

p-BLOCK ELEMENTS (13 & 14 GROUP)

BORON FAMILY

ELECTRONIC CONFIGURATION

The general outer electronic configuration is ns^2np^1 . Hence these elements belong to p-block.

Elements	Configuration
Boron [B ₅]	[He] 2s ² 2p ¹
Aluminium [Al ₁₃]	[Ne] 3s ² , 3p ¹
Gallium [Ga ₃₁]	[Ar] 3d ¹⁰ , 4s ² 4p ¹

- Indium [In₄₉] [Kr] 4d¹⁰, 5s², sp¹
- Thallium [Tl₈₁] [Xe] 4f¹⁴, 5d¹⁰, 6s²6s²6p¹
- * B is nonmetal due to its small size, high I.E. and high E.N.
- * Al, Ga, In, Tl show typical metallic properties.
- * Al is third most abundant element [7.4%]
- * Tl is highly toxic.
- * Compounds of Al are Al₂O₃, AlCl₃.6H₂O, alums, LiAlH₄, ultramarine etc.

CHEMICAL CHARACTERISTICS

Boron	Aluminium
Oxidation state : [+3] B ₂ O ₃ , BCl ₃ , H ₃ BO ₃ , Na ₂ B ₄ O ₇ [Boron also shows (-3) O.S. in metal borides]	[+3] Al ₂ O ₃ , AlCl ₃ , Al(OH) ₃ NaAlO ₂
Reaction with conc. H₂SO₄: 2B + 3H ₂ SO ₄ → 2H ₃ BO ₃ + 3SO ₂	2Al + 6H ₂ SO ₄ → Al ₂ (SO ₄) ₃ + 3SO ₂ + 6H ₂ O
Reaction with O₂: 4B + 3O ₂ $\xrightarrow{700^\circ\text{C}}$ 2B ₂ O ₃	4Al + 3O ₂ $\xrightarrow{800^\circ\text{C}}$ 2Al ₂ O ₃
Formation of chlorides : B ₂ O ₃ + 3C + 3Cl ₂ → BCl ₃ + 3CO	Al ₂ O ₃ + 3C + 3Cl ₂ → 2AlCl ₃ + 3CO
Nature of Chlorides Lewis acids : [H ₃ N → BCl ₃]	[H ₃ N → AlCl ₃]
Hydrolysis : BCl ₃ + 3H ₂ O → H ₃ BO ₃ + 3HCl	AlCl ₃ + 3H ₂ O → Al(OH) ₃ + 3HCl
Formation of nitrides : 2B + N ₂ → 2BN 2B + 2NH ₃ → 2BN + 3H ₂	2Al + N ₂ → 2AlN 2Al + 2NH ₃ → 2AlN + 3H ₂
Hydrolysis of nitride : BN + 3H ₂ O → H ₃ BO ₃ + NH ₃	AlN + 3H ₂ O → Al(OH) ₃ + NH ₃
Reducing character : 4B + 3CO ₂ → 2B ₂ O ₃ + 3C	2Al + 3CO ₂ → 2Al ₂ O ₃ + 3C 2Al + Cr ₂ O ₃ → Al ₂ O ₃ + 2Cr 2Al + Fe ₂ O ₃ → Al ₂ O ₃ + 2Fe
Treatment with steam : 2B + 2H ₂ O $\xrightarrow{\text{Steam}}$ B ₂ O ₃ + H ₂	2Al + 6H ₂ O $\xrightarrow{\text{boiling water}}$ 2Al(OH) ₃ + 3H ₂
Nonmetal Boron forms hydrides [B ₂ H ₆ , B ₄ H ₁₀ , B ₁₀ H ₁₄ , etc] B ₂ O ₃ is acidic; B ₂ O ₃ + 3H ₂ O → 2H ₃ BO ₃	Metal LiAlH ₄ Al ₂ O ₃ is amphoteric Al ₂ O ₃ + NaOH → NaAlO ₂ + H ₂ O Al ₂ O ₃ + 6HCl → 2AlCl ₃ + 3H ₂ O Aluminates are less stable Al forms alloys with other metals Becomes passive with conc. HNO ₃ due to the formation of oxide layer Al ₂ O ₃
Borates are stable Forms borides with other metals 3Mg + 2B → Mg ₃ B ₂ Attacked by conc. HNO ₃ B + 3HNO ₃ → H ₃ BO ₃ + 2NO ₂ Orthoboric acid	

p-BLOCK ELEMENTS (13 & 14 GROUP)

Maximum covalency of four is observed in the compound $K[BF_4]$
 $B(OH)_3$ is acidic
 It forms covalent compounds only
 Forms of covalent carbide B_4C

Halides exist in monomeric form BX_3
 It dissolves in fused alkalies

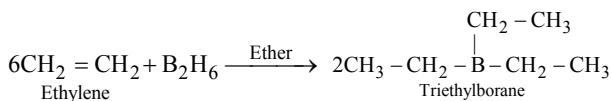
Maximum covalency of six is observed in $Na_3[AlF_6]$
 $Al(OH)_3$ is basic
 It forms both covalent and electrovalent compounds
 Forms an ionic carbide
 $Al_4C_3 \cdot [Al_4C_3] \xrightarrow{H_2O} CH_4$
 $AlCl_3$ and $AlBr_3$ exist as dimer
 It dissolves in hot alkalies.

COMPOUNDS OF BORON

1. DIBORANE (B_2H_6) : Simplest Boron hydride.

Properties :

- * Diboranes (M.P.) = $-165.5^{\circ}C$, B.P. = $-92.5^{\circ}C$ is a colourless gas with a foul smell & is extremely toxic.
- * It is an extremely reactive inflammable gas which burns in air with green flame.
- * Diborane reacts with sodium amalgum to form an addition product $B_2H_6Na_2$.
- * On heating to $700^{\circ}C$ diborane dissociates.
 $B_2H_6 \rightarrow 2B + 3H_2 \uparrow$
- * Diborane readily adds at $0^{\circ}C$ to $25^{\circ}C$ to the olefinic acetylene compound to form trialkylborane. The reaction is known as hydroboration.



- * Diborane is electron-deficient molecule & hence it reacts with several molecule having lone pair(s) of electron (e.g. CO , ether, amines etc.) to form complex compounds.
- * Boranes have great affinity for water & O_2 hence they do not occur in nature. Moreover borane cannot be prepared directly from its elements as they have positive enthalpy & positive free energy of formation.
- * $B_2H_6 + 3O_2 \rightarrow B_2O_3 + 2H_2O$; $\Delta H = -2008 \text{ kJ}$
 [Thus boranes are useful as high energy fuels]
- * $B_2H_6 + 6H_2O \rightarrow 2H_3BO_3$ (boric acid) + $6H_2$
- * $3B_2H_6 + 6NH_3 \xrightarrow{450K} B_3N_3H_6 + 12H_2$
 [(borazol) inorganic benzene]

Structure :

- * The four terminal hydrogen atoms and the two boron atoms lie in one plane. Above and below this plane, there are two bridging hydrogen atoms. The four terminal B-H bonds (strong) are regular two centre-two electron bonds while the two bridge (B-H-B) bonds (weak) are different and can be described in terms of three centre-two electron bonds.
- * Each B atom uses sp^3 hybrids for bonding. Out of the four sp^3 hybrids on each B atom, one is without an electron. The terminal B-H bonds are normal 2-centre-2-electron bonds but the two bridge bonds are 3-centre-2-electron bonds. The 3-centre-2-electron bridge bonds are also referred to as **banana bonds**.

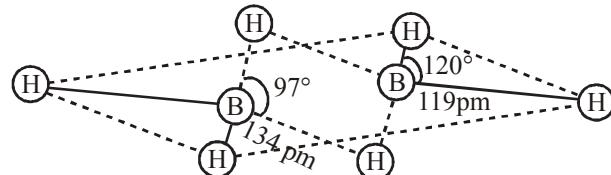


Figure : The structure of diborane, B_2H_6

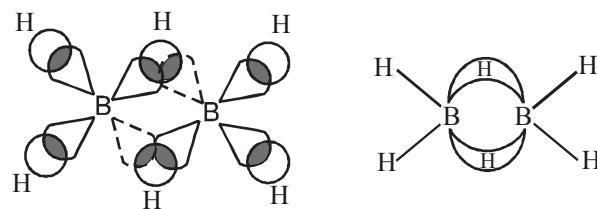


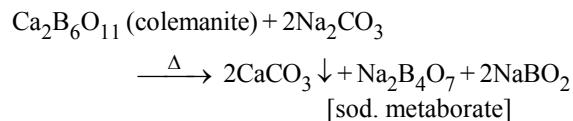
Figure : Bonding in diborane

Preparations :

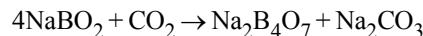
- (i) $4BCl_3 + 3LiAlH_4 \xrightarrow{\text{ether}} 2B_2H_6 + 3LiCl + 3AlCl_3$
- (ii) $8BF_3 + 6LiH \longrightarrow B_2H_6 + 6LiBF_4$
- (iii) $2BCl_3 + 6H_2 \xrightarrow{\text{silent electric discharge}} B_2H_6 + 6HCl$

2. BORAX (Sodium tetraborate decahydrate) (Tincal/ Suhaga) $[Na_2B_4O_7 \cdot 10H_2O]$

Preparation :

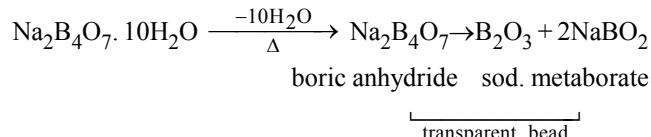


A current of CO_2 is passed in the mother liquor, sodium metaborate is converted to borax.



