

Book Name: NCERT Solutions

**Question 1:**

Discuss the pattern of variation in the oxidation states of

- (i) B to Tl and (ii) C to Pb.

**Solution 1:****(i) B to Tl**

The electric configuration of group 13 elements is  $ns^2 np^1$ . Therefore, the most common oxidation state exhibited by them should be +3. However, it is only boron and aluminium which practically show the +3 oxidation state. The remaining elements, i.e., Ga, In, Tl, show both the +1 and +3 oxidation states. On moving down the group, the +1 state becomes more stable. For example, Tl (+1) is more stable than Tl (+3). This is because of the inert pair effect. The two electrons present in the s-shell are strongly attracted by the nucleus and do not participate in bonding. This inert pair effect becomes more and more prominent on moving down the group. Hence, Ga (+1) is unstable, In (+1) is fairly stable, and Tl (+1) is very stable.

Group 13 element	Oxidation state
B	+3
Al	+3
Ga, In, Tl	+1, +3

The stability of the +3 oxidation state decreases on moving down the group.

**(ii) C to Pb**

The electronic configuration of group 14 elements is  $ns^2 np^2$ . Therefore, the most common oxidation state exhibited by them should be +4. However, the +2 oxidation state becomes more and more common on moving down the group. C and Si mostly show the +4 state.

On moving down the group, the higher oxidation state becomes less stable. This is because of the inert pair effect. Thus, although Ge, Sn, and Pb show both the +2 and +4 states, the stability of the lower oxidation state increases and that of the higher oxidation state decreases on moving down the group.

Group 14 element	Oxidation state
C	+4
Si	+4
Ge, Sn, Pb	+2, +4

$\xrightarrow{\text{stability of +2 state increases}}$   
 C   Si   Ge   Sn   Pb  
 $\xrightarrow{\text{stability of +4 state decreases}}$

**Question 2:**

How can you explain higher stability of  $\text{BCl}_3$  as compared to  $\text{TlCl}_3$ ?

**Solution 2:**

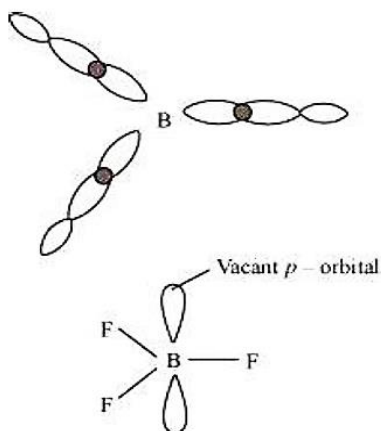
Boron and thallium belong to group 13 of the periodic table. In this group, the +1 oxidation state becomes more stable on moving down the group.  $\text{BCl}_3$  is more stable than  $\text{TlCl}_3$  because the +3 oxidation state of B is more stable than the +3 oxidation state of Tl. In Tl, the +3 state is highly oxidising and it reverts back to the more stable +1 state.

**Question 3:**

Why does boron trifluoride behave as a Lewis acid?

**Solution 3:**

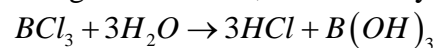
The electric configuration of boron is  $ns^2 np^1$ . It has three electrons in its valence shell. Thus, it can form only three covalent bonds. This means that there are only six electrons around boron and its octet remains incomplete. When one atom of boron combines with three fluorine atoms, its octet remains incomplete. Hence, boron trifluoride remains electron-deficient and acts as a Lewis acid.

**Question 4:**

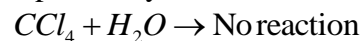
Consider the compounds,  $\text{BCl}_3$  and  $\text{CCl}_4$ . How will they behave with water? Justify.

**Solution 4:**

Being a Lewis acid,  $\text{BCl}_3$  readily undergoes hydrolysis. Boric acid is formed as a result.



$\text{CCl}_4$  completely resists hydrolysis. Carbon does not have any vacant orbital. Hence, it cannot accept electrons from water to form an intermediate. When  $\text{CCl}_4$  and water are mixed, they form separate layers.

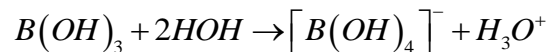


**Question 5:**

Is boric acid a protic acid? Explain.

**Solution 5:**

Boric acid is not a protic acid. It is a weak monobasic acid, behaving as a Lewis acid.



It behaves as an acid by accepting a pair of electrons from  $^-OH$  ion.

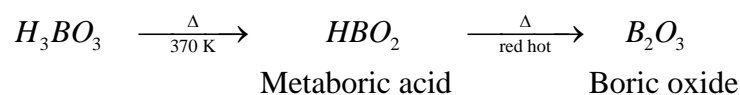
**Question 6:**

Explain what happens when boric acid is heated.

**Solution 6:**

On heating orthoboric acid ( $H_3BO_3$ ) at 370 K or above, it changes to metaboric acid ( $HBO_2$ ).

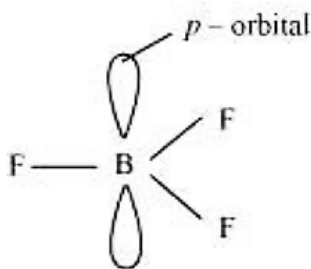
On further heating, this yields boric oxide  $B_2O_3$ .

**Question 7:**

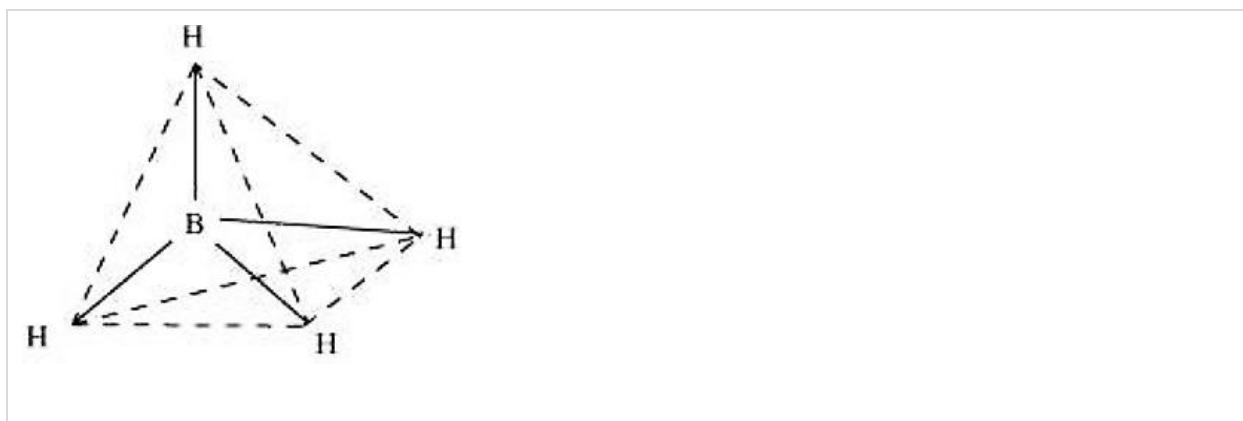
Describe the shapes of  $BF_3$  and  $BH_4^-$ . Assign the hybridisation of boron in these species.

