

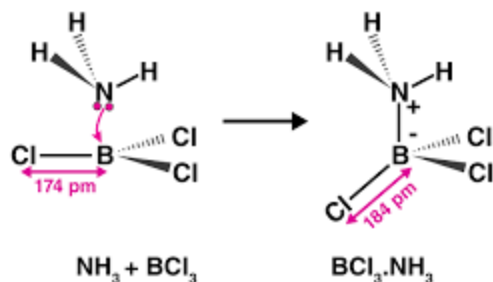
Class 11 The p-Block Elements Important Questions with Answers

Short Answer Type Questions

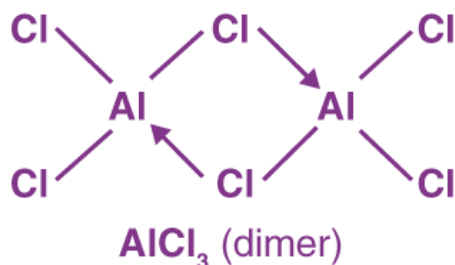
Q1. Draw the structures of $\text{BCl}_3 \cdot \text{NH}_3$ and AlCl_3 (dimer).

Answer:

The valence shell of the core B atom in BCl_3 comprises six electrons. As a result, it is an electron-deficient molecule that requires two additional electrons to complete its octet. BCl_3 is a Lewis acid, in other words. On the other hand, NH_3 contains a lone pair of electrons that it can easily transfer. As a result, NH_3 is a Lewis base. As demonstrated below, the Lewis acid (BCl_3) and Lewis base (NH_3) interact to produce an adduct:



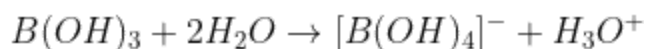
The valence shell of AlCl_3 comprises six electrons. As a result, it is an electron-deficient molecule that requires two additional electrons to complete its octet. On the other hand, chlorine possesses three lone pairs of electrons. As a result, the central Al atom of one molecule absorbs a lone pair of electrons from the Cl atom of the other molecule to complete its octet, resulting in a dimeric structure as seen below:



Q2. Explain the nature of boric acid as a Lewis acid in water.

Answer:

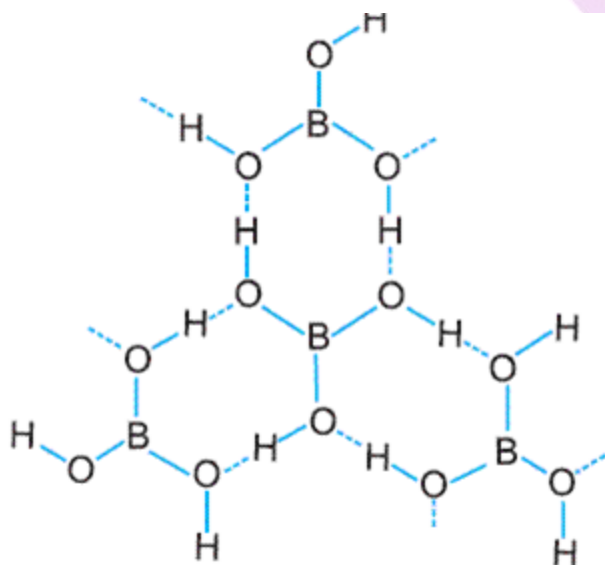
Boric acid is a weak monobasic acid that takes electrons from a hydroxyl ion to operate as a Lewis acid. Boric acid takes OH^- and forms the hydroxyl ion as a result.



Q3. Draw the structure of boric acid showing hydrogen bonding. Which species is present in water? What is the hybridisation of boron in this species?

Answer:

In its solid state, orthoboric acid H_3BO_3 has a layer structure made up of $\text{B}(\text{OH})_3$ units that form hexagonal H-bonding rings as seen below.



Q4. Explain why the following compounds behave as Lewis acids?

- (i) BCl_3
- (ii) AlCl_3

Answer:

Because of the imperfect octet of the central metal atom, BCl_3 and AlCl_3 behave as Lewis acids.

Q5. Give reasons for the following:

- (i) CCl_4 is immiscible in water, whereas SiCl_4 is easily hydrolysed.
- (ii) Carbon has a strong tendency for catenation compared to silicon.

