

Q.136 Why do halogens form interhalogen compounds?

Ans:

i. Although all halogens belong to the same group they have different electronegativites.

ii. Due to this difference in electronegativity two or more halogen atoms combine to form species which may be ionic or neutral.

Q.137 What are polyhalide ions?

Ans:

The ions formed by combination of different halogens are called polyhalide ions or interhalogen ions, For example, $K^+[Cl_3^-]$, $[NH_4]^+[I_5]$, which contain Cl_3^- and I_5^- ions.

+Q.138 Use your brain power.

i. Clorine and fluorine combine to form interhalogen componds. The halide ion will be of chlorine or fluorine?

Ans: When chlorine and fluorine combine to form interhalogen componds, the halide ion will be fluorine.

ii. Why does fluourine combine with other halogens to form maximum number of fluorides?

Ans: Flourine is the most electronegative halogen and therefore, it has more tendency to attract a shared paired of electrons towards itself. Hence, fluorine combines with other halogens to form maximum number of fluorides.

Note-

Element	Fluoride	Chloride	Bromide	Iodide
Chlorine	ClF, ClF_3,ClF_5	-	-	-
Bromine	BrF, BrF_3, BrF_5	BrCl	-	-
Iodine	IF, IF_3, IF_5,IF_7	Icl, ICl_3	IBr	-

Q.139 What is Wijs solution?

Ans:

ICl Iodine monochloride in glacial acetic acid called Wijs solution is used in determination of iodine value of an oil.

Q.140 How are interhalogen comounds classified?

Ans:

i. Depending on their composition, interhalogen compounds are classified into four types.

Type	Example
XX'	ClF, BrF, BrCl, ICl, IBr
XX'_3	ClF_3, BrF_3, IF_3
XX'_5	ClF_5, BrF_5,IF_5
XX'_7	IF_7

ii. In the general formula XX'_n. X is the halogen having larger size and is more electropositive. X' is the halogen having smaller size and more electronegativity.

Q.141 Give the general characteristics of interhalogen compounds.

Ans:

i. The compound is considered as the halide of X. For example, ClF. Here the halogen having larger size is chlorine, it is more electropositive than F and hence the interhalogen compound is named as chlorine monofluoride. (n) is the number of atoms of X' attached to X.
As the ratio [radius of X : radius of X'] increases the value of n also increases.

ii. Interhalogen compounds have even number of atoms 2, 4, 6, 8. For example, ClF_3 has 4 atoms.

iii. The properties of interhalogen compounds are generally intermediate between those of the

halogens from which they are made.

iv. The central halogen exhibits different oxidation states in different interhalogen compounds.

v. Number of X' atoms in the compounds is always odd.

vi. They are all diamagnetic.

+Q.142 Use your brain power.

i. What will be the names of the following compounds: ICl, BrF.

Ans: Name of ICl: Iodine monochloride
Name of BrF: Bromine monofluoride

ii. Which halogen (X) will have maximum number of other halogen (X') attached?

Ans: Iodine will have maximum number of other halogens (X') attached.
e.g. IF_7

+Q.143 Use your brain power.

Which hlogen has tendency to form more interhalogen compounds?

Ans: Fluorine has tendencey to form more interhalogen compounds.

+Q.144 Use your brain power.

i. Which will be more reacive?

a. CIF_3 or CIF

b. BrF_5or BrF

Ans:

a. CIF_3 is more reactive than CIF.

b. BrF_5 is more reactive than BrF.

ii. Complete the table.

Formula	Name
CIF	Chlorine monofluoride
CIF_3	……
……	Chlorine penta fluoride
BrF	……
……	Bromine penta fluoride
ICl	……
ICl_3	…….

Ans:

Formula	Name
CIF	Chlorine monofluoride
CIF_3	Chlorine trifluoride
CIF_5	Chlorine penta fluoride
BrF	Bromine monofluroride
BrF_5	Bromine penta fluoride
ICl	Iodine monochloride
ICl_3	Iodine trichloride

Q.145 Give the physical states of interhalogen componds at 25 ºC.

Ans:

XX'	
CIF	Colorless gas
BrF	Pale brown gas
BrCl	Gas
ICl	Ruby red solid (α-form) Brown red soid (β-form)
Ibr	Black solid
XX'_3	
CIF3	Colorless gas
BrF_3	Yellow green liquid
IF_3	Yellow powder
ICl_3	Orange solid dimerises to form (I_2Cl_6 having Cl-bridges)
XX'_5	
IF_5	Colorless gas at R. T. but solid below 77 K
BrF_5	Colorless liquid
CIF_5	Colorless liquid
XX'_7	
IF_7	Colorless gas

Q.146 Give the methods of preparation of interhalogen compounds.