**Solution 7:****(i)  $BF_3$** 

As a result of its small size and high electronegativity, boron tends to form monomeric covalent halides. These halides have a planar triangular geometry. This triangular shape is formed by the overlap of three  $sp^2$  hybridised orbitals of boron with the  $sp$  orbitals of three halogen atoms. Boron is  $sp^2$  hybridised in  $BF_3$ .

**(ii)  $BH_4^-$** 

Boron-hydride ion ( $BH_4^-$ ) is formed by the  $sp^3$  hybridisation of boron orbitals. Therefore, it is tetrahedral in structure.

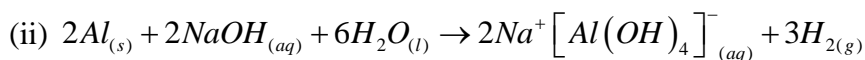
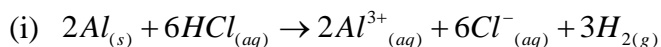
**Question 8:**

Write reactions to justify amphoteric nature of aluminium.

**Solution 8:**

A substance is called amphoteric if it displays characteristics of both acids and bases.

Aluminium dissolves in both acids and bases, showing amphoteric behaviour.

**Question 9:**

What are electron deficient compounds? Are  $BCl_3$  and  $SiCl_4$  electron deficient species?

Explain.

**Solution 9:**

In an electron-deficient compound, the octet of electrons is not complete, i.e., the central metal atom has an incomplete octet. Therefore, it needs electrons to complete its octet.

**(i)  $BCl_3$** 

$BCl_3$  is an appropriate example of an electron-deficient compound. B has 3 valence electrons. After forming three covalent bonds with chlorine, the number of electrons around it increases to 6. However, it is still short of two electrons to complete its octet.

**(ii)  $SiCl_4$** 

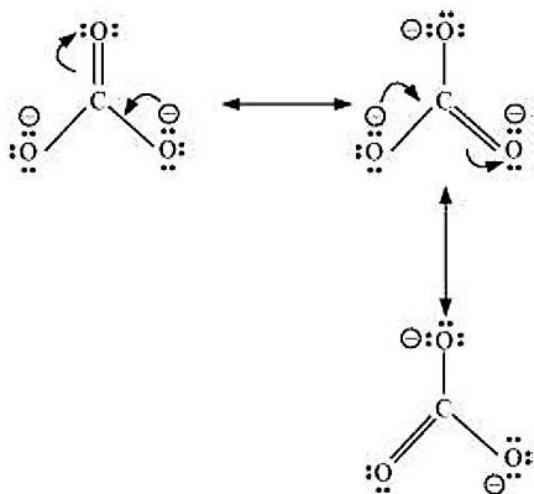
The electronic configuration of silicon is  $ns^2 np^2$ . This indicates that it has four valence electrons. After it forms four covalent bonds with four chlorine atoms, its electron count increases to eight. Thus,  $SiCl_4$  is not an electron-deficient compound.

**Question 10:**

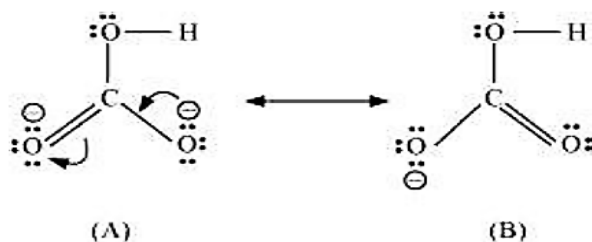
Write the resonance structures of  $\text{CO}_3^{2-}$  and  $\text{HCO}_3^-$ .

**Solution 10:**

(a)  $\text{CO}_3^{2-}$



(b)  $\text{HCO}_3^-$



There are only two resonating structures for the bicarbonate ion.

**Question 11:**

What is the state of hybridisation of carbon in (a)  $\text{CO}_3^{2-}$  (b) diamond (c) graphite?

**Solution 11:**

The state of hybridisation of carbon in:

(a)  $\text{CO}_3^{2-}$

C in  $\text{CO}_3^{2-}$  is  $sp^2$  hybridised and is bonded to three oxygen atoms.

(b) **Diamond**

Each carbon in diamond is  $sp^3$  hybridised and is bound to four other carbon atoms.

(c) **Graphite**

Each carbon atom in graphite is  $sp^2$  hybridised and is bound to three other carbon atoms.

**Question 12:**

Explain the difference in properties of diamond and graphite on the basis of their structures.

**Solution 12:**

Diamond	Graphite
It has a crystalline lattice.	It has a layered structure.
In diamond, each carbon atom is $sp^3$ hybridised and is bonded to four other carbon atoms through a $\sigma$ bond.	In graphite, each carbon atom is $sp^2$ hybridised and is bonded to three other carbon atoms through a $\sigma$ bond. The fourth electron forms a $\pi$ bond.
It is made up of tetrahedral units.	It has a planar geometry.
The C-C bond length in diamond is 154 pm.	The C-C bond length in graphite is 141.5 pm.
It has a rigid covalent bond network which is difficult to break.	It is quite soft and its layers can be separated easily.
It acts as an electrical insulator.	It is a good conductor of electricity.

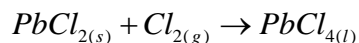
**Question 13:**

Rationalise the given statements and give chemical reactions:

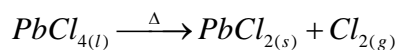
- Lead (II) chloride reacts with  $Cl_2$  to give  $PbCl_4$ .
- Lead (IV) chloride is highly unstable towards heat.
- Lead is known not to form an iodide,  $PbI_4$ .

**Solution 13:**

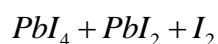
(a) Lead belongs to group 14 of the periodic table. The two oxidation states displayed by this group is +2 and +4. On moving down the group, the +2 oxidation state becomes more stable and the +4 oxidation state becomes less stable. This is because of the inert pair effect. Hence,  $PbCl_4$  is much less stable than  $PbCl_2$ . However, the formation of  $PbCl_4$  takes place when chlorine gas is bubbled through a saturated solution of  $PbCl_2$ .



(b) On moving down group IV, the higher oxidation state becomes unstable because of the inert pair effect.  $Pb(IV)$  is highly unstable and when heated, it reduces to  $Pb(II)$ .



