

Class 12th Chemistry Chapter 7 P Block Elements Revision Notes & Important Question (www.free-education.in)

Group 15

The group 15 members are:

- Nitrogen (N)
- Phosphorous (P)
- Arsenic(As)
- Antimony (Sb)
- Bismuth (Bi)

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- Phosphorous (P)
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- Antimony (Sb)
- Bismuth (Bi)

Physical Properties of group 15:

1. **Electronic configuration of group 15 members:** general electronic configuration is ns^2np^3 .

- Nitrogen (N) $[\text{He}]2s^2, 2p^3$
- Phosphorous (P) $[\text{Ne}]3s^2, 3p^3$
- Arsenic(As) $[\text{Ar}]3d^{10}, 4s^2, 4p^3$
- Antimony (Sb) $[\text{Kr}]4d^{10}, 5s^2, 5p^3$
- Bismuth (Bi) $[\text{Xe}]4f^{14}, 5d^{10}, 6s^2, 6p^3$

2. **Atomic size:** As compared to group 14 they are smaller in size due to increased nuclear charge.

Along group, size increases as every time a new shell is being added due to which nuclear charge decreases.

3. **Ionization energy:** The group 15 has high ionization energy than group 14 because of smaller size.

Along group, ionization energy decreases as size increases

4. **Electro negativity:** Because of smaller size the group 15 members are more electronegative than group 14. Out of them the increasing order of electro negativity is:

$\text{N} > \text{P} > \text{As} > \text{Sb} > \text{Bi}$

5. **Metallic character:** They are less metallic than group 14 because of small size and increased nuclear charge.

Along group metallic character increases as size increases and ionization energy decreases. The order of their metallic character is: $\text{N} < \text{P} < \text{As} < \text{Sb} < \text{Bi}$

6. **Melting point and boiling point:** The melting point depends upon the type and number of bonds formed whereas boiling point depends upon Vander wall force which increases in magnitude with increase in size.

- Boiling points: It increases down the group as size increases. The order is – $\text{N} < \text{P} < \text{As} < \text{Sb} < \text{Bi}$
- Melting point: It first increases then decreases.

The order is: $\text{N} < \text{P} < \text{As} > \text{Sb} > \text{Bi}$

The reason for this decrease in case of antimony and bismuth is due to use of only three electrons out of 5 in bond formation because of inert pair effect.

7. **Catenation :** They show only up to small extent like P exist as P_4

Nitrogen as N_2 .

8. **Oxidation states:** They have configuration ns^2np^3 . Their common oxidation states are +5 and +3.

The oxidation states shown by them are:

- Nitrogen shows: -
- -3 (Ca_3N_2) Calcium Nitride

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- -2 (NH_2NH_2) pyridine
Also show +3.
- Phosphorous shows:
-3 (Ca_3P_2) Calcium Phosphide
- Bismuth: as +3 due to inert pair effect. It has only one compound in +5 oxidation state that is BiF_5 (Bismuth pentafluoride).

Please note: **Nitrogen do not form compounds in +5 oxidation states because:**

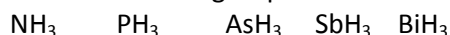
- It has no vacant d orbital therefore no excitation can occur. So, maximum covalence shown by it is 4.

Anomalous behavior of nitrogen:

- It has small size
- It has high ionization energy
- It is most electronegative
- It has no vacant d orbital
- In it no $d\pi-p\pi$ bonding can occur.

Chemical properties of group 15:

1. **Reaction with hydrogen:** Whenever any substance reacts with hydrogen they form respective hydrides. Like whenever 15 group elements react they form hydrides of order EH_3 that is:

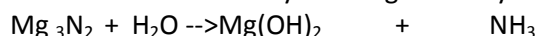


Ammonia Phosphine Arsine Stibine Bismuthine

In this NH_3 is called ammonia and PH_3 is called phosphine.

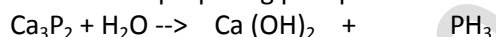
All these hydrides are called Lewis bases.

These can be formed by reacting metal hydrides with water that is:



(Magnesium nitride) (magnesium hydroxide) (ammonia)

Likewise for preparing phosphine we take calcium phosphide:



(Calcium phosphide) (calcium hydroxide) (phosphine)

Ammonia can be industrially prepared by Haber's process:

In this nitrogen and hydrogen are taken in 1:3 ratios and catalyst Fe and MoO is used. This reaction can take place at conditions of low temperature and high pressure. The structure of these hydrides is pyramidal and hybridization sp^3 .

The properties of hydrides are:

- **Bond angle:** The bond angle decreases down the group. The order of decrease of angle is:



The reason behind this is that when size of central atom increases, lone pair will push closer to bond pair-bond pair. Due to this bond angle decreases.

- **Basic character:** It refers to ability of molecule to donate its lone pair. The order of increase in basic character is:

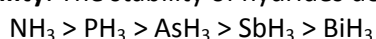


Most basic

least basic

Due to large size of bismuth the lone pair density is less closer to bismuth therefore tendency to lose electron decreases.

- **Stability:** The stability of hydrides depends upon the comparability of size. The order of stability of hydrides is:



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Due to increase in size, bond length increase due to which bond dissociation energy decrease therefore stability decrease.

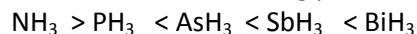
- **Reducing nature:** The order of reducing character of hydrides is:



Out of them in case of BiH_3 , the bond strength is low therefore reducing character is lowest.

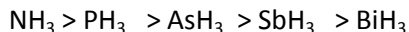
- **Boiling point:** The boiling point depends upon Vander wall force and this Vander wall force increases with increase in size.

The order of their boiling points for 15 group hydrides is:



In case of NH_3 and PH_3 , ammonia has higher boiling point than phosphine because of hydrogen bonding.

- **Solubility:** The solubility of hydrides in water for group 15 is:



Ammonia has higher solubility due to formation of hydrogen bonds.

2. **Reaction with oxygen:** Whenever group 15 elements react with oxygen they form oxides of order E_2O_3 and E_2O_5 .

E_2O_3 - trioxides

E_2O_5 - Penta oxides

Nitrogen form maximum types of different oxides ranging from +1 to +5.

The oxides of nitrogen are:

- N_2O (laughing gas) oxidation state +1
- NO oxidation state +2
- N_2O_3 oxidation state +3
- N_2O_4 oxidation state +4
- N_2O_5 oxidation state +5(most acidic)

In all the oxides pπ-pπ bonding takes place.

- P-forms oxide in oxidation state of +3 (P_4O_6), +4 (P_4O_8), +5 (P_4O_{10})
- As forms oxide as As_2O_3 , As_2O_5 (Arsenic trioxide and Arsenic pentaoxide).
- Sb forms oxide as Sb_2O_3 and Sb_2O_5 (Antimony trioxide and Antimony pentaoxide).
- Bi forms oxide as Bi_2O_3 and Bi_2O_5 (Bismuth trioxide and Bismuth pentaoxide).

Nature of their oxides:

Nitrogen and phosphorous forms acidic oxides.

Arsenic and antimony forms amphoteric oxide.

Bismuth forms basic oxide.

"Higher is the oxidation state more acidic is the oxide"

3. Reaction with halogens

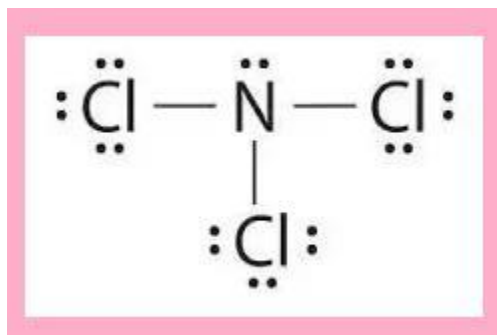
The group 15 elements combine with halogen to form their respective halides of general formula EX_3 and EX_5 .

Nitrogen does not form pent halides due to non availability of d orbital but form trihalides.

The structure of trihalides is distorted tetrahedral of hybridization sp^3 .

The geometry is given below:

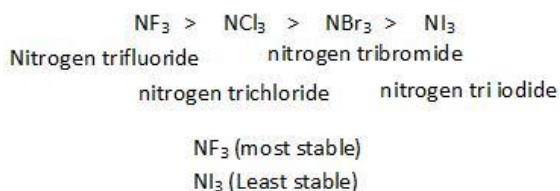
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Nitrogen trichloride

Characteristics of their trihalides:

- They are covalent and down the group ionization increase
- Trihalides of nitrogen are least stable
- Nitrogen trifluorides are maximum stable
- The order of stability of nitrogen halides are :

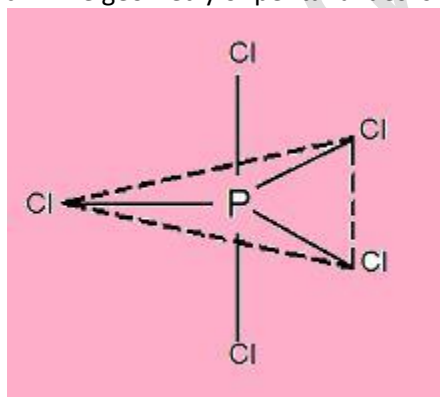


The reason behind is incomparable sizes.

- Trihalides of phosphorous arsenic and antimony are good Lewis bases.
- Down the group trihalides of group 15 stability increases due to inert pair effect.

Characteristics of pentahalides:

- Their general formula is EX_5
- Their hybridization is sp^3
- The geometry of pentahalides is trigonal bipyramidal as shown below:



Phosphorous pentachloride

- Down the group stability of pent halides decreases due to inert pair effect.
- All pent halides are Lewis acids.

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Please note that: The existence of PCl_5 (phosphorous pentachloride) is gas but in solid state it exists as dimer $\{[\text{PCl}_4]^+[\text{PCl}_6]^- \}$

Dinitrogen

Introduction

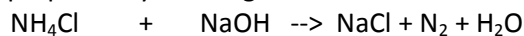
The molecular formula is N_2 .

