CBSE Class 12 physics
Important Questions
Chapter 7
The p-Block Elements

5 Marks Questions

1. Give reasons :-

(a) Oxygen molecule is diatomic where as sulphur molecule is polyatomic.

(b) The most common oxidation state of oxygen is -2.

(c) H_2O is liquid whereas H_2S is gas at room temperature.

(d) The increasing order of acidic character in 16th group hydrides is $H_2O < H_2Se < H_2Te$.

(e) SF_6 is exceptionally stable, SH_6 does not exist.

Ans. (a) Oxygen being small in size forms effective and strong P π -P π bonds with other oxygen atom. Therefore oxygen molecule is diatomic and discrete whereas Sulphur due to its larger size, its orbitals cannot overlap effectively to form P π -P π bonds & completes valency by forming σ bonds with many sulphur atom. Therefore sulphur molecule is polyatomic solid.

(b) Since oxygen is highly electronegative, it has little tendency to give electrons. Therefore its most common oxidation state is -2.

(c) H_2O is liquid at room temperature due to presence of intermolecular Hydrogen bonding which is absent in H_2S.

(d) As we move down the group, the size of atom increases this make the bond of the element with hydrogen weak. Due to weaker bonds, the bond dissociation enthalpy decreases making the molecule more acidic. Therefore the order of acidic strength is.

$H_2O < H_2S < H_2Se < H_2Te$

(e) SF_6 is exceptionally stable due to steric reasons. Hydrogen being electropositive or less electronegative than fluorine cannot make the s- electrons of sulphur to participate in bonding. Therefore SF_6 does not exist.

2. Discuss the different types of oxides.

Ans. A binary compound of oxygen with another element is called oxide. Oxides can be simple or mixed. Simple oxides can be classified as acidic, basic Amphoteric or neutral.

An oxide that combines with water to give an acid is termed acidic oxide e.g. CO_2, SO_2 etc.

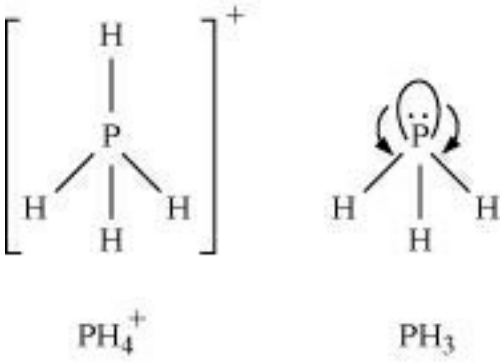
An oxide that combines with water to give a base is called basic oxide e.g. Na_2O , CaO, BaO etc.

An oxide that shows characteristics of both acids and bases is Amphoteric oxide e.g. Al_2O_3 .

An oxide that shows characteristic of neither acid nor base is called neutral oxide e.g. CO, NO and N_2O .

3. Bond angle in PH_4^+ is higher than that in PH_3. Why?

Ans. In PH_3, P is sp_3 hybridized. Three orbitals are involved in bonding with three hydrogen atoms and the fourth one contains a lone pair. As lone pair-bond pair repulsion is stronger than bond pair-bond pair repulsion, the tetrahedral shape associated with *sp*3bonding is changed to pyramidal. PH_3 combines with a proton to form PH_4^+ in which the lone pair is absent. Due to the absence of lone pair in PH_4^+, there is no lone pair-bond pair repulsion. Hence, the bond angle in PH_4^+ is higher than the bond angle in PH_3 .



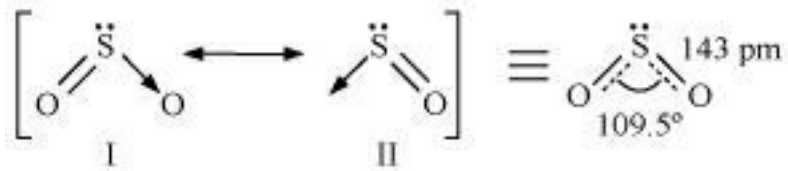
PH_4^+ PH_3

Concept insite: the long pair-bond pair repulsion is more than bond pair-bond pair repulsion.

4. Comment on the nature of two S-O bonds formed in SO_2 molecule. Are the two S-O bonds in this molecule equal?

Ans. The electronic configuration of S is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$.

