

# p-BLOCK ELEMENTS (BORON & CARBON FAMILY)

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### JEE(Advanced) Syllabus

**Preparation and properties of the following compounds:** Boron: diborane, boric acid and borax; Aluminium: alumina, aluminium chloride and alums; Carbon: oxides and oxyacid (carbonic acid); Properties of allotropes of carbon (only diamond and graphite); Silicon: silicones, silicates and silicon carbide.

### JEE(Main) Syllabus

General Introduction: Electronic configuration and general trends in physical and chemical properties of elements across the periods and down the groups; unique behaviour of the first element in each group.

**Group-13 :** Preparation, properties and uses of boron and aluminium; Structure, properties and uses of borax, boric acid, diborane, boron trifluoride, aluminium chloride and alums.

**Group-14 :** Tendency for catenation; Structure, properties and uses of allotropes and oxides of carbon, silicon tetrachloride, silicates, zeolites and silicones.



## p-block elements (Boron and Carbon Family)

### Section (A), (B) & (C) : General facts about elements, Based on Periodic trends & Based on Chemical Bonding

#### Introduction :

Group 13 to 18 of the periodic table of elements constitute the p-block. The p-block contains metals, metalloids as well as non-metals.

Configuration	$ns^2np^1$	$ns^2np^2$	$ns^2np^3$	$ns^2np^4$	$ns^2np^5$	$ns^2np^6$
						He
	B	C	N	O	F	Ne
	Al	Si	P	S	Cl	Ar
	Ga	Ge	As	Se	Br	Kr
	In	Su	Sb	Te	I	Xe
	Tl	Pb	Bi	Po	At	Rn
Group Oxidation State	+3	+4	+5	+6	+7	+8
Other Oxidation State	+1	+2, -4	+3, -3	+4, +2, -2	+5, +3, +1, -1	+6, +4, +2

The p-block elements have general valence shell electronic configuration  $ns^2 np^{1-6}$ .

The first member of each group from 13–17 of the p-block elements differ in many respects from the other members of their respective groups because of small size, high electronegativity and absence of d-orbitals.

The first member of a group also has greater ability to form  $p\pi-p\pi$  multiple bonds to itself (e.g.  $C=C$ ,  $C\equiv C$ ,  $N\equiv N$ ) and to element of second row (e.g.  $C=O$ ,  $C=N$ ,  $C\equiv N$ ,  $N=O$ ) compared to the other members of the same group.

The highest oxidation state of p-block element is equal to the group number – 10. Moving down the group, the oxidation state two less than the highest group oxidation state and becomes more stable in groups 13 to 16 due to inert pair effect (reluctance of s-subshell electrons to participate in chemical bonding).

○ Ge liquid expands when it forms the solid. This property is unique to Ga, Ge and Bi.

#### Catenation :

Carbon atoms have the tendency to link with one another through covalent bonds to form chains and rings. This property is called catenation. This is because C–C bonds are very strong. Down the group the size increases tendency to show catenation decreases. This can be clearly seen from bond enthalpies values. The order of catenation is  $C \gg Si > Ge \approx Sn$ . Lead does not show catenation. Due to the property of catenation and  $p\pi-p\pi$  bonds formation, carbon is able to show allotropic forms.

Bond	Bond enthalpy (kJ mol <sup>-1</sup> )
C—C	348
Si—Si	297
Ge—Ge	260
Sn—Sn	240

#### ANOMALOUS BEHAVIOUR OF CARBON :

Like first member of other groups, carbon also differs from rest of the members of its group. It is due to its smaller size, higher electronegativity, higher ionisation enthalpy and unavailability of d orbitals.

Carbon accommodate only four pairs of electrons around it and thus this would limit the maximum covalence to four whereas other members can expand their covalence due to the presence of d orbitals, Carbon also has unique ability to form  $p\pi-p\pi$  multiple bonds with itself and with other atoms of small size and high electronegativity. Few examples of multiple bonding are  $C=C$ ,  $C\equiv C$ ,  $C=O$ ,  $C=S$  and  $C\equiv N$ . Heavier elements do not form  $p\pi-p\pi$  bonds because their atomic orbital are too large and diffuse to have effective overlapping.



### IMPORTANT TRENDS AND ANOMALOUS PROPERTIES OF BORON

The tri-chlorides, bromides and iodides of all these elements being covalent in nature are hydrolysed in water. Species like tetrahedral  $[M(OH)_4]^-$  and octahedral  $[M(H_2O)_6]^{3+}$ , except in boron, exist in aqueous medium. It is due to the absence of d orbitals that the maximum covalence of boron is 4. Since the d-orbitals are available with Al and other elements, the maximum covalence can be expected beyond 4.

### GROUP 13 : BORON FAMILY & GROUP 14 : CARBON FAMILY

#### Occurrence :

Element	Abundance	Source	Element	Abundance	Source
B (Boron)	9 ppm (Rare element)	<ul style="list-style-type: none"> <li>Borax : <math>Na_2[B_4O_5(OH)_4] \cdot 8H_2O</math></li> <li>Colemanite : <math>Ca_2B_6O_{11} \cdot 5H_2O</math></li> <li>Kernite : <math>Na_2[B_4O_5(OH)_4] \cdot 2H_2O</math></li> <li>Boric acid : <math>H_3BO_3</math></li> </ul>	C (Carbon)	180 ppm	<ul style="list-style-type: none"> <li>Coal</li> <li>Natural gas</li> <li>oil (hydrocarbon)</li> <li>Natural Graphite</li> <li>Natural diamond</li> <li>Carbonates:</li> <li>Calcite(<math>CaCO_3</math>)</li> <li>Magnesite (<math>MgCO_3</math>)</li> <li>Dolomite(<math>MgCO_3 \cdot CaCO_3</math>)</li> </ul>
Al (Aluminium)	83000 ppm (Most abundant metal, 3 <sup>rd</sup> most Abundant element)	<ul style="list-style-type: none"> <li>Bauxite : <math>Al_2O_3 \cdot H_2O - Al_2O_3 \cdot 3H_2O</math></li> <li>Aluminosilicate rocks (feldspars, mica)</li> <li>Cryolite : <math>Na_3AlF_6</math></li> </ul>	Si (Silicon)	272000 ppm	<ul style="list-style-type: none"> <li>Silica (sand &amp; quartz) <math>SiO_2</math></li> <li>Silicate minerals</li> </ul>
Ga (Gallium)	19 ppm	• Ores of Al, Zn, Ge	Ge (Germanium)	1.5 ppm	• Silver and Zinc ores, coal
In (Indium)	0.24 ppm	• ZnS & PbS ores	Sn (Tin)	2.1 ppm	• Cassiterite ( $SnO_2$ )
Tl (Thallium)	0.5 ppm	• ZnS & PbS ores	Pb (Lead)	13 ppm	• Galena (PbS)

#### Allotropy :

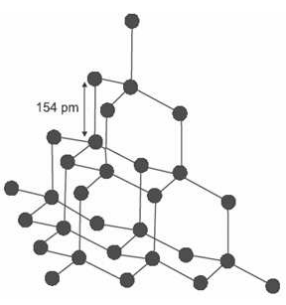
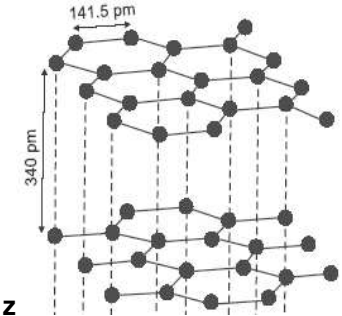
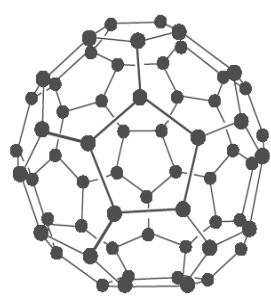
Elements	Allotropes	Elements	Allotropes
B	5 crystalline forms : $\beta$ -rhombohedral	C	Crystalline Diamond, hexagonal diamond
	2 amorphous forms		$\alpha$ -graphite, $\beta$ -graphite fullerenes
Al	No allotrope	Si	Amorphous - brown powder Crystalline - greyish metallic
Ga	No allotrope	Ge	$\alpha$ -Germanium
			$\beta$ -Germanium
			$\gamma$ -Germanium
In	No allotrope	Sn	$\alpha$ -tin (grey tin)
			$\beta$ -tin (white tin)
Tl	$\alpha$ -Thallium	$\alpha$ -Sn(diamond structure) $\xrightleftharpoons{13.2^\circ C}$ $\beta$ -Sn(metallic)	
	$\beta$ -Thallium	Pb	$\alpha$ -lead (Pb-I)
			$\beta$ -lead (Pb-II)



## Allotropy of carbon family

○ Silicon is a very high melting-point solid with the same structure as diamond. The non-existence of an allotrope with the graphite structure clearly shows the inability of silicon atoms to multiple bond with themselves.