Answer:

(i) CCl_4 is insoluble in water because water is polar and CCl_4 is non-polar. The carbon atom has no vacant orbitals to absorb the electrons given off by oxygen in water. SiCl_4 is easily hydrolyzed because Si has an empty d orbital to accommodate the electrons from the oxygen atom in water.

(ii) As atomic size increases, the bond dissociation energy drops dramatically. Because the atomic size of carbon (77 pm) is substantially smaller than that of silicon (118 pm), the dissociation energy of carbon-carbon bonds is much higher (348 kJ mol^{-1}) than that of silicon-silicon bonds (297 kJ mol^{-1}). The huge energy differential between the Carbon-Carbon and Silicon-Silicon bond energies indicates that carbon has a greater potential for catenation than silicon.

Q6. Explain the following :

- o (i) CO_2 is a gas whereas SiO_2 is a solid.
- o (ii) Silicon forms SiF_6^{2-} ion whereas corresponding fluoro compound of carbon is not known.

Answer:

(i) Carbon creates strong double bonds with two oxygen atoms due to its tiny size and good π -overlap with other small atoms, resulting in distinct CO_2 molecules.

Because of its huge size, the silicon atom has poor π -overlap with other atoms. It forms four single bonds directed towards the four apices of a tetrahedron with its four valence electrons (sp^3 -hybridisation). Each oxygen atom is bonded to two silicon atoms, resulting in a massive three-dimensional structure that is extremely stable. As a result, CO_2 is a gas, while SiO_2 is a solid.

(ii) Because all of the 3d orbitals in silicon are in the valence shell, the octet expands to form an sp^3d^2 hybridization. The valence shell of carbon, on the other hand, lacks d-orbitals. Only sp^3 hybridisation is possible. As a result, carbon is unable to form the CF_6^{2-} anion.

Q7. The +1 oxidation state in group 13 and +2 oxidation state in group 14 becomes more and more stable with increasing atomic number. Explain.

Answer:

The tendency of valence shell s-electrons to engage in bond formation declines as we proceed down the group in groups 13 and 14. The intermediate d- and f-electrons are ineffectual at sheltering the valence shell's s-electrons. The inert pair effect is what we call it.

As a result, s-electrons in group 13 and 14's valence shells are unable to participate in bonding. As a result, the +1 and +2 oxidation states in groups 13 and 14 become more stable as the atomic number increases.

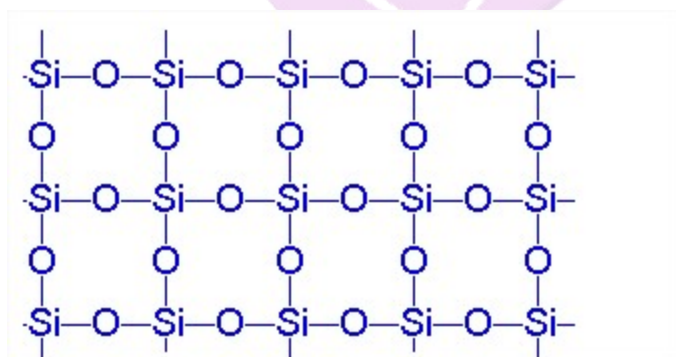
Q8. Carbon and silicon both belong to the group 14, but inspite of the stoichiometric similarity, the dioxides, (i.e., carbon dioxide and silicon dioxide), differ in their structures. Comment.

Answer:

Carbon, being the first member of group 14, has a strong propensity to create stable p-p multiple bonds with other front row elements like nitrogen and oxygen. Both oxygen atoms are connected to the carbon atom by double bonds in CO_2 .



Due to its huge atomic size, silicon, on the other hand, is hesitant to create p-p multiple bonding. Single covalent bonds bind oxygen atoms to silicon atoms in SiO_2 , resulting in a three-dimensional network.



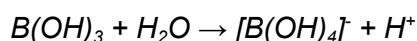
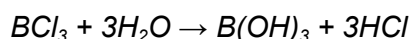
Q9. If a trivalent atom replaces a few silicon atoms in three dimensional network of silicon dioxide, what would be the type of charge on overall structure?