(c) Lead is known not to form  $PbI_4$ .  $Pb(+4)$  is oxidising in nature and  $I^-$  is reducing in nature. A combination of  $Pb(IV)$  and iodide ion is not stable. Iodide ion is strongly reducing in nature.  $Pb(IV)$  oxidises  $I^-$  to  $I_2$  and itself gets reduced to  $Pb(II)$ .

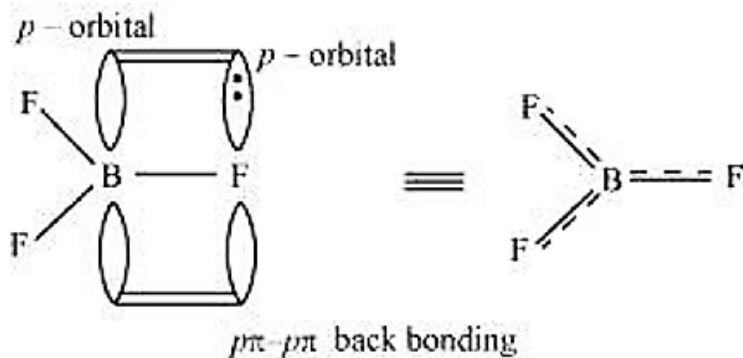


**Question 14:**

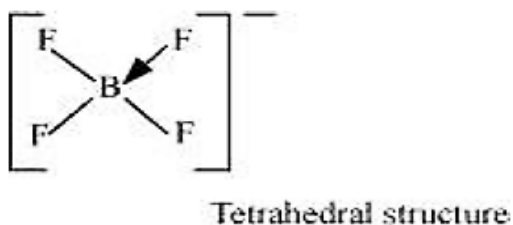
Suggest reasons why the B–F bond lengths in  $\text{BF}_3$  (130 pm) and  $\text{BF}_4^-$  (143 pm) differ.

**Solution 14:**

The B–F bond length in  $\text{BF}_3$  is shorter than the B–F bond length in  $\text{BF}_4^-$ .  $\text{BF}_3$  is an electron-deficient species. With a vacant  $p$ -orbital on boron, the fluorine and boron atoms undergo  $p\pi$ – $p\pi$  back-bonding to remove this deficiency. This imparts a double bond character to the B–F bond.



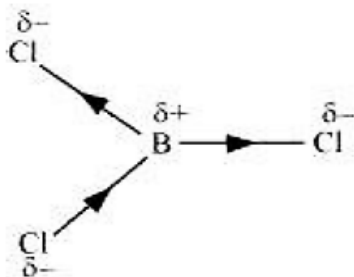
This double-bond character causes the bond length to shorten in  $\text{BF}_3$  (130 pm). However, when  $\text{BF}_3$  coordinates with the fluoride ion, a change in hybridisation from  $sp^2$  (in  $\text{BF}_3$ ) to  $sp^3$  (in  $\text{BF}_4^-$ ) occurs. Boron now forms 4  $\sigma$  bonds and the double-bond character is lost. This accounts for a B–F bond length of 143 pm in  $\text{BF}_4^-$  ion.

**Question 15:**

If B–Cl bond has a dipole moment, explain why  $\text{BCl}_3$  molecule has zero dipole moment.

**Solution 15:**

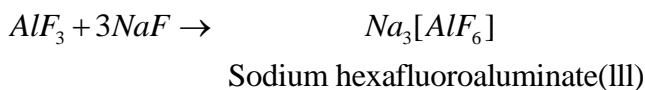
As a result of the difference in the electronegativities of B and Cl, the B–Cl bond is polar in nature. However, the  $\text{BCl}_3$  molecule is non-polar. This is because  $\text{BCl}_3$  is trigonal planar in shape. It is a symmetrical molecule. Hence, the respective dipole-moments of the B–Cl bond cancel each other, thereby causing a zero-dipole moment.

**Question 16:**

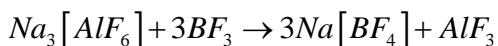
Aluminium trifluoride is insoluble in anhydrous HF but dissolves on addition of NaF. Aluminium trifluoride precipitates out of the resulting solution when gaseous  $\text{BF}_3$  is bubbled through. Give reasons.

**Solution 16:**

Hydrogen fluoride (HF) is a covalent compound and has a very strong intermolecular hydrogen-bonding. Thus, it does not provide ions and aluminium fluoride (AlF) does not dissolve in it. Sodium fluoride (NaF) is an ionic compound and when it is added to the mixture, AlF dissolves. This is because of the availability of free  $\text{F}^-$ . The reaction involved in the process is:



When boron trifluoride ( $\text{BF}_3$ ) is added to the solution, aluminium fluoride precipitates out of the solution. This happens because the tendency of boron to form complexes is much more than that of aluminium. Therefore, when  $\text{BF}_3$  is added to the solution, B replaces Al from the complexes according to the following reaction:

**Question 17:**

Suggest a reason as to why CO is poisonous.

**Solution 17:**

Carbon monoxide is highly-poisonous because of its ability to form a complex with haemoglobin. The CO-Hb complex is more stable than the  $\text{O}_2$ -Hb complex. The former prevents Hb from binding with oxygen. Thus, a person dies because of suffocation on not receiving oxygen. It is found that the CO-Hb complex is about 300 times more stable than the  $\text{O}_2$ -Hb complex.



**Question 18:**

How is excessive content of  $\text{CO}_2$  responsible for global warming?

**Solution 18:**

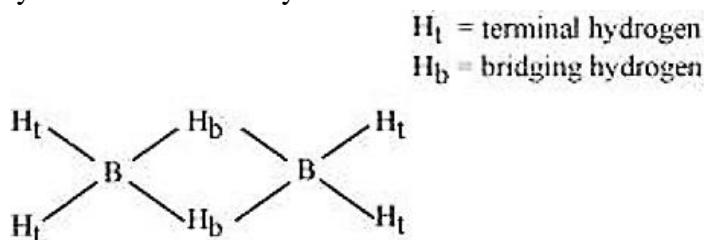
Carbon dioxide is a very essential gas for our survival. However, an increased content of  $\text{CO}_2$  in the atmosphere poses a serious threat. An increment in the combustion of fossil fuels, decomposition of limestone, and a decrease in the number of trees has led to greater levels of carbon dioxide. Carbon dioxide has the property of trapping the heat provided by sunrays. Higher the level of carbon dioxide, higher is the amount of heat trapped. This results in an increase in the atmospheric temperature, thereby causing global warming.