## Allotropes of Carbon:

	Diamond	Graphite	Fullerene
Structure			
Hybridisation	$sp^3$	$sp^2$	$sp^2$
Density ( $g/cm^3$ )	3.51	2.22	1.65
$\Delta H_f$ (KJ/mol)	1.9	0	38.1
Bond length	154 pm	141.5 pm	143.5 pm & 138.3 pm
	<ul style="list-style-type: none"> <li>Crystalline lattice.</li> <li>3-D network: each C-atoms is linked to four other C-atoms in tetrahedral manner.</li> <li>One of the hardest – next to boron nitride (only at certain conditions)</li> <li>Uses: sharpening hard tools, cutter tools; as a gem.</li> </ul>	<ul style="list-style-type: none"> <li>Layered structure</li> <li>Interlayer force-Vanderwaal's forces</li> <li>Each carbon atom is linked to three other carbon atoms, fourth electron forms a <math>\pi</math> bond.</li> <li>Good conductor along the sheet and semi-conductor perpendicular to the sheet.</li> <li>Inter layer distance 340 pm so cleavage between layers is easy. Soft and slippery– lubricant at high temperature.</li> <li>Natural graphite is found as a mixture with mica, quartz &amp; silicates.</li> </ul> $3C + SiO_2 \xrightarrow{\Delta} SiC + 2CO \xrightarrow{2500^\circ C} C(\text{graphite}) + Si \text{ gas}$ <ul style="list-style-type: none"> <li>Thermodynamically most stable among allotropes.</li> </ul> $\text{Graphite} \xrightarrow[50000-60000 \text{ atm}]{1600^\circ C} \text{synthetic diamond}$	<ul style="list-style-type: none"> <li>Cage like molecules.</li> <li><math>C_{60}</math>–Soccer ball shape–Buckminsterfullerene</li> <li>20- six membered rings and 12- five membered rings.</li> <li>Six membered ring is fused with six or five membered ring</li> <li>Five membered ring is fused only with six membered ring.</li> <li>Heating of graphite in an electrical arc in the presence of inert gases such as helium or argon can result into fullerene</li> </ul>

## Solved Examples

**Ex-1.** Thermodynamically graphite is more stable than diamond but diamond does not transform into graphite on its own. Why?

**Sol.** This conversion is not favoured by kinetic factors (the activation energy for this is very high).



### Atomic & Physical Properties

Boron is non-metallic in nature. It is extremely hard and black coloured solid. It exists in many allotropic forms. Due to very strong crystalline lattice, boron has unusually high melting point. Rest of the member are soft metals with low melting point and high electrical conductivity. Gallium with low melting point (303 K), could exist in liquid state during summer. Its high boiling point (2676 K) makes it a useful material for measuring high temperatures. Aluminium is a good conductor of heat and electricity. It is malleable and ductile. Density of the elements increases down the group from boron to thallium.

#### Boron family:

Property			B	Al	Ga	In	Tl
Character			Metalloid	Metallic	Metallic	Metallic	Metallic
Atomic Number			5	13	31	49	81
Atomic Mass/g mol <sup>-1</sup>			10.81	26.98	69.72	114.82	204.38
Electronic configuration <i>General electronic configuration = (ns<sup>2</sup> np<sup>1</sup>)</i>			[He] 2s <sup>2</sup> 2p <sup>1</sup>	[Ne] 3s <sup>2</sup> 3p <sup>1</sup>	[Ar] 3d <sup>10</sup> 4s <sup>2</sup> 4p <sup>1</sup>	[Kr] 4d <sup>10</sup> 5s <sup>2</sup> 5p <sup>1</sup>	[Xe] 4f <sup>14</sup> 5d <sup>10</sup> 6s <sup>2</sup> 6p <sup>1</sup>
Covalent Radius / pm (B < Ga < Al < In < Tl)			85	143	135	167	170
			<i>In Ga, poor shielding of 10 d-electrons</i>				
Ionic Radius X <sup>-</sup> / pm (B < Al < Ga < In < Tl)			27	53.5	62	80	88.5
Ionization enthalpy (kJ mol <sup>-1</sup> ) (B > Al < Ga > In < Tl)	Δ <sub>i</sub> H <sub>1</sub>	I	801	577	579	558	589
	Δ <sub>i</sub> H <sub>2</sub>	II	2427	1816	1979	1820	1971
	Δ <sub>i</sub> H <sub>3</sub>	III	3659	2744	2962	2704	2877
			<i>Poor shielding of d-orbital and f-orbital in Ga &amp; Tl respectively</i>				
Electronegativity (B > Al < Ga < In < Tl)			2.0	1.5	1.6	1.7	1.8
			<i>Marginal increase after Al</i>				
Melting point / K			2453	933	303	430	576
Boiling point / K (B > Al > Ga > In > Tl)			3923	2740	2676	2353	1730
Density/[g cm <sup>-3</sup> (at 293 K)] (B < Al < Ga < In < Tl)			2.35	2.70	5.90	7.31	11.85
Oxidation State			+3	+3	+3, +1	+3, +1	+3, +1
			<i>+1 oxidation state arises due to inert pair effect.</i>				
			<i>Stability of Oxidation state: +1: Ga &lt; In &lt; Tl +3 : Al &gt; Ga &gt; In &gt; Tl</i>				

#### Carbon family :

Property	C	Si	Ge	Sn	Pb
Character	Non Metallic	Non Metallic	Metalloid	Metallic	Metallic
Atomic Number	6	14	32	50	82
Atomic Mass/g mol <sup>-1</sup>	12.01	28.09	72.60	118.71	207.2
Electronic configuration <i>General electronic configuration = (ns<sup>2</sup> np<sup>2</sup>)</i>	[He] 2s <sup>2</sup> 2p <sup>2</sup>	[Ne] 3s <sup>2</sup> 3p <sup>2</sup>	[Ar] 3d <sup>10</sup> 4s <sup>2</sup> 4p <sup>2</sup>	[Kr] 4d <sup>10</sup> 5s <sup>2</sup> 5p <sup>2</sup>	[Xe] 4f <sup>14</sup> 5d <sup>10</sup> 6s <sup>2</sup> 6p <sup>2</sup>



Covalent Radius / pm (C < Si < Ge < Sn < Pb)			77	118	122	140	146
Ionic Radius M <sup>4+</sup> / pm (Si < Ge < Sn < Pb)			–	40	53	69	78
Ionization enthalpy (kJ mol <sup>-1</sup> ) (C > Si > Ge > Sn < Pb)	$\Delta_i H_1$	I	801	577	579	558	589
	$\Delta_i H_2$	II	2427	1816	1979	1820	1971
	$\Delta_i H_3$	III	3659	2744	2962	2704	2877
Poor shielding f-orbital							
Electronegativity (C > Si ≈ Ge ≈ Sn ≈ Pb)			2.5	1.8	1.8	1.8	1.9
Melting point / K			4373	1693	1218	505	600
Boiling point / K			–	3550	3123	2896	2024
Density/[g cm <sup>-3</sup> (at 293 K)] (C (diamond) > Si < Ge < Sn < Pb)			3.51	2.34	5.32	7.26	11.34
Oxidation State			+4	+4	+4, +2	+4, +2	+4, +2
			+2 oxidation state arises due to inert pair effect.				
			Stability of Oxidation state: +2: Ge < Sn < Pb +4: Ge > Sn > Pb				

## The Elements

Preparation of elements :

### BORON :

Source	Process	Comments
From Borax (Na <sup>+</sup> ) <sub>2</sub> B <sub>4</sub> O <sub>7</sub> ·10H <sub>2</sub> O	<ul style="list-style-type: none"> <li>Na<sub>2</sub>B<sub>4</sub>O<sub>7</sub> + 2HCl + 5H<sub>2</sub>O → 4H<sub>3</sub>BO<sub>3</sub> + 2NaCl</li> <li>2H<sub>3</sub>BO<sub>3</sub> <math>\xrightarrow{\Delta}</math> B<sub>2</sub>O<sub>3</sub> + 3H<sub>2</sub>O</li> <li>B<sub>2</sub>O<sub>3</sub> + 3Mg/Na <math>\xrightarrow{\text{High temp.}}</math> 2B + 3MgO/Na<sub>2</sub>O</li> </ul>	<ul style="list-style-type: none"> <li>low purity (95-98%) boron (black)</li> <li>The product thus obtained is boiled with HCl and filtered when Na<sub>2</sub>O or MgO dissolves leaving behind elemental boron. It is thoroughly washed to remove HCl and then dried finally.</li> </ul>
From BX <sub>3</sub>	<ul style="list-style-type: none"> <li>2BX<sub>3</sub> + 3H<sub>2</sub> <math>\xrightarrow[\text{or Tantalum}]{\text{red hot W}}</math> 2B (crystalline) + 6HX (X = Cl or Br) 99.9% pure</li> <li>2BCl<sub>3</sub> + 3Zn → 3ZnCl<sub>2</sub> + 2B</li> <li>2BI<sub>3</sub> <math>\xrightarrow[\text{or Tantalum}]{\text{red hot W}}</math> 2B↑ + 3I<sub>2</sub>↑ (Van Arkel method)</li> </ul>	Problem in obtaining high purity boron: <ul style="list-style-type: none"> <li>High melting point (2180°C)</li> <li>Liquid gets corroded</li> </ul>
From Diborane (B <sub>2</sub> H <sub>6</sub> )	<ul style="list-style-type: none"> <li>B<sub>2</sub>H<sub>6</sub> <math>\xrightarrow{\Delta}</math> 2B (crystalline) + 3H<sub>2</sub>↑</li> </ul>	<ul style="list-style-type: none"> <li>Thermal decomposition of diborane.</li> </ul>
From potassium fluoroborate (KBF <sub>4</sub> )	<ul style="list-style-type: none"> <li>KBF<sub>4</sub> + 3K <math>\xrightarrow{\Delta}</math> 4KF + B</li> </ul>	<ul style="list-style-type: none"> <li>By heating it with potassium metal.</li> <li>It is then treated with dilute HCl to remove KF and B is then washed and dried.</li> </ul>