Answer:

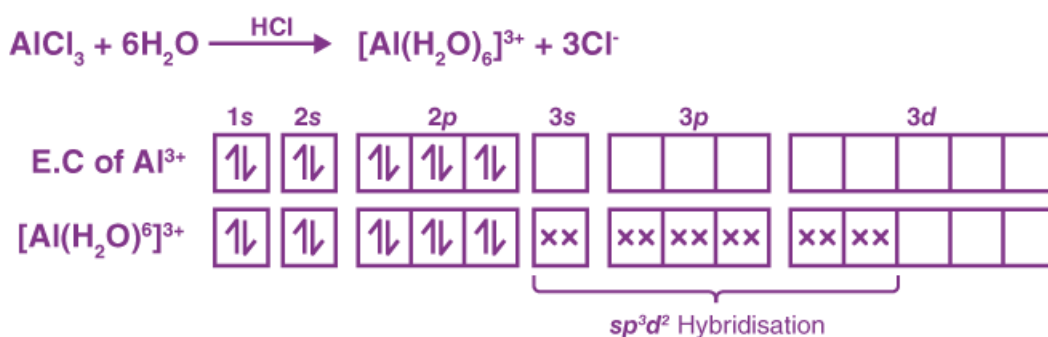
In SiO_2 , the tetrahedral atoms are responsible for the three-dimensional structure of the Si atoms. These atoms are replaced by trivalent atoms, which have a free valence electron, resulting in one negative charge in the structure. As a result, the entire compound has a negative charge.

Q10. When BCl_3 is treated with water, it hydrolyses and forms $[\text{B}(\text{OH})_4]^-$ only whereas AlCl_3 in acidified aqueous solution forms $[\text{Al}(\text{H}_2\text{O})_6]^{3+}$ ion. Explain what is the hybridisation of boron and aluminum in these species?

Answer:



$\text{B}(\text{OH})_3$ accepts an electron pair (as OH^-) due to its incomplete octet, resulting in $[\text{B}(\text{OH})_4]^-$. Boron has one 2s orbital and three 2p orbitals in this ion. As a result, B hybridisation in $[\text{B}(\text{OH})_4]^-$ is sp^3 .

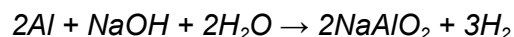
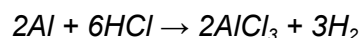


Hence, hybridisation of Al is sp^3d^2 .

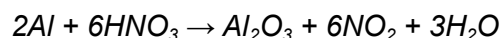
Q11. Aluminum dissolves in mineral acids and aqueous alkalis and thus shows amphoteric character. A piece of aluminum foil is treated with dilute hydrochloric acid or dilute sodium hydroxide solution in a test tube and on bringing a burning matchstick near the mouth of the test tube, a pop sound indicates the evolution of hydrogen gas. The same activity when performed with concentrated nitric acid, reaction doesn't proceed. Explain the reason.

Answer:

Because aluminium is amphoteric, it dissolves in acids and alkalies, releasing H_2 gas, which burns with a pop.



When Al interacts with concentrated HNO_3 , a thin coating of Al_2O_3 forms on the metal's surface, preventing further reaction. This layer is referred to as the protective layer.



Concentrated nitric acid does not react with aluminium. When aluminium combines with nitric acid, a the protective layer of "Aluminium Oxide" is generated since "nitric acid" is an oxidising agent. Nitric acid cannot react with the "inner aluminium metal" due to the protective layer of "Aluminium oxide."

Q12. Explain the following :

- o (i) Gallium has higher ionisation enthalpy than aluminium.
- o (ii) Boron does not exist as B^{3+} ion.
- (iii) Aluminium forms $[AlF_6]^{3-}$ ion but boron does not form $[BF_6]^{3-}$ ion.
- (iv) PbX_2 is more stable than PbX_4 .
- o (v) Pb^{4+} acts as an oxidising agent but Sn^{2+} acts as a reducing agent.
- o (vi) Electron gain enthalpy of chlorine is more negative as compared to fluorine.
- o (vii) $Tl(NO_3)_3$ acts as an oxidising agent.
- o (viii) Carbon shows catenation property but lead does not.
- o (ix) BF_3 does not hydrolyse.
- o (x) Why does the element silicon, not form a graphite like structure whereas carbon does.

