Chapter 2
p-Block Elements – I

I. Choose the correct answer:

Question 1.
An aqueous solution of borax is ……
(a) neutral
(b) acidic
(c) basic
(d) amphoteric
Answer:
(c) basic.
Hint: $Na_2B_4O_7 + 7H_2O \rightleftharpoons \underset{\text{Strong base}}{2NaOH} + \underset{\text{Weak acid}}{4H_3BO_3}$

Question 2.
Boric acid is an acid because its molecule ……
(a) contains replaceable H^+ ion
(b) gives up a proton
(c) combines with proton to form water molecule
(d) accepts OH^- from water, releasing proton.
Answer:
(d) accepts OH^- from water, releasing proton

Hint: $B(OH)_3 + H_2O \rightleftharpoons [B(OH)_4]^- + H^+$

Question 3.
Which among the following is not a borane?
(a) B_2H_6
(b) B_3H_6
(C) B_4H_{10}
(d) none of these
Answer:
(a) B_2H_6
Hint:

- Nido borane – B_nH_{4+n}
- aracno borane – B_nH_{6+n} , B_3H_6 is not a borane

Question 4.
Which of the following metals has the largest abundance in the earth's crust?
(a) Aluminium

(b) calcium
(c) Magnesium
(d) Sodium
Answer:
(a) Aluminium

Question 5.
In diborane, the number of electrons that accounts for banana bonds is ……
(a) six
(b) two
(c) four
(d) three
Answer:
(c) four

Hint: There are two 3c – $2e^-$ bonds i.e., the bonding in the bridges account for 4 electrons.

Question 6.
The element that does not show catenation among the following p-block elements is ……
(a) Carbon
(b) silicon
(c) Lead
(d) germanium
Answer:
(c) Lead

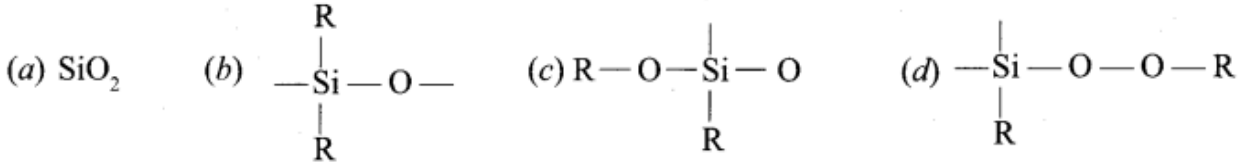
Question 7.
Carbon atoms in fullerene with formula C_{60} have ……
(a) sp^3 hybridised
(b) sp hybridised
(c) sp^2 hybridised
(d) partially sp^2 and partially sp^3 hybridised
Answer:
(c) sp^2 hybridised

Question 8.
Oxidation state of carbon in its hydrides ……
(a) +4
(b) -4
(c) +3
(d) +2
Answer:

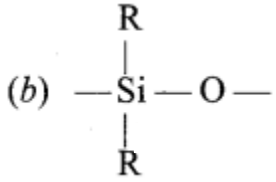
(a) +4
Hint: CH_4^+in which the oxidation state of carbon is 4.

Question 9.
The basic structural unit of silicates is ……
(a) $(SiO_3)^{2-}$
(b) $(SiO_4)^{2-}$
(c) $(SiO)^-$
(d) $(SiO_4)^{4-}$
Answer:
(d) $(SiO_4)^{4-}$

Question 10.
The repeating unit in silicone is ……



Answer:



Question 11.
Which of these is not a monomer for a high molecular mass silicone polymer?
(a) Me_3SiCl
(b) $PhSiCl_3$
(c) $MeSiCl_3$
(d) Me_3SiCl_3
Answer:
(a) Me_3SiCl

Question 12.
Which of the following is not sp^2 hybridised?
(a) Graphite
(b) graphene
(c) Fullerene
(d) dry ice
Answer:
(a) dry ice
Hint: dry ice – solid CO_2 in which carbon is in sp hybridized state

Question 13.