**Question 19:**

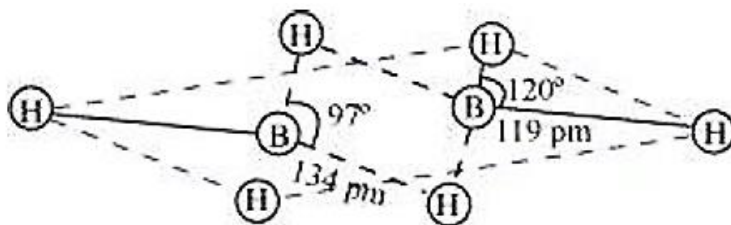
Explain structures of diborane and boric acid.

**Solution 19:****(a) Diborane**

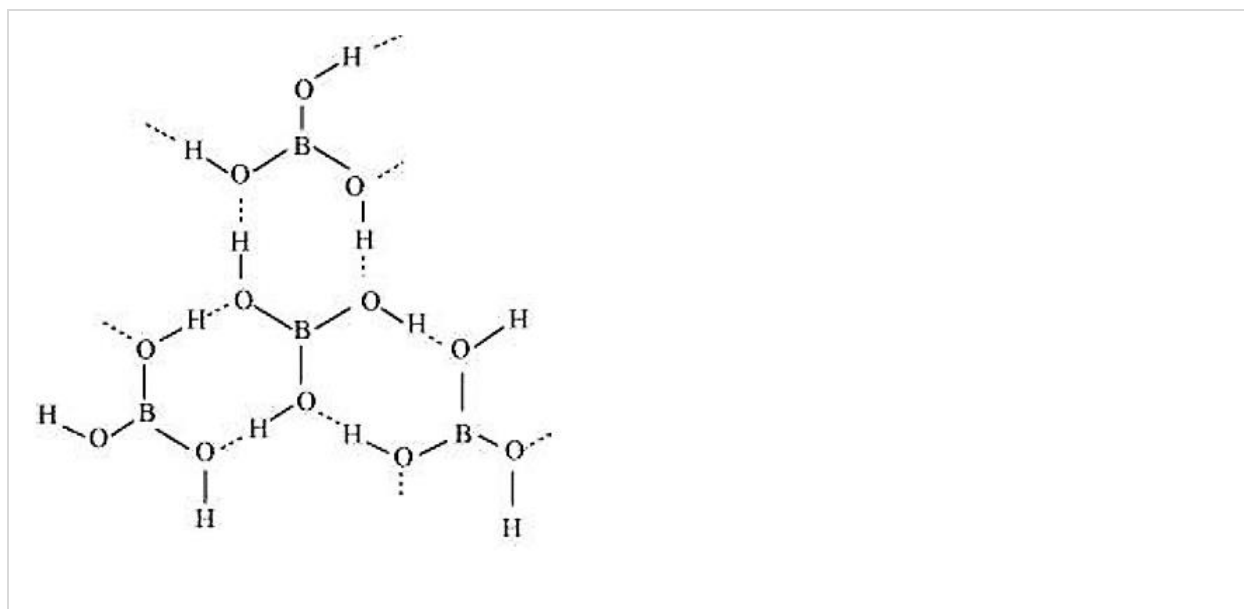
$\text{B}_2\text{H}_6$  is an electron-deficient compound.  $\text{B}_2\text{H}_6$  has only 12 electrons –  $6e^-$  from 6 H atoms and  $3e^-$  each from 2 B atoms. Thus, after combining with 3 H atoms, none of the boron atoms has any electrons left. X-ray diffraction studies have shown the structure of diborane as:



2 boron and 4 terminal hydrogen atoms ( $\text{H}_t$ ) lie in one plane, while the other two bridging hydrogen atoms ( $\text{H}_b$ ) lie in a plane perpendicular to the plane of boron atoms. Again, of the two bridging hydrogen atoms, one H atom lies above the plane and the other lies below the plane. The terminal bonds are regular two-centre two-electron ( $2c - 2e^-$ ) bonds, while the two bridging ( $\text{B}-\text{H}-\text{B}$ ) bonds are three-centre two-electron ( $3c - 2e^-$ ) bonds.

**(b) Boric acid**

Boric acid has a layered structure. Each planar  $\text{BO}_3$  unit is linked to one another through H atoms. The H atoms form a covalent bond with a  $\text{BO}_3$  unit, while a hydrogen bond is formed with another  $\text{BO}_3$  unit. In the given figure, the dotted lines represent hydrogen bonds.

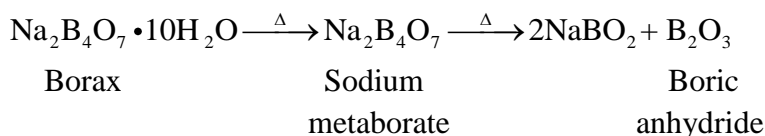
**Question 20:**

What happens when

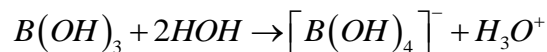
- Borax is heated strongly,
- Boric acid is added to water,
- Aluminium is treated with dilute NaOH,
- BF<sub>3</sub> is reacted with ammonia?

**Solution 20:**

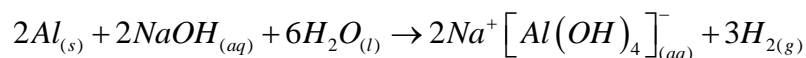
- When heated, borax undergoes various transitions. It first loses water molecules and swells. Then, it turns into a transparent liquid, solidifying to form a glass-like material called borax bead.



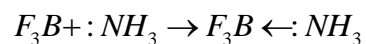
- When boric acid is added to water, it accepts electrons from <sup>-</sup>OH ion.



- Al reacts with dilute NaOH to form sodium tetra hydroxo aluminate(III). Hydrogen gas is liberated in the process.



- BF<sub>3</sub> (a Lewis acid) reacts with NH<sub>3</sub> (a Lewis base) to form an adduct. This results in a complete octet around B in BF<sub>3</sub>.



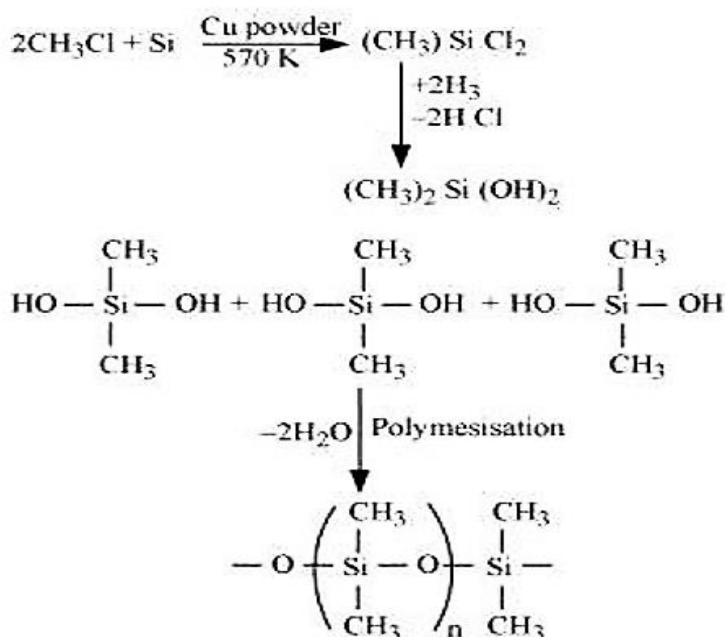
**Question 21:**

Explain the following reactions

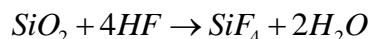
- Silicon is heated with methyl chloride at high temperature in the presence of copper;
- Silicon dioxide is treated with hydrogen fluoride;
- CO is heated with ZnO;
- Hydrated alumina is treated with aqueous NaOH solution.