During the formation of



SO_2, one electron from 3*p* orbital goes to the 3*d* orbital and S undergoes sp^2 hybridization. Two of these orbitals form sigma bonds with two oxygen atoms and the third contains a lone pair. *p*-orbital and *d*-orbital contain an unpaired electron each. One of these electrons forms $p\pi - p\pi$ bond with one oxygen atom and the other forms $p\pi : p\pi$ bond with the other oxygen. This is the reason SO_2 has a bent structure. Also, it is a resonance hybrid of structures I and II.

Both S-O bonds are equal in length (143 pm) and have a multiple bond character.

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

Ans. General trends in group15 elements

(i) Electronic configuration: All the elements in group 15 have 5 valence electrons. Their

general electronic configuration is $ns^2 np^3$.

(ii) Oxidation states: All these elements have 5 valence electrons and require three more electrons to complete their octets. However, gaining electrons is very difficult as the nucleus will have to attract three more electrons. This can take place only with nitrogen as it is the smallest in size and the distance between the nucleus and the valence shell is relatively small. The remaining elements of this group show a formal oxidation state of -3 in their covalent compounds. In addition to the -3 state, N and P also show -1 and -2 oxidation states.

All the elements present in this group show +3 and +5 oxidation states. However, the stability of +5 oxidation state decreases down a group, whereas the stability of +3 oxidation state increases. This happens because of the inert pair effect.

(iii) Ionization energy and electronegativity

First ionization decreases on moving down a group. This is because of increasing atomic sizes. As we move down a group, electronegativity decreases, owing to an increase in size.

(iv) Atomic size: On moving down a group, the atomic size increases. This increase in the atomic size is attributed to an increase in the number of shells.

6. Discuss the trends in chemical reactivity of group 15 elements.

Ans. General trends in chemical properties of group - 15

(i) Reactivity towards hydrogen:

The elements of group 15 react with hydrogen to form hydrides of type EH_3, where E = N, P, As, Sb, or Bi. The stability of hydrides decreases on moving down from NH_3 to BiH_3.

(ii) Reactivity towards oxygen:

The elements of group 15 form two types of oxides: E_2O_3 and E_2O_5, where E = N, P, As, Sb, or Bi. The oxide with the element in the higher oxidation state is more acidic than the other. However, the acidic character decreases on moving down a group.

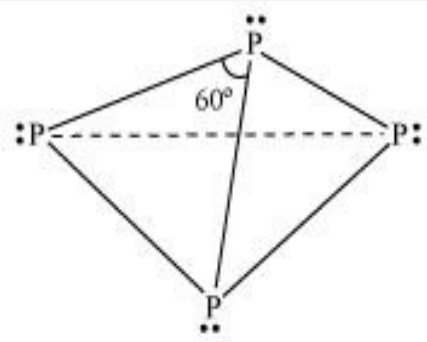
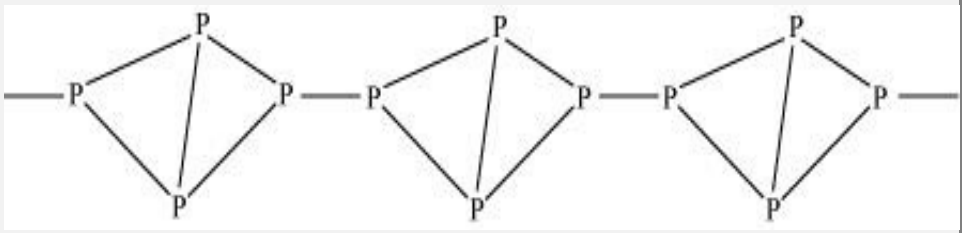
(iii) Reactivity towards halogens: The group 15 elements react with halogens to form two series of salts: EX_3 and EX_5. However, nitrogen does not form NX_5 as it lacks the *d*-

orbital. All trihalides (except NX_3) are stable.

(iv) Reactivity towards metals: The group 15 elements react with metals to form binary compounds in which metals exhibit -3 oxidation states.

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

Ans.

White phosphorus	**Red Phosphorus**
It is a soft and waxy solid. It possesses a garlic smell.	It is a hard and crystalline solid, without any smell.
It is poisonous.	It is non-poisonous.
It is insoluble in water but soluble in carbon disulphide.	It is insoluble in both water and carbon disulphide.
It undergoes spontaneous combustion in air.	It is relatively less reactive.
In both solid and vapour states, it exists as a P4 molecule. 	It exists as a chain of tetrahedral P4 units. 