The geometry at which carbon atom in diamond are bonded to each other is ……
(a) Tetrahedral
(b) hexagonal
(c) Octahedral
(d) none of these
Answer:
(a) Tetrahedral

Question 14.
Which of the following statements is not correct?
(a) Beryl is a cyclic silicate
(b) Mg_2SiO_4 is an orthosilicate
(c) SiO_4^{4-} is the basic structural unit of silicates
(d) Feldspar is not aluminosilicate
Answer:
(d) Feldspar is a three dimensional silicate

Question 15.
AlF_3 is soluble in HF only in the presence of KF. It is due to the formation of …… [NEET]
(a) $K_3[AlF_3H_3]$
(b) $K_3[AlF_6]$
(C) AlH_3
(d) $K[AlF_3H]$
Answer:
(6)$K_3[AlF_6]$
Hint: $AlF_3 + 3KF \rightarrow K_3[AlF_6]$

Question 16.
Match items in column – I with the items of column – II ans assign the correct code

Column-I	Column-II
A Borazole	1. $B(OH)_3$
B Boric acid	2. $B_3N_3H_6$
C Quartz	3. $Na_2[B_4O_5(OH)_4]\ 8H_2O$
D Borax	4. SiO_2

	A	B	C	D
(*a*)	2	1	4	3
(*b*)	1	2	4	3
(*c*)	1	2	4	3
(*d*)	None of these			

Answer:
(a) A – 2, B – 1, C – 4, D – 3

Question 17.
Duralumin is an alloy of ……
(a) Cu, Mn
(b) Cu, Al, Mg
(c) Al, Mn
(d) Al, Cu, Mn, Mg
Answer:
(d) Al, Cu, Mn, Mg
Hint: Al – 95% , Cu – 4% , Mn – 0.5% , Mg – 1.1 %

Question 18.
Thermodynamically the most stable form of carbon is ……
(a) Diamond
(b) graphite
(c) Fullerene
(d) none of these
Answer:
(b) graphite

Question 19.
The compound that is used in nuclear reactors as protective shields and control rods is ……
(a) Metal borides
(b) metal oxides
(c) Metal carbonates
(d) metal carbide
Answer:
(a) Metal borides

Question 20.
The stability of +1 oxidation state increases in the sequence ……
(a) Al < Ga < In < Tl
(b) Tl < In < Ga < Al
(c) In < Tl < Ga < Al
(d) Ga< In < Al < Tl
Answer:
(a) Al < Ga < In < Tl

II. Answer the following questions:

Question 1.
Write a short note on anamolous properties of the first element of p-block.
Answer:
In p-block elements the first member of each group differs from the other elements of the corresponding group. The following factors are responsible for this anomalous behaviour.

1. Small size of the first member.
2. High ionisation enthalpy and high electronegativity.
3. Absence of d-orbitals in their valance shell.

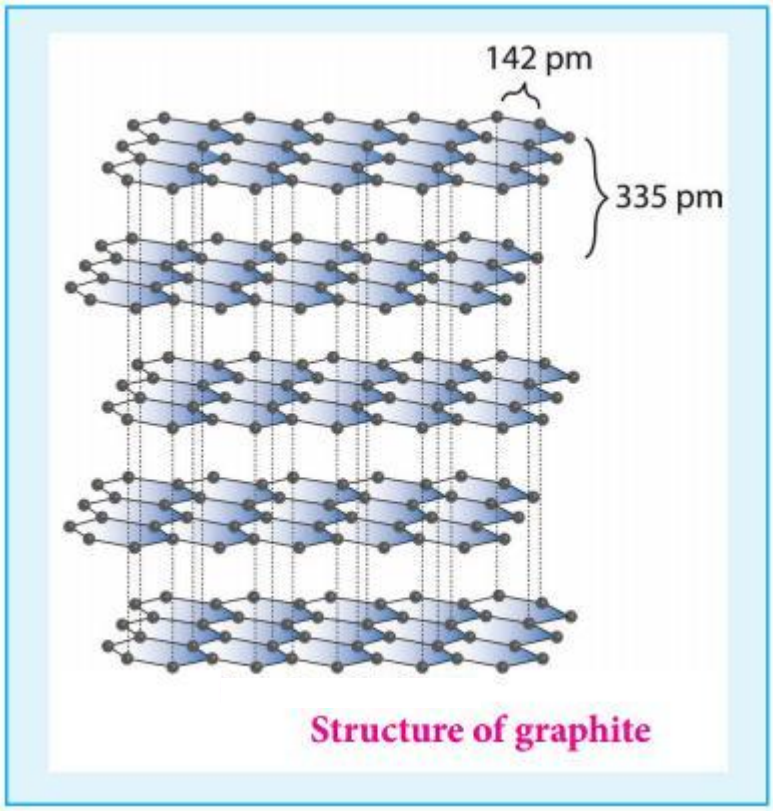
The first member of the group-13, boron is a metalloid while others are reactive metals. Moreover, boron shows diagonal relationship with silicon of group -14. The oxides of boron and silicon are similar in their acidic nature.