Answer:

(i) Due to the inability of d- and f- electrons, which have a screening effect, to compensate for the rise in nuclear charge, Ga's ionisation enthalpy value is larger than Al's.

(ii) Boron's valence shell has three electrons. Boron does not lose all of its valence electrons to create B^{3+} ions due to its small size and high sum of the first three ionisation enthalpies, $\Delta_i H_1 + \Delta_i H_2 + \Delta_i H_3$.

(iii) Because aluminium contains a d-orbital in its valence shell, it has created $(AlF_6)^{3-}$, whereas boron does not have a d-orbital in its valence electron. As a result, the maximum boron covalence cannot be greater than 4. As a result, while Aluminum can produce $[AlF_6]^{3-}$, Boron cannot form $[BF_6]^{3-}$.

(iv) The +2 oxidation state of Pb is more stable than the +4 oxidation state due to the inert pair effect. As a result, PbX_2 , which has a +2 oxidation state, is more stable than PbX_4 , which has a +4 oxidation state.

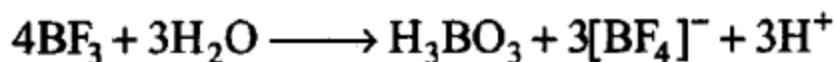
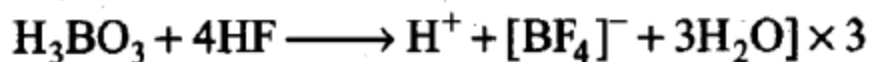
(v) Due to the inert pair effect, Pb^{4+} gains two electrons and becomes Pb^{2+} , which is more stable. By shedding electrons, Sn^{2+} is less stable than Sn^{4+} . As a result, Pb^{4+} is an oxidising agent, whereas Sn^{2+} is a reducing agent.

(vi) In comparison to chlorine, fluorine has a lower negative electron gain enthalpy. It's because fluorine atoms are so small. As a result, substantial interelectronic repulsions exist in fluorine's relatively small 2p orbitals, resulting in less attraction for the incoming electron.

(vii) Tl's +3 oxidation state is less stable than its +1 oxidation state because of a significant inert pair effect. Because $\text{Tl}(\text{NO}_3)_3$ has a +3 oxidation state, it may easily gain two electrons and become TlNO_3 , which has a +1 oxidation state. $\text{Tl}(\text{NO}_3)_3$, as a result, works as an oxidizing agent.

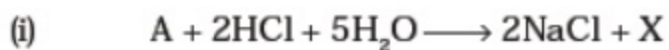
(viii) Carbon atoms have a natural tendency to build chains and rings by forming covalent bonds with one another. Catenation is the term for this characteristic. This is due to the fact that C-C bonds are extremely strong. As the size of the group grows larger, electronegativity diminishes, and the tendency to demonstrate catenation reduces. Bond enthalpy values clearly demonstrate this.

(ix) BF_3 does not entirely hydrolyze like the other boron halides. Instead, it forms boric acid and fluoroboric acid when it hydrolyzes incompletely. This is due to the H_3BO_3 reaction that occurs when the HF is first produced.



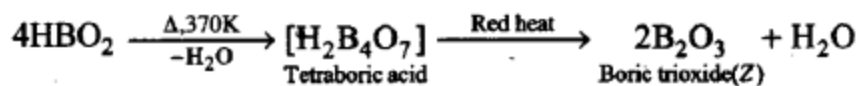
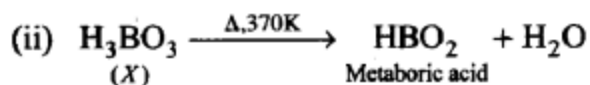
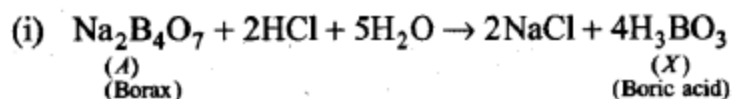
(x) Carbon is sp^3 hybridised in graphite. Because of its small size and maximum electronegativity in group 14, carbon has a tendency to form numerous $\text{p}\pi\text{-p}\pi$ bonds. Silicon cannot form numerous bonds due to its huge size and low electronegativity. As a result, silicon is unable to form a graphite-like structure.