It was discovered by Daniel Rutherford in 1772.

- It is a diatomic gas.
- The triple bond that exists between nitrogen of molecule is quite strong therefore bond dissociation energy is high.
- It is an inert gas.
- Nitrogen is smallest in its group.
- Nitrogen is most electronegative.
- Nitrogen has highest ionization energy in its group.
- Nitrogen has no vacant d orbital.

Preparation of Dinitrogen

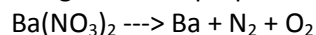
- It is prepared by reacting ammonium chloride with sodium hydroxide that is:



Ammonium chloride soda lime sodium chloride

This nitrogen so formed has impurities nitric oxide and nitric acid. So, in order to remove them we have to bubble this nitrogen through concentrated sulphuric acid.

- Pure nitrogen can be prepared by heating Barium nitrate :



Barium nitrate Barium Nitrogen

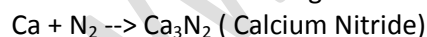
(On heating)

Physical properties of nitrogen

- It is colorless, odorless and tasteless gas.
- It is slightly soluble in water.
- It exists as N_2
- It is non toxic gas.

Chemical properties of nitrogen

1. **Reaction with metal:** Nitrogen reacts with metal to form metal nitrides.



1. **Reaction with non metal:** They react with non metal to form compounds like:



Uses of nitrogen:

- Liquid nitrogen is used as preservative for specimens.
- It is used to manufacture compounds like nitric acid etc.
- It is used to create inert atmosphere.

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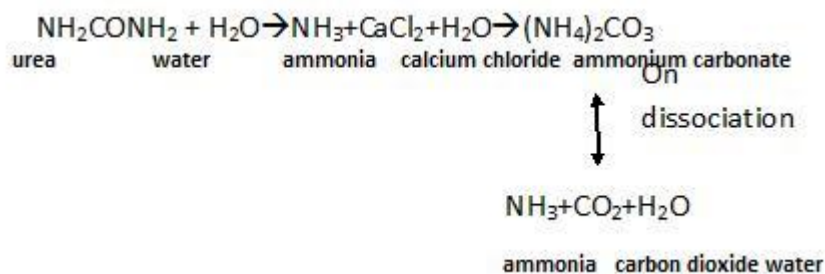
Ammonia

The molecular formula of ammonia is NH_3 .

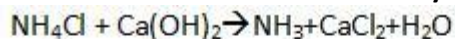
Preparation:

Lab preparations:

1. **Hydrolysis of urea:** The reaction involved is given below that is



2. **By reacting ammonium chloride with calcium hydroxide:**



Ammonium chloride ammonia calcium chloride

2. **By reacting ammonium sulphate with sodium hydroxide:**



Ammonium sulphate sodium sulphate

Industrial preparation:

In this nitrogen and hydrogen are taken in 1:3 ratios and catalyst Fe and MoO is used. This reaction can take place at conditions of low temperature and high pressure. The structure of these hydrides is pyramidal and hybridization sp^3 .



The reaction takes place at low temperature, high pressure, catalyst Fe, catalytic promoter MoO (molybdenum oxide).

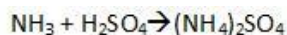
Physical properties of ammonia

- It is colorless gas with pungent smell.
- It is highly soluble in water forming ammonium hydroxide.
- It can be easily liquefied.
- It has high boiling point due to hydrogen bonding.

Chemical properties of ammonia

1. **Basic nature:** It behaves as a Lewis base because of lone pair of electrons. Also it has tendency to behave as bronsted base that is :

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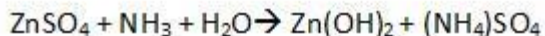
Ammonia sulphuric acid ammonium sulphate



Ammonia hydrogen chloride ammonium chloride

Both the reactions above are neutralization reactions

2. **It behaves as weak base** that means it precipitates hydroxides.



Zinc sulphate ammonia

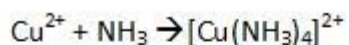
zinc hydroxide ammonium sulphate
(White ppt.)



Ferric chloride ammonium hydroxide rust ammonium chloride

(Brown color)

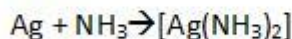
2. The lone pair present helps in forming complexes so we can say it is a **complexion agent**.



Cuprous ion ammonia

tetraamminecopper(II) ion
Blue color

Likewise:



Silver ammonia

diamine silver (I) ion
White color

This complexing nature of ammonia is due to the lone pair present in it so, it can act as electron donor.

Uses of ammonia

- Ammonia helps in making nitrogenous fertilizers like ammonium sulphate etc.
- It is used in manufacture of nitric acid.
- The liquid ammonia is used as refrigerant.

Oxides of nitrogen

The nitrogen forms variety of oxides that are given below:

- N_2O (laughing gas) oxidation state +1
 - NO oxidation state +2
 - N_2O_3 oxidation state +3
 - N_2O_4 oxidation state +4
 - N_2O_5 oxidation state +5 (most acidic)
1. **N_2O : nitrous oxide or laughing gas**
- In it the oxidation state of nitrogen is +1.

Preparation:

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- It is prepared by heating ammonium nitrate that is:
- NH_4NO_3 (on heating) $\rightarrow \text{N}_2\text{O} + \text{H}_2\text{O}$
- (Ammonium Nitrate) Nitrous Oxide Water
- The laughing gas so formed is colourless, neutral and exist in gaseous state.
- Its structure is :

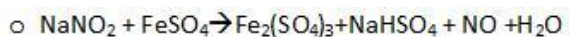


Nitrous oxide

2. NO (nitric oxide)

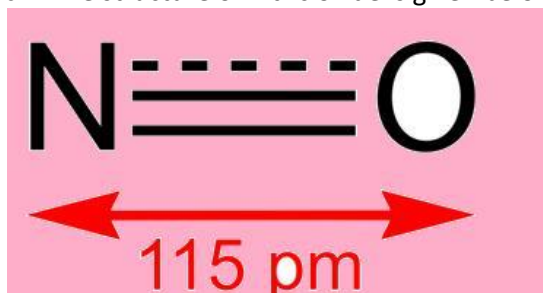
- In it the oxidation state of nitrogen is +2.

Preparation:



Sodium nitrite ferrous sulphate ferric sulphate sodiumhydrogensulphate water

- The NO formed is colorless and neutral gas.
- The structure of nitric oxide is given below:



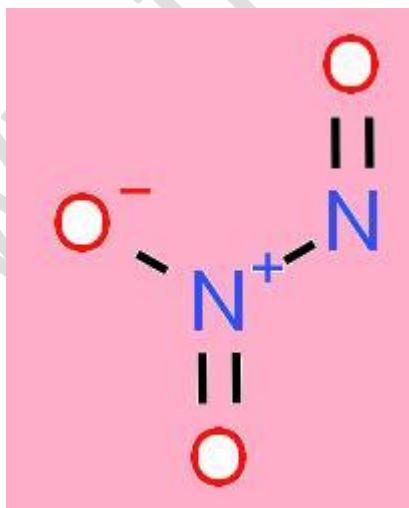
Nitric oxide

3. N_2O_3 (nitrogen trioxide)

- In it the oxidation state is +3.

Preparation:

- $\text{NO} + \text{N}_2\text{O}_4 \rightarrow \text{N}_2\text{O}_3$
- This nitrogen trioxide is blue solid and acidic in nature.
- The structure of it is:



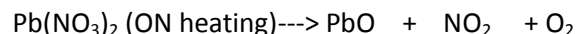
Nitrogen trioxide

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4. NO_2 (Nitrogen dioxide)

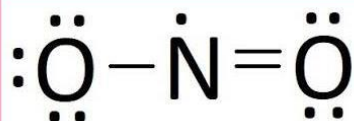
- In it the oxidation state of N is +4.

Preparation:



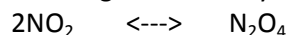
Lead Nitrate LeadOxide Nitrogen dioxide

- The nitrogen dioxide so formed is brown gas with acidic nature.
- The structure of it is:



Nitrogen dioxide

This single electron system in it helps it in existing as dimer (N_2O_4).



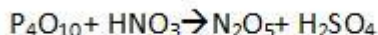
Nitrogen dioxide Dimer of Nitrogen dioxide

On cooling we get dimer and on heating dimer we get nitrogen dioxide.

5. N_2O_5 (nitrogen pent oxide)

- In it the oxidation state is +5.
- This is most acidic among all oxides of nitrogen.

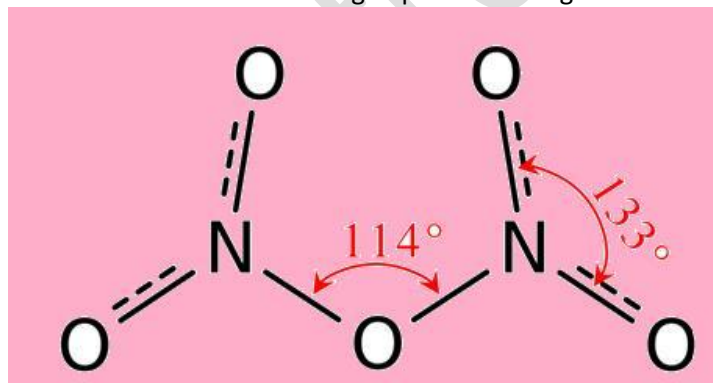
Preparation:



phosphorousoxide nitric acid nitrogen pentaoxide sulphuric acid

This nitrogen pent oxide is colorless gas with acidic nature.

- The structure of this nitrogen pent oxide is given below:

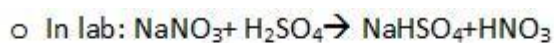


Nitrogen pentaoxide

Nitric acid (HNO_3)

Preparation:

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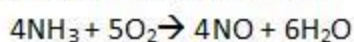


sodium nitrate sulphuric acid sodium bisulphate nitric acid

- Industrially : It is prepared from Ostwald's process

The reaction involves various steps:

(a) Oxidation of ammonia :



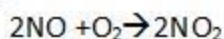
ammonia oxygen nitric oxide water

Ammonia Catalyst –Pt

Pressure 9 bar

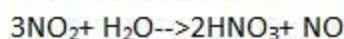
Temperature 500K

(b) NO is further oxidized



nitric oxide oxygen nitrogen dioxide

(c) Then hydrolysis of NO_2



nitrogen dioxide water nitric acid nitric oxide

The nitric acid so prepared is 98% pure rest 2% can be purified by concentrated sulphuric acid.

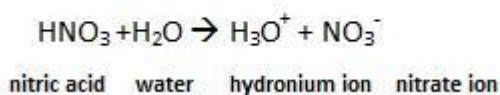
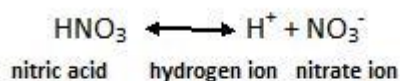
Physical properties of nitric acid

- It is colorless liquid.
- The impure nitric acid is yellow because of nitrogen dioxide in it as impurity therefore nitric acid is called as fuming nitric acid also.
- It is corrosive in nature.

Chemical properties of nitric acid

It keeps on oxidizing and forms nitrogen dioxide that is why we see brown color fumes coming out from the bottle.

1. **Acidic nature:** Nitric acid is acidic in nature because it dissociates to give hydrogen ion when dissolved in water:



Because this is acidic therefore, it reacts with base showing neutralization reaction:



Nitric Acid Sodium Hydroxide Sodium Nitrate Water

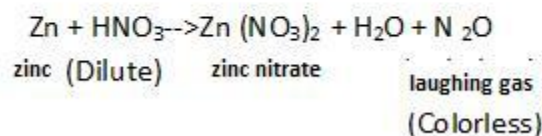
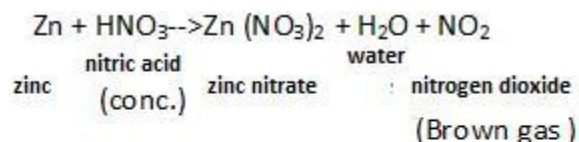
2. **Reaction with metals:** To give nitrates and nascent hydrogen:



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This nascent hydrogen can bring about reduction of substance:

Example:



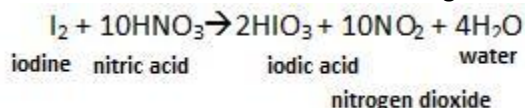
Please note certain metals like chromium, aluminium do not dissolve in nitric acid due to formation of passive layer of oxide film on it which prevents further reaction.

Aqua regia: It is a mixture of nitric acid and hydrochloric acid in ratio 1:3 and it is used in dissolving noble metals.

1. **Oxidizing nature of nitric acid:** It helps in oxidation of non metals like for example:

- Converting $\text{I}_2 \rightarrow \text{IO}_3^-$
 $\text{I}_2 \rightarrow \text{IO}_3^-$

In this oxidation state of iodine is changed from 0 to +5 that is increase in oxidation number:



Test for nitrates

It is also called as brown ring test.

In this we take test tube and sample (salt containing nitrate) to it.

- Then slowly pour concentrated sulphuric acid to it.
- Then we put solution of ferrous sulphate and allow it to stand.
- Then on interface a brown ring is formed that shows the presence of nitrates.
- The ring that is formed is chemically $[\text{Fe}(\text{H}_2\text{O})_5(\text{NO})]^{2+}$ (Nitroso ferrous sulphate).

Uses of nitric acid:

- In manufacturing of ammonium nitrate and other fertilizers.
- In manufacturing of explosives like TNT (trinitrotoluene).
- In purification of gold and silver by using aqua regia.
- It is used as oxidizer in rocket fuels.

Formation of oxy-acids

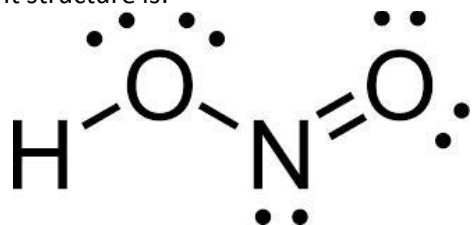
(a) Oxy-acids of nitrogen: nitrogen forms four types of oxy-acids that is:

- Nitric acid (HNO_3)
- Nitrous acid (HNO_2)
- Hypo nitrous acid ($\text{H}_2\text{N}_2\text{O}_2$)
- Per nitric acid (HNO_4).

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Nitrous acid: Nitrous acid oxidizes H_2S to S , KI to I_2 and act as an oxidizing agent. In the presence of strong oxidizing agent it also acts as reducing agent like it reduces potassium dichromate etc to form complex.

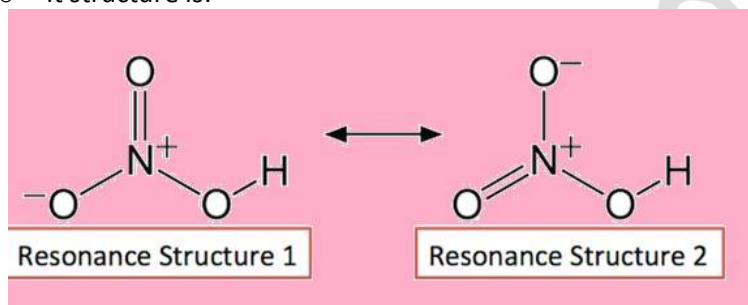
Its structure is:



Nitrous acid

Nitric acid:

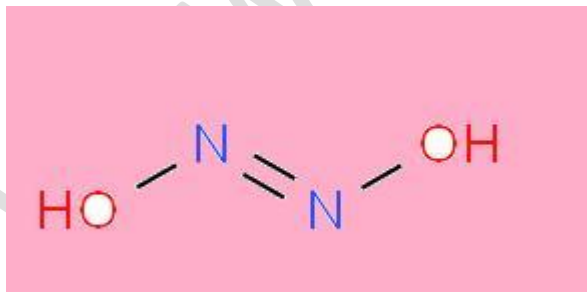
- It stains skin yellow due to formation of nitro compound xanthoprotein. It is also called as aqua Fortis meaning strong water because it attacks almost all metals.
- It also forms a constant boiling mixture with water which has 68% of acid.
- Concentrated nitric acid attains a yellow color on standing. This is due to the presence of nitrogen dioxide which is formed due to decomposition of nitric acid in sunlight. This yellow color may be removed by warming it or bubbling air through it.
- Fuming nitric acid contains nitrogen dioxide in concentrated nitric acid. It is obtained by distilling concentrated nitric acid with little amount of starch.
- Its structure is:



Nitric acid

Hypo nitrous acid:

- It is a weak dibasic acid
- Its structure is:



Hypo nitrous acid

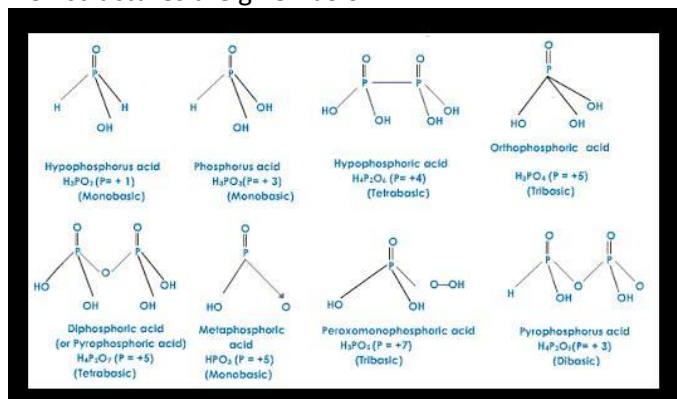
Oxy-acids of phosphorous: Its oxy acids are:

- Hypo phosphorous acid (H_3PO_2)
- Phosphorous acid (H_3PO_3)

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- Orthophosphoric acid (H_3PO_4)
- Metaphosphoric acid (HPO_3)
- Hypo phosphoric acid ($\text{H}_4\text{P}_2\text{O}_6$)
- Pyro phosphoric acid ($\text{H}_4\text{P}_2\text{O}_7$)
- Pyro phosphorus acid ($\text{H}_4\text{P}_2\text{O}_5$)
- Isohyphosphoric acid ($\text{H}_4\text{P}_2\text{O}_6$)

Their structures are given below:



Hypo phosphoric acid

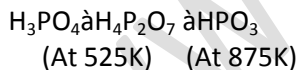
- It is also called as phosphinic acid.
- It is powerful reducing agent because of the presence of two P-H bonds.
- The oxidation state of P is +1(monobasic).

Phosphorous acid

- It is also called as phosphonic acid.
- It is dibasic acid.
- In it the oxidation state of P is +3.
- It is strong reducing agent but weaker than hypo phosphorous acid due to only one P-H bond.
- It undergoes disproportionate reaction giving orthophosphoric acid and phosphine.

Orthophosphoric acid

- It is a weak tri basic acid.
- In it the P is in +5 oxidation state.
- It has no oxidizing or reducing properties.
- On heating it gives pyro phosphoric acid at 525K and meta phosphoric at 875K.



Metaphosphoric acid

- It is also called as glacial phosphoric acid.
- It is monobasic having P in +5 oxidation state.
- It has no reducing property.
- It exists as polymer and thus contains P-O-P bonds which can further form calgon.

Hypo phosphoric acid

- It is tetra basic in nature.
- Due to absence of P-H bond it has no reducing properties.
- In the P is in +4 oxidation state.

Pyro phosphoric acid

- It is also called as di phosphoric acid.

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- In it the oxidation state is +5.
- It is also tetra basic.
- It has no reducing property.