Question 2.
Describe briefly allotropism in p- block elements with specific reference to carbon.
Answer:
Some elements exist in more than one crystalline or molecular forms in the same physical state. This phenomenon is called allotropism. Most common allotropes of carbon are,

1. Graphite
2. Diamond
3. Fullerenes
4. Carbon nanotubes
5. Graphene.

1. Graphite:

- It is the most stable allotropic form of carbon at normal temperature and pressure.
- It is soft and conducts electricity.
- It is composed of flat two dimensional sheets of carbon atoms.
- Each sheet is a hexagonal net of sp^2 hybridised carbon atoms with a C – C bond length of 1.41 A.
- Structure of graphite,

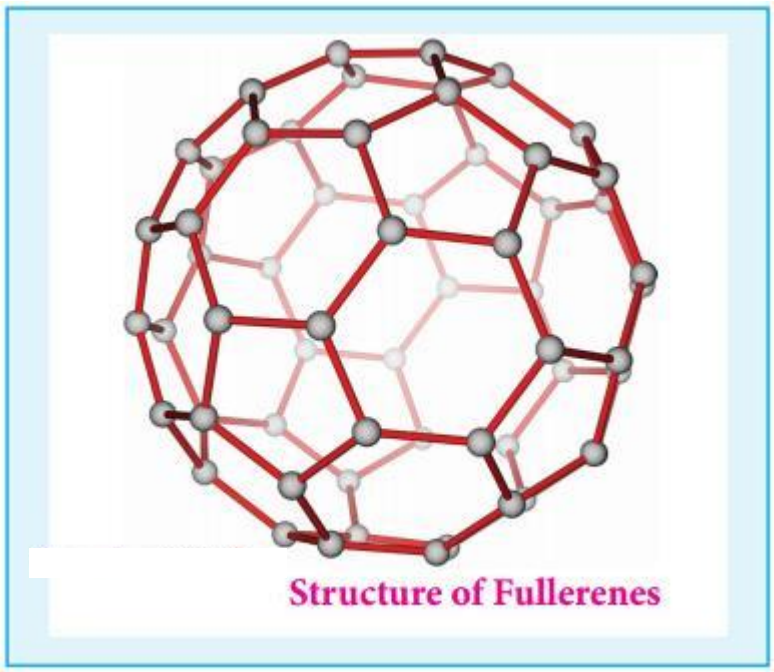


2. Diamond:

- It is very hard.
- The carbon atoms in diamond are sp^1 hybridised, with a C – C bond length of 1.54 A.
- In the diamond, carbon atoms are arranged in tetrahedral manner.
- Structure of Diamond,

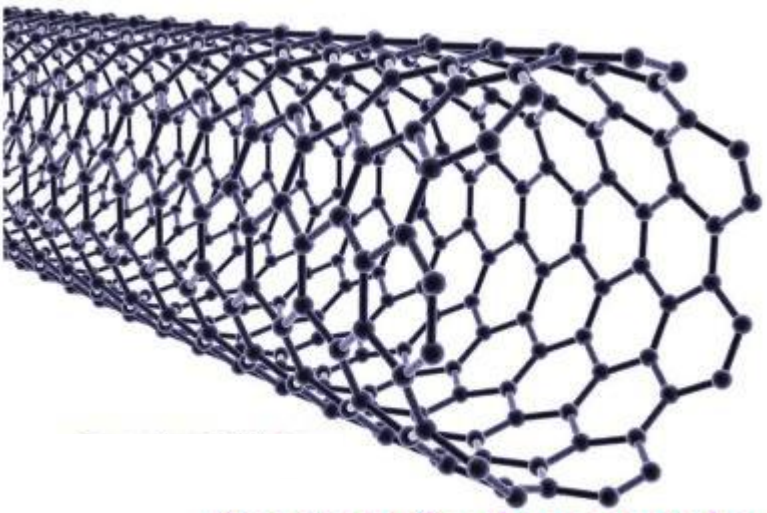
3. Fullerenes:

- It is a newly synthesised allotropes of carbon.
- The C_{60} molecules have a soccer ball-like structure and is called buckminsterfullerene or buckyballs.
- It has a fused ring structure consists of 20 six-membered rings and 12 five-membered rings.
- Each carbon atom is sp^2 hybridised.
- The C – C bond distance is 1.44 A and C = C distance is 1.38 A.
- Structure of fullerene,



4. Carbon nanotubes:

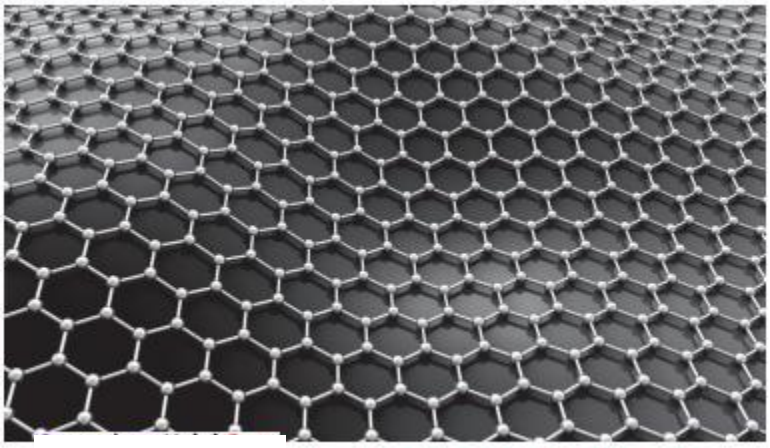
1. It is recently discovered allotropes, have graphite-like tubes with fullerene ends.
2. These nanotubes are stronger than steel and conduct electricity.
3. Structure of Carbon nanotubes.



Structure of carbon nanotubes

5. Graphene:

- It has a single planar sheet of sp^2 hybridised carbon atoms that are densely packed in a honeycomb crystals lattice.
- Structure of Graphene,



Structure of graphene

Question 3.
Boron does not react directly with hydrogen. Suggest one method to prepare diborane from BF_3.
Answer:
Boron does not react directly with hydrogen. However it forms a variety of hydrides called boranes. Treatment of gaseous boron trifluoride with sodium hydride around 450 K gives

diborane.

$$\underset{\text{(Borontrifluoride)}}{2BF_3} + 6NaH \xrightarrow{450\ K} \underset{\text{(Diborane)}}{B_2H_6} + 6NaF$$

Question 4.
Give the uses of Borax.
Answer:
Uses of borax:

1. Used for the identification of coloured metal ions (Borax bead test)
2. Manufacture of optical and borosilicate glass, enamels and glazes for pottery.
3. Flux in metallurgy.
4. Good preservative.

Question 5.
What is catenation? describe briefly the catenation property of carbon.
Answer:
Catenation is an ability of an element to form a chain of atoms.

The conditions for catenation are

- The valency of the element is greater than or equal to two.
- The element should have the ability to bond with itself.
- The self-bond must be as strong as its bond with other elements.
- Kinetic inertness of catenated compound towards other molecules.

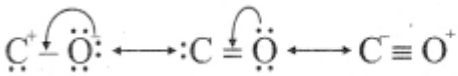
Carbon possesses all the above properties and shows catenation.

Carbon forms a wide range of compounds with itself and with other elements such as H, O, N, S and halogens.

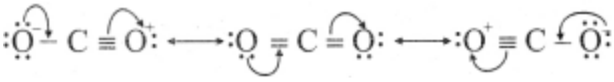
Question 6.
Write a note on Fisher tropsch synthesis.
Answer:
The reaction of carbon monoxide with hydrogen at a pressure of less than 50 atm using metal catalysts at 500-700 K yields saturated and unsaturated hydrocarbons.

$$nCO + (2n+1)H_2 \rightarrow C_nH_{(2n+2)} + 2H_2O; \quad nCO + 2nH_2 \rightarrow C_nH_{2n} + nH_2O$$

Question 7.
Give the structure of CO and CO_2.
Answer:
Structure of CO:



Structure of CO_2:



Question 8.
Give the uses of silicones.
Answer:
Uses of silicones:

1. Silicones are used for low temperature lubrication and in vacuum pumps, high temperature oil baths etc.
2. They are used for making water proofing clothes.
3. They are used as insulting material in electrical motor and other appliances
4. They are mixed with paints and enamels to make them resistant towards high temperature, sunlight, dampness and chemicals.