**Solution 21:**

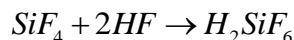
- When silicon reacts with methyl chloride in the presence of copper (catalyst) and at a temperature of about 537 K, a class of organosilicon polymers called methyl substituted chlorosilanes ( $\text{MeSiCl}_3$ ,  $\text{Me}_2\text{SiCl}_2$ ,  $\text{Me}_3\text{SiCl}$ , and  $\text{Me}_4\text{Si}$ ) are formed.



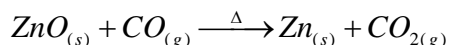
- When silicon dioxide ( $\text{SiO}_2$ ) is heated with hydrogen fluoride (HF), it forms silicon tetrafluoride ( $\text{SiF}_4$ ). Usually, the Si–O bond is a strong bond and it resists any attack by halogens and most acids, even at a high temperature. However, it is attacked by HF.



The  $\text{SiF}_4$  formed in this reaction can further react with HF to form hydrofluorosilicic acid.



- When CO reacts with ZnO, it reduces ZnO to Zn. CO acts as a reducing agent.



- When hydrated alumina is added to sodium hydroxide, the former dissolves in the latter because of the formation of sodium meta-aluminate.



**Question 22:**

Give reasons:

- (i) Conc.  $\text{HNO}_3$  can be transported in aluminium container.
- (ii) A mixture of dilute  $\text{NaOH}$  and aluminium pieces is used to open drain.
- (iii) Graphite is used as lubricant.
- (iv) Diamond is used as an abrasive.
- (v) Aluminium alloys are used to make aircraft body.
- (vi) Aluminium utensils should not be kept in water overnight.
- (vii) Aluminium wire is used to make transmission cables.

**Solution 22:**

- (i) Concentrated  $\text{HNO}_3$  can be stored and transported in aluminium containers as it reacts with aluminium to form a thin protective oxide layer on the aluminium surface. This oxide layer renders aluminium passive.
- (ii) Sodium hydroxide and aluminium react to form sodium tetra hydroxo aluminate (III) and hydrogen gas. The pressure of the produced hydrogen gas is used to open blocked drains.
$$2\text{Al} + 2\text{NaOH} + 6\text{H}_2\text{O} \rightarrow 2\text{Na}^+ [\text{Al}(\text{OH})_4]^- + 3\text{H}_2$$
- (iii) Graphite has a layered structure and different layers of graphite are bonded to each other by weak van der Waals' forces. These layers can slide over each other. Graphite is soft and slippery. Therefore, graphite can be used as a lubricant.
- (iv) In diamond, carbon is  $sp^3$  hybridised. Each carbon atom is bonded to four other carbon atoms with the help of strong covalent bonds. These covalent bonds are present throughout the surface, giving it a very rigid 3-D structure. It is very difficult to break this extended covalent bonding and for this reason, diamond is the hardest substance known. Thus, it is used as an abrasive and for cutting tools.
- (v) Aluminium has a high tensile strength and is very light in weight. It can also be alloyed with various metals such as Cu, Mn, Mg, Si, and Zn. It is very malleable and ductile. Therefore, it is used in making aircraft bodies.
- (vi) The oxygen present in water reacts with aluminium to form a thin layer of aluminium oxide. This layer prevents aluminium from further reaction. However, when water is kept in an aluminium vessel for long periods of time, some amount of aluminium oxide may dissolve in water. As aluminium ions are harmful, water should not be stored in aluminium vessels overnight.
- (vii) Silver, copper, and aluminium are among the best conductors of electricity. Silver is an expensive metal and silver wires are very expensive. Copper is quite expensive and is also very heavy. Aluminium is a very ductile metal. Thus, aluminium is used in making wires for electrical conduction.

**Question 23:**

Explain why is there a phenomenal decrease in ionisation enthalpy from carbon to silicon?

**Solution 23:**

Ionisation enthalpy of carbon (the first element of group 14) is very high (1086 kJ/mol).

This is expected owing to its small size. However, on moving down the group to silicon, there is a sharp decrease in the enthalpy (786 kJ). This is because of an appreciable increase in the atomic sizes of elements on moving down the group.

**Question 24:**

How would you explain the lower atomic radius of Ga as compared to Al?

**Solution 24:**

Atomic radius (in pm)	
Aluminium	143
Gallium	135

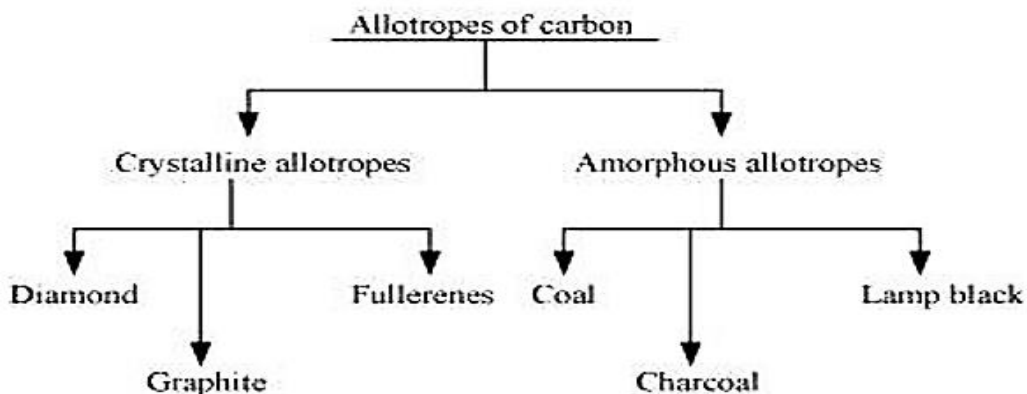
Although Ga has one shell more than Al, its size is lesser than Al. This is because of the poor shielding effect of the 3*d*-electrons. The shielding effect of *d*-electrons is very poor and the effective nuclear charge experienced by the valence electrons in gallium is much more than it is in the case of Al.