**ALUMINIUM :**

Method	Process	Comments
Electrolytic reduction (Hall-Heroult process)	<p>The electrolytic reactions are:</p> <p>Cathode : <math>\text{Al}^{3+}(\text{melt}) + 3\text{e}^- \longrightarrow \text{Al}(\text{l})</math></p> <p>Anode : <math>\text{C}(\text{s}) + \text{O}^{2-}(\text{melt}) \longrightarrow \text{CO}(\text{g}) + 2\text{e}^-</math></p> <p style="padding-left: 40px;"><math>\text{C}(\text{s}) + 2\text{O}^{2-}(\text{melt}) \longrightarrow \text{CO}_2(\text{g}) + 4\text{e}^-</math></p> <p>The overall reaction may be taken as:</p> <p style="padding-left: 40px;"><math>2\text{Al}_2\text{O}_3 + 3\text{C} \longrightarrow 4\text{Al} + 3\text{CO}_2</math></p> <p><i>Several other extraction processes will be studied in detail in Metallurgy.</i></p>	<ul style="list-style-type: none"> <li>The purified <math>\text{Al}_2\text{O}_3</math> is mixed with <math>\text{Na}_3\text{AlF}_6</math> (cryolite) or <math>\text{CaF}_2</math> (fluorspar) which lowers the melting point of the mixture and brings conductivity. The fused matrix is electrolysed. Steel cathode and graphite anode are used. The graphite anode is useful here for reduction to the metal.</li> <li>The electrolysis of the molten mass is carried out in an electrolytic cell using carbon electrodes. The oxygen liberated at anode reacts with the carbon of anode producing CO and <math>\text{CO}_2</math>. This way for each kg of aluminium produced, about 0.5 kg of carbon anode is burnt away.</li> </ul>

**CARBON :**

Preparation of	Process
Carbon black (soot)	By incomplete combustion of hydrocarbon.
Graphite	$3\text{C} + \text{SiO}_2 \xrightarrow{\Delta} \text{SiC} + 2\text{CO} \xrightarrow{2500^\circ\text{C}} \text{C (graphite)} + \text{Si gas}$
Diamond	<ul style="list-style-type: none"> <li>Natural diamond can be extracted from mines.</li> <li>Synthetic diamond</li> </ul> <p style="text-align: center;"><math>\text{Graphite} \xrightarrow[50000-60000 \text{ atm}]{1600^\circ\text{C}} \text{synthetic diamond.}</math></p>

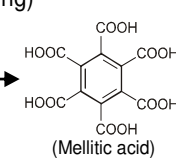
**SILICON :**

From	Process	Comments
$\text{SiO}_2$	$\text{SiO}_2(\text{excess}) + 2\text{C} \longrightarrow \text{Si (pure)} + 2\text{CO}$ $\text{Si (pure)} + 2\text{Cl}_2 \longrightarrow \text{SiCl}_4$ $\text{SiCl}_4 + 2\text{Mg} \longrightarrow \text{Si (highly pure)} + \text{MgCl}_2$	Reducing $\text{SiO}_2$ with high purity coke in an electric furnace
$\text{Na}_2[\text{SiF}_6]$	<p>Sodium Reduction of <math>\text{Na}_2[\text{SiF}_6]</math></p> $\text{Na}_2[\text{SiF}_6] + 4\text{Na} \longrightarrow \text{Si (ultra pure)} + 6\text{NaF}$	Zone refining is used to get ultra pure silicon from highly pure silicon, which can be used in semi-conductor industry.



## Section (D) : Properties of Elements

### Chemical Properties :

Reaction with	Boron Family			Carbon Family				
O <sub>2</sub>	4E + 3O <sub>2</sub> $\xrightarrow{\Delta}$ 2E <sub>2</sub> O <sub>3</sub>			E + O <sub>2</sub> $\xrightarrow{\Delta}$ EO <sub>2</sub> (dioxide) E + $\frac{1}{2}$ O <sub>2</sub> $\xrightarrow{\Delta}$ EO (mono oxide)				
	B <sub>2</sub> O <sub>3</sub> Al <sub>2</sub> O <sub>3</sub> Ga <sub>2</sub> O <sub>3</sub> In <sub>2</sub> O <sub>3</sub> Tl <sub>2</sub> O <sub>3</sub>	– – – – –	acidic amphoteric amphoteric basic basic	CO <sub>2</sub> SiO <sub>2</sub> GeO <sub>2</sub> SnO <sub>2</sub> PbO <sub>2</sub>	– – – – –	acidic acidic acidic amphoteric amphoteric	CO SiO GeO SnO PbO	– – – – –
N <sub>2</sub>	2E + N <sub>2</sub> $\xrightarrow{\Delta}$ 2EN EN + H <sub>2</sub> O $\xrightarrow{\Delta}$ E(OH) <sub>3</sub> + NH <sub>3</sub> ∴ E = B or Al			2C(s)+O <sub>2</sub> (g)+4N <sub>2</sub> (g) $\xrightarrow{1273\text{ K}}$ 2CO(g) + 4N <sub>2</sub> (g) (Producer gas)				
X <sub>2</sub> (Halogen)	2E + 3X <sub>2</sub> $\longrightarrow$ 2EX <sub>3</sub> ; (X=F, Cl, Br, I)			E + 2X <sub>2</sub> $\longrightarrow$ EX <sub>4</sub> ; (X = F, Cl, Br, I)				
	BX <sub>3</sub> AlF <sub>3</sub> GaF <sub>3</sub> InF <sub>3</sub> TlI <sub>3</sub>	– – – – –	covalent ( <i>BI<sub>3</sub> cannot be formed directly</i> ) ionic ionic ionic exist as Tl <sup>+</sup> I <sub>3</sub> <sup>–</sup> & TlI also forms	<ul style="list-style-type: none"><li>All members form MX<sub>4</sub> ; Ge &amp; Pb form MX<sub>2</sub></li><li>PbI<sub>4</sub> does not exist</li><li>Stability of EX<sub>4</sub> decreases down the group</li><li>Stability of EX<sub>2</sub> increases down the group</li><li>Stability : GeX<sub>4</sub> &gt; GeX<sub>2</sub> ; PbX<sub>2</sub> &gt; PbX<sub>4</sub></li></ul>				
H <sub>2</sub> O	B – does not react with water Al $\xrightarrow[+H_2O]{25^\circ C}$ Al(OH) <sub>3</sub> $\xrightarrow[+H_2O]{>480^\circ C}$ Al <sub>2</sub> O <sub>3</sub> Ga $\xrightarrow{\quad}$ Not attacked by cold & hot water unless oxygen is present. In $\xrightarrow{\quad}$ Not attacked by cold & hot water unless oxygen is present. Tl – oxidises in moist air & decomposes steam at red heat.			C(s) + H <sub>2</sub> O (steam) $\xrightarrow[\text{heat}]{\text{red}}$ CO(g) + H <sub>2</sub> (g) (water gas) E(s) + H <sub>2</sub> O(steam) $\xrightarrow[\text{heat}]{\text{red}}$ EO <sub>2</sub> +H <sub>2</sub> ; (Si,Ge,Sn) <ul style="list-style-type: none"><li>Pb is unaffected by water, probably because of a protective oxide layer.</li><li>C, Si, Ge – not attacked by cold water.</li></ul>				
Acids	B $\xrightarrow[(\text{Hot \& Conc.})]{+H_2SO_4}$ H <sub>3</sub> BO <sub>3</sub> + SO <sub>2</sub> $\xrightarrow[(\text{Hot \& Conc.})]{+HNO_3}$ H <sub>3</sub> BO <sub>3</sub> + NO <sub>2</sub> (Boron reacts with only oxidising acids) Al $\xrightarrow{+HCl}$ AlCl <sub>3</sub> + H <sub>2</sub> $\xrightarrow[(\text{Conc.})]{+HNO_3}$ Do not react because it forms passive oxide layer. Ga, In, Tl can also react with dilute mineral acids.			C $\xrightarrow[\text{dilute}]{+HCl}$ No reaction Si $\xrightarrow[\text{dilute}]{+HCl}$ No reaction Ge $\xrightarrow[\text{dilute}]{+HCl}$ No reaction Sn dissolves in HCl (dil. & conc) but Pb in only dil.HCl. Pb $\xrightarrow[(\text{does not dissolve in})]{HCl \text{ (conc.)}}$ PbCl <sub>2</sub> + H <sub>2</sub> (coating) $\xrightarrow{H_2SO_4}$ PbSO <sub>4</sub> + H <sub>2</sub> (coating) C (graphite) $\xrightarrow[(\text{Hot \& conc.})]{+HNO_3}$  (Mellite acid) $\xrightarrow[(\text{mixture})]{+HF/HNO_3}$ Graphite oxide Si + 6HF $\rightarrow$ H <sub>2</sub> SiF <sub>6</sub> + 2H <sub>2</sub> E + dil. HNO <sub>3</sub> $\rightarrow$ E(NO <sub>3</sub> ) <sub>2</sub> (Sn,Pb)				