Properties :

- * Sparingly soluble in cold water. Soluble in hot water.
- * Aqueous solution is alkaline due to hydrolysis.
 $Na_2B_4O_7 + 7H_2O \rightleftharpoons 4H_3BO_3 + 2NaOH$
- * Action of heat :



Gives bead test with metal oxides :

$CuO + B_2O_3 \rightarrow Cu(BO_2)_2$ copper meta borate (blue)

$Mn(BO_2)_2$ amethyst

$Co(BO_2)_2$ blue

Uses :

- * In borax bead test.
- * Preservation for food stuffs.
- * In making heat and shock resistance glass.
- * Welding, soldering and in metallurgy.
- * Used in match and leather industries.

3. BORIC ACID (H_3BO_3)
Preparation :

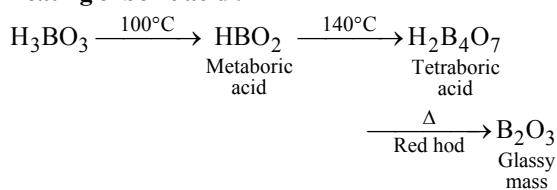
- * It is obtained from borax by treating with dil. HCl.

$$Na_2B_4O_7 + 2HCl + 5H_2O \rightarrow 2NaCl + 4H_3BO_3$$
- * It can also be obtained from the mineral colemanite by passing SO_2 through a mixture of powdered mineral in boiling water.

$$Ca_2B_6O_{11} + 4SO_2 + 11H_2O \rightarrow 2Ca(HSO_3)_2 + 6H_3BO_3$$

Properties :

- * It is a white crystalline solid, with a soapy touch.
- * Sparingly soluble in water but highly soluble in hot water.
- * It is a weak monobasic acid, does not act as a proton donor but behaves as a Lewis acid.
- * **Heating of boric acid :**



- * With C_2H_5OH and conc. H_2SO_4 , it gives triethylborate which burns with green edged flame.

Uses :

- * As a food preservative.
- * As a mild antiseptic for eyewash under the name boric lotion.
- * For the preparation of glazes and enamels in pottery.

4. BORON TRIHALIDES

- * All trihalides, BX_3 ($X = F, Cl, Br, I$), have a trigonal planar structure.
- * Lewis acid strength increases in the order :
 $BF_3 < BCl_3 < BBr_3 < BI_3$.
- * When small amounts of $BF_3(g)$ are passed through water, a solution of fluoroboric acid results.
- * BF_3 and SiF_4 (colourless gases)
- * BCl_3 and $SiCl_4$ (volatile liquids)
- * $BCl_3 + 3H_2O \rightarrow H_3BO_3$ (boric acid) + $3HCl$

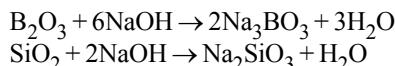
DIAGONAL RELATIONSHIP BETWEEN BORON & SILICON

- * B and Si do not occur in free state.
- * B and Si are non metals.
- * B and Si act as semi conductors.
- * B and Si show two allotropic forms (crystalline & amorphous)

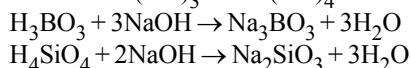
Hydrides : Both form hydrides :

$[B]$	$[Si]$
B_2H_6	diborane – 6
B_4H_{10}	tetraborane – 10

Oxides : Oxides of both the elements are acidic in nature :



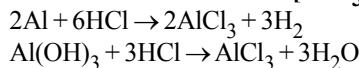
Hydroxides : $B(OH)_3$ and $Si(OH)_4$ are weak acids



Carbides : B_4C and SiC are very hard substances and are used as abrasive.

ALUMINIUM CHLORIDE
Preparation : Anhydrous $AlCl_3$

- (i) $2Al + 6HCl$ (dry gas) $\rightarrow 2AlCl_3 + 3H_2$
- (ii) $2Al + 3Cl_2 \rightarrow 2AlCl_3$
- (iii) $Al_2O_3 + 3C + 3Cl_2 \xrightarrow{1000^{\circ}C} 2AlCl_3 + 3CO$

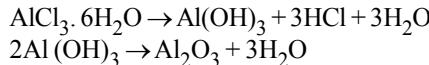
Hydrated aluminium chloride [$AlCl_3 \cdot 6H_2O$]

Properties

- * $AlCl_3$ (anhydrous) is white, hygroscopic substance.
- * V.D. corresponds to Al_2Cl_6 (at $350^{\circ}C$) and $AlCl_3$ (at $750^{\circ}C$)
- * Soluble in organic solvents (C_6H_6 , CS_2 etc)

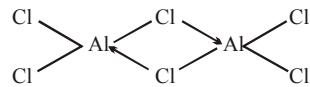
Addition compounds : Forms addition compounds with NH_3 , PH_3 , $COCl_2$ etc. [e.g. $AlCl_3 \cdot 6NH_3$]

Hydrolysis : It is highly soluble in water and undergoes hydrolysis. $AlCl_3 + 3H_2O \rightarrow Al(OH)_3 + 3HCl$

Action of heat : Hydrated form on heating gives Al_2O_3 .



Structure : (Halogen bridge dimer):



Uses : * Catalyst in the manufacture of petrol by cracking and in Friedel Crafts reactions.

- * Reagent in the manufacture of dyes, drugs and perfumes.

ALUMS
General formula : $M_2SO_4 \cdot M_2^1(SO_4)_3 \cdot 24H_2O$

M = monovalent cation : Na^+ , K^+ , Rb^+ etc.

M^1 = Trivalent cation : Al^{3+} , Fe^{3+} , Mn^{3+} etc.

Examples : $M_2SO_4 \cdot M_2^1(SO_4)_3 \cdot 24H_2O$

M	M^1	Name of the alum
K^+	Al^{3+}	Potash alum
NH_4^+	Al^{3+}	Ammonium alum
K^+	Cr^{3+}	Chrome alum
NH_4^+	Fe^{3+}	Ferric alum

Properties :

- * Alums are fairly soluble in cold water but soluble in hot water.
- * Solutions of alums are acidic.
- * Alums are isomorphous and form mixed crystal.
- * Lose water of crystallization when heated and swells up (burnt alum).

p-BLOCK ELEMENTS (13 & 14 GROUP)

Uses :

- * Used as a mordant in dyeing and printing.
- * In purification of water, leather tanning.
- * As antiseptic and in stopping bleeding from cuts.

Example 1 :

In diborane –

- (A) 4-bridged and two terminal hydrogens are present.
- (B) 2-bridged and four terminal hydrogens are present.
- (C) 3-bridged and three terminal hydrogens are present.
- (D) None of the above

Sol. (B). In diborane (B_2H_6) there are two bridged and four terminals H-atoms which along with two B atoms lie in plane perpendicular to each other.

Example 2 :

Aq. solution of borax reacts with two mol of acids, why?

Sol. $Na_2B_4O_7 + 7H_2O \rightarrow 2B(OH)_3 + 2Na[B(OH)_4]$
 $B(OH)_3$ or H_3BO_3 is an acid and does not react with acid.
Hence $Na[B(OH)_4]$ reacts with acid.

Example 3 :

Which of the following statements is incorrect about aluminium?

- (A) It liberates H_2 from acids.
- (B) It liberates H_2 from bases.
- (C) It liberates H_2 from both acids and bases.
- (D) It liberates H_2 from acids but not from bases.

Sol. (D). Al liberates H_2 from both acids and alkalies.
For example, $2Al + 6HCl \rightarrow 2AlCl_3 + 3H_2$

TRY IT YOURSELF-1

Q.1 Arrange group 13 elements in increasing order of atomic radii. Given reason.

Q.2 Highest first ionization enthalpy is possessed by –
(A) B (B) Al
(C) Ga (D) In

Q.3 When borax is heated in Bunsen burner flame with CoO . What is formed and colour imparted is ?
(A) Co_2O_3 , Blue (B) $Co(BO_2)_2$, Blue
(C) $Co(BO_2)_2$, Green (D) Co_2O_3 , Green

Q.4 The number of $3c - 2e^-$ bond in diborane is
(A) 0 (B) 1
(C) 2 (D) 3

Q.5 Borax dissolve in water to give solution which is –
(A) Acidic (B) Alkaline
(C) Amphoteric (D) Neutral

Q.6 Among the group 13 the only element which is non-metallic?
(A) B (B) Al (C) Ga (D) In

Q.7 Which type of hydride is BH_3 ?
(A) Electron deficient (B) Electron precise
(C) Electron excess (D) Lewis base

Q.8 Which of the following statement is correct regarding B_2H_6
(A) Each boron atom is sp^3 hybridised
(B) In B_2H_6 there are 4 normal B – H bonds.

- (C) In B_2H_6 two bonds are formed between three atoms B – H – B by using only two electrons per bond.
- (D) All of these

Q.9 Which of the following element was exceptionally high melting point ?

- (A) Al (B) Ga
- (C) B (D) In

ANSWERS

(1) B < Ga < Al < In < Tl (2) (A)	(3) (B)
(4) (C) (5) (B) (6) (A)	
(7) (A) (8) (D) (9) (C)	

CARBON FAMILY

ELECTRONIC CONFIGURATION

The general outer electronic configuration of elements of IVA group is ns^2np^2 .