Question 9.
$AlCl_3$ behaves like a lewis acid. Substantiate this statement.
Answer:
In $AlCl_3$, Al in electron-deficient it needs two electrons to complete octet so it act as lewis acid. $AlCl_3$ usually exist as a dimer to achieve octet by bridged Cl atom electron deficient compounds are lewis acids.

Question 10.
Describe the structure of diborane.
Answer:
In diborane two BH_2 units are linked by two bridged hydrogens. Therefore, it has eight B-H bonds. However, diborane has only 12 valance electrons and are not sufficient to form normal covalent bonds. The four terminal B-H bonds are normal covalent bonds (two centre – two electron bond or 2c-2e bond). The remaining four electrons have to used for the bridged bonds, i.e. two three centred B-H-B bonds utilise two electrons each.
Hence, these bonds are three centre – two electron bonds. The bridging hydrogen atoms are in a plane as shown in the figure. In dibome, the boron is sp^3 hybridised. Three of the four sp^3 hybridised orbitals contains single electron and the fourth orbital is empty.
Two of the half-filled hybridised orbitals of each boron overlap with the two hydrogens to form four-terminal 2c-2e bonds, leaving one empty and one half filled hybridised orbitals on each boron. The Three centre – two-electron bonds, B-H-B bond formation involves overlapping the half filled hybridised orbital of one boron, the empty hybridised orbital of the other boron and the half-filled 1s orbital of hydrogen.

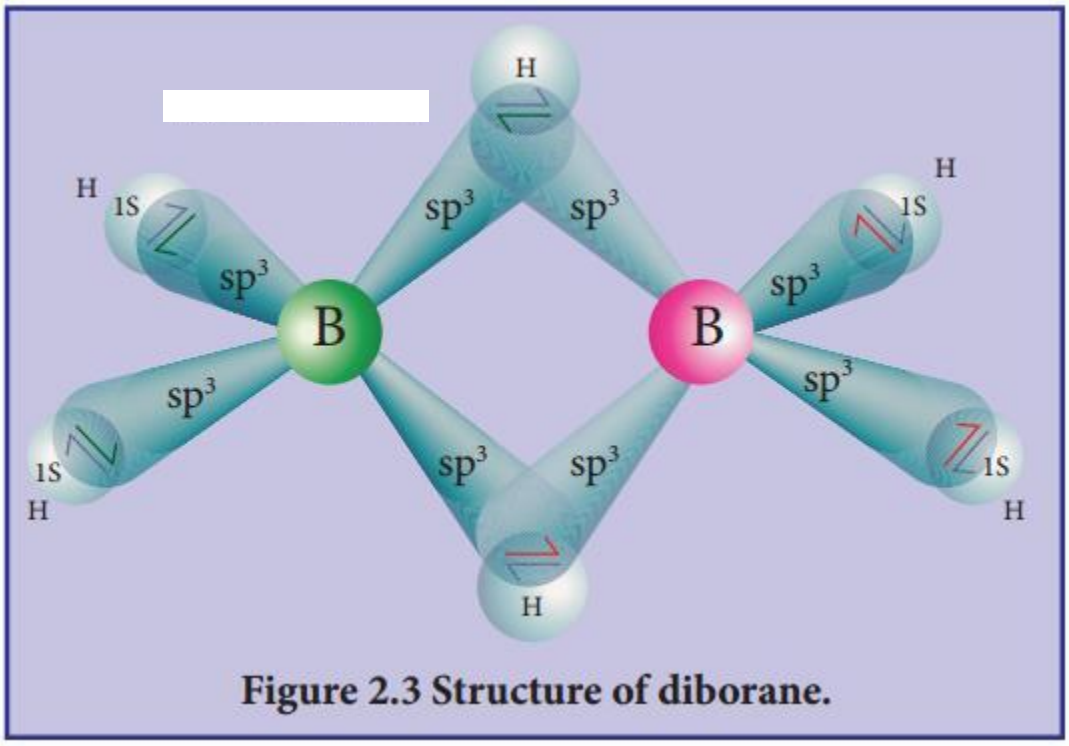


Figure 2.3 Structure of diborane.