Ans:

i. Both halogens are in equal volume:

a. $\underset{\text{Chlorine}}{Cl_2} + \underset{\text{Fluourine}}{F_2} \xrightarrow[\text{Cu vessel}]{523K} \underset{\text{Chlorine monofluoride}}{2ClF}$

b. $\underset{\text{Iodine}}{I_2} + \underset{\text{Fluorine}}{Cl_2} \xrightarrow[\text{Boil}]{HCl+HNO_3} \underset{\text{Chlorine monofluoride}}{2ICl}$

c. $\underset{\text{Iodine}}{Br_2} + \underset{\text{Chlorine}}{Cl_2} \rightarrow \underset{\text{Iodine monochloride}}{2BrCl}$

ii. When one halogen is in excess:

a. $\underset{\text{Chlorine}}{Cl_2} + \underset{\text{Fluorine (Excess)}}{3F_2} \rightarrow \underset{\text{Chlorine trifluoride}}{2ClF_3}$

b. $\underset{\text{Iodine}}{I_2} + \underset{\text{Chlorine (Excess)}}{3Cl_2} \rightarrow \underset{\text{Iodine trichloride}}{2ICl_3}$

c. $\underset{\text{Bromine}}{Br_2} + \underset{\text{Fluorine (Excess)}}{3F_2} \rightarrow \underset{\text{Bromine trifluoride}}{2BrF_3}$

Q.147 What happens when

i. Cl_2 reacts with F_2 in equal volume at 473 K.

ii. Br_2 reacts with excess of F_2

Ans:

i. When Cl_2 reacts with F_2 in equal volume at 437 K, chlorine monofluoride is formed.

$\underset{\text{Chlorine}}{Cl_2} + \underset{\text{Fluorine}}{F_2} \rightarrow \underset{\text{Chlorine monofluoride}}{2ClF}$

ii. When Br_2 reacts with excess of F_2, bromine trifluoride is formed.

$\underset{\text{Bromine}}{Br_2} + \underset{\text{Fluorine (Excess)}}{3F_2} \rightarrow \underset{\text{Bromine trifluoride}}{2BrF_3}$

Q.148 Give the reaction of halogen with interhalogen eompounds.

Ans: $Br_2 + BrF_3 \rightarrow 3BrF$

$Br_2 + ClF_3 \rightarrow 2BrF_3 + BrCl$

Q.149 Show the special reaction for ICl

Ans: $I_2 + KClO_3 \rightarrow ICl + KIO_3$

+Q.150 Use your brain power

In the special reaction for ICl, identify the oxidant & reductant. Denote the oxidation states of the species.

Ans: I_2 is reductant while Cl_2 is oxidant.

$$\underset{0}{I_2} + \underset{+1-1-2}{KClO_3} \longrightarrow \underset{+1-1}{ICl} + \underset{+1+5-2}{KIO_3}$$

Q.150 Complete the following.

i. $ICl_3 + H_2O \rightarrow$ ____ + ____ + ICl

ii. $I_2 + KClO_3 \rightarrow$ ____ + KIO_3

iii. $BrCl + H_2O \rightarrow$ ____ + HCl

iv. $Cl_2 + ClF_3 \rightarrow$ ____

v. $H_2C = CH_2 + ICl \rightarrow$ ____

Ans:

i. $ICl_3 + 3H_2O \rightarrow HIO_3 + 5HCl + ICl$

ii. $I_2 + KClO_3 \rightarrow ICl + KIO_3$

iii. $BrCl + H_2O \rightarrow HOBr + HCl$

iv. $Cl_2 + ClF_3 \rightarrow 3ClF$

v. $H_2C = CH_2 + ICl \rightarrow I - CH_2 - CH_2 - Cl$

Q. 151 Explain the properties of interhalogen compounds.

Ans:

	Reaction/Property	XX'	XX'$_3$
1	Thermal stability	ClF > ICl > IBr > BrCl > BrF	
2	Hydrolysis Gives oxoacids	$BrCl + H_2O \longrightarrow HOBr + HCl$ $5ICl + 3H_2O \longrightarrow HIO_3 + 5HCl + 2I_2$	$ICl_3 + H_2O \longrightarrow HIO_3 + 5HCl + ICl$
3	Disproportionation/ Autoionisation	$BrF \longrightarrow 2Br_2 + BrF_5$	$2ClF_3 \rightarrow ClF_2^{\oplus} + ClF_4^{\ominus}$ $ICl_3 \xrightarrow{341\ K} ICl + Cl_2$
4	Flourination	---------	$U + ClF_3 \longrightarrow UF_6(l) + ClF(g)$
5	Addition across olefins	$H_2C = CH_2 + ICl \rightarrow H-\underset{H}{\overset{I}{C}}-\underset{H}{\overset{Cl}{C}}-H$	

Q.152 State the uses of interhalogen compounds.