Elements	Configuration
Carbon [C ₆]	[He] 2s ² 2p ²
Silicon [Si ₁₄]	[Ne] 3s ² 3p ²
Germanium [Ge ₃₂]	[Ar] 3d ¹⁰ , 4s ² 4p ²
Tin [Sn ₅₀]	[Kr] 4d ¹⁰ , 5s ² 5p ²
Lead [Pb ₈₂]	[Xe] 4f ¹⁴ , 5d ¹⁰ , 6s ² 6p ²

PROPERTIES

- * Covalent radii : C < Si < Ge < Sn < Pb
- * Ionizations enthalpies C > Si > Ge > Pb > Sn (IE₁ values)
- * M.P. : C > Si > Ge > Pb > Sn
- * B.P. : Si > Ge > Sn > Pb
- * Metallic character : C < Si < Ge < Sn < Pb
- * C and Si are non metals.
- * Ge is metalloid.
- * Sn and Pb are metals. Pb is the end product of the heavier radioactive elements.
- * **Oxides :** (i) **Monoxide [MO]** : CO, SiO, GeO, SnO, PbO
SiO (unstable) CO → neutral ; GeO → basic
SnO, PbO → amphoteric
(ii) **Dioxides [MO₂]** : CO₂, SiO₂, GeO₂, SnO₂ and PbO₂
CO₂, SiO₂ → acidic ; GeO₂, SnO₂, PbO₂ → amphoteric

CATENATION

The property of forming bonds with atoms of the same element or tendency to self linking is called catenation. Carbon shows maximum catenation. On moving down the group catenation tendency decreases. This is because the strength of C – C bond is very high and in case of other elements, strength of M – M (where M= Si, Ge, Sn, Pb) bond decreases down the group.

ALLOTROPES

Allotropy is the phenomenon in which an element exists in different physical forms having different physical properties but chemical properties are same or similar. Due to property of catenation and π - π bond formation, carbon is able to show allotropic forms.

(i) Crystalline :
(a) Diamond :

- * Density and hardness is very much greater for diamond because of closed packing in diamond due to sp^3 hybrid and are tetrahedrally arranged around it.
- * Diamond crystals are non conductor of electricity because of not presence of mobile electron.
- * 1 carat of diamond = 200 mgm.

(b) Graphite :

- * In graphite carbon are sp^2 hybridised and due to this carbon exist as hexagonal layer.
- * Each carbon is lined with 3 carbons and one carbon will be left and form a two dimensional shed like structure.
- * Distance between two layers is very large so no regular bond is formed between two layers. The layers are attached with weak vander waal force of attraction.
- * The carbon have unpaired electron so graphite is a good conductor of electricity.
- * C – C bond length in Graphite is shorter (1.42 Å) than that of Diamond (1.54 Å).
- * Graphite has high melting point so it is employed in manufacture of crucible.

(c) Buck Minster Fullerene :

- * It has the formula C_{60} and is made from interlocking hexagonal and pentagonal rings of carbon atoms.
- * Such molecules are now thought to exist even in chimney root or candle smoke.
- * The structure of C_{60} is similar to the surface of a football which has also set of interlocking hexagons and pentagons.
- * Another molecule C_{70} has been recently discovered.
- * These and similar large carbon molecules are sometimes referred as "bucky balls".

(ii) Amorphous Allotropic Forms of Carbon:
(a) Lamp Black:

- * Obtained by incompletely combustion of compounds which contains higher % of carbon, benzene, turpentine, acetylene etc. These all on combustion form black carbon called lamp black.
- * Black blue ink, printing ink, black paints, varnishes are made from lamp black.

(b) Coke :

- * Obtained by destructive distillation of coal.
- * Coke is usually employed as weak reducing agent with compared to CO.

(c) Wood Charcoal:

- * Obtained by incomplete combustion of wood.
- * Used to decolourise organic compound.

OXIDES OF CARBON
1. CARBON MONOXIDE

It is a colour less toxic gas. It has the highest bond energy amongst monoxide of other members [1070 kJ mol^{-1}]. It forms carbonyls with transition metals $\text{Ni}(\text{CO})_4$, $\text{Fe}(\text{CO})_5$, $\text{Cr}(\text{CO})_6$. These coordination compounds are also called

organometallics. CO is found in exhaust fumes of automobiles.

Formation of Carbon monoxide (CO)

- * By incomplete combustion of carbon. $2\text{C} + \text{O}_2 \rightarrow 2\text{CO}$
- * Reduction of oxides of heavy metals with carbon
 $\text{ZnO} + \text{C} \rightarrow \text{Zn} + \text{CO}$; $\text{Fe}_2\text{O}_3 + 3\text{C} \rightarrow 2\text{Fe} + 3\text{CO}$
- * $\text{PbO} + \text{C} \xrightarrow{\Delta} \text{Pb} + \text{CO}$
- * By dehydration of formic acid with conc. H_2SO_4 (lab. method)
 HCOOH (Formic acid) $\xrightarrow[373\text{ K}]{\text{H}_2\text{SO}_4}$ CO (pure) + H_2O
- * By action of conc. H_2SO_4 on potassium ferrocyanide
 $\text{K}_4[\text{Fe}(\text{CN})_6] + 6\text{H}_2\text{SO}_4 + 6\text{H}_2\text{O} \xrightarrow{\Delta} 2\text{K}_2\text{SO}_4 + \text{FeSO}_4 + 3(\text{NH}_4)_2\text{SO}_4 + 6\text{CO}$

Physical Properties:

- * It is a neutral oxide.
- * Colourless & odourless gas, slightly soluble in water.
- * Poisonous nature due to its ability to form a stable complex with the haemoglobin present in the RBC.
 $\text{Haemoglobin} + \text{CO} \rightarrow \text{Carboxy haemoglobin}$
 Haemoglobin loses its O_2 carrying capacity which causes death.

Chemical properties :

- * Formation of metal carbonyls
 $\text{Ni} + 4\text{CO} \xrightarrow{330-340\text{K}} \text{Ni}(\text{CO})_4$ (Nickel carbonyl)
- * $\text{Fe} + 5\text{CO} \xrightarrow[100\text{ atm}]{473\text{K}} \text{Fe}(\text{CO})_5$ (Iron carbonyl)
- * **Absorption :** CO is readily absorbed by a soln. of CuCl in conc. HCl or NH_3 due to the formation of soluble complexes.
 $\text{CuCl} + \text{NH}_3 + \text{CO} \rightarrow [\text{Cu}(\text{CO})\text{NH}_3]^+ \text{Cl}^-$ (soluble complex)
 $\text{COCuCl} + \text{HCl} + \text{CO} \rightarrow \text{H}^+ [\text{Cu}(\text{CO})\text{Cl}_2]^-$ (soluble complex)
- * **With Cl_2 :** $\text{CO} + \text{Cl}_2 \xrightarrow{\text{sunlight or camphor}} \text{COCl}_2$ (Phosgene)
- * **With NaOH :** $\text{CO} + \text{NaOH} \xrightarrow[\text{high T}]{\text{high P}} \text{HCOONa}$

Tests of carbon monoxide :

- * It burns with blue flame.
- * Filter paper soaked with PdCl_2 is turned pink, green or black. PdCl_2 is reduced to the metal.
- * It reduces iodine penta oxide into free iodine, which give colour with CCl_4 , CS_2 or CHCl_3 .

2. CARBON DIOXIDE (CO_2)
Preparation :

- * By burning carbon, fossil fuels & other org. Compounds in air. $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$
 $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$
- * By action of HCl on carbonates (laboratory method)
 $\text{CaCO}_3 + 2\text{HCl} \xrightarrow{\Delta} \text{CaCl}_2 + \text{CO}_2 + \text{H}_2\text{O}$
 $\text{NaHCO}_3 + \text{HCl} \xrightarrow{\Delta} \text{NaCl} + \text{H}_2\text{O} + \text{CO}_2$

Physical Properties:

- * Colourless & odourless (about 1.5 time heavier than air)
- * Not poisonous, but does not support life.
- * Solid CO_2 is called dry ice. It sublimes at -78°C and at 1 atmospheric pressure.
- * It is a linear, monomeric and nonpolar molecule.
- * It is soluble in water and is used as fire extinguisher.

Chemical properties:

- * Non combustible nature (certain active metals Na, K, Mg burn in it) $2\text{Mg} + \text{CO}_2 \rightarrow 2\text{MgO} + \text{C}$
 $\text{Zn} + \text{CO}_2 \rightarrow \text{ZnO} + \text{CO}$
- * Acidic nature: It dissolves in water to some extent to form carbonic acid.
 $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3 \rightleftharpoons \text{H}^+ + \text{HCO}_3^-$
- * It reacts with metallic oxides
 $\text{CaO} + \text{CO}_2 \rightarrow \text{CaCO}_3$; $\text{Na}_2\text{O} + \text{CO}_2 \rightarrow \text{Na}_2\text{CO}_3$
- * On reduction with coke gives $\text{CO}[\text{CO}_2 + \text{C} \rightarrow 2\text{CO}]$.
- * It is a resonance hybrid of three non-equivalent structures. $[\text{O}=\text{C}=\text{O} \leftrightarrow \text{O}^-\equiv\text{C}-\text{O}^-\leftrightarrow\text{O}^-\text{C}\equiv\text{O}^+]$

Example 4 :

In graphite, electrons are –

- (A) Localised on every third C-atom.
- (B) Present in anti-bonding orbital.
- (C) Localised on each C-atom.
- (D) Spread out between the structure.

Sol. (D). In graphite, each carbon is sp^2 hybridized and forms four covalent bonds with other C-atoms overlap side wise to give π -electron cloud which is delocalized and thus the electrons are spread out between the structure.

SILICON
Occurrence :

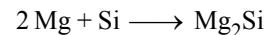
- (a) 26% of silicon is found in earth's crust.
- (b) As SiO_2 is found in sand, quartz etc.
- (c) As silicates it is found in felspar ($\text{K Al Si}_2\text{O}_3$), mica $\text{KH}_2\text{Al}(\text{SiO}_4)_3$, clays etc.

Extraction :

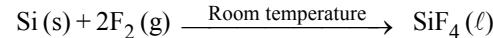
Commercial form of silicon is obtained by reduction of SiO_2 with C or CaC_2 in an electric furnace. High purity silicon is obtained either from SiCl_4 or from SiHCl_3 . These volatile compounds are purified by exhaustive fractional distillation and then reduced with very pure Zn or Mg. The resulting spongy Si is melted, grown into cylindrical single crystal and then purified by zone refining.