Q13. Identify the compounds A, X and Z in the following reactions :

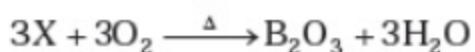
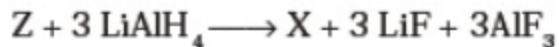


Answer:

The solution is:

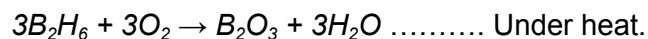
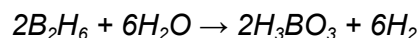
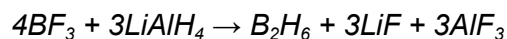


Q14. Complete the following chemical equations:



Answer:

The solution is :



Long Answer Type Questions

Q1. Describe the general trends in the following properties of the elements in Groups 13 and 14.

- (i) Atomic size
- (ii) Ionisation enthalpy
- (iii) Metallic character
- (iv) Oxidation states
- (v) Nature of halides

Answer:

(i) Group 13 has a larger atomic size because the atomic size grows as you go down a group, therefore an extra shell with electrons is added, resulting in a poor shielding effect.

The presence of the shielding effect is high because the d and f orbitals are completely occupied in Group 14, which has a covalent radius and a small radius.

(ii) The group has no effect on the ionisation enthalpy, which decreases as the size of the group grows. Because the nuclear charge is complemented by the screening effect, Group 13 has unpredictable ionisation enthalpy.

Because of the low shielding effect, Group 14 has a high ionisation enthalpy, which then decreases.

(iii) Except for Boron, all elements in group 13 are non-metallic, and the low metallic character is due to the shielding effect.

Sn and Pb are metals in Group 14, and the metallic nature grows as the group progresses, therefore carbon is categorised as a non-metal and the rest are metalloids.

(iv) Because of the lone pairs, Group 13 has a lot of +3 oxidation states, although they gradually transition to +1 as the group order progresses.

Group 14 has oxidation states of +4, +2, and +2, with high enthalpies and covalent nature.

(v) Some electron acceptors act as Lewis Acids, and Group 13 generates trihalides.

Halides are covalent compounds formed by Group 14 accepting or sharing electrons.

Q2. Account for the following observations:

- (i) AlCl_3 is a Lewis acid
- (ii) Though fluorine is more electronegative than chlorine yet BF_3 is a weaker Lewis acid than BCl_3
- (iii) PbO_2 is a stronger oxidising agent than SnO_2
- (iv) The +1 oxidation state of thallium is more stable than its +3 state.

Answer:

(i) Because the Al atoms in AlCl_3 have only six electrons in their valence shell, they can only take a pair of octets. As a result, it functions as a Lewis acid.

(ii) BCl_3 is the correct answer, not BF_3 (though BF_3 is expected to be the answer). In BF_3 , the boron atom is sp^2 hybridised and has an empty 2p orbital. Because electron density is leaving the more electronegative atom, this process is known as backbonding.

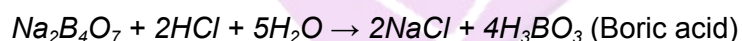
(iii) Lead and tin are both in the +4 oxidation state in PbO_2 and SnO_2 . Pb^{2+} ions are more stable than Sn^{2+} ions because of the stronger inert pair effect. The oxidation state of Sn^{+4} is more stable than the oxidation state of Sn^{+2} . However, because the +2 oxidation state of Pb is more stable due to the inert pair effect, Pb^{+4} easily converts to Pb^{+2} and works as a good oxidizer.

(iv) Tl +1 oxidation state is more stable than Th +3 oxidation state due to inert pair effect. It has a high effective nuclear charge due to the existence of d and f orbitals in inner shells, which have a weak shielding effect. As a result, the ns^2 electron pair becomes increasingly tethered to the nucleus and unwilling to participate in bonding.

Q3. When aqueous solution of borax is acidified with hydrochloric acid, a white crystalline solid is formed which is soapy to touch. Is this solid acidic or basic in nature? Explain.