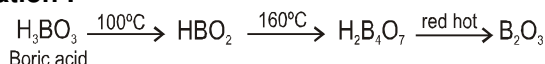
<b>NaOH</b>	$2B + 2NaOH + 2H_2O \longrightarrow 2NaBO_2 + 3H_2$ $2B + 6NaOH \xrightarrow{\text{fused}} 2Na_3BO_3 + 3H_2$ $Al \xrightarrow[NaOH]{NaOH + H_2O} NaAlO_2 \cdot 2H_2O + H_2$ <div style="text-align: center;">or <math>Na^+[Al(OH)_4]^-</math></div> $\xrightarrow{NaOH} Na_3AlO_3 + H_2$ <i>(Al &amp; Ga readily dissolves in alkalis).</i> <i>In &amp; Tl do not react with alkali.</i>	<b>C – unaffected by alkalis</b> $Si + 2NaOH + H_2O \longrightarrow Na_2SiO_3 + 2H_2$ $E_{(Sn, Pb)} + NaOH \xrightarrow{\Delta} Na_2EO_3 + H_2$ <div style="text-align: center;">or <math>Na_2[E(OH)_6]</math></div>
	<b>Metal</b> $3Mg + 2B \rightarrow Mg_3B_2$ $3Ca + 2B \rightarrow Ca_3B_2$	$2Mg + Si \xrightarrow{\Delta} Mg_2Si$ (magnesium silicide)
<b>Reducing Property</b>	$B \xrightarrow[\Delta]{SiO_2} B_2O_3 + Si$ $\xrightarrow[\Delta]{CO_2} B_2O_3 + C$ $Al \xrightarrow[\Delta]{MnO_2} Al_2O_3 + Mn$ $\xrightarrow[\Delta]{Cr_2O_3} Al_2O_3 + Cr$	

## Section (E) : Oxides, Hydroxides, Oxyacids, Borax

Oxides, oxy acids and hydroxide

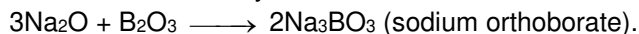
**Boron trioxide (B<sub>2</sub>O<sub>3</sub>) :**

**Preparation :**



**Properties :**

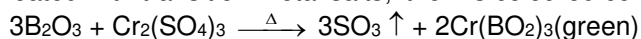
It is an acidic oxide and is an anhydride of boric acid and it reacts with alkalis or bases to form borates.



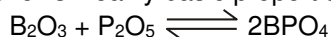
It reacts with water slowly to form orthoboric acid.



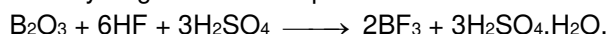
When heated with transition metal salts, it forms coloured compounds.



It also shows weakly basic properties according to the following reaction.



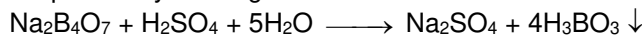
It reacts with hydrogen fluoride in presence of H<sub>2</sub>SO<sub>4</sub> forming BF<sub>3</sub>.



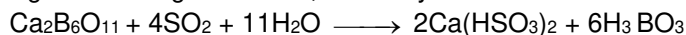
**Boric acid (H<sub>3</sub>BO<sub>3</sub>) :**

**Preparation :**

(i) It is precipitated by treating a concentrated solution of borax with sulphuric acid.

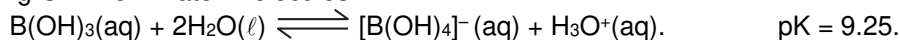


(ii) From Colemanite: Powdered colemanite is suspended in water and excess SO<sub>2</sub> is passed through it. On filtering and cooling the filtrate, white crystals of H<sub>3</sub>BO<sub>3</sub> are obtained.



**Properties:**

It is a weak monobasic acid, soluble in water and in aqueous solution the boron atom completes its octet by accepting OH<sup>-</sup> from water molecules:

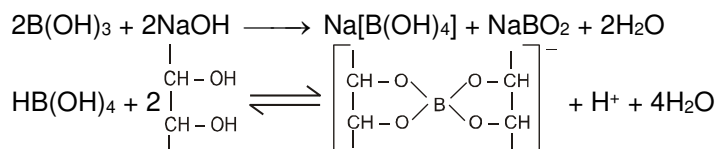


It, therefore, functions as a Lewis acid and not as a proton donor like most acids.

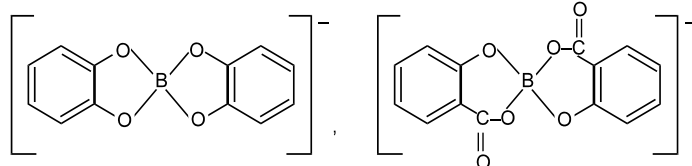


Since  $B(OH)_3$  only partially reacts with water to form  $H_3O^+$  and  $[B(OH)_4]^-$ , it behaves as a weak acid. Thus  $H_3BO_3$  cannot be titrated satisfactorily with  $NaOH$  as a sharp end point is not obtained. If certain organic polyhydroxy compounds such as glycerol, mannitol or sugars are added to the titration mixture, then  $B(OH)_3$  behaves as a strong monobasic acid and it can be now titrated with  $NaOH$  and the end point is detected using phenolphthalein as indicator ( $pH = 8.3 - 10.0$ ).

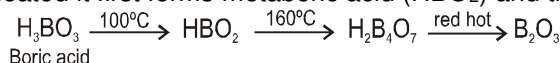
The added compound must be a cis-diol, to enhance the acid properties. The cis-diol forms very stable complex with the  $[B(OH)_4]^-$ , thus removing it from solution. The reaction is reversible and thus removal of one of the products shifts the equilibrium in the forward direction and thus all the  $B(OH)_3$  reacts with  $NaOH$ ; in effect it acts as a strong acid in the presence of the cis-diol.



Ethanol does not form similar complex but catechol, salicylic acids, mannitol form similar complexes.



When heated it first forms metaboric acid ( $HBO_2$ ) and then boron trioxide.



Orthoboric acid is greasy to touch less soluble in cold water but more soluble in hot water. In the solid state, the  $B(OH)_3$  units are hydrogen bonded together in to two dimensional sheets with almost hexagonal symmetry. The layered are quite a large distance apart ( $3.18 \text{ \AA}$ ) and thus the crystal breaks quite easily into very fine particles.

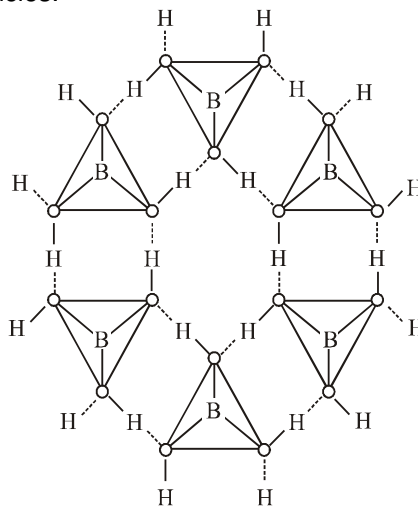
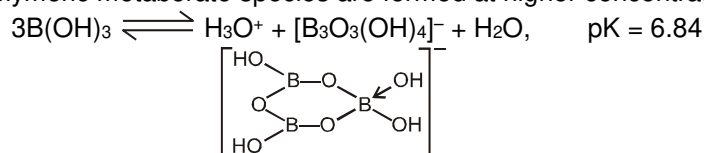
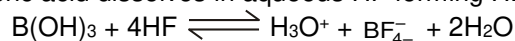


Figure : 1

- Polymeric metaborate species are formed at higher concentration, for example,

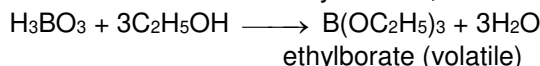


- Boric acid dissolves in aqueous  $HF$  forming  $BF_4$  (fluoroboric acid).



**Test for Borate radical :**

When boric acid is heated with ethyl alcohol, the evolved gas is burned forming a green edged flame.

**Uses :**

- (i) It is an antiseptic and its water solution is used as an eyewash.
- (ii) It is also used in glass, enamel and pottery industry.

### Solved Examples

**Ex-2.** It has been observed that  $\text{BF}_3$  does not hydrolyses completely whereas  $\text{BCl}_3$  or  $\text{BBr}_3$  get easily hydrolysed to form  $\text{B}(\text{OH})_3$  and  $\text{HX}$  ? Explain.

**Sol.** The greater stability of B–F bond as compared to B–Cl and B–Br bonds is due to additional  $\pi$ -bonding in B–F bonds of  $\text{BF}_3$  molecules. The B–Cl and B–Br bonds are relatively weak and are easily cleaved by water forming strong B–OH bonds instead of stable addition product ( $\text{BF}_3 \cdot \text{OH}_2$ ) formed by  $\text{BF}_3$ .

**Borax ( $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ ) :****Preparation :**

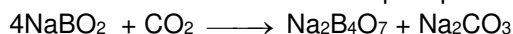
It is found in nature but can also be prepared by the following methods.

(i) From Colemanite.

When colemanite powder is heated with  $\text{Na}_2\text{CO}_3$  solution, the following reaction occurs with the precipitation of  $\text{CaCO}_3$ .