Question 11.
Write a short note on hydroboration.
Answer:
Diborane adds on to alkenes and alkynes in ether solvent at room temperature. This reaction is called as hydroboration and is highly used in synthetic organic chemistry especially for anti-Markovnikov addition.
$B_2H_6 + 3RCH = CHR \rightarrow B(CH_2 - CH_2R)_3 + 6H_2$

Question 12.
Give one example for each of the following:

1. icosogens
2. tetragen
3. prictogen
4. chalcogen

Answer:
1. Icosogens:

- Boron
- Aluminium
- Gallium

2. Tetragen:

- Carbon
- Silicon
- Germanium

3. Prictogen:

- Oxygen
- Sulfur
- Selenium

4. Chalcogen:

- Fluorine
- Chlorine
- Bromine

Question 13.
Write a note on the metallic nature of p-block elements.
Answer:

1. The tendency of an element to form a cation by loosing electrons is known as an electropositive or metallic character.
2. This character depends on the ionisation energy.
3. Generally on descending a group the ionisation energy decreases and hence the metallic character increases.

In p-block, the elements present in lower left part are metals while the elements in the upper right part are non-metals. Elements of group 13 have metallic character except the first element boron which is a metalloid, having properties intermediate between the metal and nonmetals. The atomic radius of boron is very small and it has a relatively high nuclear charge and these properties are responsible for its nonmetallic character.

In the subsequent groups the non-metallic character increases. In group 14 elements, carbon is a nonmetal while silicon and germanium are metalloids. In group 15, nitrogen and phosphorus are nonmetals and arsenic & antimony are metalloids. In group 16, oxygen, sulphur and selenium are nonmetals and tellurium is a metalloid. All the elements of group 17 and 18 are non-metals.

Question 14.
Complete the following reactions:
(a) $B(OH)_3 + NH_3 \rightarrow$
(b) $Na_2B_4O_7 + H_2SO_4 + H_2O \rightarrow$
(c) $B_2H_6 + 2NaOH + 2H_2O \rightarrow$
(d) $B_2H_6 + CH_3OH \rightarrow$
(e) $BF_3 + 9H_2O \rightarrow$
(f) $HCOOH + H_2SO_4 \rightarrow$
(g) $SiCl_4 + NH_3 \rightarrow$

(h) $SiCl_4 + C_2H_5OH \rightarrow$
(i) $B + NaOH \rightarrow$
(j) $H_2B_4O_7$ Redhot$-\!\!\rightarrow\!\!-\!\!-\!\!-\!\!-\!\!-$

Answer:

(a) $B(OH)_3 + NH_3 \xrightarrow{\Delta} \underset{\text{(Boron nitride)}}{BN} + 3H_2O$

(b) $Na_2B_4O_7 + H_2SO_4 + 5H_2O \longrightarrow \underset{\text{(Boric acid)}}{4H_3BO_3} + 2Na_2SO_4$

(c) $B_2H_6 + 2NaOH + 2H_2O \longrightarrow \underset{\text{(Sodiummeteborate)}}{4NaBO_2} + 6H_2$

(d) $B_2H_6 + 6CH_3OH \longrightarrow \underset{\text{(Trimethyl borate)}}{2B(OCH_3)_3} + 6H_2$

(e) $4BF_3 + 9H_2O \longrightarrow \underset{\text{(Boric acid)}}{4H_3BO_3} + 3H^+ + 3[BF_4]^-$

(f) $HCOOH + H_2SO_4 \longrightarrow \underset{\text{(Carbon monoxide)}}{CO} + H_2O + H_2SO_4$

(g) $SiCl_4 + NH_3 \xrightarrow[\text{ether}]{330\ K} \underset{\text{(Chlorosizalanes)}}{Cl_3Si - NH - SiCl_3}$

(h) $SiCl_4 + C_2H_5OH \longrightarrow \underset{\text{(Tetraethoxy silane)}}{Si(OC_2H_5)_4} + 2Cl_2$

(i) $2B + 6NaOH \longrightarrow \underset{\text{(Sodium borate)}}{2Na_3BO_3} + H_2O$

(j) $H_2B_4O_7 \xrightarrow{\text{Red hot}} \underset{\text{(Boric anhydride)}}{2B_2O_3} + H_2O$

Question 15.
How will you identify borate radical?

