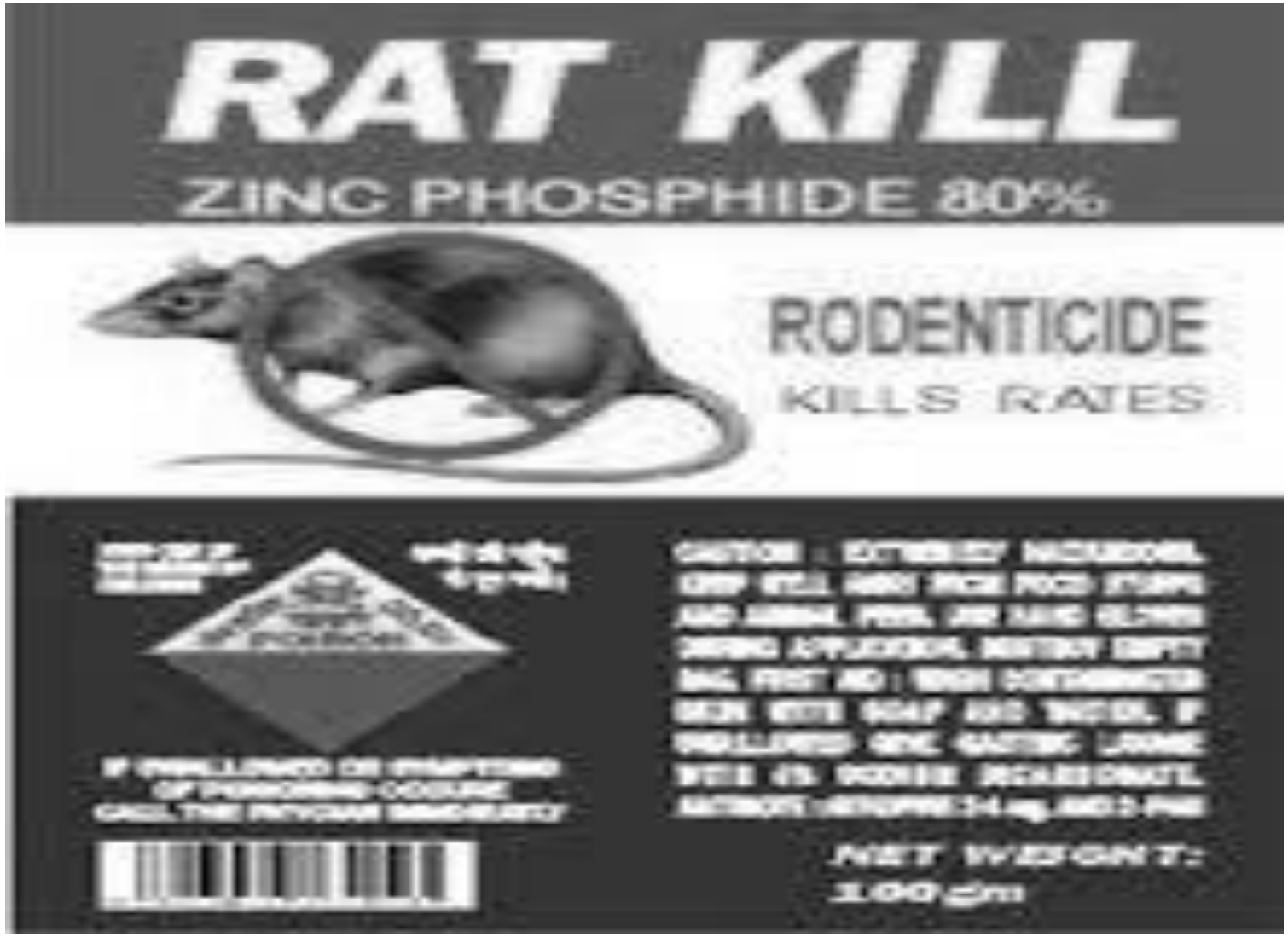
Phosphorous



Phosphorus was discovered by German chemist, Brandt in 1669. Literal meaning of phosphorus is light bearer because it can glows in dark. It lies in group VA(15) in periodic table. Due to good affinity of phosphorus towards oxygen, phosphorus does not occur free in nature. Mostly phosphorus occurs in the form of compounds or minerals. Phosphorite $3Ca_3(PO_4)_2$, Fluorapalite $3Ca_3(PO_4)_2.CaF_2$ and chlorapatite 3Ca2(PO4)2.CaCl2 are major ores of phosphorus. Phosphorus is an essential constituent in plant cells and animal cells. Phosphate is an important constituent of DNA. Calcium phosphate constitutes about 30 percent of bones and teeth. It is called element of bone.