Ans:

i. Uses of XX' type interhalogen compounds:

a. ICl is used to determine iodine value of oils.

b. As catalyst for oxidation of As (III)

c. For preparation of polyhalides.

ii. Uses of XX'_3 type interhalogen componds:

a. For preparation of polyhalides.

b. As fluorinating agent.

c. As nonaqueous solvent.

Q.153 Draw the structure and give the shapes of the following componds.

i. ICl ii. ClF_3 iii. BrF_5 iv. ClF_5

Ans:

Formula	Name	Structure	Shape
ICl	Iodine monochloride	:Cl—I—Cl:	Linear
ClF_3	Chloride trifluoride	F, Cl — F, 89q, F	Bent T- shaped
BrF_3	Bromine trifluoride	Br, F, 86q, F, F	Bent T- shaped
BrF_5	Bromine pentafluoride	Br, F, F, F, F, F	Square Pyramidal
ClF_5	Chlorine pentafluoride	Cl, F, F, F, F, F	Square pyramidal

Note-

O.S. central Halogen	No. of lone pairs of electrons	Examples
+7	0	IF_7
+5	1	ClF_5, BrF_5, IF_5
+3	2	ClF_3, BrF_3, IF_3, I_2Cl_6
+1	3	ClF, BrF, IF, BrCl, ICl, IBr

7.13 Compounds of Xenon

+Q.154 Can you recall?

i. What is the correlation between ionization energies and reactivity of elements?

Ans: Higher the ionization energy, less is the reactivity of elements.

ii. Trends in ionization energy down a group.

Ans: While going down a group, ionization energy decreases.

Q.155 Explain heavier noble gases like Kr, Xe and Rn can form componds due to low ionization energy.

Ans:

i. group 18 elements have very high ionisation energies and due to this property they are unreactive.

ii. Each noble gas atom has a completely filled valence electron shell which makes it inert.

iii. The first ionization potential decreases down the group, hence heavier noble gases Kr, Xe and Rn can form compounds due to low ionization energy.

Q.156 When was the first true compound of noble gas made?

Ans:

First true compound of noble gas was made in 1962 by Neil Bartelt and Lohman.

$$Xe + 2[PtF_6] \rightleftharpoons [XeF]^+[Pt_2F_{11}]^-$$

Only Xenon reacts directly with fluorine to form Xenon fluorides.

Q.157 Give some examples of compound of xenon.

Ans: XeF_2, XeF_4, XeF_6 are stable fluoride of xenon.Xenon also forms compounds with oxygen, such as XeO_3, $XeOF_2$, $XeOF_4$, XeO_2F_2.

★Q.158 How are xenon fluorided XeF_2, XeF_4 and XeF_6 obtained? Give suitable reactions.

Ans:

i Xenon fluorides are generally prepared by direct reaction of xenon and fluorine in different ratios and conditions, such as temperature, electric discharge and photochemical reaction.

ii. $Xe + F_2 \xrightarrow[\text{Ni tube, 400°C}]{\text{sealed}} XeF_2$

iii. $Xe + F_2 \xrightarrow[5-6\text{ atoms}]{\text{Ni tube , 400°C}} XeF_4$
1 : 5

iv. $Xe + 2F_2 \xrightarrow[-80°C]{\text{electric discharge}} XeF_4$

v. $Xe + 3F_2 \xrightarrow[\text{low temp}]{\text{electric discharge}} XeF_6$

Q.159 Give the reaction of xenon with the following
i. H_2O ii. PF_5

Ans:

i. XeF_2 undergoes hydrolysis to form HF
$2XeF_2 + 2H_2O \rightarrow 4HF + 2Xe + O_2$

ii. XeF_2 forms adducts on reaction with PF_5.
$XeF_2 + PF_5 \rightarrow XeF_2.PF_5$

Q.160 Match the following.

	A		B
i.	$XeOF_2$	a.	Xenon trioxydifluoride
ii.	XeO_2F_2	b.	Xenon monooxydifluride
iii.	XeO_3F_2	c.	Xenon dioxytetrafluoride
iv.	XeO_2F_4	d.	Xenon dioxydifluoride

Ans: i – b, ii – d, iii – a, iv – c.