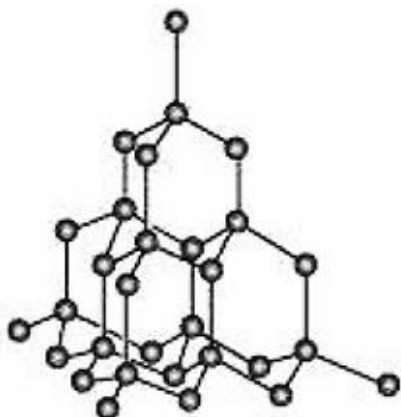
**Question 25:**

What are allotropes? Sketch the structure of two allotropes of carbon namely diamond and graphite. What is the impact of structure on physical properties of two allotropes?

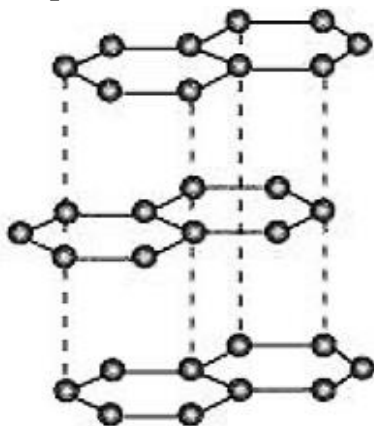
**Solution 25:**

Allotropy is the existence of an element in more than one form, having the same chemical properties but different physical properties. The various forms of an element are called allotropes.



**Diamond:**

The rigid 3-D structure of diamond makes it a very hard substance. In fact, diamond is one of the hardest naturally-occurring substances. It is used as an abrasive and for cutting tools.

**Graphite:**

It has  $sp^2$  hybridised carbon, arranged in the form of layers. These layers are held together by weak van der Waals' forces. These layers can slide over each other, making graphite soft and slippery. Therefore, it is used as a lubricant.

**Question 26:**

(a) Classify following oxides as neutral, acidic, basic or amphoteric:

CO, B<sub>2</sub>O<sub>3</sub>, SiO<sub>2</sub>, CO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, PbO<sub>2</sub>, Tl<sub>2</sub>O<sub>3</sub>

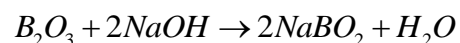
(b) Write suitable chemical equations to show their nature.

**Solution 26:**

(1) CO = Neutral

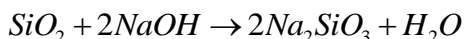
(2) B<sub>2</sub>O<sub>3</sub> = Acidic

Being acidic, it reacts with bases to form salts. It reacts with NaOH to form sodium metaborate.



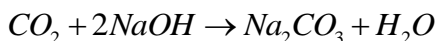
(3)  $\text{SiO}_2$  = Acidic

Being acidic, it reacts with bases to form salts. It reacts with NaOH to form sodium silicate.



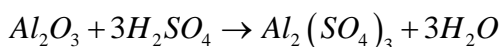
(4)  $\text{CO}_2$  = Acidic

Being acidic, it reacts with bases to form salts. It reacts with NaOH to form sodium carbonate.



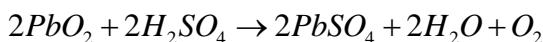
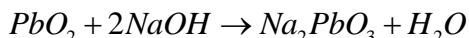
(5)  $\text{Al}_2\text{O}_3$  = Amphoteric

Amphoteric substances react with both acids and bases.  $\text{Al}_2\text{O}_3$  reacts with both NaOH and  $\text{H}_2\text{SO}_4$ .



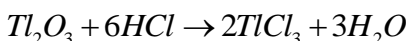
(6)  $\text{PbO}_2$  = Amphoteric

Amphoteric substances react with both acids and bases.  $\text{PbO}_2$  reacts with both NaOH and  $\text{H}_2\text{SO}_4$ .



(7)  $\text{Tl}_2\text{O}_3$  = Basic

Being basic, it reacts with acids to form salts. It reacts with HCl to form thallium chloride.



### Question 27:

In some of the reactions thallium resembles aluminium, whereas in others it resembles with group I metals. Support this statement by giving some evidences.

### Solution 27:

Thallium belongs to group 13 of the periodic table. The most common oxidation state for this group is +3. However, heavier members of this group also display the +1 oxidation state. This happens because of the inert pair effect. Aluminium displays the +3 oxidation state and alkali metals display the +1 oxidation state. Thallium displays both the oxidation states. Therefore, it resembles both aluminium and alkali metals.

Thallium, like aluminium, forms compounds such as  $\text{TlCl}_3$  and  $\text{Tl}_2\text{O}_3$ . It resembles alkali metals in compounds  $\text{Tl}_2\text{O}$  and  $\text{TlCl}$ .

**Question 28:**

When metal X is treated with sodium hydroxide, a white precipitate (A) is obtained, which is soluble in excess of NaOH to give soluble complex (B). Compound (A) is soluble in dilute HCl to form compound (C). The compound (A) when heated strongly gives (D), which is used to extract metal. Identify (X), (A), (B), (C) and (D). Write suitable equations to support their identities.

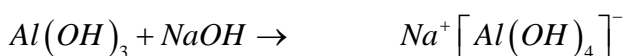
**Solution 28:**

The given metal X gives a white precipitate with sodium hydroxide and the precipitate dissolves in excess of sodium hydroxide. Hence, X must be aluminium.

The white precipitate (compound A) obtained is aluminium hydroxide. The compound B formed when an excess of the base is added is sodium tetra hydroxo aluminate (III).

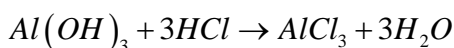


Aluminium (X)   Sodium hydroxide   white ppt.(A)



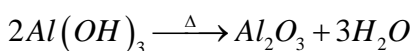
(A)                      Sodium tetrahydroxoaluminate(III)  
(Soluble complex B)

Now, when dilute hydrochloric acid is added to aluminium hydroxide, aluminium chloride (compound C) is obtained.



(A)                      (C)

Also, when compound A is heated strongly, it gives compound D. This compound is used to extract metal X. Aluminium metal is extracted from alumina. Hence, compound D must be alumina.



(A)                      (D)

**Question 29:**

What do you understand by (a) inert pair effect (b) allotropy and (c) catenation?

**Solution 29:****(a) Inert pair effect**

As one moves down the group, the tendency of s-block electrons to participate in chemical bonding decreases. This effect is known as inert pair effect. In case of group 13 elements, the electronic configuration is  $ns^2 np^1$  and their group valency is +3. However, on moving down the group, the +1 oxidation state becomes more stable. This happens because of the poor shielding



of the  $ns^2$  electrons by the  $d$ - and  $f$ - electrons. As a result of the poor shielding, the  $ns^2$  electrons are held tightly by the nucleus and so, they cannot participate in chemical bonding.