Properties :

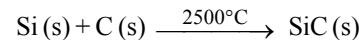
- * Amorphous silicon is chemically more reactive than crystalline silicon. Amorphous silicon is brownish powder. It burns brilliantly in oxygen and ignites spontaneously in fluorine.
 $\text{Si} + \text{O}_2 \rightarrow \text{SiO}_2$; $\text{Si} + 2\text{F}_2 \rightarrow \text{SiF}_4$
- * It decomposes steam at red heat. It dissolves in the mixture of HNO_3 and HCl . However, it dissolves readily in alkaline medium. $\text{Si} + 2\text{H}_2\text{O} \rightarrow \text{SiO}_2 + 2\text{H}_2$
- * It combines with certain metals forming silicides



- * Silicon is particularly unreactive at room temperature towards most of the elements except fluorine.



- * Reaction with carbon :


Uses :

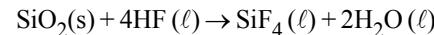
- * Silicon is added to steel as such or more usually in form of ferrosilicon (all alloy of Fe and Si) to make it acid-resistant.
- * High purity silicon is used as semiconductors in electronic devices such as transistors.
- * It is used in the preparation of alloys such as silicon-bronze, magnesium silicon bronze and ferrosilicon.

COMPOUNDS OF SILICON
1. SILICA (SiO_2)
Occurrence :

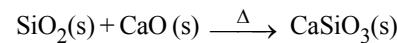
Silica or silicon dioxide occurs in nature in the free state as sand, quartz and flint and in the combined state as silicates like, Feldspar: $\text{K}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 6\text{SiO}_2$, Kaolinite : $\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$ etc.

Properties :

- * It is a solid at room temperature.
- * High m.p. (1873 K) does not boil.
- * Pure silica is colourless, but sand is usually coloured yellow or brown due to the presence of ferric oxide as an impurity.
- * Silicon dioxide is insoluble in water and all acids except hydrofluoric acid.



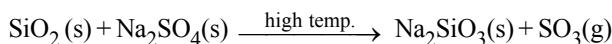
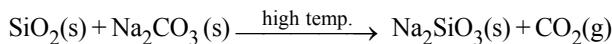
- * It also combines with metallic oxides at high temperature giving silicates, e.g.



- * Gives silicate when fused with NaOH .

- * It is soluble in water.

- * When silica is heated strongly with metallic salts, silicates are formed and the volatile oxides are driven off as vapours.



- * On reduction with coke gives SiC .
 $[\text{SiO}_2 + 3\text{C} \rightarrow \text{SiO} + 2\text{CO}]$

Structures of Silica :

Silica has a three-dimensional network structure. In silica, silicon is sp^3 -hybridized and is thus linked to four oxygen atoms and each oxygen atom is linked to two silicon atoms forming a three-dimensional giant molecule.

This three-dimensional network structure imparts stability to SiO_2 crystal and hence a large amount of energy is required to break the crystal resulting in high melting point.

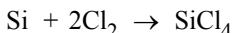
Uses:

- * Sand is used in large quantities to make mortar and cement.
- * Being transparent to ultraviolet light, large crystal of quartz are used for making lenses for optical instruments and for controlling the frequency of radio-transmitters.
- * Powdered quartz is used for making silica bricks.
- * Silica gel ($\text{SiO}_2 \cdot x\text{H}_2\text{O}$) is used as a desiccant (for absorbing moisture) and as an adsorbent in chromatography.

2. SILICON TETRACHLORIDE (SiCl_4)

Preparation :

Silicon tetrachloride, SiCl_4 , is prepared by the action of chlorine on hot silicon.



Properties :

- * Silicon tetrachloride has a relative density of 1.483, its melting point is -70°C , and its boiling point is 57.6°C .
- * Silicon tetrachloride is a colourless volatile liquid, it is soluble in water.
- * Silicon tetrachloride has covalent bonding, as in methane.

3. SILICONES

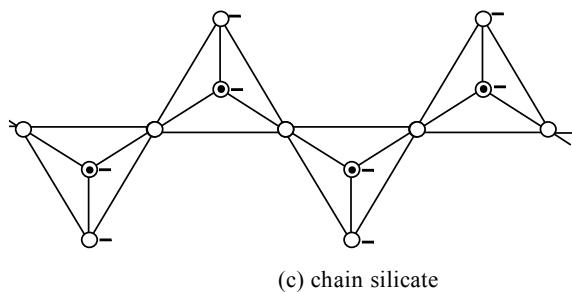
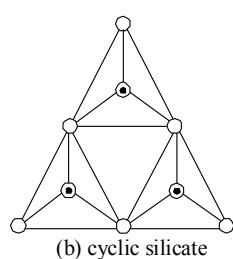
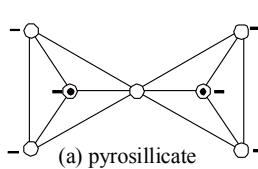
Silicones are a group of organo silicon polymers.

These are formed by the hydrolysis of alkyl or aryl substituted chlorosilanes and their subsequent polymerization. They have in general high thermal stability, high dielectric strength and resistance to oxidation and chemicals. Silicones are used to prepare sealant, greases, etc.

4. SILICATES

Silicates are regarded as the salts of silicic acid, H_4SiO_4 . All the silicates are comprised of SiO_4 units. These units have a tetrahedral structure formed as a result of sp^3 hybridization. They can complete their octet by taking up 4 electrons from a metal, getting converted to an anion $[\text{SiO}_4]^{4-}$.

Representations of SiO_4^{4-} tetrahedra : Depending upon the way these SiO_4 units are linked, silicates of different structure and complexity are obtained. Some representative types are :



Preparation : Silicates can be prepared by fusing an alkali metal carbonate with sand in an electric furnace at about 1400°C .

Example of silicates :

- (i) **Orthosilicates :** e.g., Zircon ZrSiO_4 ; Forestrite or Olivine Mg_2SiO_4 Phenacite Be_2SiO_4 ; Willemite Zn_2SiO_4 .
- (ii) **Pyrosilicates :** e.g., Pyrosilicate ion $\text{Si}_2\text{O}_7^{6-}$, Thortevite $\text{Sc}_2\text{Si}_2\text{O}_7$
- (iii) **Cyclic structure :** e.g., Beryl $\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$; Wollastonite $\text{Ca}_3\text{Si}_3\text{O}_9$; Catapleite $\text{Na}_2\text{ZrSi}_3\text{O}_9 \cdot 2\text{H}_2\text{O}$
- (iv) **Chain silicate :** e.g., Synthetic silicates Li_2SiO_3 , Na_2SiO_3 ;
- (v) **Two dimensional sheet silicates :** e.g., Talc $\text{Mg}(\text{Si}_2\text{O}_5)_2\text{Mg}(\text{OH})_2$

Glass :

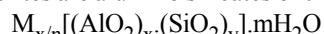
- * Glass is a hard, brittle, transparent, amorphous solid or supercooled liquid made up of silicates of Na, Ca and other metals like Pb, Zn etc.
- * Being amorphous solid it has no sharp melting point and melts at high temperature.
- * Glass has no definite chemical formula, however it may be represented as : $x \text{M}_2\text{O} \cdot y \text{M}'\text{O} \cdot 6 \text{SiO}_2$ where M = alkali metals Na, K, M' = bivalent metals Ca, Pb, Zn etc., x and y are integers.

Raw materials needed to manufacture glass are :

- (a) Silica (SiO_2)
- (b) Alkali metal salts (Na_2CO_3 , NaNO_3 , Na_2SO_4 , NaNO_3)
- (c) Heavy metal oxides (PbO , Pb_3O_4)
- (d) Alkaline earth metal salts (CaCO_3 , BaCO_3 , CaO)

ZEOLITES

Zeolites are alumino silicates of the general formula,



where, M may be a simple cation like Na^+ , K^+ , or Ca^{2+} n is the charge on the simple cation, m is the number of molecules of water of hydration.

Some well known zeolites are Erionite, Germelineite, Faujasite (natural), Linde-A (synthetic), ZSM-5.

Zeolites are widely used as a catalyst in petrochemical industries for cracking of hydrocarbons and isomerisation. ZSM-5 used to convert alcohols directly into gasoline. Hydrated zeolites are used as ion exchangers in softening of "hard" water.

TRY IT YOURSELF-2

ANSWERS

(1) (C) **(2)** (A) **(3)** (B)
(4) (C) **(5)** (C) **(6)** (B)

ADDITIONAL EXAMPLES

Example 1 :

Crystalline boron can be obtained by reduction of B_2O_3 with—

(1) C (2) N₂ (3) H₂SO₄ (4) Al powder



Example 2 :

The geometry of metaborane ion is –

Sol. (4). Metaborate ion $B(OH)_4^-$ is tetrahedral.

Example 3 :

Which of the following is methanide –

(1) Be_2C (2) Al_4C_3 (3) Mg_2C_3 (4) Both (1) & (2)

Sol. (4). Both Be_2C and Al_4C_3 has C^{4-} ion and on hydrolysis gives CH_4 .

Example 4 :

CO reacts with metals to form –

(1) Metal carbonates (2) Metal bicarbonates
 (3) Metal carbonyls (4) Metal carbides

Sol. (3). $\text{Ni(s)} + 4 \text{CO(g)} \xrightarrow{80^\circ\text{C}} \text{Ni(CO)}_4 \text{(g)}$

QUESTION BANK
CHAPTER 10 : THE p-BLOCK ELEMENTS (GROUP 13 & 14)
EXERCISE - 1 [LEVEL-1]

Choose one correct response for each question.