Answer:

Boric acid is generated when an aqueous solution of borax is acidified with HCl.



Boric acid is a crystalline white substance. It has a soapy feel to it due to its planar layered structure. It isn't a protonic acid because it doesn't ionise in water to release H^+ ions. B(OH)_3 absorbs a pair of electrons from the oxygen atom of a molecule of H_2O , releasing a proton, due to the tiny size of the boron and the presence of only six electrons in its valence shell. As a result, it behaves as a Lewis acid.

Q4. Three pairs of compounds are given below. Identify that compound in each of the pairs which has group 13 element in more stable oxidation state.

Give reason for your choice. State the nature of bonding also.

- (i) TlCl_3 , TlCl
- (ii) AlCl_3 , AlCl
- (iii) InCl_3 , InCl

Answer:

(i) TlCl is a more stable compound. It's a type of ionic compound. Because the inert pair effect is strongest in thallium, the +1 oxidation state is more stable than the +3 state.

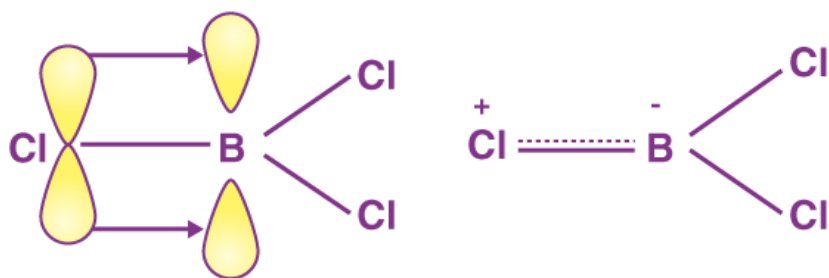
(ii) AlCl_3 is a more stable compound. The anhydrous state is covalent, whereas the aqueous state is ionic. The oxidation state of +3 is more stable than that of +1. Because AlCl_3 has no inert pair effect, it is a covalent molecule that accepts electrons to become stable and so acts as a Lewis acid.

(iii) InCl_3 is a more stable compound. In nature, the anhydrous state is more covalent and less ionic. The inert pair effect is significant, although not as strong as in thallium. Indium exists in both +1 and +3 oxidation states due to the inert pair effect, with the +3 oxidation state being more stable than the +1 oxidation state.

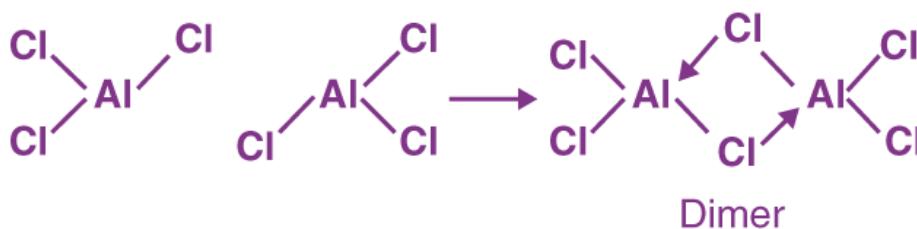
Q5. BCl_3 exists as monomer whereas AlCl_3 is dimerised through halogen bridging. Give reason. Explain the structure of the dimer of AlCl_3 also.

Answer:

Despite the fact that BCl_3 is an electron-deficient molecule, it exists as a monomer. It gains stability through the formation of $p\pi-p\pi$ back bonding. Chlorine donates two electrons to boron's vacant 2p-orbital. The lengths of the three bonds are identical.



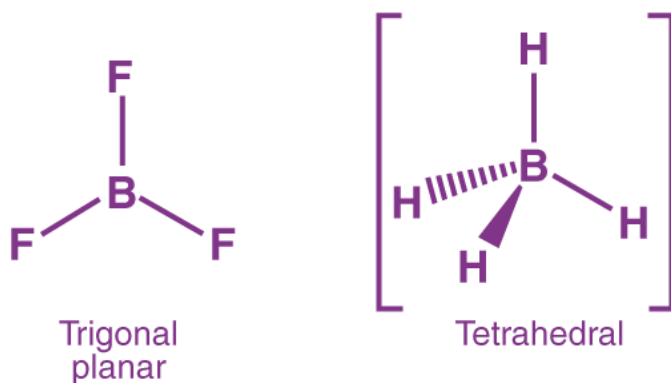
As a result, the backbonding that gives the molecule its double bond property is delocalized. AlCl_3 is an electron-poor chemical as well. Back bonding is not possible in AlCl_3 because aluminium is greater than boron. The octet of aluminium metal is completed by creating a coordinating connection with the chlorine atom of another molecule, AlCl_3 . As a result, a dimer molecule is formed when chlorine atoms build bridges between two Al atoms.