**(b) Allotropy**

Allotropy is the existence of an element in more than one form, having the same chemical properties but different physical properties. The various forms of an element are called allotropes. For example, carbon exists in three allotropic forms: diamond, graphite, and fullerenes.

**(c) Catenation**

The atoms of some elements (such as carbon) can link with one another through strong covalent bonds to form long chains or branches. This property is known as catenation. It is most common in carbon and quite significant in Si and S.

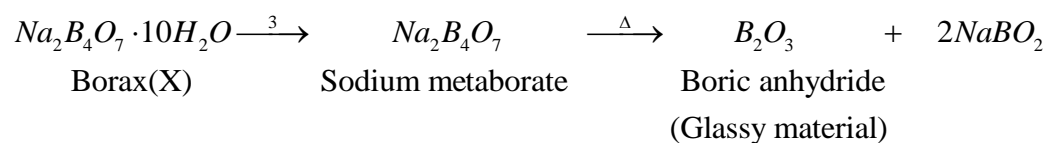
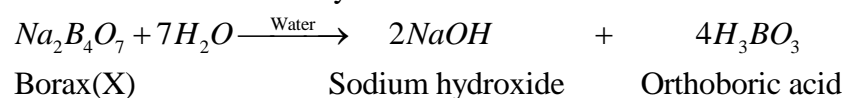
**Question 30:**

A certain salt X, gives the following results.

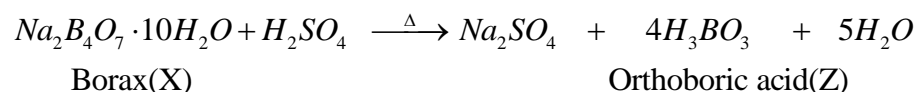
- (i) Its aqueous solution is alkaline to litmus.
  - (ii) It swells up to a glassy material Y on strong heating.
  - (iii) When conc.  $H_2SO_4$  is added to a hot solution of X, white crystal of an acid Z separates out.
- Write equations for all the above reactions and identify X, Y and Z.

**Solution 30:**

The given salt is alkaline to litmus. Therefore, X is a salt of a strong base and a weak acid. Also, when X is strongly heated, it swells to form substance Y. Therefore, X must be borax. When borax is heated, it loses water and swells to form sodium metaborate. When heating is continued, it solidifies to form a glassy material Y. Hence, Y must be a mixture of sodium metaborate and boric anhydride.

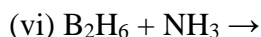
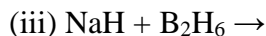
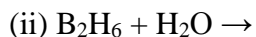
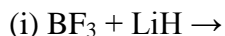
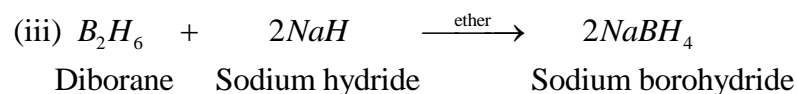
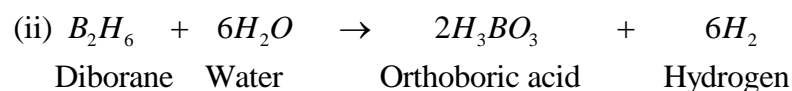
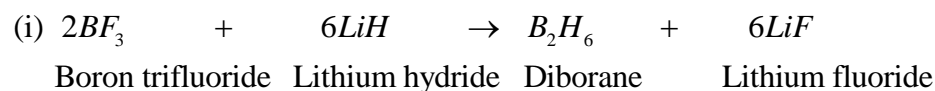


When concentrated acid is added to borax, white crystals of orthoboric acid (Z) are formed.

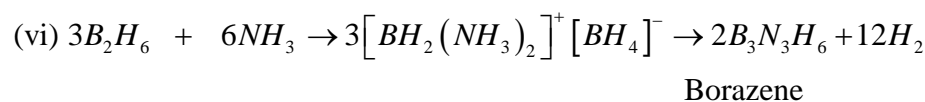
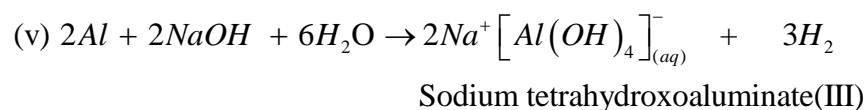
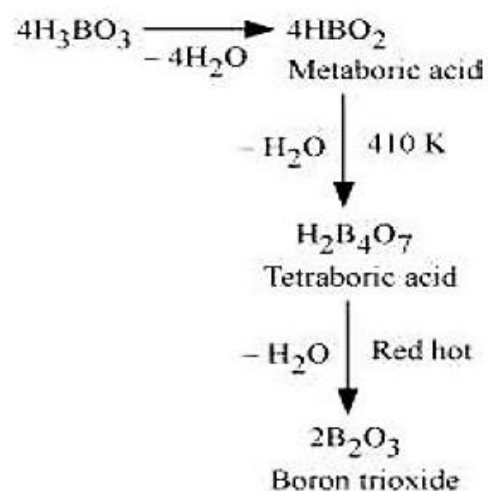


**Question 31:**

Write balanced equations for:

**Solution 31:**

(iv)



**Question 32:**

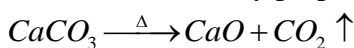
Give one method for industrial preparation and one for laboratory preparation of CO and CO<sub>2</sub> each.

**Solution 32:****Carbon dioxide**

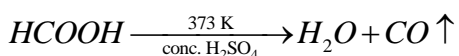
In the laboratory, CO<sub>2</sub> can be prepared by the action of dilute hydrochloric acid on calcium carbonate. The reaction involved is as follows:



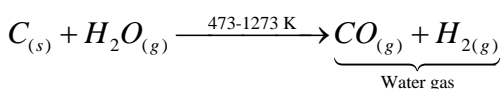
CO<sub>2</sub> is commercially prepared by heating limestone. The reaction involved is as follows:

**Carbon monoxide**

In the laboratory, CO is prepared by the dehydration of formic acid with conc. H<sub>2</sub>SO<sub>4</sub>, at 373 K. The reaction involved is as follows:



CO is commercially prepared by passing steam over hot coke. The reaction involved is as follows:

**Question 33:**

An aqueous solution of borax is

- |             |                |
|-------------|----------------|
| (a) neutral | (b) amphoteric |
| (c) basic   | (d) acidic     |

**Solution 33:**

(c) Borax is a salt of a strong base (NaOH) and a weak acid (H<sub>3</sub>BO<sub>3</sub>). It is, therefore, basic in nature.