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

Ans. The elements of group 16 are collectively called chalcogens.

(i) Elements of group 16 have six valence electrons each. The general electronic configuration of these elements is $ns^2\ np^4$, where n varies from 2 to 6.

(ii) Oxidation state:

Asthese elements have six valence electrons $\left(ns^2\ np^4\right)$, they should display an oxidation state of -2. However, only oxygen predominantly shows the oxidation state of -2 owing to its high electronegativity. It also exhibits the oxidation state of -1 $\left(H_2O_2\right)$, zero $\left(O_2\right)$, and +2 $\left(OF_2\right)$. However, the stability of the -2 oxidation state decreases on moving down a group due to a decrease in the electronegativity of the elements. The heavier elements of the group show an oxidation state of +2, +4, and +6 due to the availability of *d*-orbitals.

(iii) Formation of hydrides:

These elements form hydrides of formula H_2E, where E = O, S, Se, Te, PO. Oxygen and sulphur also form hydrides of type H_2E_2. These hydrides are quite volatile in nature.

9. Describe the manufacture of H_2SO_4 by contact process?

Ans. Sulphuric acid is manufactured by the contact process. It involves the following steps:

Step (i): Sulphur or sulphide ores are burnt in air to form SO_2.

Step (ii): By a reaction with oxygen, SO_2 is converted into SO_3 in the presence of V_2O_5 as a catalyst.

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

Step (iii): SO_3 produced is absorbed on H_2SO_4 to give $H_2S_2O_7$ (oleum).

$$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$$

This oleum is then diluted to obtain H_2SO_4 of the desired concentration.

In practice, the plant is operated at 2 bar (pressure) and 720 K (temperature). The sulphuric acid thus obtained is 96-98% pure.

10. How is SO_2 an air pollutant?

Ans. Sulphur dioxide causes harm to the environment in many ways:

1. It combines with water vapour present in the atmosphere to form sulphuric acid. This causes acid rain. Acid rain damages soil, plants, and buildings, especially those made of marble.

2. Even in very low concentrations, SO_2 causes irritation in the respiratory tract. It causes throat and eye irritation and can also affect the larynx to cause breathlessness.

3. It is extremely harmful to plants. Plants exposed to sulphur dioxide for a long time lose colour from their leaves. This condition is known as chlorosis. This happens because the formation of chlorophyll is affected by the presence of sulphur dioxide.

11. What are the oxidation states of phosphorus in the following:

(i) H_3PO_3 **(ii)** PCl_3 **(iii)** $Ca3P_2$

(iv) Na_3PO_4 **(v)** POF_3 **?**

Ans. Let the oxidation state of p be x.

(i) H_3PO_3

3+x+3(–2) = 0

3 + x – 6 = 0

x – 3 = 0

x = +3

(ii) PCl_3

x + 3(–1) =

x – 3 = 0

x = +3

(iii) Ca_3P_2

3(+2) + 2(x) = 0

6 + 2x = 0

2x = –6

x = –3

(iv) Na_3PO_4

3(+1) + x + 4(–2) = 0

3+x–8=0

x –5 = 0

x = +5

(v) POF_3

x + (–2) + 3(–1) = 0

x – 5 = 0

x = +5

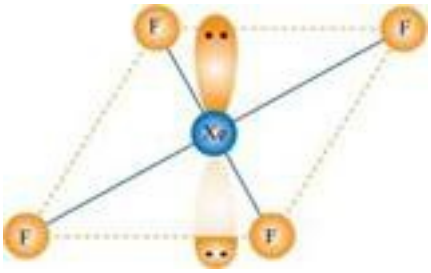
12. Give the formula and describe the structure of a noble gas species which is isostructural with:

(i) ICl_4^-

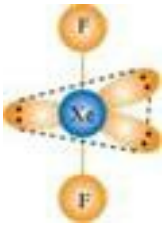
(ii) IBr_2^-

(iii) BrO_3^-

Ans. (i) XeF_4 is isoelectronic with ICl_4^- and has square planar geometry.



(ii) XeF_2 is isoelectronic to IBr_2^- and has a linear structure.



(iii) XeO_3 is isostructural to BrO_3^- and has a pyramidal molecular structure.