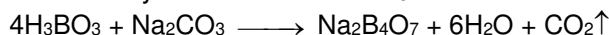


The filtrate is cooled when white crystals of borax are precipitated. The mother liquor on treatment with  $\text{CO}_2$  converts  $\text{NaBO}_2$  to  $\text{Na}_2\text{B}_4\text{O}_7$  which precipitates out on crystallization.



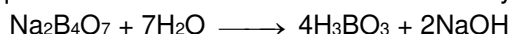
(ii) From orthoboric acid.

Borax is obtained by the action of  $\text{Na}_2\text{CO}_3$  on orthoboric acid.

**Properties :**

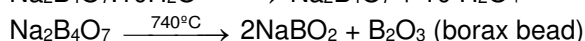
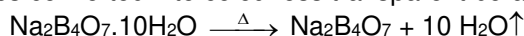
(i) Borax is a white powder, less soluble in cold water, more soluble in hot water.

(ii) Its aqueous solution is alkaline because of its hydrolysis to weak acid  $\text{H}_3\text{BO}_3$  and strong alkali  $\text{NaOH}$ .

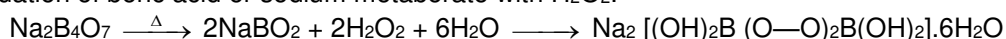


(iii) Action of heat.

When borax powder is heated, it first swells due to loss of water in the form of steam but at  $740^\circ\text{C}$  it becomes converted into colourless transparent borax bead.

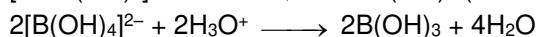
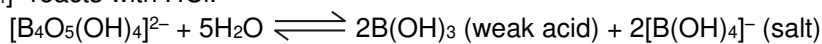


(iv) Oxidation of boric acid or sodium metaborate with  $\text{H}_2\text{O}_2$ .



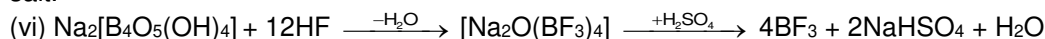
Sodium per oxoborate is used as a brightener in washing powder. In very hot water (over  $80^\circ\text{C}$ ) the peroxide linkages  $-\text{O}-\text{O}-$  break down to give  $\text{H}_2\text{O}_2$ .

(v) It is a useful primary standard for titrating against acids. One mole of it reacts with two moles of acid. This is because when borax is dissolved in water both  $\text{B}(\text{OH})_3$  and  $[\text{B}(\text{OH})_4]^-$  are formed, but only the  $[\text{B}(\text{OH})_4]^-$  reacts with  $\text{HCl}$ .



On cooling, the white flakes of boric acid are obtained

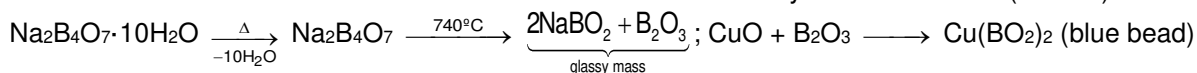
Borax is also used as a buffer since its aqueous solution contain equal amounts of weak acid and its salt.



Correct formula of borax is  $\text{Na}_2[\text{B}_4\text{O}_5(\text{OH})_4] \cdot 8\text{H}_2\text{O}$ . It contains boron in both planar  $\text{BO}_3$  and tetrahedral  $\text{BO}_4$  units. It contains five B–O–B linkages.

**Borax-bead test :**

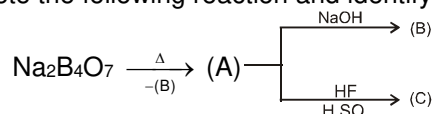
Borax reacts with certain metal salts such as,  $\text{Ni}^{2+}$ ,  $\text{Co}^{2+}$ ,  $\text{Cr}^{3+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Mn}^{2+}$  etc. to form coloured metaborates. The colour of the metaborates can be used to identify the metallic ions (cations) in salts.

**Uses :**

- (i) In borax bead test.
- (ii) In purifying gold.
- (iii) As flux during welding of metals.
- (iv) In production of glass.

## Solved Examples

- Ex-3** (a)  $\text{Na}_2\text{B}_4\text{O}_7 + \text{concentrated H}_2\text{SO}_4 + \text{H}_2\text{O} \longrightarrow (\text{A}) \xrightarrow[\text{(ii) ignite}]{\text{(i) C}_2\text{H}_5\text{OH}} (\text{B})$   
 (B) is identified by the characteristic colour of the flame. Identify (A) and (B).  
 (b) Complete the following reaction and identify the products formed.



- Sol.** (a)  $\text{Na}_2\text{B}_4\text{O}_7 + \text{concentrated H}_2\text{SO}_4 + 5\text{H}_2\text{O} \longrightarrow \text{Na}_2\text{SO}_4 + 4\text{H}_3\text{BO}_3$   
 $\text{H}_3\text{BO}_3 + 3\text{C}_2\text{H}_5\text{OH} \longrightarrow \text{B}(\text{OC}_2\text{H}_5)_3\text{-volatile (burn with green edged flame)} + 3\text{H}_2\text{O}$   
 (b)  $\text{Na}_2\text{B}_4\text{O}_7 \xrightarrow[-(\text{NaBO}_2)]{\Delta} \text{B}_2\text{O}_3 \begin{cases} \xrightarrow{\text{NaOH}} \text{NaBO}_2 \\ \xrightarrow[\text{H}_2\text{SO}_4]{\text{HF}} \text{BF}_3 \end{cases}$

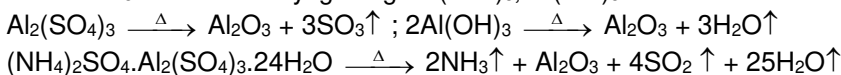
**Aluminium Oxide ( $\text{Al}_2\text{O}_3$ ) :**

It is also called alumina. It occurs in nature in the form of bauxite and corundum. It is also found in the form of gems. Some important aluminium oxide gems are :

- (A) Oriental Topaz-yellow ( $\text{Fe}^{3+}$ ),
- (B) Sapphire-blue ( $\text{Fe}^{2+ / 3+} / \text{Ti}^{4+}$ ),
- (C) Ruby-red ( $\text{Cr}^{3+}$ ),
- (D) Oriental Emerald-green ( $\text{Cr}^{3+} / \text{V}^{3+}$ )

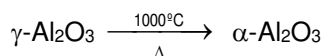
**Preparation :**

Pure  $\text{Al}_2\text{O}_3$  is obtained by igniting  $\text{Al}_2(\text{SO}_4)_3$ ,  $\text{Al}(\text{OH})_3$  or ammonium alum.

**Properties :**

It is a white amorphous powder insoluble in water but soluble in acids (forming eg.,  $\text{AlCl}_3$ ) as well as alkalis (forming e.g.,  $\text{NaAlO}_2$ ). Thus amphoteric in nature. It is a polar covalent compound. Exists in two forms  $\alpha\text{-Al}_2\text{O}_3$  or corundum and  $\gamma\text{-Al}_2\text{O}_3$ .

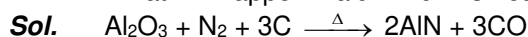
Addition of  $\text{Cr}_2\text{O}_3$  or  $\text{Fe}_2\text{O}_3$  makes alumina coloured.

**Uses :**

- (i) It is used for the extraction of aluminium.
- (ii) It is used for making artificial gems.
- (iii) It is used for the preparation of compounds of aluminium.
- (iv)  $\alpha\text{-Al}_2\text{O}_3$  is used in making furnace linings. It is a refractory material.
- (v) It is used as a catalyst in organic reactions.
- (vi) Corundum is extremely hard and is used as 'Jewellers rouge' to polish glass.
- (vii)  $\gamma\text{-Al}_2\text{O}_3$  dissolves in acids absorbs moisture and is used in chromatography.

## Solved Examples

- Ex-4** What will happen if aluminium is heated with coke in an atmosphere of nitrogen ?

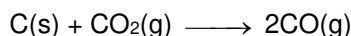




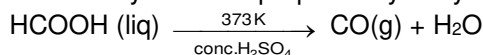
## Carbonmonoxide (CO) :

### Preparation :

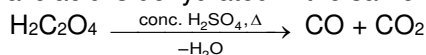
(i) It is formed together with  $\text{CO}_2$ , when carbon or carbonaceous matter is oxidized by air or oxygen. It is also produced when  $\text{CO}_2$  is reduced by red-hot carbon; this reaction is of importance in metal extractions.



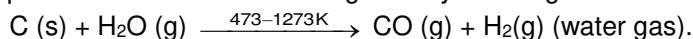
(ii) In the laboratory it can be prepared by dehydrating methanoic acid with concentrated sulphuric acid.



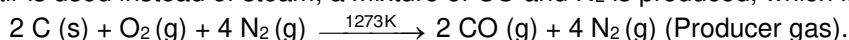
(iii) If oxalic acid is dehydrated in the same way,  $\text{CO}_2$  is formed as well.



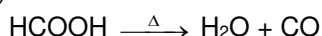
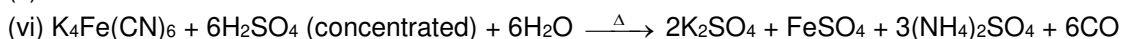
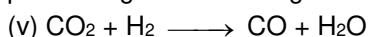
(iv) On commercial scale it is prepared by the passage of steam over hot coke. The mixture of CO and  $\text{H}_2$  thus produced is known as water gas or synthesis gas.