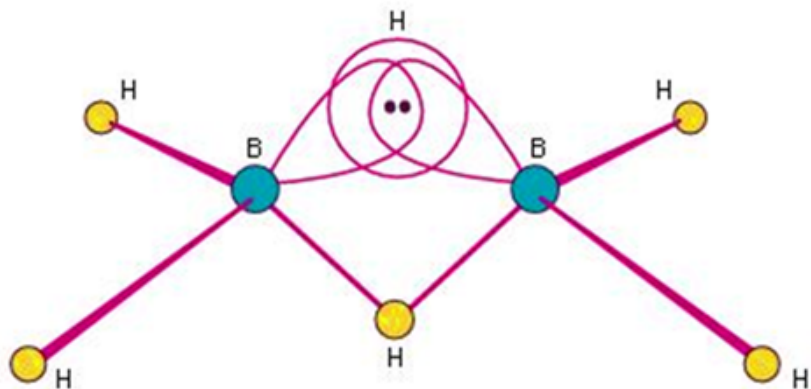
Q6. Boron fluoride exists as BF_3 but boron hydride doesn't exist as BH_3 . Give reason. In which form does it exist? Explain its structure.

Answer:

Due to $p\pi-p\pi$ back bonding, BF_3 exists as a monomer. Fluorine donates two electrons to boron's empty $2p$ -orbital. The delocalization minimises the electron shortage on boron, boosting the BF_3 molecule's stability. Back bonding does not occur in BH_3 due to the absence of a lone pair of electrons on H.



To put it another way, boron's electron shortage persists, and BH_3 does not exist. BH_3 dimerises to create B_2H_6 to decrease electron deficit. As a result, diborane is the dimeric form of boron hydride. A lone pair exists in hydrogen in BH_3 . As a result, it is unable to compensate for boron deficit by dimerizing to generate B_2H_6 , which has the structure of a banana.

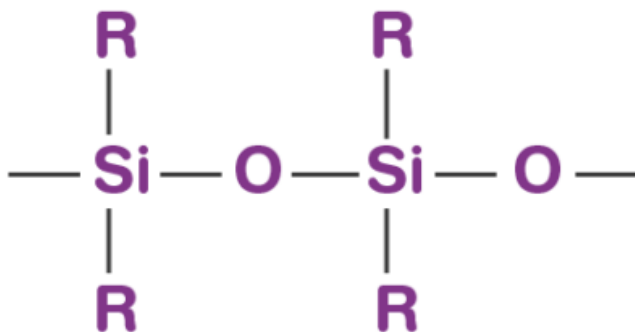


Q7. (i) What are silicones? State the uses of silicones.

(i) What are boranes? Give chemical equation for the preparation of diborane.

Answer:

(i) Silicones are a form of polymer also known as polysiloxanes. This category of polymers includes any inert, synthetic material made up of iterative units of siloxane. It's a chain of oxygen and silicon atoms that's usually mixed with hydrogen and carbon.



Silicones are the most popular sort of synthetic object on the market today, and they're utilised in thousands of applications that ensure people's safety and well-being.

Uses of Silicones include:

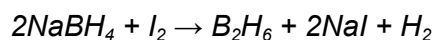
- (a) Silicones are non-toxic, heat-stable, and hydrophobic (water-repellent) by nature. By exposing them to silicone vapour, they are used to make waterproof cloth, paper, wool, wood, and other materials.

- (b) Silicone oils are lubricants that can be utilised at both high and low temperatures.
- (c) Electric motors and other electrical appliances use them as insulating materials.
- (d) Silicone rubbers are important because they keep their suppleness across a wide temperature range.
- (e) To make them resistant to the effects of high temperatures, sunshine, and damp, these are blended with paints and enamels.