Answer:
When boric acid or borate salt is heated with ethyl alcohol in presence of concentrated H_2SO_4, an ester triethyl borate is formed. The Vapour of this ester burns with a green edged flame and this reaction is used to identify the presence of borate.

$$4H_3BO_3 + 3C_2H_5OH \xrightarrow{\text{con. } H_2SO_4} \underset{\text{(Triethylborate)}}{B(OC_2H_5)_3} + 3H_2O$$

Question 16.
Write a note on zeolites.

Answer:
Zeolites:

1. Zeolites are three-dimensional crystalline solids containing aluminium, silicon and oxygen in their regular three-dimensional framework.
2. They are hydrated sodium alumino silicates with general formula, $Na_2O.(Al_2O_3).x(SiO_2)y(H_2O)$ ($x = 2$ to 10; $y = 2$ to 6)

3. Zeolites have the porous structure in which the monovalent sodium ions and water molecules are loosely held.
4. The Si and Al atoms are tetrahedrally coordinated with each other through shared oxygen atoms.
5. Zeolites structure looks like a honeycomb consisting of a network of interconnected tunnels and cages.
6. Zeolite crystal to act as a molecular sieve. They help to remove the permanent hardness of the water.

Question 17.
How will you convert boric acid to boron nitride?
Answer:
Fusion of urea with boric acid $B(OH)_3$, in an atmosphere of ammonia at 800 – 1200 K gives

$$\underset{\text{(Boric acid)}}{B(OH)_3} + NH_3 \xrightarrow{\Delta} \underset{\text{(Boron nitride)}}{BN} + 3H_2O$$

Question 18.
A hydride of 2nd period alkali metal
(A) on reaction with compound of Boron
(B) to give a reducing agent
(C) identify A, B and C.
Answer:

1. A hydride of 2nd period alkali metal (A) is lithium hydride (LiH).
2. Lithium hydride (A) reacts with diborane (B) to give lithium borohydride (C) which is acts as a reducing agent.

$$\underset{\substack{\text{(Diborane)}\\\text{(B)}}}{B_2H_6} + \underset{\substack{\text{(Lithiumhydride)}\\\text{(A)}}}{2LiH} \xrightarrow{\text{Ether}} \underset{\text{(Lithiumborohydride)}\\\text{(C)}}{2LiBH_4}$$

(A) Lithium hydride – LiH
(B) Diborane – B_2H_6
(C) Lithium borohydride – $LiBH_4$

Question 19.
A double salt which contains fourth-period alkali metal
(A) on heating at 500K gives
(B) Aqueous solution of (B) gives white precipitate with $BaCl_2$ and gives a red colour compound with alizarin. Identify A and B.
Answer:
1. A double salt which contains fourth-period alkali metal (A) is potash alum
$K_2SO_4 . Al_2(SO_4)_3 . 24H_2O$
2. On heating potash alum (A) 500 k give anhydrous potash alum (or) burnt alum (B).

$$\underset{\substack{\text{(Potash alum)}\\\text{(A)}}}{K_2SO_4 \cdot Al_2(SO_4)_3 . 24H_2O} \xrightarrow{500\ K} \underset{\substack{\text{(Burnt alum)}\\\text{(B)}}}{K_2SO_4 \cdot Al_2(SO_4)_3} + 24H_2O$$

3. Aqueous solution of burnt alum, has sulphates ion, potassium ion and aluminium ion.
Sulphate ion reacts with $BaCl_2$ to form white precipitate of Barium Sulphate
$(SO_4)_2 + BaCl_2 \rightarrow BaSO_4 + 2Cl^-$
Aluminium ion reacts with alizarin solution to give a red colour compound.
Question 20.
CO is a reducing agent. Justify with an example.
Answer:
Both thermodynamic and kinetic factors make carbon monoxide (CO) a better reducing agent. When CO is used to reduce a metal oxide, it gets oxidized to CO_2 Thermodynamically, CO_2 is much more stable than CO. For example,
$CO + Fe_2O_3 \rightarrow 2Fe + 3CO_2$