When air is used instead of steam, a mixture of CO and  $\text{N}_2$  is produced, which is called producer gas.



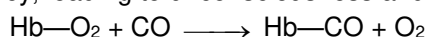
Water gas and producer gas are very important industrial fuels. Carbon monoxide in water gas or producer gas can undergo further combustion forming carbon dioxide with the liberation of heat.



(viii) Also obtained as by-product when carbon is used in reduction processes such as, of phosphite rock to give phosphorus.

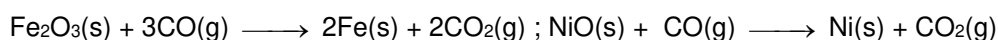
### Properties :

(i) Carbon monoxide is a colourless, odourless gas which burns in air with a blue flame, forming  $\text{CO}_2$ . It is sparingly soluble in water and is a neutral oxide. CO is toxic, because it forms a complex with haemoglobin in the blood and this complex is more stable than oxy-haemoglobin. This prevents the haemoglobin in the red blood corpuscles from carrying oxygen round the body. This causes oxygen deficiency, leading to unconsciousness and then death.



Ordinary gas masks are no protection against the gas, since it is not readily adsorbed on active charcoal. In the presence of air, a mixture of manganese (IV) oxide and copper(II) oxide catalytically oxidizes it to  $\text{CO}_2$ , and this mixed catalyst is used in the breathing apparatus worn by rescue teams in mine disasters.

(ii) Carbon monoxide is a powerful reducing agent, being employed industrially in the extraction of iron and nickel.



(iii) It reacts with many transition metals, forming volatile carbonyls; the formation of nickel carbonyl followed by its decomposition is the basis of the Mond's process for obtaining very pure nickel.



(iv) In addition to reacting with oxygen, carbon monoxide combines with sulphur to give carbonyl sulphide and with chlorine in the presence of light to give carbonyl chloride (phosgene), used in the production of polyurethane foam plastics. Phosgene is an exceedingly poisonous gas.



(v) Although carbon monoxide is not a true acid anhydride since it does not react with water to produce an acid, it reacts under pressure with fused sodium hydroxide to give sodium methanoate :

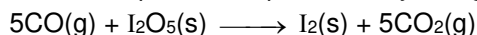




(vi) With hydrogen under pressure and in the presence of zinc oxide or chromium (III) oxide catalyst it reacts to give methanol; this reaction is of industrial importance.



(vii) CO is readily absorbed by an ammonical solution of copper (I) chloride to give  $\text{CuCl} \cdot \text{CO} \cdot 2\text{H}_2\text{O}$ . It reduces an ammonical solution of silver nitrate to silver (black) and, in the absence of other gaseous reducing agents, this serves as a test for the gas. It can be estimated by reaction with iodine pentoxide, the iodine which is produced quantitatively being titrated with standard sodium thiosulphate solution.

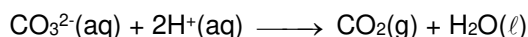


(viii) It reduces an aqueous  $\text{PdCl}_2$  solution to metallic Pd.

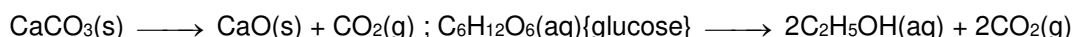
## Carbon dioxide ( $\text{CO}_2$ ) :

### Preparation :

(i) In the laboratory it can be conveniently made by the action of dilute hydrochloric acid on marble chips:



(ii) Industrially it is produced as a by-product during the manufacture of quicklime and in fermentation processes:

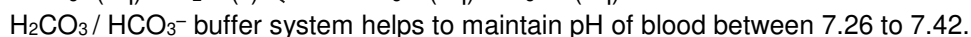
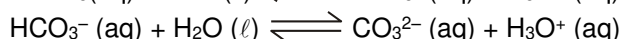
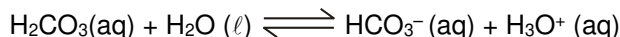


### Properties :

(i) It is a colourless, odourless and heavy gas which dissolves in its own volume of water at ordinary temperature and pressure. Like all gases, it dissolves much more readily in water when the pressure is increased and this principle is used in the manufacture of soda water and fizzy drinks.

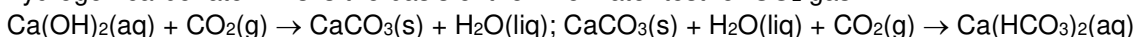
(ii)  $\text{CO}_2$  is easily liquefied (critical temperature =  $31.1^\circ\text{C}$ ) and a cylinder of the gas under pressure is a convenient fire extinguisher. When the highly compressed gas is allowed to expand rapidly solid carbon dioxide ('dry ice') is formed. Solid carbon dioxide sublimates at  $-78^\circ\text{C}$  and, since no massy liquid is produced, it is a convenient means of producing low temperatures.

(iii) Carbon dioxide is the acid anhydride of carbonic acid, which is a weak dibasic acid and ionises in two steps as follows :



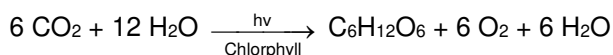
A solution of carbonic acid in water will slowly turn blue litmus red and when the solution is boiled, all the  $\text{CO}_2$  is evolved.

(iv) Carbon dioxide readily reacts with alkalis forming the carbonate and, if  $\text{CO}_2$  is in excess, the hydrogen carbonate. This is the basis of the lime-water test for  $\text{CO}_2$  gas.



The above reaction accounts for the formation of temporarily hard water.

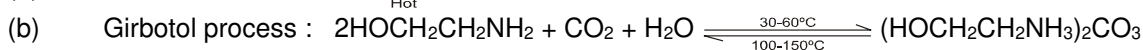
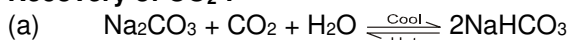
(v) Carbon dioxide, which is normally present to the extent of  $\sim 0.03\%$  by volume in the atmosphere, is removed from it by the process known as photosynthesis. It is the process by which green plants convert atmospheric  $\text{CO}_2$  into carbohydrates such as glucose. The overall chemical change can be expressed as:



By this process plants make food for themselves as well as for animals and human beings. But the increase in combustion of fossil fuels and decomposition of limestone for cement manufacture in recent years seem to increase the  $\text{CO}_2$  content of the atmosphere. This may lead to increase in green house effect and thus, raise the temperature of the atmosphere which might have serious consequences.

(vi) Gaseous  $\text{CO}_2$  is extensively used to carbonate soft drinks. Being heavy and non-supporter of combustion it is used as fire extinguisher. A substantial amount of  $\text{CO}_2$  is used to manufacture urea.

### Recovery of $\text{CO}_2$ :







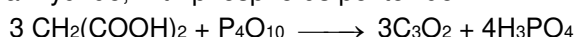
## Solved Examples

**Ex-5.**  $\text{H}_2\text{C}_2\text{O}_4 \xrightarrow{\Delta} \text{gas (A)} + \text{gas (B)} + \text{liquid (C)}$   
 oxalic acid  
 Gas (A) burns with blue flame and is oxidised to gas (B). Gas (B) turns lime water milky.  
 $\text{Gas (A)} + \text{Cl}_2 \longrightarrow (\text{D}) \xrightarrow{\text{NH}_3, \Delta} (\text{E}) \xleftarrow{\text{NH}_3, \Delta} (\text{B})$   
 Identify (A) to (E) and explain reactions involved.

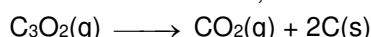
**Sol.**  $\text{H}_2\text{C}_2\text{O}_4 \xrightarrow{\Delta} \text{CO} + \text{CO}_2 + \text{H}_2\text{O}$   
 $\text{CO} + \text{Cl}_2 \longrightarrow \text{COCl}_2 \xrightarrow{\text{NH}_3, \Delta} \text{NH}_2\text{CONH}_2 \xleftarrow{\text{NH}_3, \Delta} \text{CO}_2$

### Carbon suboxide ( $\text{C}_3\text{O}_2$ ) :

This is an evil-smelling gas and can be made by dehydrating propanedioic acid (malonic acid), of which it is the anhydride, with phosphorus pentoxide :



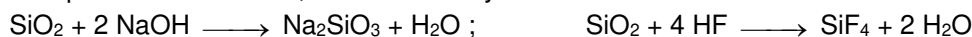
When heated to about  $200^\circ\text{C}$ , it decomposes into  $\text{CO}_2$  and C:



The molecule is thought to have a linear structure:  $\text{O}=\text{C}=\text{C}=\text{O}$ .

### Silicon Dioxide ( $\text{SiO}_2$ ) :

Silicon dioxide, commonly known as silica, occurs in several crystallographic forms. Quartz, cristobalite and tridymite are some of the crystalline forms of silica, and they are interconvertible at suitable temperature. Silicon dioxide is a covalent, three-dimensional network solid in which each silicon atom is covalently bonded in a tetrahedral manner to four oxygen atoms. Each oxygen atom in turn covalently bonded to another silicon atoms. Each corner is shared with another tetrahedron. The entire crystal may be considered as giant molecule in which eight membered rings are formed with alternates silicon and oxygen atoms. Silica in its normal form is almost non-reactive because of very high Si–O bond enthalpy. It resists the attack by halogens, dihydrogen and most of the acids and metals even at elevated temperatures. However, it is attacked by HF and NaOH.

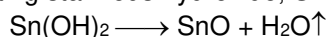


Quartz is extensively used as a piezoelectric material; it has made possible to develop extremely accurate clocks, modern radio and television broadcasting and mobile radio communications. Silica gel used as a drying agent and as a support for chromatographic materials and catalysts. Kieselghur, an amorphous form of silica is used in filtration plants.

### Stannous Oxide ( $\text{SnO}$ ) :

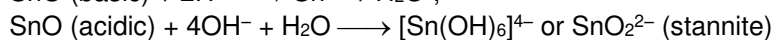
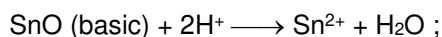
#### Preparation :

By heating stannous hydroxide,  $\text{Sn}(\text{OH})_2$ , in absence of air.

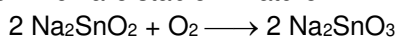


#### Properties :

$\text{SnO}$  is an amphoteric dark grey or black solid oxide, insoluble in water. It dissolves in acids to form stannous salts.



Stannites are only known in aqueous solutions. Stannites absorb oxygen from air and are oxidised to stannate which are stable in nature.



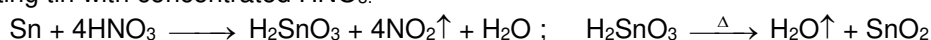
#### Uses :

For the preparation of stannous chloride and stannous sulphate.

### Stannic Oxide ( $\text{SnO}_2$ ) :

#### Preparation :

By heating tin with concentrated  $\text{HNO}_3$ .



**Properties :**

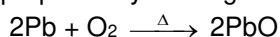
- (i) It is a white solid insoluble in water.
- (ii) It is amphoteric in nature.
- (iii) It dissolves in concentrated  $\text{H}_2\text{SO}_4$  to form stannic sulphate.  

$$\text{SnO}_2 + 2\text{H}^+ \longrightarrow \text{Sn}^{+4} + 2\text{H}_2\text{O}$$
- (iv) It also dissolves in concentrated alkalis to form alkali metal stannate solution.  

$$\text{SnO}_2 + 6\text{OH}^- \longrightarrow [\text{Sn}(\text{OH})_6]^{2-} \text{ or } \text{SnO}_3^{2-} \text{ (stannate)}$$

**Litharge (PbO) :**

PbO is prepared by heating Pb at  $180^\circ\text{C}$ . It is a volatile yellow organic solid.



It is an amphoteric oxide and dissolves in acids as well as in alkalis.

It is used in rubber industry and in the manufacture of flint glasses, enamels, and storage batteries.

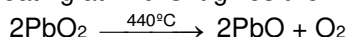
**Lead Dioxide ( $\text{PbO}_2$ ) :****Preparation :**

- (i)  $\text{PbO} + \text{NaOCl} \xrightarrow{\Delta} \text{PbO}_2 \text{ (insoluble)} + \text{NaCl}$
- (ii)  $\text{Pb}_3\text{O}_4 + 4\text{HNO}_3 \text{ (dilute)} \longrightarrow 2\text{Pb}(\text{NO}_3)_2 + \text{PbO}_2 + 2\text{H}_2\text{O}$

**Properties :**

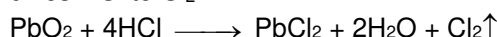
It is a chocolate/dark brown coloured insoluble solid.

- (i) On heating at  $440^\circ\text{C}$  it gives the monoxide.



- (ii)  $\text{PbO}_2$  is an oxidising agent and reduced to PbO since stability of  $\text{Pb(II)} > \text{Pb(IV)}$  based on inert pair effect.

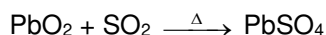
- (a) It oxidizes HCl to  $\text{Cl}_2$ .



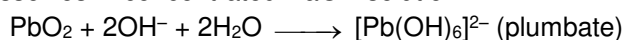
- (b) It oxidises Mn salt to permanganic acid.



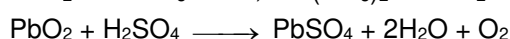
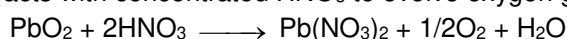
- (c) It reacts with  $\text{SO}_2$  at red heat to form lead sulphate.



- (iii) It dissolves in concentrated NaOH solution.



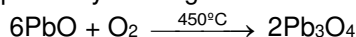
- (iv) It reacts with concentrated  $\text{HNO}_3$  to evolve oxygen gas.

**Uses :**

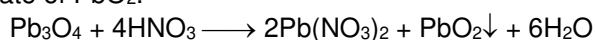
It is used in match industry for making ignition surface of match boxes, in the preparation of  $\text{KMnO}_4$  and in explosives.

**Red Lead ( $\text{Pb}_3\text{O}_4$ ) :****Preparation :**

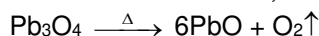
It is prepared by heating PbO at  $450^\circ\text{C}$  for a long time.

**Properties :**

- (i) It is a red powder insoluble in water but when heated with concentrated  $\text{HNO}_3$  it gives a red precipitate of  $\text{PbO}_2$ .



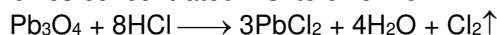
- (ii) When heated above  $550^\circ\text{C}$ , it decomposes into PbO.



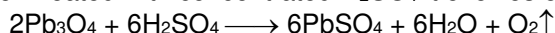




(iii) It oxidizes concentrated HCl to chlorine.



(iv) When heated with concentrated  $\text{H}_2\text{SO}_4$  it evolves oxygen.



#### Uses :

It is used as an oxidizing agent, for making metal protecting paints like red oxide paint, for making special lead cement and for making flint glass.

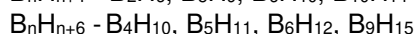
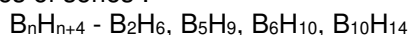
## Section (F) : Hydrides

### Compounds

#### Hydrides

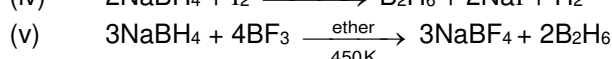
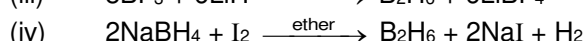
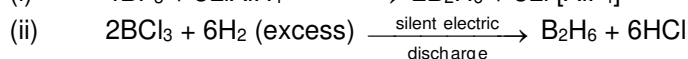
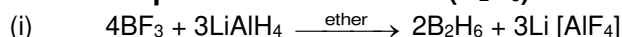
#### Boranes

Binary compounds of B with H are called boron hydrides or boranes. These compounds form following two types of series :

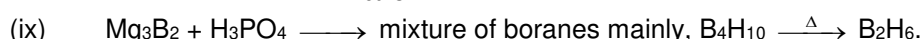
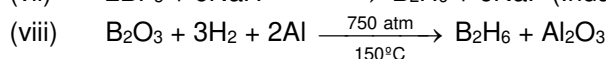
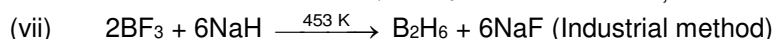


The chemistry of diborane has aroused considerable interest because of its usefulness in many synthetic reactions and also because the elucidation of its structure helped to clarify the basic concepts about the structure of electron deficient compounds.

#### Preparation of Diborane ( $\text{B}_2\text{H}_6$ ) :



(vi) It can also be prepared by treating  $\text{NaBH}_4$  with concentrated  $\text{H}_2\text{SO}_4$  or  $\text{H}_3\text{PO}_4$ .

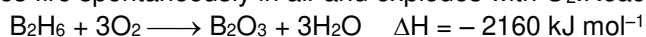


#### Properties :

(i)  $\text{B}_2\text{H}_6$  is colourless gas and highly reactive (boiling point 183 K).

(ii) Controlled pyrolysis of diborane leads to most of the higher boranes.

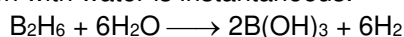
It catches fire spontaneously in air and explodes with  $\text{O}_2$ . Reaction with oxygen is extremely exothermic.



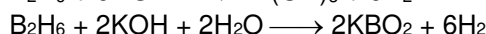
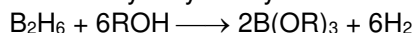
○ Mixtures of diborane with air or oxygen inflame spontaneously producing large amount of heat. Diborane has a higher heat of combustion per unit weight of fuel than most other fuels. It is therefore used as a rocket fuel.

○ At red-heat the boranes decomposes to boron and hydrogen.

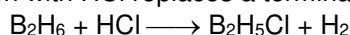
(iii) Reaction with water is instantaneous.



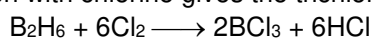
Diborane is also hydrolysed by weaker acids (e.g. alcohols) or aqueous alkali.



(iv) Reaction with HCl replaces a terminal H with Cl.



(v) Reaction with chlorine gives the trichloride.



(vi) The electron deficient 3c-2e BHB bridges are sites of nucleophilic attack.