(ii) Boranes, like Alkanes, are binary compounds combining boron and hydrogen. Diborane is a type of covalent hydride with the formula B_2H_6 . Boron trifluoride is treated with $LiAlH_4$ in diethyl ether to produce diborane.

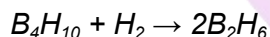
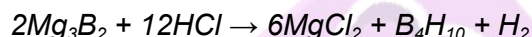


The oxidation of sodium borohydride with iodine can also be used to make it. Consider the following scenario:



The reaction of a metal hydride with boron produces diborane. This process is frequently utilised in the industrial manufacturing of diborane. The reaction of iodine with sodium borohydride in diglyme can yield diborane in modest doses.

When magnesium boride is heated with HCl, a mixture of volatile boranes forms:



Q8. A compound (A) of boron reacts with NMe_3 to give an adduct (B) which on hydrolysis gives a compound (C) and hydrogen gas. Compound (C) is an acid. Identify the compounds A, B and C. Give the reactions involved.

Answer:

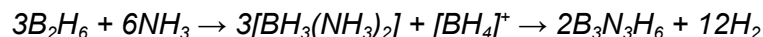
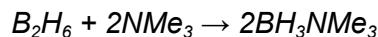
The breakdown of polymers into monomers using water molecules and an enzyme catalyst is known as hydrolysis. Hydrolysis reactions release energy by breaking bonds.

Because compound A combines with Boron to form [B], it is a Lewis acid because it accepts electrons. When [B] interacts with [C], hydrogen is liberated, and [A] becomes B_2H_6 . Thus B is $2BH_3NMe_3$, while C is boric acid.

A = B_2H_6 (Diborane)

B = $2BH_3NMe_3$ (Adduct)

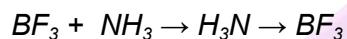
C = $2B_3N_3H_6$ (Inorganic Borazine)



Q9. A nonmetallic element of group 13, used in making bullet proof vests is extremely hard solid of black colour. It can exist in many allotropic forms and has unusually high melting point. Its trifluoride acts as Lewis acid towards ammonia. The element exhibits maximum covalency of four. Identify the element and write the reaction of its trifluoride with ammonia. Explain why does the trifluoride act as a Lewis acid.

Answer:

Boron is the nonmetallic element of group 13. It has a grey-black colour and is quite hard in nature. It has a high melting point of 2300 degrees Celsius. It comes in two allotropic varieties: Amorphous powder (a) crystalline solid (b) amorphous solid. It produces BF_3 or trifluoride. Because it is an electron-deficient molecule, BF_3 works as a Lewis acid.



Boron accepts an electron pair donated by NH_3 to saturate its outer shell. Because boron's valency shell only has four orbitals, it has a maximum covalency of four. Because monomeric trihalides lack electrons, they act as powerful Lewis acids. Trifluoride of boron reacts readily with Lewis bases like NH_3 to complete the octet of boron. Boron is unable to exceed the above-mentioned covalence due to the absence of d electrons.

Q10. A tetravalent element forms monoxide and dioxide with oxygen. When air is passed over heated element (1273 K), producer gas is obtained. Monoxide of the element is a powerful reducing agent and reduces ferric oxide to iron. Identify the element and write formulas of its monoxide and dioxide. Write chemical equations for the formation of producer gas and reduction of ferric oxide with the monoxide.

Answer:

Carbon is a tetravalent element that is being discussed. As a result of the reaction with oxygen, it can form carbon monoxide and dioxide.

Formation of producer gas is as follows:

- 1) $2C + O_2 \rightarrow 2CO$ (Carbon is directly oxidised as a result of this process)
- 2) $HCOOH \rightarrow H_2O + CO$ (At 373K, formic acid is dehydrated with concentrated H_2SO_4)
- 3) $C + H_2O \rightarrow CO + H_2$ (Water gas is a combination of CO and H_2)
- 4) $2C + O_2 + 4N_2 \rightarrow 2CO + 4N_2$ (The producer gas is a combination of CO and N_2)

Ferric Oxide Reduction Using Monoxide:

