

# CHEMISTRY STUDY MATERIALS FOR CLASS 12 (NCERT BASED NOTES OF CHAPTER – 7)

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DATE:- 17/07/2021

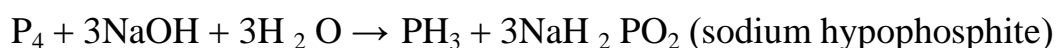
## The p-Block Elements

### Phosphorus

#### The allotropic forms of phosphorus:

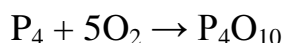
Phosphorus exists mainly in three allotropic forms – white (yellow) phosphorus, red phosphorus and black phosphorus

1. **White phosphorus:** It is a translucent white waxy solid. It is poisonous, insoluble in water but soluble in carbon disulphide and glows in dark (chemiluminescence). It dissolves in boiling NaOH solution in an inert atmosphere giving  $\text{PH}_3$  (phosphine).

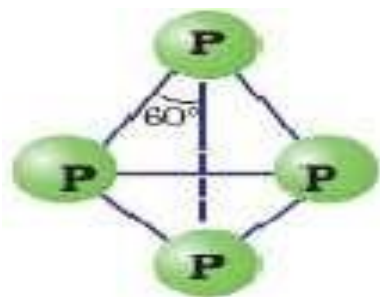


White phosphorus is less stable and therefore, more reactive. This is because in white phosphorus, the P-P-P bond angles are only  $60^\circ$ . So it has greater angular strain and highly unstable.

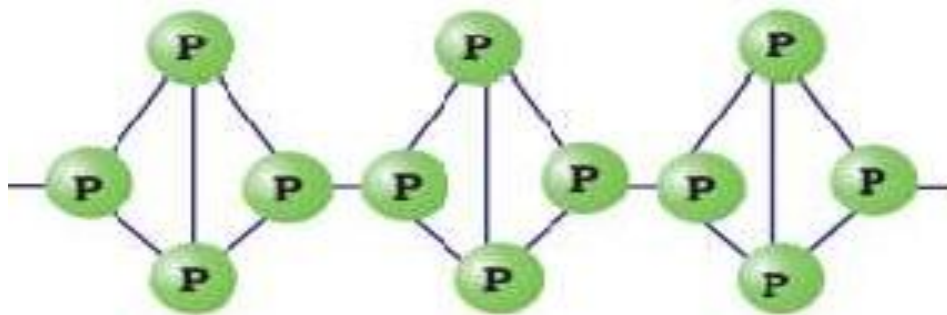
It readily catches fire in air to give dense white fumes of  $\text{P}_4\text{O}_{10}$ .



It consists of discrete tetrahedral  $\text{P}_4$  molecule



2. **Red phosphorus:** It is obtained by heating white phosphorus at 573K in an inert atmosphere for several days. Red phosphorus has iron grey luster. It is odourless, non-poisonous and insoluble in water as well as in carbon disulphide. Chemically, red phosphorus is much less reactive than white phosphorus. It does not glow in the dark. It contains polymeric chains of  $\text{P}_4$  tetrahedral.



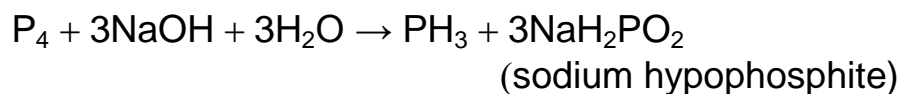
3. **Black phosphorus:** It has two forms-  $\alpha$ -black phosphorus and  $\beta$ -black phosphorus.  $\alpha$ -black phosphorus is formed when red phosphorus is heated in a sealed tube at 803K. It does not oxidise in air.  $\beta$ -Black phosphorus is prepared by heating white phosphorus at 473K under high pressure. It does not burn in air up to 673K.

### Phosphine (PH<sub>3</sub>)

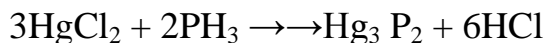
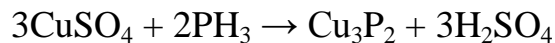
**Preparation:** It is prepared by the reaction of calcium phosphide with water or dilute HCl.



In the laboratory, it is prepared by heating white phosphorus with concentrated NaOH solution in an inert atmosphere of CO<sub>2</sub>.



**Properties:** It is a colourless gas with rotten fishy smell and is highly poisonous. It is slightly soluble in water. The solution of PH<sub>3</sub> in water decomposes in presence of light giving red phosphorus and H<sub>2</sub>. When absorbed in copper sulphate or mercuric chloride solution, the corresponding phosphides are obtained.



Like NH<sub>3</sub>, Phosphine is weakly basic and gives phosphonium compounds with acids.



**Uses:** Phosphine is technically used to produce Holme's signal. Containers containing calcium carbide and calcium phosphide are pierced and thrown in the sea. The gases evolved burn and serve as a signal.

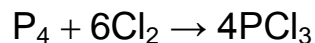
It is also used in smoke screens.

## Phosphorus Halides

Phosphorus forms two types of halides-  $PX_3$  and  $PX_5$

### Phosphorus trichloride ( $PCl_3$ )

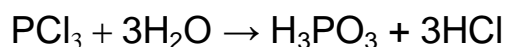
**Preparation:** It is obtained by passing dry chlorine over heated white phosphorus.



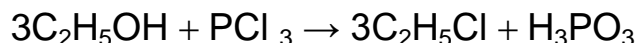
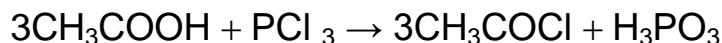
It is also obtained by the action of thionyl chloride with white phosphorus.



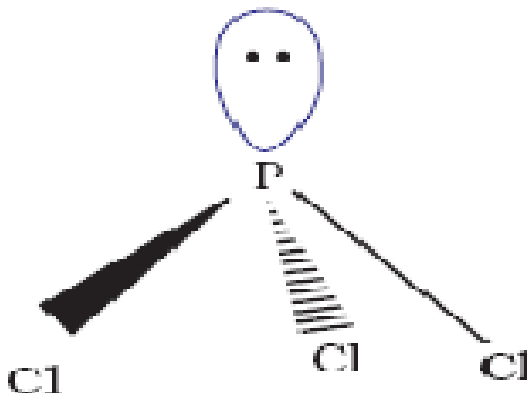
It is a colourless oily liquid and hydrolyses in the presence of moisture.



It reacts with organic compounds containing  $-OH$  group such as  $CH_3COOH$ ,  $C_2H_5OH$ .

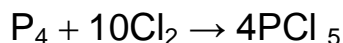


**Structure:** It has a pyramidal shape as shown, in which phosphorus is  $sp^3$  hybridized.

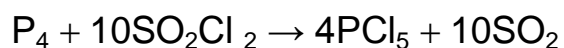


### Phosphorus Pentachloride ( $PCl_5$ )

**Preparation:** Phosphorus Pentachloride is prepared by the reaction of white phosphorus with excess of dry chlorine.

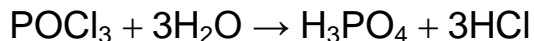
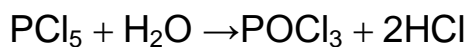


It can also be prepared by the action of  $SO_2Cl_2$  on phosphorus.



## Properties

$\text{PCl}_5$  is a yellowish white powder and in moist air, it hydrolyses to  $\text{POCl}_3$  and finally gets converted to Phosphoric acid.



When heated, it sublimes but decomposes on strong heating.

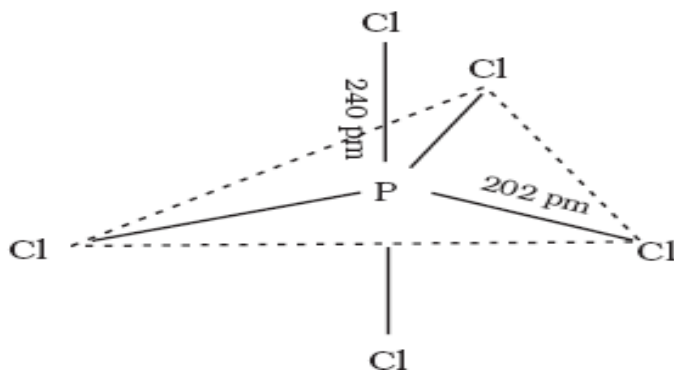


It reacts with organic compounds containing  $-\text{OH}$  group to give chloro derivative.



## Structure:

In gaseous and liquid phases, it has a trigonal bipyramidal structure. The three equatorial  $\text{P}-\text{Cl}$  bonds are equivalent, while the two axial bonds are longer than equatorial bonds. This is due to the fact that the axial bond pairs suffer more repulsion as compared to equatorial bond pairs.



In the solid state it exists as an ionic solid,  $[\text{PCl}_4]^+[\text{PCl}_6]^-$  in which the cation,  $[\text{PCl}_4]^+$  is tetrahedral and the anion,  $[\text{PCl}_6]^-$  is octahedral.

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