PART - 1: INTRODUCTION

Q.1 Choose the correct statement-
 (A) The maximum oxidation state shown by a p-block element is equal to the total number of valence electrons.
 (B) In boron, carbon and nitrogen families the group oxidation state is the most stable state for the lighter elements in the group.
 (C) Both (A) and (B)
 (D) None of these

Q.2 The non-metals and metalloids exist in the ___ of the periodic table.
 (A) p-block (B) s-block
 (C) d-block (D) Both (B) and (C)

Q.3 Choose the correct statement for p block elements-
 (A) The non-metallic character of elements decreases down the group.
 (B) The second period elements of p-groups starting from boron are restricted to a maximum covalence of four.
 (C) Both (A) and (B)
 (D) None of these

Q.4 The heavier elements of p block form-
 (A) $p\pi-p\pi$ (B) $d\pi-p\pi$
 (C) $d\pi-d\pi$ (D) Both (B) and (C)

Q.5 The first member of a group of p block elements differs from the heavier members in its ability to form ___ multiple bonds to itself
 (A) $p\pi-p\pi$ (B) $p\pi-d\pi$
 (C) $d\pi-d\pi$ (D) None of these

PART - 2 : GROUP 13 ELEMENTS

Q.6 In IIIA group, Tl (thallium) shows +1 oxidation state while other members show +3 oxidation state, due to -
 (A) Presence of lone pair of electron in Tl
 (B) Inert pair effect
 (C) Large ionic radius of Tl ion
 (D) None of these

Q.7 Boron trioxide is ___ while aluminium and gallium oxides are ___ and those of indium and thallium are ___ in their properties.
 (A) acidic, amphoteric, basic
 (B) amphoteric, basic, acidic
 (C) acidic, basic, amphoteric
 (D) basic, amphoteric, acidic

Q.8 Choose the correct statement for aluminium-
 (A) Bright silvery-white metal.
 (B) High tensile strength.
 (C) High electrical and thermal conductivity.
 (D) All of these

Q.9 Electropositive character for the elements of group 13 follows the order :
 (A) $B > Al > Ga > In > Tl$ (B) $B < Al < Ga < In < Tl$
 (C) $B < Al > Ga < In > Tl$ (D) $B < Al > Ga > In > Tl$

Q.10 Choose the correct statement for group 13 elements-
 (A) Aluminium shows many chemical similarities to boron as both are metals.
 (B) Aluminium is the third most abundant element in the earth's crust.
 (C) Boron is extremely hard and blue coloured solid.
 (D) All of these

Q.11 Aluminium vessels should not be washed with materials containing washing soda since
 (A) Washing soda is expensive.
 (B) Washing soda is easily decomposed.
 (C) Washing soda reacts with Al to form soluble aluminate.
 (D) Washing soda reacts with aluminium to form insoluble aluminium oxide.

Q.12 Choose the correct statement for group 13 elements-
 (A) Density of the elements increases down the group from boron to thallium.
 (B) In thallium +1 oxidation state is predominant whereas the +3 oxidation state is highly oxidising in character.
 (C) Both A and B
 (D) None of these

Q.13 Which of the following statement is correct with respect to the property of elements in the carbon family with an increase in atomic number, their -
 (A) Atomic size decreases
 (B) Ionization energy increases
 (C) Metallic character decreases
 (D) Stability of +2 oxidation state increases

PART - 3 : COMPOUNDS OF BORON

Q.14 Choose the correct statement -
 (A) Borax dissolves in water to give an acidic solution.
 (B) Borax is a white crystalline solid.
 (C) Boric acid is a strong monobasic acid.
 (D) All of these

Q.15 Choose the correct statement for diborane-
 (A) Colourless
 (B) Highly toxic
 (C) catches fire upon exposure to air
 (D) All of these

Q.16 Borax is used -
 (A) to identify the metallic radicals in the qualitative analysis.
 (B) as a flux in welding metals.
 (C) in the manufacture of glass, soap and porcelain.
 (D) All of these

Q.17 When orthoboric acid (H_3BO_3) is heated, the residue left is
 (A) Metaboric acid (B) Boron
 (C) Boric anhydride (D) Borax

Q.18 Borax-bead test is responded by
 (A) divalent metals
 (B) heavy metals
 (C) light metals
 (D) metals which form coloured metaborates.

Q.19 Which of the following does not exist in free form
 (A) BF_3 (B) BCl_3
 (C) BBr_3 (D) BH_3

Q.20 Borax is not used –
 (A) as a styptic to stop bleeding.
 (B) in making enamel and pottery glazes.
 (C) as a flux in soldering.
 (D) in making optical glasses.

Q.21 Which of the following statements is correct in the context of diborane (B_2H_6) ?
 (A) There are 12 valence electrons-three from each of the two boron atoms and six from the six hydrogen atoms.
 (B) Two of the six hydrogen atoms form two bridges between two boron atoms.
 (C) The two bridging hydrogen atoms are in a plane perpendicular to the rest of the molecule and prevent rotation between the two boron atoms.
 (D) All of these

Q.22 Which of the following compounds are formed when BCl_3 is treated with water?
 (A) H_3BO_3 (B) B_2H_6
 (C) B_2O_3 (D) HBO_2

Q.23 B_2H_6 reacts with $(CH_3)_3N$ to produce:
 (A) $BH_3^+ \bar{N}(CH_3)_3$ (B) $B_2H_6^+ \bar{N}(CH_3)_2CH_3 \cdot BH_3$
 (C) $(CH_3)_3N^+ BH_3^-$ (D) $BH_3^+ \bar{N}(CH_3)_2CH_3 BH_3^-$

Q.24 Choose the correct statement –
 (A) $LiBH_4$ and $NaBH_4$ are used as reducing agents in organic synthesis.
 (B) Borohydrides are prepared by the reaction of metal hydrides with B_2H_6 in diethyl ether.
 (C) Both (A) and (B)
 (D) None of these

Q.25 Which is the hardest compound of boron?
 (A) B_2O_3 (B) BN
 (C) B_4C (D) B_2H_6

Q.26 Two types of bonds present in B_2H_6 are covalent and –
 (A) Ionic (B) Co-ordinate
 (C) Hydrogen bridge bond (D) None

Q.27 Chemically borax is –
 (A) sodium metaborate
 (B) sodium orthoborate
 (C) sodium tetraborate decahydrate
 (D) sodium hexaborate.

Q.28 Innumerable compounds of carbon is due to its
 (A) High reactivity
 (B) Catenation tendency
 (C) Covalent & ionic tendency
 (D) Different valency

Q.29 The tendency of group 14 elements to show +2 oxidation state increases in the order of
 (A) $C < Si < Sn < Pb < Ge$ (B) $C < Si < Ge < Sn < Pb$
 (C) $Ge < Sn < Pb < C < Si$ (D) $Pb < Sn < Ge < C < Si$

Q.30 Choose the correct statement for group 14 elements –
 (A) The first ionization enthalpy of group 14 members is higher than the corresponding members of group 13.
 (B) All group 14 members are solids.
 (C) Both A and B
 (D) None of these

Q.31 Choose the correct statement –
 (A) Carbon and silicon are non-metals.
 (B) Tin and lead are soft metals with low melting points.
 (C) Both (A) and (B)
 (D) None of these

Q.32 Select the member(s) of group 14 that forms the most acidic dioxide –
 (A) carbon (B) lead
 (C) silicon (D) germanium

Q.33 Select the member(s) of group 14 that is commonly found in +2 oxidation state,
 (A) carbon (B) lead
 (C) silicon (D) germanium

Q.34 Choose the incorrect statement –
 (A) Stability of dihalides of group 14 increases down the group.
 (B) PbI_4 exists.
 (C) Both (A) and (B)
 (D) None of these

Q.35 Amongst the elements of group 14, the reducing power of the divalent species decreases in the order
 (A) $Ge > Sn > Pb$ (B) $Sn > Ge > Pb$
 (C) $Pb > Sn > Ge$ (D) $Sn > Pb > Ge$

Q.36 Carbon shows a maximum covalency of four whereas other members can expand their covalence due to –
 (A) absence of d-orbitals in carbon
 (B) ability of carbon to form $p\pi-p\pi$ multiple bonds.
 (C) small size of carbon.
 (D) catenation of carbon.

Q.37 The reducing character of hydrides of group 14 elements
 (A) Maximum for CH_4 and minimum for PbH_4
 (B) Maximum for CH_4 and minimum for SnH_4
 (C) Maximum for PbH_4 and minimum for SiH_4
 (D) Maximum for PbH_4 and minimum for CH_4

Q.38 Which of the following hydrides is least stable to hydrolysis?
 (A) CH_4 (B) SiH_4
 (C) SnH_4 (D) PbH_4

Q.29 When excess of carbon dioxide is passed through lime water, the milkeness first formed disappears due to –
 (A) the reversible reaction taking place.
 (B) formation of water soluble calcium bicarbonate.
 (C) huge amount of heat evolved during the reaction.
 (D) formation of water soluble complex of calcium.

Q.30 Which of the following does not show similarity between boron and aluminium?
 (A) Both form oxides of type M_2O_3 when heated with oxygen at high temperature.
 (B) Both dissolve in alkalies and evolve hydrogen.
 (C) Hydroxides of both the elements are basic in nature.
 (D) Both form nitrides of MN type when heated with N_2 .

Q.31 Choose the correct statement
 (A) Conc. HNO_3 can be transported in Al container.
 (B) Graphite is used as lubricant.
 (C) Both (A) and (B)
 (D) None of these

Q.32 Thermite is a mixture of iron oxide and
 (A) aluminium powder (B) zinc powder
 (C) iron turnings (D) copper turnings

Q.33 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.

Q.34 The reason behind the lower atomic radius of Ga as compared to Al is –
 (A) poor screening effect of d-electrons for the outer electrons from increased nuclear charge.
 (B) increased force of attraction of increased nuclear charge on electrons.
 (C) increased ionisation enthalpy of Ga as compared to Al
 (D) anomalous behaviour of Ga.

Q.35 Which acids cannot be stored in glass?
 (A) HF (B) HCl
 (C) H_2SO_4 (D) HI

EXERCISE - 3 (NUMERICAL VALUE BASED QUESTIONS)

NOTE : The answer to each question is a NUMERICAL VALUE.