Pyrophosphorous acid

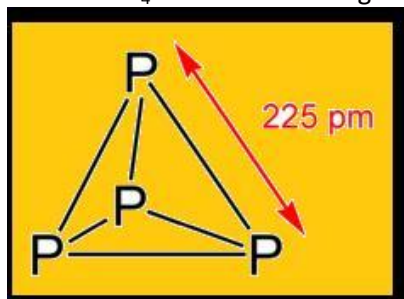
- It is also called as di phosphorous acid.
- In it the oxidation state of P is +3.
- It contains P-O-P bond and is dibasic.
- It is strong reducing agent due to presence of P-H bonds.

Isohyphosphoric acid

- It contains one P-O-P bond and one P-H bond.
- It is also called as diphosphoric acid.
- It is tri basic in nature in it the oxidation state of P is +3 which are attached to hydrogen and rests have +5 oxidation state.
- It has reducing properties also.

Phosphorous

It exists as P_4 with tetrahedral geometry as shown below:



Phosphorous

It has three forms:

- White P
- Black P
- Red P

White phosphorous

- It has a normal tetrahedral structure. They are soft waxy solids.
- They can be cut with knife.
- They are poisonous.
- They are chemiluminescent.
- It is most reactive form of phosphorous.
- It undergoes disproportionate reaction as shown :
- $P_4 + NaOH \rightarrow PH_3 + NaH_2PO_2$
- Phosphorous Sodiumhydroxide Phosphine Sodiumhypo Phosphite
- In this oxidation state of phosphorous changes from 0 to +1 and -3.

Black phosphorous

It exists in two forms:

Alpha phosphorous

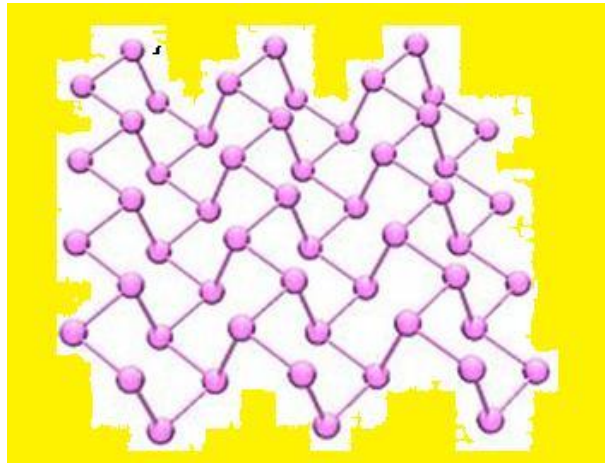
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Beta phosphorous

Alpha phosphorous: is formed by heating red phosphorous at 803 K

Beta phosphorous: is formed by heating white phosphorous at 473K

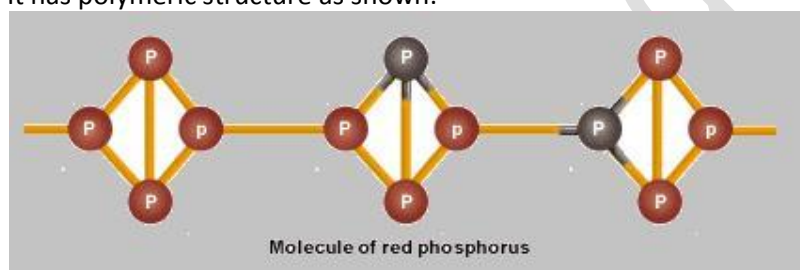
It has most stable due to three dimensional structure as shown:



Alpha phosphorous

Red phosphorous

- It is obtained by heating white phosphorous at 573 K in inert atmosphere.
- It has polymeric structure as shown:



Red phosphorous

- It is crystalline solid.
- It shines grey.
- It is non poisonous.
- It is more stable.
- It is also chemiluminescent.
- Stability of different forms of phosphorous:

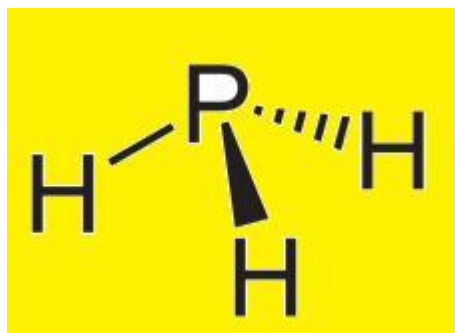
White P < red P < black P

Phosphine

Its molecular formula is PH_3

Its structure is:

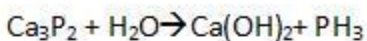
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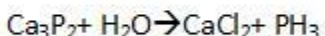
Phosphine

Preparation

It is prepared by dropping water on calcium phosphide.

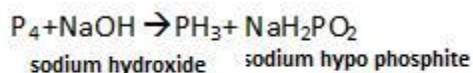


Calcium phosphide calcium hydroxide phosphine



Calcium phosphide phosphine

Lab preparation: By disproportionate reaction



phosphorous sodium hydroxide phosphine sodium hypo phosphite

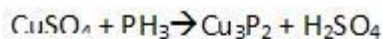
This phosphine produced can be purified by reacting it with HI to get PH_4I and then this PH_4I react with KOH to form pure PH_3 , KI and water.

Physical properties:

- It is colorless gas with smell of rotten fish.
- It is poisonous.
- It is slightly soluble in water.
- The solution of phosphine is unstable and decomposes in presence of light.

Chemical properties

1. It is weakly basic due to lone pair of electrons.
2. It undergoes precipitation reaction that is:



Copper sulphate copper phosphide
(Black ppt.)



silver nitrate silver phosphide
(Black ppt.)

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Uses of phosphine:

- (a) Combustion of PH_3 is used in Holmes's signals for ships.
- (b) It is also used as smoke screens in warfare.

Introduction of group 16

The members of this family are:

- Oxygen (O)
- Sulphur (S)
- Selenium (Se)
- Tellurium (Te)
- Polonium (Po)

Physical properties of group 16

1. The electronic configuration for them are : $ns^2 np^4$

- Oxygen (O) $[\text{He}]2s^2, 2p^4$
- Sulphur (S) $[\text{Ne}]3s^2, 3p^4$
- Selenium (Se) $[\text{Ar}]3d^{10}4s^2, 4p^4$
- Tellurium (Te) $[\text{Kr}]4d^{10}5s^2, 5p^4$
- Polonium (Po) $[\text{Xe}]4f^{14}, 5d^{10}, 6s^2, 6p^4$

- 2. **Atomic size:** It increases down the group as every time a new shell is added as we move down. If we compare size of group 16 elements with group 15 then we see that group 16 is smaller due to increased nuclear charge.
- 3. **Ionization energy:** If we compare ionization energy of group 16 and group 15 we see, that group 16 has lower energy than group 15 because of half filled stable electronic configuration of group 15 i.e. $ns^2 np^3$.

As we move down the group, the ionization energy decreases because the size increases down the group.

- 4. **Electro negativity:** The group 16 elements are more electro negative than group 15 because of small size of group 16 elements. This group has second highest electro negativity in whole periodic table.
 - Oxygen is second most electronegative in periodic table.
 - Down the group electro negativity decreases as size increases.
- 5. **Oxidation states:** They generally show -2 oxidation state.
 - For oxygen: Common oxidation state is -2 but oxygen also show +2 oxidation state like in case of OF_2 and in O_2F_2 the oxidation state is +1. The oxidation state of oxygen is in +ve because oxygen is less electronegative than fluorine.
 - For sulphur: The oxidation state shown is +2, +4, +6 (because of vacant d orbital). Like in SO_2 the oxidation state of sulphur is +4 and in sulphuric acid the oxidation state is +6 and in H_2S it is -2.
 - Down the group the vacant d orbital are present therefore they all can show +2, +4, +6 oxidation states.

Anomalous behavior of oxygen:

- It has smallest size in its family.
- It has highest ionization energy.
- No vacant d orbital is present in it.
- It is highly electronegative in its family.

5. Electron gain enthalpy

Along period it is more negative because of attraction towards electron because of increased nuclear charge. Down the group electron gain enthalpy keeps on becoming less negative because nuclear charge decreases and size increases.

The trend that was expected

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- $O > S > Se > Te$ (wrong trend)
- $O < S > Se > Te$ (right trend)
- Please note that oxygen has less electron gain enthalpy than sulphur because due to small size of oxygen the incoming electron suffers repulsion therefore electron gain enthalpy is less negative as compared to sulphur.

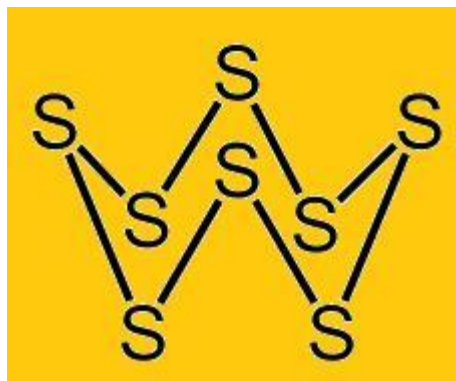
This whole group is called chalcogens as they are ore forming.

For example:

- Al –bauxite ore
- Pb-galena
- Hg-cinnabar ore
- Zn-zinc blende and many more.

Elemental state of oxygen and sulphur

Oxygen exists as diatomic gas, whereas sulphur exists as S_8 in solid form in a puckered ring like structure as shown below:



Sulphur (crown-like structure)

- In case of oxygen $p\pi-p\pi$ bonding takes place but in sulphur no such bonding takes place. That is the reason oxygen exists as gas and sulphur exists as solid.

Chemical properties of group 16

Trends in chemical reactions:

- The order of reactivity of group 16 elements is:
 $O > S > Se > Te$

That is oxygen is quite reactive and as we move down reactivity decreases.

- Oxygen in this group is quite reactive as the bond between oxygen atoms is quite strong and the energy required to break it is 493.3 kJ/mol.
- Almost all the reactions of oxygen are exothermic, therefore, the reactions are called combustion reactions.

The most stable compounds of this group are: **selenides and tellurides.**

1. **Reaction with hydrogen:** When group 16 elements combine with hydrogen they form hydrides with general formula H_2X

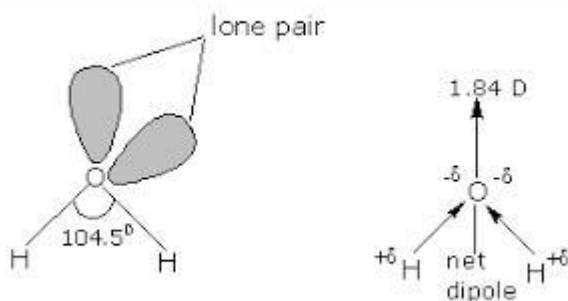
The hydrides formed are:



(Water) (hydrogen sulphide) (hydrogen selenide) (hydrogenteluride)

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All of them have bent geometry with sp^3 hybridization. The geometry shown by them is:



Structure of water

The properties of hydrides are:

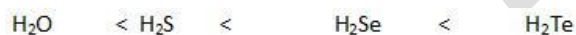
- **Bond angle:** The bond angle decreases down the group. The order of decrease of angle is:



Water hydrogen sulphide hydrogen selenide hydrogen telluride

The reason behind this is that when size of central atom increases, lone pair will push closer to bond pair-bond pair. Due to this bond angle decreases.

- **Basic character:** It refers to ability of molecule to donate its lone pair. The order of increase in basic character is:



Most basic

least basic

- **Stability:** The stability of hydrides depends upon the comparability of size. The order of stability of hydrides is: Due to increase in size, bond length increase due to which bond dissociation energy decrease therefore stability decrease.

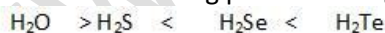
- **Reducing nature:** The order of reducing character of hydrides are:

Out of them in case of H_2Te the bond strength is low therefore reducing character is lowest.



- **Boiling point:** The boiling point depends upon Vander wall force and this Vander wall force increases with increase in size.

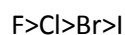
The order of their boiling points for 15 group hydrides is:



In case of H_2O and H_2S , water has higher boiling point than hydrogen sulphide because of hydrogen bonding.

2. Reaction with halogen: They react with halogen to form halides of formula EX_4 , EX_6 and EX_2 .

The order of stability oh halides are:

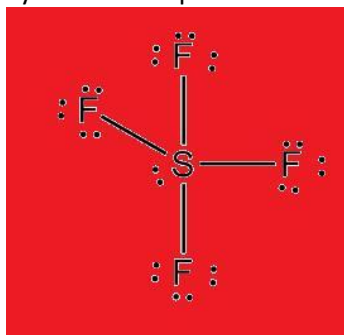


The group 16 elements react with iodine to form tetra iodides.

- Oxygen only forms halides OF_2 and O_2F Out of them oxy difluoride is most stable halide.
- Sulphur forms SCl_2 (sulphur dichloride), SF_6 (sulphur hexafluoride) and SF_4 (sulphur tetra fluoride).

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- The geometry of SF_4 is tetrahedral with hybridization sp^3d and geometry of SF_6 is trigonal bipyramidal with hybridization sp^3d^2 as shown:



Sulphur tetrafluoride



Sulphur hexafluoride

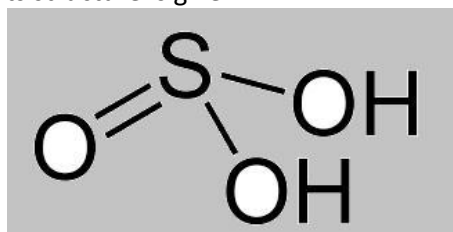
Hexa halides are only formed by fluorine because as size increases, coordination number decreases, therefore others they will not form halides .

- Out of all halides sulphur hexahalide is most non reactive halide in this group because it has excess octet .So, no vacant d orbital is present moreover it is protected from all sides by fluorine .

3. Oxo acids of sulphur

Some important oxo acids of sulphur are:

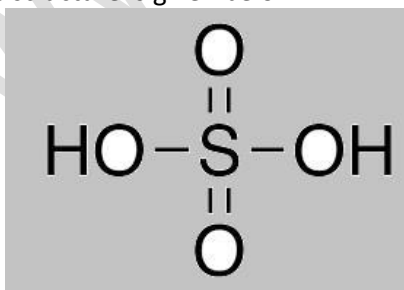
- **Sulphurous acid:** it is reducing in nature.
- It acts as oxidizing and reducing action.
- It bleaches the articles due to reduction.
- Its structure is given :



Sulphurous acid

(b) Sulphuric acid:

- It is called king of chemicals.
- It is used as an acid, oxidizing agent, dehydrating agent etc.
- It is highly viscous due to hydrogen bonding.
- It is also called as brown oil of vitrol.
- It is further concentrated and form rectified oil.
- It is prepared by contact process.
- Its structure is given below:

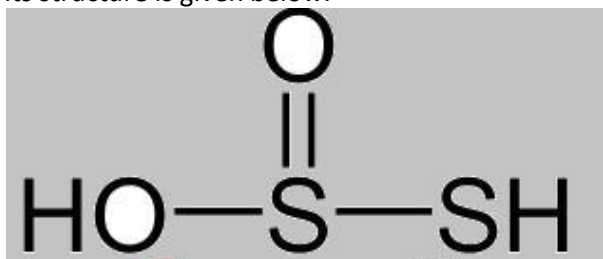


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Sulphuric acid

(c)Thiosulphurous acid

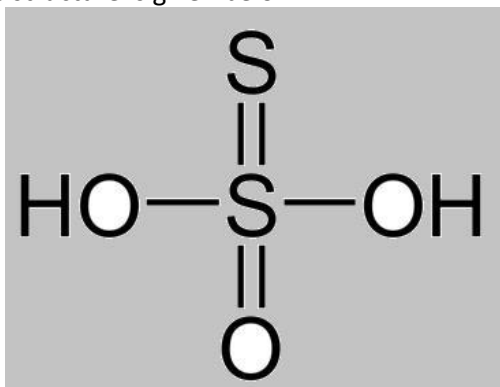
- It contains double bond between S atoms.
- Its structure is given below:



Thiosulphurous acid

(d)Thiosulphuric acid:

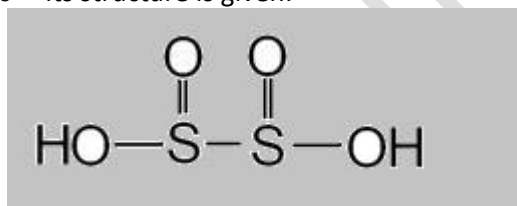
- It contains one double bond S linkage between S atoms.
- Its structure is given below:



Thiosulphuric acid

(e)Dithionous acid

- It contains one S-S bond.
- Its structure is given:



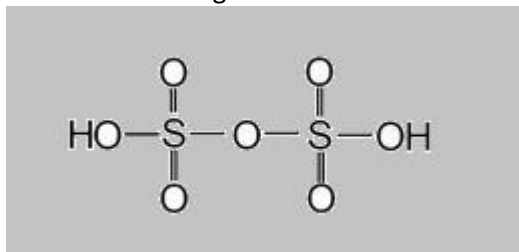
Dithionous acid

(f)Pyrosulphuric acid

- It is known as oleum.
- It contains one S-S linkage.
- Sulphur dissolves in oleum to give clear brightly colored solution which contains polyatomic sulphur cations of general formula S_4^{2-} .
- The color of solution depends upon the time of reaction and strength of oleum.
- The bright yellow color solution has S_2^{2-} ions, deep blue solution S_8^{2+} and bright red solution has totally unexpected S_2^{2+} .

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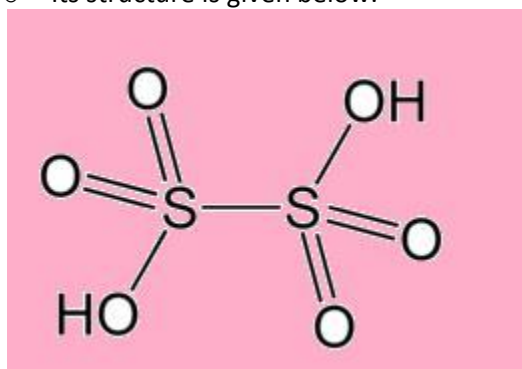
- Its structure is given below:



Pyrosulphuric acid

(g) Dithionic acid:

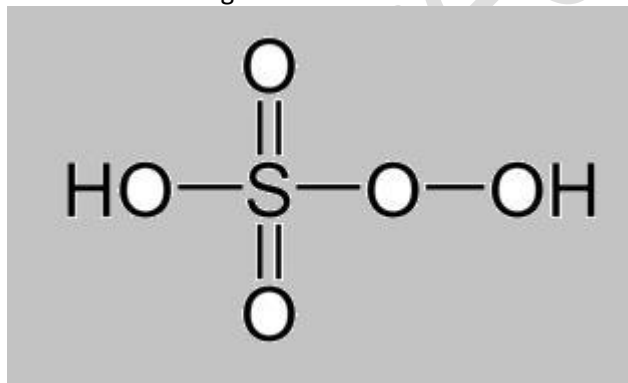
- It contains one S-S bond.
- Its structure is given below:



Dithionic acid

(h) Peroxymonosulphuric acid:

- It contains one peroxo group, it is also known as Caro's acid.
- It contains one peroxo group.
- In it the oxidation state of S is +6.
- Its structure is given below.



Peroxymonosulphuric acid

Di oxygen

Oxygen is 21% by volume of air.

It is prepared by Karl Wilhelm Scheele and the other reactions were done by Priestly.

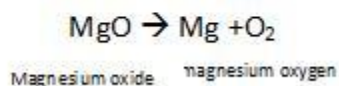
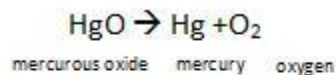
Isotopes of oxygen: O^{16} , O^{17} , O^{18}

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Preparation of dioxygen

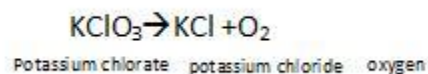
General method of preparation:

We get oxygen whenever we heat any metal oxide like:



In laboratory we prepare oxygen by:

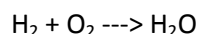
By heating potassium chlorate



This reaction occurs on heating, in presence of MnO_2 at 420K.

Industrial preparation: By electrolysis of water.

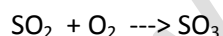
The silent electric discharge is passed so that the reaction do not becomes reversible.



Properties of di oxygen

- It is colorless, odorless and tasteless gas.
- It is soluble in water.
- It is highly inflammable.
- Chemical properties.
- It is neutral to litmus solution.
- It is supporter of combustion.
- It oxidizes food and produce energy.
- Reaction with metals :
- $\text{Mg} + \text{O}_2 \rightarrow \text{MgO}$
Magnesium Oxide
- $\text{Al} + \text{O}_2 \rightarrow \text{Al}_2\text{O}_3$
Aluminium Oxide

It also reacts with some compounds:



Uses of di oxygen

- It is supporter of life.
- It is used in oxy acetylene flame.
- Liquid oxygen is used as rocket fuel.
- The radioactive isotope of it is used as tracer for many chemical reactions.
- It is used to prepare synthesis gas.

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Classification of oxides

We have different types of oxides

- Normal oxides
- Poly oxides

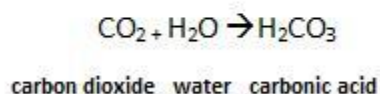
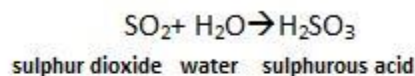
The poly oxides are of further different types:

- Peroxides: In this the O_2^{2-} ion is present like H_2O_2
- Super oxides: In this the O_2^- ion is present like KO_2
- Sub oxides: In this oxygen has valence less than -2 like N_2
- Mixed oxides: In this oxygen has oxidation number in fraction like Fe_3O_4

On the basis of nature they are classified as:

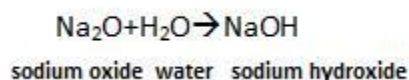
- Acidic
- Basic
- Neutral

1. **Acidic oxides:** That dissolve in water to give acids:



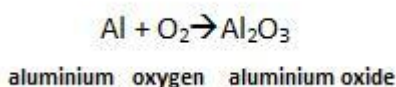
All non metallic are acidic in nature.

2. **Basic oxides:** That dissolves in water to give bases.

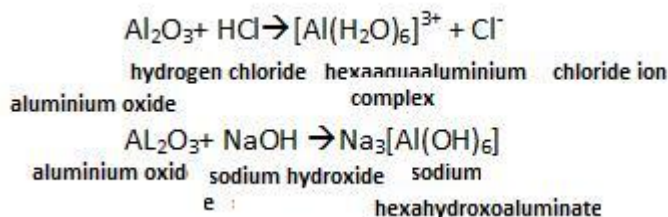


The metal oxides are basic in nature.

3. **Amphoteric oxides:** Metalloids give amphoteric oxides.



It behave as acid as well as base.



4. **Neutral oxides**

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They are very less in number. They are neither acidic nor basic

Example: laughing gas.

Ozone

It is represented as O_3 . It is found in upper atmosphere.

Preparation:

- It is prepared when ultraviolet rays. They react with oxygen of upper atmosphere and splits oxygen molecule in oxygen atoms. Then this oxygen atom combines with oxygen molecule to form ozone:
- $3O_2 \rightarrow 2O_3$
- Oxygen Ozone
- The reaction is endothermic approx. 142.7kJ of heat is needed.
- For preparing pure ozone we use ozoniser, in which the electric spark is passed through oxygen gas and we get ozone.

Properties of ozone

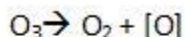
Physical properties

- It is blue gas with pungent odour.
- It is heavier than air.
- It is slightly soluble in water.
- It is diamagnetic.
- The depletion of ozone is harmful for us.

Chemical properties

1. Effect of heat: If we heat ozone it decompose to give oxygen molecule that is $2O_3 \rightarrow 3O_2$
2. Oxidizing agent: It is stronger oxidizing agent than oxygen gas

Because it decomposes to form:



ozone oxygen nascent oxygen

So both the oxygen form oxidizes the other.

- Like it converts $PbS \rightarrow PbSO_4$

The reaction involved is:

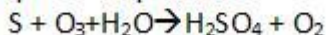


lead sulphide ozone lead sulphate oxygen

- It converts S to sulphuric acid



sulphur sulphuric acid



sulphur ozone water sulphuric acid oxygen

Sulphuric acid

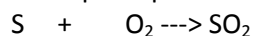
Its molecular formula is H_2SO_4 .

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Preparation of sulphuric acid

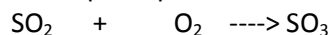
It is prepared from Contact's process that is:

1st step: Preparation of sulphur dioxide:



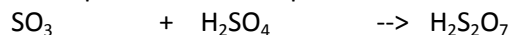
Sulphur Oxygen Sulphur dioxide

2nd step: Preparation of sulphur trioxide:



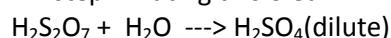
Sulphur dioxide Oxygen Sulphur trioxide

3rd step: Reaction of sulphur trioxide with concentrated Sulphuric acid:



Sulphur Trioxide Sulphuric Acid Oleum

4th step: Diluting this oleum:



Oleum Water Sulphuric Acid

This sulphuric acid formed is 99% pure.

Sulphuric acid

Its molecular formula is H_2SO_4 .

Preparation of sulphuric acid

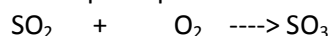
It is prepared from Contact's process that is:

1st step: Preparation of sulphur dioxide:



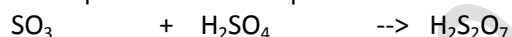
Sulphur Oxygen Sulphur dioxide

2nd step: Preparation of sulphur trioxide:



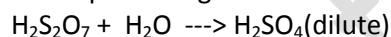
Sulphur dioxide Oxygen Sulphur trioxide

3rd step: Reaction of sulphur trioxide with concentrated Sulphuric acid:



Sulphur Trioxide Sulphuric Acid Oleum

4th step: Diluting this oleum:



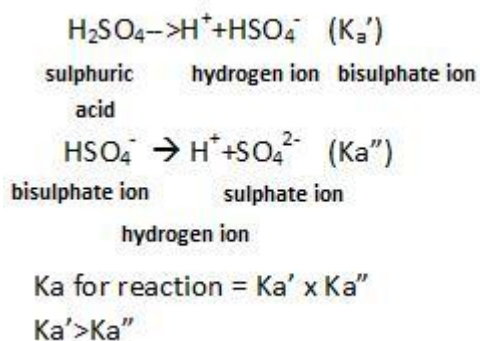
Oleum Water Sulphuric Acid

This sulphuric acid formed is 99% pure.

It is highly reactive due to:

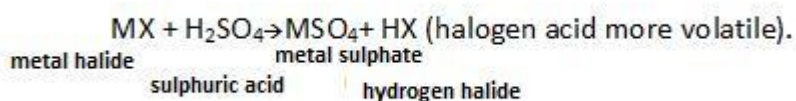
- Low volatility
 - Strong acidic character
 - Strong affinity for water
 - Its ability to act as oxidizing agent
1. **Dissociation:** Sulphuric acid is dibasic in nature

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Because of formation of this bisulphate and sulphate ions it forms two types of salts bisulphate's and bisulphites that is NaHSO_4 and Na_2SO_4 .

- Because of low volatility, it can be used for preparing volatile acids that is halogen acids.

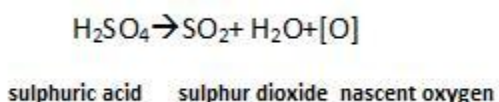


- It behaves as dehydrating agent, that is, if it falls on skin it causes burning sensation. In a same way it can convert sugar solution to black mass.

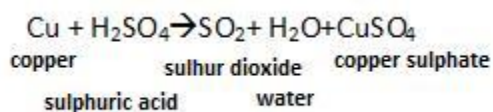
(conc. H_2SO_4)



- It behaves as oxidizing agent.



It oxidizes many like Cu to Cu^{2+} .



Uses of sulphuric acid

- It is used in making fertilizers.
- It is king of chemicals so have wide use in industries.
- It is dehydrating agent.
- It acts as an oxidizing agent.

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Introduction

The members of group 17 are:

- Fluorine(F)
- Chlorine(Cl)
- Bromine(Br)
- Iodine (I)
- Astatine (At)

Physical properties of group 17

1. **Electronic configuration**-The general electronic configuration for this group is ns^2np^5
 - Fluorine (F) $[\text{He}]2s^2, 2p^5$
 - Chlorine (Cl) $[\text{Ne}]3s^2, 3p^5$
 - Bromine (Br) $[\text{Ar}]3d^{10}4s^2 4p^5$
 - Iodine (I) $[\text{Kr}]4d^{10}5s^2, 5p^4$
 - Astatine (At) $[\text{Xe}]4f^{14}, 5d^{10}, 6s^2, 6p^4$
2. **Atomic size**: It increases down the group as every time a new shell is added as we move down. If we compare size of group 17 elements with group 16 then we see that group 17 is smaller due to increased nuclear charge.
3. **Ionization energy**: If we compare ionization energy of group 17 and group 16 we see that group 17 has higher energy than group 16 because of smaller size of group 17 elements.
4. **Electron gain enthalpy**:
 - Along period it is more negative because of attraction towards electron as of increased nuclear charge.
 - Down the group electron gain enthalpy keeps on becoming less negative because nuclear charge decreases and size.
 - So, the group 17 has highest electron gain enthalpy due to smallest size in periodic table.
 - Please note that: Fluorine has less electron gain enthalpy than chlorine because due to small size of oxygen the incoming electron suffers repulsion therefore, electron gain enthalpy is less negative as compared to chlorine.
5. **Electro negativity**: Group 17 elements are more electro negative than group 16 because of small size of group 17 elements. This group has highest electro negativity in whole periodic table.
Fluorine is most electronegative in periodic table. Down the group electronegativity decreases as the size increases.
6. **Melting point and boiling points**: It increases down the group as size and mass increases the Vander wall force also increases therefore melting and boiling point increases.
7. **Color**: All halogens are colored like:
Fluorine: Dull yellow in color.
Chlorine: Greenish yellow.
Bromine: Reddish brown.
Iodine: Violet.
8. **Oxidation states**: They show variable oxidation states like:
Fluorine: -1
Chlorine: -1, +1, +3, +7
Bromine : -1, +1, +3, +5, +7
Iodine: -1, +1, +3, +5, +7
 - Higher oxidation states of halogens are used when they are combining with small size highly electronegative ions.
 - All halogens are very reactive and reactivity decreases down the group.

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- All act as Lewis acids as they accept electron.
- Fluorine is the strong oxidizing agent among all.

Anomalous behavior of Fluorine:

- Smallest size.
- Highest electronegativity.
- No vacant d orbital.

Low F-F bond dissociation energy.

Trends in chemical reactions

1. **Reaction with hydrogen:** They form their respective halogen acids of formula HX that is :

HF (Hydrogen Fluoride) HCl (Hydrogen Chloride) HBr (Hydrogen Bromide)
HI (Hydrogen Iodide)

The properties of halogen acids are:

- (a) All have linear structure with bond angle 180 degree.
- (b) Out of all only HF is liquid otherwise all are gases.
HF is liquid due to hydrogen bonding they occur as associated molecules.
- (c) Stability: The stability of hydrides depends upon the comparability of size. The order of stability of hydrides is:
 $HF > HCl > HBr > HI$
Due to increase in size, bond length increase due to which bond dissociation energy decrease therefore stability decrease.
- (d) Reducing nature: The order of reducing character of hydrides is:
 $HF < HCl < HBr < HI$
All are Arrhenius acids. The HI has weakest bond therefore release of H is much easier.
- (e) Boiling point: The boiling point depends upon Vander wall force and this Vander wall force increases with increase in size.
 $HF > HCl < HBr < HI$
Due to hydrogen bonding HF has highest boiling point.
- (f) Polarity: All halogen acids are polar in nature. Greater the size of anion more is the polarizability more is the covalent character. Out of all, HF is highly polar.

2. **Reaction with oxygen:** They react with oxygen to form their respective oxides.

Due to less electro negativity difference the oxides are un-stable.

The oxides formed by them are :

Fluorine – OF_2 and O_2F_2

Chlorine – $Cl_2O, ClO_2, Cl_2O_6, Cl_2O_7$

Bromine – Br_2O, BrO_2, BrO_3

Iodine – I_2O_4, I_2O_5, I_2O_7

The order of stability of their halides are :

$I > Br > Cl > F$

The reason behind this trend is due to some thermodynamic reasons.

Chlorine gas (Cl_2)

It was discovered by Scheele .The name of chlorine was given by Davy.

Preparation

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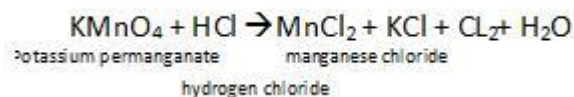
Lab. Preparation:

- By heating pyrolusite ore that is MnO_2 with HCl



Manganese dioxide hydrogen chloride manganese chloride

- (b) By heating potassium permanganate with HCl :



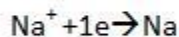
Industrial preparation:

- (a) By deacon's process : $\text{HCl} + \text{O}_2 \rightarrow \text{Cl}_2 + \text{H}_2\text{O}$
hydrogen chloride oxygen chlorine gas water
- (b) By electrolysis of sodium chloride :

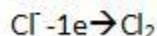


sodium chloride sodium ion chloride ion

Reaction at cathode:



Reaction at anode:



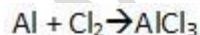
(Greenish yellow gas)

Physical properties of chlorine gas:

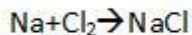
- It is greenish yellow gas.
- It has strong pungent suffocating odor.
- It is poisonous gas.
- It is soluble in water and the solution so formed is chlorine water.

Chemical properties of chlorine gas

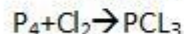
- Effect on litmus:** Dry chlorine gas has no effect on litmus but the moist chlorine do have the effect, as it turns blue litmus red due to formation of HCl .
- Reaction with metals and non metals:** It reacts with metals and non metals to form respective chlorides that is given below:



Aluminium chloride

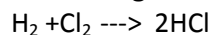


Sodium chloride



phosphorous trichloride

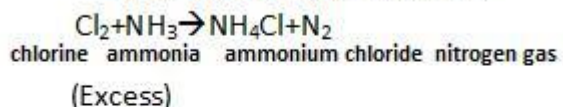
- It has great affinity for hydrogen to form HCl



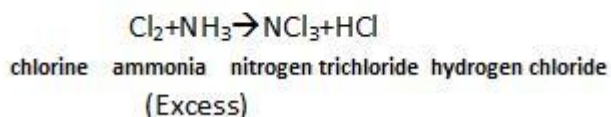
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4. Reaction with ammonia

- When Ammonia in excess:

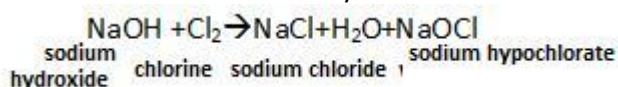


- When chlorine in excess:

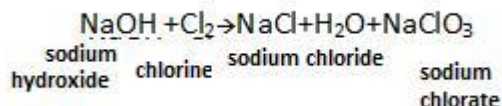


○ Reaction with alkalis

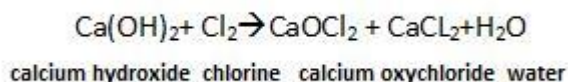
- With dilute and cold sodium hydroxide



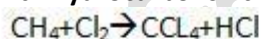
- With hot and concentrated NaOH:



With calcium hydroxide it forms bleaching powder:



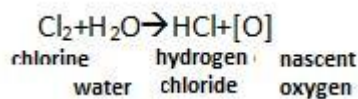
5. Reaction with hydrocarbons: It occurs in presence of light.



Methane chlorine Carbon tetrachloride

6. Bleaching action of chlorine gas

It is due to nascent oxygen produced by moist chlorine:

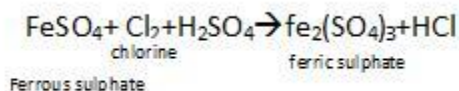


Colored matter + [O] → colorless matter

7. Chlorine act as oxidizing agent: It is due to nascent oxygen.

For example:

- It oxidizes $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+}$



○

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Uses of chlorine gas

- It is used for bleaching purpose.
- It is used in extraction of gold and silver.
- It is used in manufacture of dyes etc.
- It is used in preparation of poisonous gases like phosgene COCl_2 , tear gas CCl_3NO_2

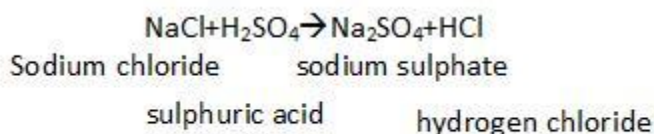
Hydrogen chloride

It was discovered by Glauber and the Davy was the one who said that it consist of H and Cl.

Preparation of hydrogen chloride

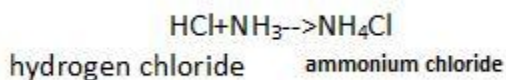
Preparation:

It is prepared by reacting sodium chloride with sulphuric acid and the following reaction occurs:

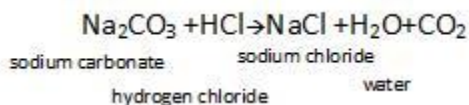


Properties of hydrogen chloride

- It is colorless gas with pungent smell.
- It can be easily liquefied.
- It freezes to white crystalline solid.
- It is highly soluble in water.
- It readily reacts with ammonia forming ammonium chloride:



-
- It forms aqua regia that is a mixture of HNO_3 with HCl in ratio of 1:3 that helps in dissolving noble metals.
- It can decompose salts of weaker acids:



Uses of hydrogen chloride

- It is used in manufacturing of chlorine gas, ammonium chloride, etc.
- It is used for extracting glue from bones.
- It is used in making medicines.
- It is used in making aqua regia.

Oxy acids of halogens

The oxy acids of halogens are:

Fluorine

- $\text{HFO} (+1)$ Hypofluorous acid

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Chlorine

- HClO (+1) Hypochlorous acid
- HClO_2 (+2) Chlorous acid
- HClO_3 (+3) Chloric acid
- HClO_4 (+4) Perchloric acid

Bromine

- HBrO (+1) Hypobromous acid
- HBrO_3 (+3) Bromic acid
- HBrO_4 (+4) Perbromic acid

Iodine

- HIO (+1) Hypoiodous acid
- HIO_3 (+3) Iodic acid
- HIO_4 (+4) Periodic acid

Properties of oxy acids of halogens

Acidic strength :

- The acidic strength of these oxy acids having same oxidation number decreases with increase in size because the electro negativity decreases as we go down the group from chlorine to iodine.
- This is the reason that to withdraw electrons from oxygen atom towards itself decreases from chlorine to iodine.
- As a result the tendency to pull the electrons from hydrogen decreases and the release of hydrogen ion becomes difficult.
- The order of acidic strength is :
 $\text{HClO} < \text{HClO}_2 < \text{HClO}_3 < \text{HClO}_4$

1. Oxidizing power and thermal stability :

- As the oxidation number increase the oxidation power decreases in order :
 $\text{HClO} > \text{HClO}_2 > \text{HClO}_3 > \text{HClO}_4$
- This is because the halogen oxygen bond becomes more covalent. As a result the thermal stability increases. Thus the hypohalites are stronger oxidizing agents than perhalates.
- With increase in oxidation number of halogen the thermal stability of both the acids and salts increases thus the stability of oxy acids are in order:
 $\text{HClO} < \text{HClO}_2 < \text{HClO}_3 < \text{HClO}_4$
- As the number of oxygen atoms increases in an ion, there is greater dispersal of negative charge therefore, greater is the stability of ion formed.
- The acidity of oxo- acids of different halogens which have same oxidation number decreases from chlorine to iodine. This is due to decrease in electro negativity with increase in size.

Inter-halogen compounds

The compound of one halogen with the other halogen is called inter halogen compounds. They are formed due to large electro negativity and size difference between halogens.

Let's take an example: Let's assume two halogens A and B.

B is more electronegative than A then they will form four types of compounds:

- AB example: ClF (Chlorine monofluoride), BrF (Bromine monofluoride).
- AB_3 example: ClF_3 (Chlorine trifluoride), BrF_3 (Bromine trifluoride).
- AB_5 example: BrF_5 (Bromine pentafluoride).
- AB_7 example: IF_7 (iodine heptafluoride).

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The inter-halogen compounds are unstable and very reactive.

Properties:

- The larger halogen always serves as a central atom.
- The bonds formed are covalent.
- As the size difference decreases stability decreases and the polarity increases.
- Hydrolysis of these compounds always produces halide ion from smaller halogen and oxy halide from bigger halogen.
- They are strong oxidizing agents.

Structure of inter-halogen compounds:

1. AB type – linear
2. AB₃ type - trigonal bi pyramidal
3. AB₅ type - square pyramidal
4. AB₇ type - pentagonal bipyramidal

Introduction

This group has noble gases or inert gases

The members of this group are:

Helium (He)

Neon (Ne)

Argon (Ar)

Krypton (Kr)

Xenon (Xe)

Radon (Rn)

Physical properties of group 18

1. The electronic configuration for them are ns^2np^6

- Helium $1s^2 2s^2$
- Neon $1s^2, 2s^2, 2p^6$
- Argon $1s^2, 2s^2, 2p^6, 3s^2, 3p^6$
- krypton $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^{10}, 4p^6$
- xenon $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^{10}, 4p^6, 4d^{10}, 5s^2, 5p^6$
- radon $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^{10}, 4p^6, 4d^{10}, 5s^2, 5p^6, 4f^{14}, 5d^{10}, 6s^2, 6p^6$

2. **Atomic size** : : It increases down the group as every time a new shell is added as we move down. They actually have Vander wall radii.

3. **Ionization energy**: They have highest ionization energy due to complete octet.

4. **Electron gain Enthalpy**: It is positive as they have complete octet so they have no attraction for incoming electron.

5. **Melting and boiling point**: It is low due to weak force that exists that is Vander wall force.

Down the group size increases therefore Vander wall force also increases so as melting and boiling point increase.

6. All noble gases are **odorless and colorless and tasteless**.

7. All noble gases are **sparingly soluble in water**.

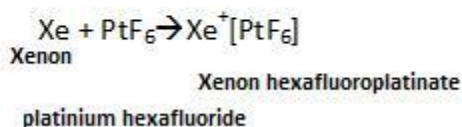
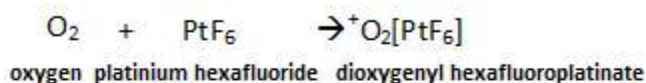
8. All are inert gases as they have **complete octet**.

9. All of them **are monatomic**.

Chemical properties of group 18

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- According to the stable electronic configuration fact they have no compounds but the scientist Neil Bart let found that oxygen and xenon are very much similar.
Like both have almost same masses. Atomic radius of both is same.
- So, like oxygen combines with platinum fluoride in the same way xenon also combines:

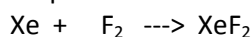


Compounds of Xenon and fluorine

Xenon easily combines with fluorine to form xenon fluorides:

(a) XeF_2

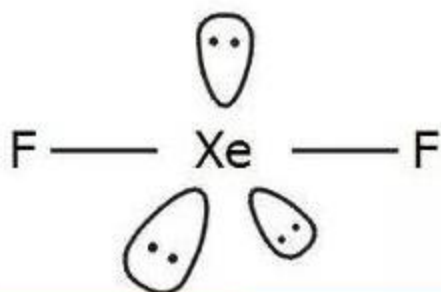
Preparation:



(Xenon) Fluroide XenonFluoride

2 : 1 (catalyst is nickel, 673k and 1 bar)

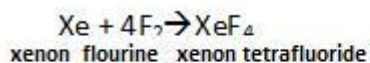
Structure:



Xenon difluoride

Reaction of it with water:

(b)XeF₄ xenon tetrafluoride

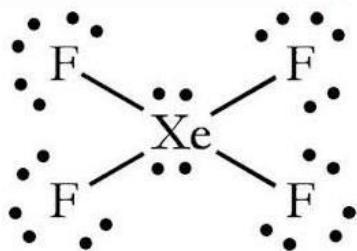


1 : 5 (catalyst Ni ,temp.373 k ,6-7 bar)

Preparation:

The structure of xenon tetrafluoride is:

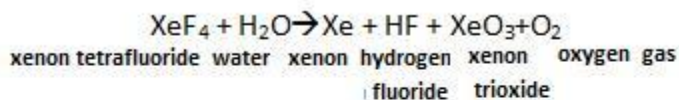
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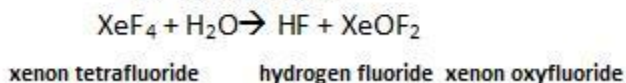
Xenon tetrafluoride

Reaction with water:

At normal temperature they are explosive in nature.

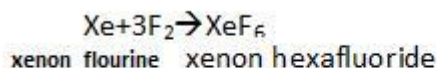


temp -80celsius

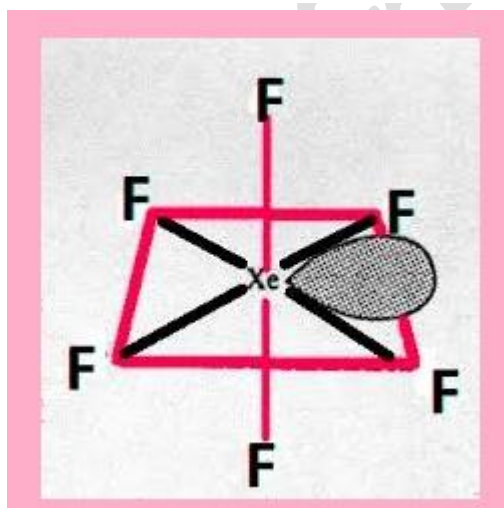


(c) XeF_6 xenon hexafluoride

Preparation:



1: 20(catalyst nickel,temp.573k,60-70 bar)



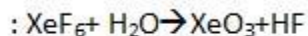
xenon hexafluoride

Reaction with water

(d) XeO_3 xenon trioxide

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Preparation:

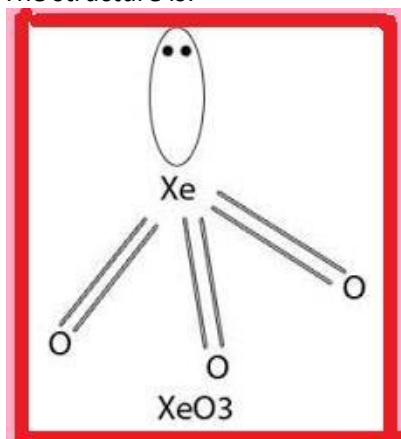


xenon hexafluoride xenon trioxide hydrogen fluoride

The hybridization is: sp^3 .

The geometry is pyramidal.

The structure is:



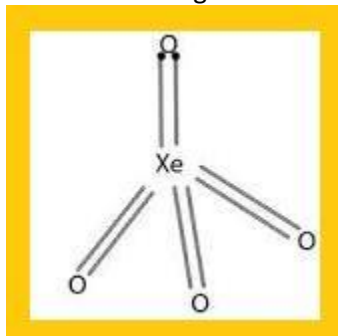
xenon trioxide

(e) XeO_4 (xenon tetra oxide)

The hybridization is sp^3 .

The geometry is tetrahedral.

The structure is given below:

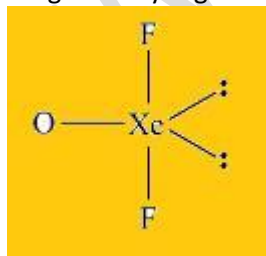


xenon tetra oxide

(f) XeOF_2 (xenon oxy fluoride)

The hybridization is sp^3d .

The geometry is given below:



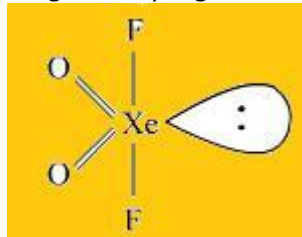
xenon oxy fluoride

Class 12th Chemistry Chapter 7 P Block Elements Revision Notes & Important Question (www.free-education.in)

(g) XeO_2F_2

The hybridization is sp^3d^2 .

The geometry is given below:



Xenon dioxyfluoride

Uses of noble gases

- Helium is used in weather balloons.
- A mixture of helium and oxygen is used in cylinders by divers etc.
- Liquid helium is used maintain low temperature or we can say it is cryogenic liquid.
- Neon is used in sign board signals.
- Neon is used in filling up sodium vapor lamp.
- Neon is used in protecting electrical instruments like voltmeter.
- Argon is used in filling electric bulbs.
- Argon helps in providing inert atmosphere.
- Krypton is used in flash bulbs of high speed photography.
- Radon is used in treatment of cancer.
- Radon is used to treat metals.