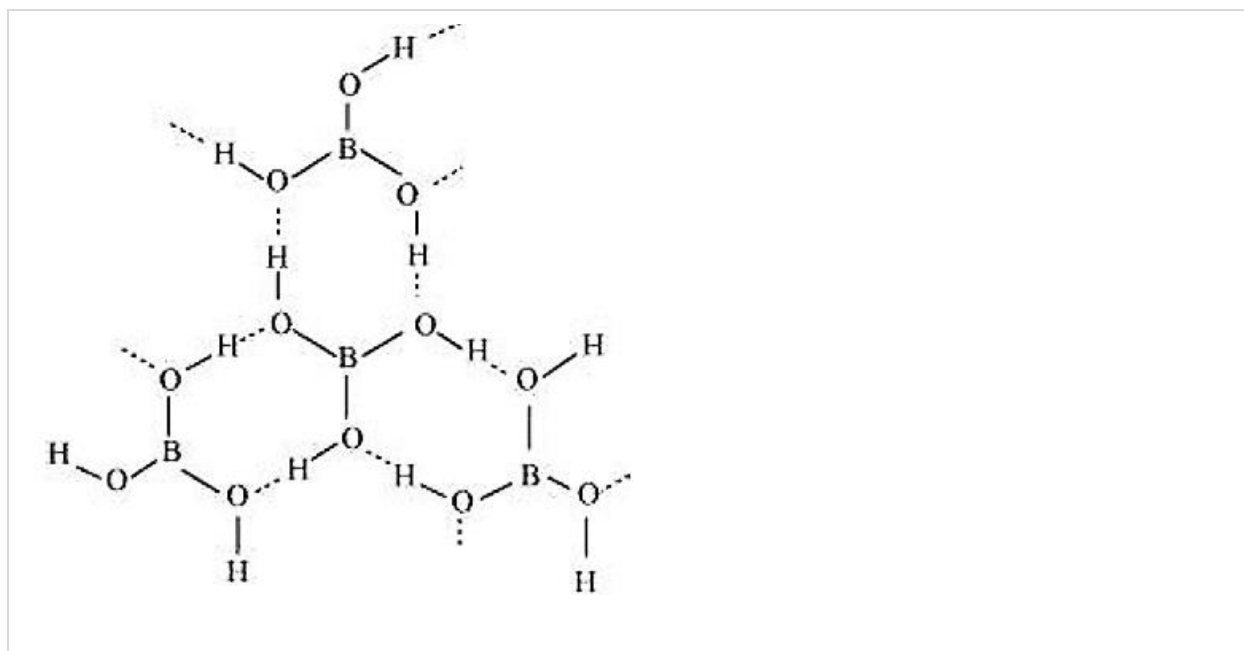
**Question 34:**

Boric acid is polymeric due to

- |                          |                                    |
|--------------------------|------------------------------------|
| (a) its acidic nature    | (b) the presence of hydrogen bonds |
| (c) its monobasic nature | (d) its geometry                   |

**Solution 34:**

(b) Boric acid is polymeric because of the presence of hydrogen bonds. In the given figure, the dotted lines represent hydrogen bonds.

**Question 35:**

The type of hybridisation of boron in diborane is

- (a)  $sp$                       (b)  $sp^2$     (c)  $sp^3$                       (d)  $dsp^2$

**Solution 35:**

(c) Boron in diborane is  $sp^3$  hybridised.

**Question 36:**

Thermodynamically the most stable form of carbon is

- (a) diamond                      (b) graphite  
(c) fullerenes                      (d) coal

**Solution 36:**

(b) Graphite is thermodynamically the most stable form of carbon.

**Question 37:**

Elements of group 14

- (a) exhibit oxidation state of +4 only  
(b) exhibit oxidation state of +2 and +4  
(c) form  $M^{2-}$  and  $M^{4+}$  ion  
(d) form  $M^{2+}$  and  $M^{4+}$  ions

**Solution 37:**

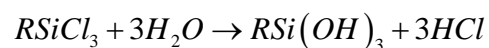
(b) The elements of group 14 have 4 valence electrons. Therefore, the oxidation state of the group is +4. However, as a result of the inert pair effect, the lower oxidation state becomes more and more stable and the higher oxidation state becomes less stable.

Therefore, this group exhibits +4 and +2 oxidation states.

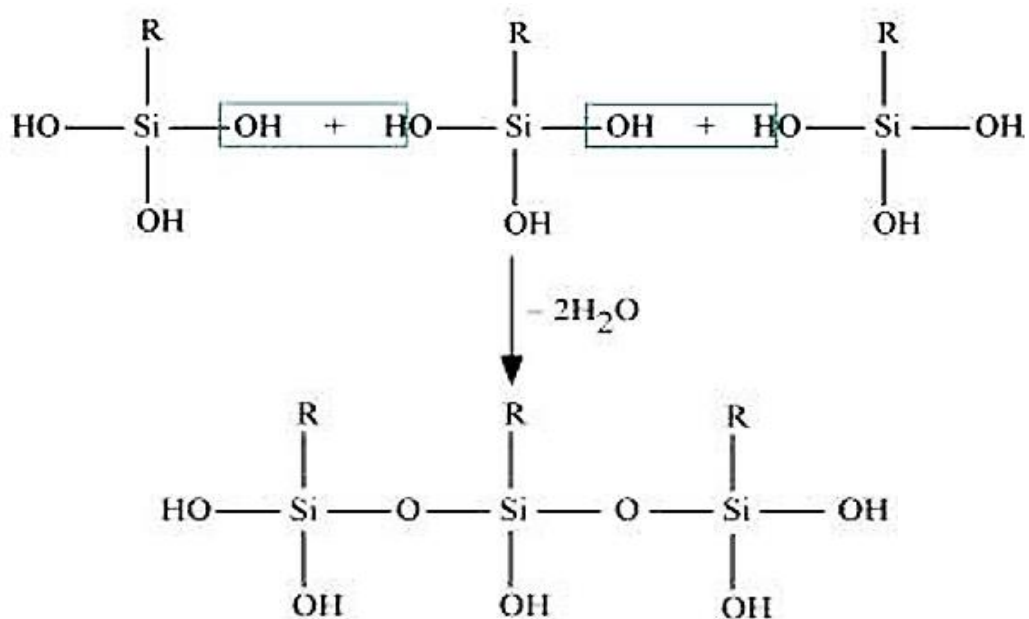
Group 14 element	Oxidation state
C	+4
Si	+4
Ge, Sn, Pb	+2, +4

**Question 38:**

If the starting material for the manufacture of silicones is  $\text{RSiCl}_3$ , write the structure of the product formed.

**Solution 38:**

(i)



(ii)