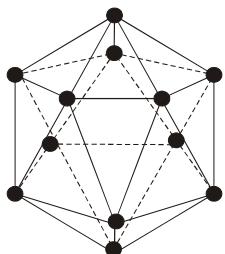
Q.1 Three moles of B_2H_6 are completely reacted with methanol. The number of moles of boron containing product formed is

Q.2 1 mol each of H_3PO_2 , H_3PO_3 and H_3PO_4 will neutralise x mole of $NaOH$, y mol of $Ca(OH)_2$ and z mol of $Al(OH)_3$ (assuming all as strong electrolytes) x, y, z are in the ratio of P : Q : R. Find the ratio of (P + Q + R).

Q.3 B – H – B bridge in B_2H_6 is formed by the sharing of X number of electrons. Find the value of X.

Q.4 The number of corner or O-atom shared per tetrahedron in 2D-silicate is –

Q.5 Boron exist in different allotropic forms. All allotropic form contains icosahedral units (icosahedral is a regular shape with 12 corners and 20 faces) with boron atoms at all 12 corners and all bonds are equivalent .



Calculate heat evolved at constant pressure (in kJ) per mole of boron atoms undergoing above change if

$$\Delta H_{BE}(B-B) = 300 \text{ kJ/mol}$$

Q.6 BH_3 has the X-centre two-electron bonds in its dimeric structure. Find the value of X.

Q.7 $Al(CH_3)_3$ has the X-centre two-electron bonds in its dimeric structure. Find the value of X.

Q.8 $AlCl_3$ has the X-centre two-electron bonds in its dimeric structure. Find the value of X.

Q.9 Number of correct statements are –
 (i) Conc. HNO_3 can be transported in aluminium container.
 (ii) A mixture of dilute $NaOH$ 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.

Q.10 In oxides CO , B_2O_3 , SiO_2 , CO_2 , Al_2O_3 , PbO_2 , Tl_2O_3 Number of amphoteric oxides are :

EXERCISE - 4 | PREVIOUS YEARS AIEEE / JEE MAIN QUESTIONS

EXERCISE - 5 (PREVIOUS YEARS AIPMT/NEET EXAM QUESTIONS)

Q.1 Which of the following is the electron deficient molecule
 (A) B_2H_6 (B) C_2H_6 [AIPMT 2005]
 (C) PH_3 (D) SiH_4

Q.2 The correct order regarding the electronegativity of hybrid orbitals of carbon is [AIPMT 2006]
 (A) $\text{sp} > \text{sp}^2 > \text{sp}^3$ (B) $\text{sp} < \text{sp}^2 > \text{sp}^3$
 (C) $\text{sp} < \text{sp}^2 < \text{sp}^3$ (D) $\text{sp} > \text{sp}^2 < \text{sp}^3$

Q.3 Which of the following oxidation states are the most characteristic for lead and tin respectively [AIPMT 2007]
 (A) +2, +4 (B) +4, +4
 (C) +2, +2 (D) +4, +2

Q.4 Which of the following anions is present in the chain structure of silicates – [AIPMT 2007]
 (A) $(\text{Si}_2\text{O}_5^{2-})_n$ (B) $(\text{SiO}_3^{2-})_n$
 (C) SiO_4^{4-} (D) $\text{Si}_2\text{O}_7^{6-}$

Q.5 The stability of + 1 oxidation state increases in the sequence: [AIPMT 2009]
 (A) $\text{Ti} < \text{In} < \text{Ga} < \text{Al}$ (B) $\text{In} < \text{Ti} < \text{Ga} < \text{Al}$
 (C) $\text{Ga} < \text{In} < \text{Al} < \text{Ti}$ (D) $\text{Al} < \text{Ga} < \text{In} < \text{Ti}$

Q.6 Which one of the following molecular hydrides acts as a Lewis acid? [AIPMT (PRE) 2010]
 (A) NH_3 (B) H_2O
 (C) B_2H_6 (D) CH_4

Q.7 Name the type of the structure of silicate in which one oxygen atom of $[\text{SiO}_4]^{4-}$ is shared? [AIPMT (PRE) 2011]
 (A) Three dimensional (B) Linear chain silicate
 (C) Sheet silicate (D) Pyrosilicate

Q.8 Which of the following statements is incorrect? [AIPMT (MAINS) 2011]
 (A) Pure sodium metal dissolves in liquid ammonia to give blue solution.
 (B) NaOH reacts with glass to give sodium silicate.
 (C) Aluminium reacts with excess NaOH to give $\text{Al}(\text{OH})_3$.
 (D) NaHCO_3 on heating gives Na_2CO_3 .

Q.9 Which of the following oxide is amphoteric?
 [AIPMT (MAINS) 2011]
 (A) SnO_2 (B) CaO
 (C) SiO_2 (D) CO_2

Q.10 Aluminium is extracted from alumina (Al_2O_3) by electrolysis of a molten mixture of [AIPMT (PRE) 2012]
 (A) $\text{Al}_2\text{O}_3 + \text{HF} + \text{NaAlF}_4$ (B) $\text{Al}_2\text{O}_3 + \text{CaF}_2 + \text{NaAlF}_4$
 (C) $\text{Al}_2\text{O}_3 + \text{Na}_3\text{AlF}_6 + \text{CaF}_2$ (D) $\text{Al}_2\text{O}_3 + \text{KF} + \text{Na}_3\text{AlF}_6$

Q.11 The basic structural unit of silicates is – [NEET 2013]
 (A) SiO_4^{2-} (B) SiO^-
 (C) SiO_4^{4-} (D) SiO_3^{2-}

Q.12 Which of these is not a monomer for a high molecular mass silicone polymer? [NEET 2013]
 (A) PbSiCl_3 (B) MeSiCl_3
 (C) Me_2SiCl_2 (D) Me_3SiCl

Q.13 The stability of +1 oxidation state among Al, Ga, In and Tl increases in the sequence: [AIPMT 2015]
 (A) $\text{Ti} < \text{In} < \text{Ga} < \text{Al}$ (B) $\text{In} < \text{Ti} < \text{Ga} < \text{Al}$
 (C) $\text{Ga} < \text{In} < \text{Al} < \text{Ti}$ (D) $\text{Al} < \text{Ga} < \text{In} < \text{Ti}$

Q.14 Boric acid is an acid because its molecule –
 (A) Contains replaceable H^+ ion [NEET 2016 PHASE 2]
 (B) Gives up a proton
 (C) Accepts OH^- from water releasing proton
 (D) Combines with proton from water molecule

Q.15 AlF_3 is soluble in HF only in presence of KF. It is due to the formation of [NEET 2016 PHASE 2]
 (A) $\text{K}_3[\text{AlF}_3\text{H}_3]$ (B) $\text{K}_3[\text{AlF}_6]$
 (C) AlH_3 (D) $\text{K}[\text{AlF}_3\text{H}]$

Q.16 Which one of the following elements is unable to form MF_6^{3-} ion? [NEET 2018]
 (A) B (B) Al
 (C) Ga (D) In

Q.17 The correct order of atomic radii in group 13 elements is [NEET 2018]
 (A) $\text{B} < \text{Ga} < \text{Al} < \text{Ti} < \text{In}$ (B) $\text{B} < \text{Al} < \text{Ga} < \text{In} < \text{Ti}$
 (C) $\text{B} < \text{Al} < \text{In} < \text{Ga} < \text{Ti}$ (D) $\text{B} < \text{Ga} < \text{Al} < \text{In} < \text{Ti}$

p-BLOCK ELEMENTS

(13 & 14 GROUP)

TRY IT YOURSELF-1

(1) $\text{B} < \text{Ga} < \text{Al} < \text{In} < \text{Ti}$

Down the group radii increases, but radii of Gallium is smaller than that of Aluminium. As in Ga there is participation of 10d e^- which provide poor shielding effect for outer e^- .

(2) (A) **(3)** (B) **(4)** (C) **(5)** (B)

(6) (A) **(7)** (A) **(8)** (D) **(9)** (C)

TRY IT YOURSELF-2

(1) (C) **(2)** (A) **(3)** (B)
(4) (C) **(5)** (C) **(6)** (B)

ANSWER KEY

EXERCISE - 1

Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
A	C	A	C	D	A	B	A	D	D	B	C	C	D	B	D	D	C	D	D	A	D	A	C	C	C	C	
Q	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
A	B	B	C	C	A	B	B	A	A	D	B	B	D	C	D	B	C	C	D	C	A	C	C	D	C	A	

EXERCISE - 2

Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
A	A	D	D	C	A	C	D	A	C	C	B	B	C	D	B	B	C	C	D	B	C	A	C	C	C	
Q	26	27	28	29	30	31	32	33	34	35																
A	D	B	D	B	C	C	A	B	A	A																

EXERCISE - 3

Q	1	2	3	4	5	6	7	8	9	10
A	6	3	2	3	750	3	3	2	7	2

EXERCISE - 4

Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A	B	B	C	B	D	B	D	C	A	D	C	C	A	A	B	D

EXERCISE - 5

Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
A	A	A	A	B	D	C	D	C	A	C	C	D	D	C	B	A	D

CHAPTER-10 : p-BLOCK ELEMENTS

EXERCISE-1

(1) (C). The maximum oxidation state shown by a p-block element is equal to the total number of valence electrons.
 In boron, carbon and nitrogen families the group oxidation state is the most stable state for the lighter elements in the group.

(2) (A). The non-metals and metalloids exist only in the p block of the periodic table.

(3) (C). The non-metallic character of elements decreases down the group. The heaviest element in each p-block group is the most metallic in nature. The second period elements of p-groups starting from boron are restricted to a maximum covalence of 4 (using 2s and three 2p orbitals)

(4) (D). The heavier elements of p block form $d\pi-d\pi$ and $d\pi-d\pi$ bonds.

(5) (A). The first member of a group differs from the heavier members in its ability to form $p\pi-p\pi$ multiple bonds to itself.

(6) (B). Inert pair effect become significant for the 6th and 7th period of p-block element.

(7) (A). Boron trioxide is acidic and reacts with basic (metallic) oxides forming metal borates. Aluminium and gallium oxides are amphoteric and those of indium and thallium are basic in their properties.

(8) (D). Aluminium is a bright silvery-white metal, with high tensile strength. It has a high electrical and thermal conductivity.

(9) (D). As we move from B to Al, the sum of $\Delta_i H_1 + \Delta_i H_2 + \Delta_i H_3$ decreases substantially (6887 kJ mol⁻¹ to 5137 kJ mol⁻¹) due to increase in the atomic size and hence Al has a high tendency to lose electrons. Since the electrode potentials increase from Al to Tl, therefore, their electropositive character decreases, i.e., Al (-1.66 V) to Ga (-0.56 V) to In (-0.34V) to Tl (+1.26V) accordingly.

(10) (B). Boron is non-metallic in nature. It is extremely hard and black coloured solid. Aluminium is the most abundant metal and the third most abundant element in the earth's crust (8.3% by mass) after oxygen (45.5%) and Si (27.7%).

(11) (C). $Na_2CO_3 + H_2O \rightarrow 2NaOH + CO_2$
 $2NaOH + 2Al + 6H_2O \rightarrow 2Na[Al(OH)_4] + 3H_2$

(12) (C). Density of the elements increases down the group from boron to thallium. In thallium +1 oxidation state is predominant whereas the +3 oxidation state is highly oxidising in character.

(13) (D). In carbon family stability +2 oxidation state increases on moving down the group in the periodic table with an increase in atomic number due to screening effect.

(14) (B). Borax dissolves in water to give an alkaline solution. Boric acid is a weak monobasic acid.

(15) (D). Diborane is a colourless, highly toxic gas with a boiling point of 180K. Diborane catches fire spontaneously upon exposure to air.

(16) (D). Borax is used to identify the metallic radicals in the qualitative analysis, as a flux in welding metals and in the manufacture of glass, soap and porcelain.

(17) (C). $2H_3BO_3 \rightarrow B_2O_3 + 3H_2O$.

(18) (D). Only those cations, which form coloured metaborates can give borax-bead test.

(19) (D). Boron form different hydride of general formula B_nH_{n+4} and B_nH_{n+6} but BH_3 is unknown.

(20) (A). Borax is not used as styptic to stop bleeding.

(21) (D). B_2H_6 : There are 12 valence electrons-three from each of the two boron atoms and six from the six hydrogen atoms
 Two of the six hydrogen atoms form two bridges between two boron atoms
 The two bridging hydrogen atoms are in a plane perpendicular to the rest of the molecule and prevent rotation between the two boron atoms

(22) (A). $BCl_3 + 3H_2O \rightarrow H_3BO_3 + 3HCl$

(23) (C). B_2H_6 reacts with $(CH_3)_3N$ to produce $(CH_3)_3N^+BH_3^-$.

(24) (C). $LiBH_4$ and $NaBH_4$ are used as reducing agents in organic synthesis.
 $2MH + B_2H_6 \rightarrow 2M^+ [BH_4]^-$ [M = Li or Na]

(25) (C). Boron carbide B_4C is a very hard substance like SiC.

(26) (C). The two types of bonds present in B_2H_6 are covalent and- hydrogen bridge bond.

(27) (C). Borax is $Na_2B_4O_7 \cdot 10H_2O$.

(28) (B). Generally IV group element shows catenation tendency and carbon has more catenation power.

(29) (B). The tendency to show +2 oxidation state increases down the group. It is due to inability of ns^2 electrons of valence shell to participate in bonding.

(30) (C). The first ionization enthalpy of group 14 members is higher than the corresponding members of group 13. All group 14 members are solids.

(31) (C). Carbon and silicon are non-metals.
 Tin and lead are soft metals with low melting points.

(32) (A). Oxides in higher oxidation states of elements are generally more acidic than those in lower oxidation states. The dioxides - CO_2 , SiO_2 and GeO_2 are acidic.

(33) (B). Germanium forms stable compounds in +4 state and only few compounds in +2 state. Tin forms compounds in both oxidation states (Sn in +2 state is a reducing agent). Lead compounds in +2 state are stable & in +4 state are strong oxidising agents.

(34) (B). PbI_4 does not exist because Pb-I bond initially formed during the reaction does not release enough energy to unpair $6s^2$ electrons and excite one of them to higher orbital to have four unpaired electrons around lead atom.

(35) (A). The elements of group 14, the reducing power of the divalent species decreases in the order : $Ge > Sn > Pb$

(36) (A). In carbon, only s and p-orbitals are available for bonding, therefore, it can accommodate only four pairs of electrons around it.

(37) (D). The reducing character of hydrides of group 14 elements is maximum for PbH_4 and minimum for CH_4 .

(38) (B). Silicon hydrides are most easily hydrolysed.

$$\text{SiH}_4 + 3\text{H}_2\text{O} \rightarrow \text{H}_2\text{SiO}_3 + 4\text{H}_2$$

$$\text{SiH}_4 + 2\text{NaOH} + \text{H}_2\text{O} \rightarrow \text{Na}_2\text{SiO}_3 + 4\text{H}_2$$

(39) (B). The tetrahalides of group 14 elements (except that of carbon) act as strong Lewis acids.

(40) (D). There is an increase in number of shells from top to bottom.

(41) (C). In graphite, layers or sheets are held by weak van der Waals forces.

(42) (D). Buckyball or buckminsterfullerene is an allotrope of carbon, it is referred as C-60. It has sp^2 -hybridised nature & resembles with soccer ball.

(43) (B). Due to property of catenation, carbon can form various length of chains hence the number of carbon compounds is very large.

(44) (C). Lead pencil contains graphite.

(45) (C). Fullerenes are cage like molecules with a shape like soccer ball.

(46) (D). Graphite is thermodynamically more stable than diamond. It conducts heat and electricity due to movement of π electrons between the layers. It is crystalline form of carbon.

(47) (C). Silicon has a strong tendency to form polymers like silicones. The chain length of silicone polymer can be controlled by adding Me_3SiCl .

(48) (A).

$$\text{---O} \left(\begin{array}{c} \text{CH}_3 \\ | \\ \text{Si} \end{array} \right)_n \begin{array}{c} \text{CH}_3 \\ | \\ \text{Si} \end{array} \text{---}$$

Silicone

(49) (C). $\text{CO} + \text{NaOH} \xrightarrow[{\text{Sod. formate}}]{200^\circ\text{C}} \text{HCOONa}$

(50) (C). Its low solubility in water makes it of biological and chemical importance. It form carbonic acid with water which dissociates to give HCO_3^- ions. $\text{H}_2\text{CO}_3/\text{HCO}_3^-$ buffer system helps to maintain pH of blood between 7.26–7.42.

(51) (D). Three dimensional sheet structures are formed when three oxygen atoms of each $[\text{SiO}_4]^{4-}$ tetrahedral are shared.

(52) (C). Dry ice is solid CO_2 .

(53) (D). CO_2 is a linear, non-polar molecule. $\text{O} \rightleftharpoons \text{C} \rightleftharpoons \text{O}$

(54) (A). The species present in solution when CO_2 is dissolved in water are $\text{CO}_2, \text{H}_2\text{CO}_3, \text{HCO}_3^-, \text{CO}_3^{2-}$

(3) (D). Generally red lead decompose into PbO and O_2 .

(4) (C). CO_2 is acidic oxide and thus more effectively absorbed by an alkali.

(5) (A). $\text{SiO}_2 + 2\text{Mg} \rightarrow \text{Si} + 2\text{MgO}$

(6) (C). Sodium oxalate react with conc. H_2SO_4 to form CO and CO_2 gas.

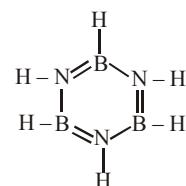
(7) (D). It is hydrolysed with water to form a $\text{Si}(\text{OH})_4$.

(8) (A). Ga is less electropositive in nature. It has the weak metallic bond so it expand on solidification.

(9) (C). Except $\text{B}(\text{OH})_3$ all other hydroxide are of metallic hydroxide having the basic nature $\text{B}(\text{OH})_3$ are the hydroxide of nonmetal showing the acidic nature.

(10) (C). PbCl_2 is most ionic because on going down the group the metallic character increases and also the inert pair effect predominates.

(11) (B). Borazole ($\text{B}_3\text{N}_3\text{H}_6$) has 3 double bond and 9 single bonds. 3π bonds, one from each double bond.



(12) (B). The species which also forms π -bond in addition σ -bonds is BF_3 .

(13) (C). Artificial gem used for cutting glass is SiC .

(14) (D). The non existence of PbI_4 is due to highly oxidising power of Pb^{4+} ions and highly reducing power of I^- ions.

(15) (B). $\text{B}_2\text{H}_6 + 6\text{H}_2\text{O} \rightarrow 2\text{H}_3\text{BO}_3 + 6\text{H}_2$

(16) (B). SnCl_2 is ionic solid, SnCl_2 is reducing in nature and SnCl_4 is covalent liquid.

(17) (C). $(\text{Me})_2\text{SiCl}_2$ on hydrolysis will produce $\text{---O}-(\text{Me})_2\text{Si}-\text{O}-\text{n}-$.

(18) (C). This order is observed due to relative tendency of the halogen atom to back donate its electrons to vacant p-orbital of boron atom. In BF_3 , fluorine transfers two electrons to vacant 2p-orbital of boron forming π - π bonds. This reduces the electron deficiency of boron. The tendency to form back bonding decreases from BF_3 to BI_3 .