Q.161 Use your brain power
What are the missing entries?

Formula	Name
$XeOF_2$	Xenon monooxydifluoride
…….	Xenon dioxydifluoride
XeO_3F_2	……
XeO_2F_4	……...

Ans:

Formula	Name
$XeOF_2$	Xenon monooxydifluoride
XeO_2F_2	Xenon dioxydifluoride
XeO_3F_2	Xenon trioxydifluoride
XeO_2F_4	Xenon dioxytetrafluoride

Q.162 How is XeO_3 prepared?

Ans: Fluorides of Xenon react with water to form XeO_3.

$$3XeF_4 + 6H_2O \rightarrow 2Xe + XeO_3 + 12HF + 1\frac{1}{2}O_2$$

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

Q.163 Write a note on preparation of oxyfluorides of xenon.

Ans:

i. Partial hydrolysis of XeF_4 yields different oxyfluorides.

$$XeF_4 + H_2O \xrightarrow{80°C} XeOF_2 + 2HF$$

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

ii. Reaction of xenon oxytetrafluoride with SiO_2 or hydrolysis yields xenon dioxydifluoride.
a.

$$\underset{\text{Xenon Monooxytetrafluoride}}{2XeOF_4} + \underset{\text{Silicon dioxide}}{SiO_2} \rightarrow \underset{\text{Xenon dioxydifluoride}}{2XeO_2F_2} + \underset{\text{Silicon tetrafluoride}}{SiF_4}$$

b. $\underset{\text{Xenon monooxytetrafluoride}}{XeOF_4} + \underset{\text{Water}}{H_2O} \rightarrow \underset{\text{Xenon dioxydifluoride}}{XeO_2F_2} + \underset{\text{Hydrogen fluoride}}{2HF}$

Q.164 Complete the following.

i. $2XeOF_4 + SiO_2 \rightarrow$ _____ $+ SiF_4$

ii. $XeF_6 + H_2O \rightarrow$ _____ $+ 2HF$

iii. $XeOF_4 + H_2O \rightarrow$ _____ $+ HF$

Ans:

i. $2XeOF_4 + SiO_2 \rightarrow 2XeO_2F_2 + SiF_4$

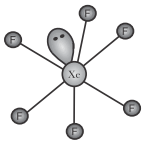
ii. $XeF_6 + H_2O \rightarrow XeOF_4 + 2HF$

iii. $XeOF_4 + H_2O \rightarrow XeO_2F_2 + 2HF$

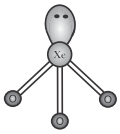
Q.165 Draw structures of XeF_6, XeO_3, $XeOF_4$, XeF_2.

Ans:

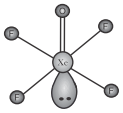
i. Structure of XeF_6



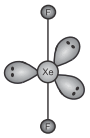
ii. Structure of XeO_3:



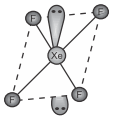
iii. Structure of $XeOF_4$



iv. Structure of XeF_2:



Q.166 Draw the structure of XeF_4.
Ans:



Q.167 State the uses of helium.
Ans:

i. Mixture of He and O_2 is used for artificial breathing of asthama patients.
ii. Mixture of He and O_2 is used for respiration by sea divers.
iii. For filling balloons, a mixture of helium (85%)and hydrogen (15%)is used.
iv. Helium is used for producing inert atmosphere required for welding purpose and metallury of some metals.
v. Liquid helium is used for producing low temperature required for research.
vi. In low temperature gas thermometry, for production of lasers.
vii. Used to pressurise fuel tanks of liquid fueled rockets.
viii. Used as shielding gas for arc welding.
ix. In supersonic wind tunnels.
x. Helium nucleus is used as a bombarding particle for disintegration of atoms.
xi. Used for magnetic resonance imaging.

Q.168 State the uses of Neon
Ans:

i. In Neon discharge lamps and signs. These signs are visible from the long distances and also in mist or fog.
ii. Mixture of Ne and He is used in certain protective electrical devices such as voltage stabilizers and current rectifiers.
iii. For production of lasers.
iv. In fluorescent tubes.

Q.169 State the uses of Argon
Ans:

i. For producing inert atmosphere in welding and steel production.
ii. Mixture of 85 % Ar and 15 % N_2 is filled in electric bulb to increase life of filament.
iii. In filling fluorescent tubes and radio valves.
iv. It is mixed with neon to get lights of various colors.

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