Symbol	P
Atomic Number	15
Atomic mass	31amu
Electronic configuration	$1s^2 2s^2 2p^6 3s^2 3p^3$

Allotropy

Phosphorous occurs in many allotropic forms. Among them white or yellow and red Phosphorous are most common. Black Phosphorous is thermodynamically most stable allotrope.

Allotropes of phosphorus

The different allotropic forms of phosphorous are as follows.

1. White or yellow phosphorus
2. Red phosphorus
3. Black phosphorus
4. Violet phosphorus
5. Scarlet phosphorus

Preparation, properties and uses of phosphine (PH_3)

Phosphine is a colourless gas with rotten fish smell. It is a poisonous gas.

Molecular formula = PH_3

Mol. wt. = 34

Vapour density = 17

General methods of preparation of phosphine

1. From phosphonium iodide: When phosphonium iodide is warmed with KOH solution, phosphine gas is formed.

$$PH_4I + KOH \longrightarrow KI + H_2O + PH_3$$

2. From calcium phosphide: When calcium phosphide is reacted with water, phosphine gas is formed.

$$Ca_3P_2 + 6H_2O \longrightarrow 3Ca(OH)_2 + 2PH_3$$

In this reaction, some amount of P_2H_4 may be produced as by product.

Laboratory preparation of phosphine (PH_3)

When white phosphorus is heated with caustic soda or caustic potash, phosphine gas is formed.

$$P_4 + 3NaOH + 3H_2O \xrightarrow{\Delta} \underset{\text{Sod. Hypophosphite}}{3NaH_2PO_2} + \underset{\text{Phosphine}}{PH_3\uparrow}$$

I. Physical properties

1. Phosphine is colourless gas with rotten fish smell.
2. It is heavier than air.
3. Pure PH_3 is not spontaneously inflammable but PH_3 with P_2H_4 is spontaneously inflammable.
4. It is slightly soluble in water.
5. It is highly poisonous gas.

Chemical properties

1. Action of air: Phosphine is non-supporter of combustion. But when phosphine is heated with oxygen, phosphorous pentoxide or phosphoric acid is formed.

$4PH_3 + 8O_2 \longrightarrow P_2O_5 + 6H_2O$

$PH_3 + 2O_2 \longrightarrow H_3PO_4$

2. Basic nature: PH_3 is feebly basic but does not change the colour of moist red litmus paper. It forms series of phosphonium compounds.

$PH_3 + HCl \longrightarrow PH_4Cl$

$PH_3 + HBr \longrightarrow PH_4Br$

$PH_3 + HI \longrightarrow PH_4I$

However, it is weaker base than NH_3.

$PH_3 + H_2O \longrightarrow PH_4^+ + OH^-$

3. Action with Cl2 gas: Phosphine reacts with Cl_2 to give PCl_3 or PCl_5 depending upon the reaction condition.

$PH_3 + 3Cl_2 \longrightarrow PCl_3 + 3HCl$

$PH_3 + 4Cl_2 \longrightarrow PCl_5 + 3HCl$

4. Phosphine as reducing agent: When PH_3 gas is passed into copper sulphate solution, black precipitate of copper phosphides is formed.

$2PH_3 + 3CuSo4 \longrightarrow Cu3P2\downarrow + H2SO4$

Similarly, when phosphine gas is passed into mercuric chloride ($HgCl_2$) solution then a red precipitate of mercuric phosphide is obtained.

$3HgCl_2 + 2PH_3 \longrightarrow Hg_3P_2\downarrow + 6HCl$

Brilliant red ppt.

Structure of PH_3

The phosphine molecule has pyramidal structure with one lone pair electrons on phosphorous atom.

Test of PH_3

a. It has rotten fish smell.

b. When PH_3 is passed into $CuSO_4$ solution, then black precipitate is formed.

Uses

a. PH_3 can be used as reducing agent.

b. It is used to prepare PCl_3, PCl_5, P_2O_5, etc.

c. Dense fumes are produced when phosphine is burned so it is used to make smoke screens.

d. It is used as a dopant in semiconductor industries.