$\begin{array}{c} \text{O} \rightarrow \text{O} \\ | \\ \text{F} - \text{B} - \text{F} \\ | \\ \text{O} \rightarrow \text{O} \end{array} \quad \begin{array}{c} \text{F} \cdots \text{B} \cdots \text{F} \\ | \quad \quad \quad | \\ \text{F} \quad \text{B} \quad \text{F} \end{array}$

(19) (D). $\text{B}(\text{OH})_3$ orthoboric acid is acidic in nature and can accept OH^- ions to release H^+ in solution.

$$\text{H}_3\text{BO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{H}_2\text{BO}_3^-$$

(20) (B). Stability of +3 oxidation state decreases from Al to Tl. B always shows +3 oxidation state in all of its compounds.

(21) (C). In graphite C-atom is sp^2 -hybridised.

(22) (A). Both boron and aluminium in their trihalides (MX_3) possess six electrons in their valence shell. To complete the octet they can accept a lone pair of electrons acting as Lewis acids.

EXERCISE-2

(1) (A). $\text{B}_2\text{O}_3 + 3\text{C} + 3\text{Cl}_2 \rightarrow 2\text{BCl}_3 + 3\text{CO}$
 BCl_3 is obtained by passing chlorine over the heated mixture of B_2O_3 and powdered charcoal.

(2) (D). $2\text{KOH} + 2\text{Al} + 2\text{H}_2\text{O} \rightarrow 2\text{KAlO}_2 + 3\text{H}_2$

(v) Aluminium alloys are used for making aircraft body because these are,
 (a) Light in weight, (b) Corrosion resistant
 (c) Strong and hard (d) Highly ductile

(vi) Aluminium utensils should not be kept in water because it is attacked by water (though slowly) and get corroded.

(vii) Aluminium wires are used to make electrical cables because aluminium is a good conductor of electricity.

(10) 2. Neutral oxides : CO

Acidic oxides : CO_2 , SiO_2 , B_2O_3

Basic oxides : Ti_2O_3

Amphoteric oxides : PbO_2 , Al_2O_3

EXERCISE-4

(1) **(B).** Bauxite ore

(2) **(B).** Graphite is a soft solid lubricant extremely difficult to melt. In graphite carbon atoms are arranged in large plates of rings of strongly bound carbon atom with weak interplate bonds.

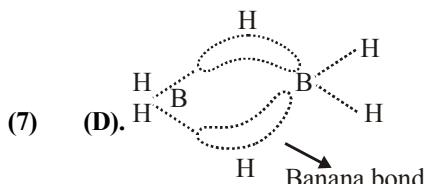
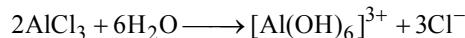
(3) **(C).** From the option we know that Hg is a liquid metal at room temperature having lowest M.P.

(4) **(B).** White tin $\xrightleftharpoons[\text{(Tetrahedral)}]{\text{Low temp.}}$ Grey tin $\xrightleftharpoons[\text{(Cubical shape)}]$

Therefore, crystalline structure of tin become change.

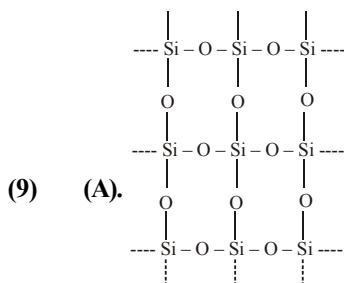
(5) **(D).** sp^2 , sp^3

(6) **(B).** $\text{Al}(\text{H}_2\text{O})_6]^{3+} + 3\text{Cl}^-$



Four $2\text{C} - 2\text{e}^-$ bonds and two $3\text{C} - 2\text{e}^-$ bond in B_2H_6 .

(8) **(C).** $\text{AlCl}_3 + \text{H}_2\text{O} \longrightarrow \text{Al}(\text{OH})_3 \xrightarrow{\Delta} \text{Al}_2\text{O}_3$
 Dryness

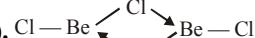


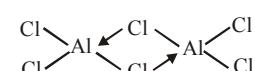
Each silicon atom is surrounded by four oxygen atom and each oxygen atom is bonded to two silicon atom.

(10) **(D).** SnO_2

(11) **(C).** $\text{SiX}_2 < \text{GeX}_2 < \text{SnX}_2 < \text{PbX}_2$

order of stability

(12) **(C).** 

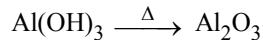


Due to deficiency of e^- (Lewis acidic nature)

Cl of both Be and Al having bridged structure in solid phase Be and Al also have diagonal relationship.

(13) **(A).** Due to non-availability of d-orbitals, boron is unable to expand its octet. Therefore, the maximum covalence of boron cannot exceed 4.

(14) **(A).** $\text{Al}(\text{M}) + \text{NaOH} \rightarrow \text{Al}(\text{OH})_3 \xrightarrow{\text{NaOH}}$ white gel ppt (X)



Al_2O_3 is used in chromatography as an absorbent.

(15) **(B).** BCl_3 and AlCl_3 are e^- deficient and thus act as Lewis acid.

(16) **(D).** Inert pair effect is prominent character of p-block element.

EXERCISE-5

(1) **(A).** B_2H_6 is electron deficient molecule because boron atom has three half filled orbitals in excited state.

(2) **(A).** Among the three given hybrid orbitals, sp hybrid orbital is most electronegative. Contribution of s in sp hybrid orbital is maximum so this orbital is closer to nucleus. Naturally it will have greater tendency to pull electron towards it. Hence it becomes more electronegative & sp^3 becomes least electronegative.

(3) **(A).** All the group 14 elements show tetravalency which can be explained on the basis of shifting of one e^- of ns to the vacant np orbital. These four orbitals give rise to four sp^3 hybrid orbitals.

When ns² electrons of the outermost shell do not participate in bonding is called inert pair effect. The last three elements of group 4 i.e. Ge, Sn and Pb, have a tendency to form divalent as well as tetravalent ions. Since the inert pair effect increases from Ge to Pb, the stability of tetravalent ion decreases and that of divalent ion increases that is why Pb^{4+} is more stable than Pb^{4+} and Sn^{4+} ions is more stable than Sn^{2+} .

(4) **(B).** Chain silicates are formed by sharing two oxygen atoms by each tetrahedra. Anions of chain silicate have two general formula:

(i) $(\text{SiO}_3^{2-})_n$ (ii) $(\text{Si}_4\text{O}_{11})^{6-}$

(5) (D). Group-13 elements exhibit +3 and +1 oxidation states. Stability of the lower oxidation state increases on moving down the group, order is:
 $\text{Al}^+ < \text{Ga}^+ < \text{In}^+ < \text{Tl}^+$

(6) (C). Electron deficient molecules behave as Lewis acid. Among the given molecules, only dibroane is electron deficient, i.e. does not have complete octet. Thus, it acts as a Lewis acid. NH_3 and H_2O being electron rich molecules behave as Lewis base.

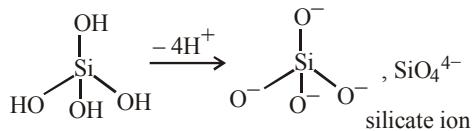
(7) (D). Pyrosilicate contains two units of SiO_4^{4-} joined along a corner containing oxygen atom.

(8) (C). $2\text{Al(s)} + 2\text{NaOH(aq)} + 6\text{H}_2\text{O(l)}$
 $\rightarrow 2\text{Na}^+[\text{Al}(\text{OH})_4]^- \text{(aq)} + 3\text{H}_2\text{(g)}$.
 (Sodium tetrahydroxoaluminate (III))

(9) (A). SnO_2 is an amphoteric oxide because it reacts with acids as well as bases to form corresponding salts.
 $\text{SnO}_2 + 2\text{H}^+ \rightarrow \text{Sn}^{4+} + 2\text{H}_2\text{O}$
 $\text{SnO}_2 + 6\text{OH}^- \rightarrow [\text{Sn}(\text{OH})_6]^{2-}$ or SnO_3^-
 CaO is basic in nature while SiO_2 and CO_2 are acidic in nature.

(10) (C). $\text{Na}_3\text{AlF}_6, \text{CaF}_2$ increases conductance and decreases melting point of Al_2O_3 .

(11) (C). Silicates – Salt of silicic acid H_4SiO_4



(12) (D). Silicones are organo-silicon polymer containing

$$\begin{array}{c} \text{R} & \text{R} \\ | & | \\ \text{Si} - \text{O} - \text{Si} \\ | & | \\ \text{R} & \text{R} \end{array}$$
 linkage.
 Me_3SiCl contain only one Cl, it can't form high molecular mass silicon polymer.
 It act a chain terminating organo silane.

(13) (D). In group 13 elements, stability of +3 oxidation state decreases down the group while that of +1 oxidation state increases due to inert pair effect.
 Hence, stability of +1 oxidation state increases in the sequence: $\text{Al} < \text{Ga} < \text{In} < \text{Tl}$.

(14) (C). Boric acid is a weak monobasic acid. It is not a protonic acid but acts as a Lewis acid by accepting electrons from a hydroxyl ion.
 $\text{B(OH)}_3 + 2\text{H}_2\text{O} \rightarrow [\text{B}(\text{OH})_4]^- + \text{H}_3\text{O}^+$

(15) (B). $\text{AlF}_3 + \text{KF} \xrightarrow{\text{HF}} \text{K}_3[\text{AlF}_6]$
 (Maximum C.N. of Al^{3+} is six so it form AlF_6^{3-}).

(16) (A). 'B' has no vacant d-orbitals in its valence shell, so it can't extend its covalency beyond 4. i.e. 'B' cannot form the ion like $\text{MF}_6^{3(-)}$ i.e. $\text{BF}_6^{3(-)}$.

(17) (D). Elements B Ga Al In Tl
 Atomic radii (pm) 85 135 143 167 170