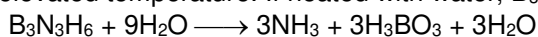
- Small amines such as  $\text{NH}_3$ ,  $\text{CH}_3\text{NH}_2$  and  $(\text{CH}_3)_2\text{NH}$  give unsymmetrical cleavage of diborane.  
 $\text{B}_2\text{H}_6 + 2\text{NH}_3 \longrightarrow [\text{H}_2\text{B}(\text{NH}_3)_2]^+ + [\text{BH}_4]^-$
- Large amines such as  $(\text{CH}_3)_3\text{N}$  and pyridine give symmetrical cleavage of diborane.  
 $2(\text{CH}_3)_3\text{N} + \text{B}_2\text{H}_6 \longrightarrow 2\text{H}_3\text{B} \longleftarrow \text{N}(\text{CH}_3)_3$   
 $\text{B}_2\text{H}_6 + 2\text{Me}_3\text{P} \longrightarrow 2\text{Me}_3\text{PBH}_3$
- $\text{B}_2\text{H}_6 + 2\text{CO} \xrightarrow{200^\circ\text{C}, 20\text{ atm}} 2\text{BH}_3\text{CO}$  (borane carbonyl)
- The boronium ion products  $[\text{H}_2\text{BL}_2]^+$ , are tetrahedral and can undergo substitution by other bases  
 $[\text{H}_2\text{B}(\text{NH}_3)_2]^+ + 2\text{PR}_3 \longrightarrow [\text{H}_2\text{B}(\text{PR}_3)_2]^+ + 2\text{NH}_3$
- The reaction with ammonia depends on conditions.  

$$\text{B}_2\text{H}_6 + \text{NH}_3 \xrightarrow[\text{low temperature}]{\text{Excess NH}_3} \text{B}_2\text{H}_6 \cdot 2\text{NH}_3 \text{ or } [\text{H}_2\text{B}(\text{NH}_3)_2]^+ [\text{BH}_4]^- \text{ (ionic compound).}$$

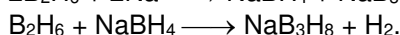
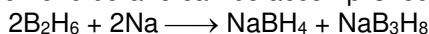
$$\xrightarrow[\text{higher temperature } (> 200^\circ\text{C})]{\text{Excess NH}_3} (\text{BN})_x \text{ boron nitride.}$$

$$\xrightarrow[\text{higher temperature } (200^\circ\text{C})]{\text{Ratio } 2\text{NH}_3 : 1 \text{ B}_2\text{H}_6} \text{B}_3\text{N}_3\text{H}_6 \text{ borazine.}$$

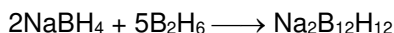
Borazine is much more reactive than benzene. Borazine readily undergoes addition reactions which do not occur with benzene. Borazine also decomposes slowly and may be hydrolysed to  $\text{NH}_3$  and boric acid at elevated temperature. If heated with water,  $\text{B}_3\text{N}_3\text{H}_6$  hydrolyses slowly.



- (vii) Reduction of diborane can be accomplished with sodium or with sodium borohydride.



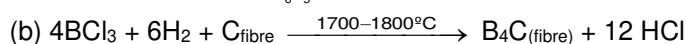
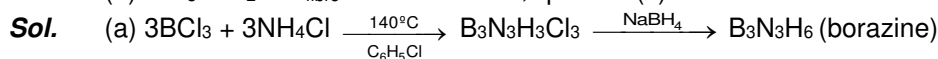
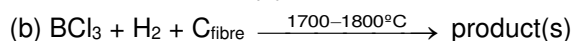
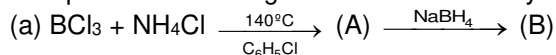
- Reductions of diborane with  $\text{NaBH}_4$  can also lead to higher borane anions.



- (viii)  $\text{B}_2\text{H}_6 + 2\text{LiH} \longrightarrow 2\text{LiBH}_4$

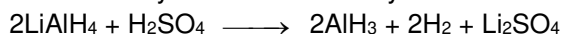
## Solved Examples

**Ex-6.** Complete the following reactions and identify the products formed.



### Aluminium Hydride ( $\text{AlH}_3$ ) :

Aluminium hydride is obtained by interaction of  $\text{LiAlH}_4$  with 100%  $\text{H}_2\text{SO}_4$  in THF :



The white hydride is thermally unstable. With donor ligands however, a range of molecular complexes  $\text{AlH}_3\text{L}$  &  $\text{AlH}_3\text{L}_2$  are formed indicative of the lewis acidic behaviour of  $\text{AlH}_3$ .

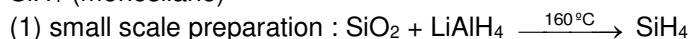
### Hydrides of carbon :

Carbon forms a vast number of chain and ring compounds including :

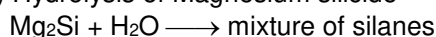
- The alkanes (Paraffins)  $\text{C}_n\text{H}_{2n+2}$
- The alkenes (olefines)  $\text{C}_n\text{H}_{2n}$
- The alkynes (acetylenes)  $\text{C}_n\text{H}_{2n-2}$
- Aromatic compounds

### Silanes

$\text{SiH}_4$  (monosilane)



(2) Hydrolysis of Magnesium silicide



(3) Reduction of chlorosilanes by  $\text{LiAlH}_4$  to produce silane

(4) Photolysis of  $\text{SiH}_4\text{--H}_2$  mixture can make higher silanes

(5) Among silanes only  $\text{SiH}_4$  &  $\text{Si}_2\text{H}_6$  are indefinitely stable at  $25^\circ\text{C}$ .



## Section (G) : Halides

### Halides, Alums and Other metal salts :

#### Boron Halide :

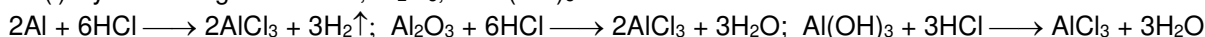
Boron trihalides are strictly monomeric, trigonal planar molecules. This difference from aluminium is attributed to back-donation from “nonbonding” electrons on halogen atoms into the “empty”  $p_z$  orbital of boron which lends some double bond character to B–X bonding (manifested by bond shortening) and stabilizes the monomer.

#### Aluminium Chloride ( $\text{AlCl}_3 \cdot 6\text{H}_2\text{O}$ ) :

It is a colourless crystalline solid, soluble in water. It is covalent. Anhydrous  $\text{AlCl}_3$  is a deliquescent white solid.

#### Preparation :

(i) By dissolving aluminium,  $\text{Al}_2\text{O}_3$ , or  $\text{Al}(\text{OH})_3$  in dilute HCl :



The solution obtained is filtered and crystallized when the crystals of  $\text{AlCl}_3 \cdot 6\text{H}_2\text{O}$  are obtained.

(ii) Anhydrous  $\text{AlCl}_3$  is obtained by the action of  $\text{Cl}_2$  on heated aluminium.

(iii) By heating a mixture of  $\text{Al}_2\text{O}_3$  and coke and passing chlorine over it.

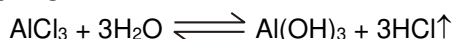


#### Properties :

(i) **Action of heat** : Hydrated salt when heated strongly is converted to  $\text{Al}_2\text{O}_3$ .



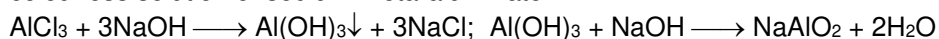
(ii) **Action of moisture on anhydrous  $\text{AlCl}_3$**  : When exposed to air, anhydrous  $\text{AlCl}_3$  produces white fumes of HCl.



(iii) **Action of  $\text{NH}_3$**  : Anhydrous  $\text{AlCl}_3$  absorbs  $\text{NH}_3$  since the former is a Lewis acid.

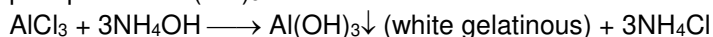


(iv) **Action of NaOH solution** : When NaOH solution is added dropwise to an aqueous  $\text{AlCl}_3$  solution, a gelatinous precipitate of  $\text{Al}(\text{OH})_3$  is first formed which dissolves in excess of NaOH solution to give a colourless solution of sodium meta-aluminate.



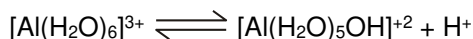
This reaction is important as a test to distinguish between an aluminium salt from salts of Mg, Ca, Sr, and Ba. (When NaOH solution is added to their salt solutions, a white precipitate of hydroxide forms which does not dissolve in excess of NaOH).

(v) **Action of  $\text{NH}_4\text{OH}$  solution** : When  $\text{NH}_4\text{OH}$  solution is added to a solution of  $\text{AlCl}_3$ , a white precipitate of  $\text{Al}(\text{OH})_3$  is formed which does not dissolve in excess of  $\text{NH}_4\text{OH}$ .

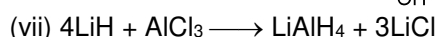
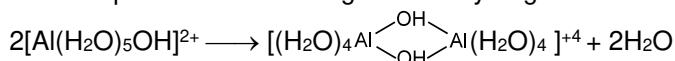


This reaction is important as a test to distinguish an Al salt from a Zn salt. (With a Zn salt a white precipitate of  $\text{Zn}(\text{OH})_2$  is formed which dissolves in excess of  $\text{NH}_4\text{OH}$  solution).

(vi) **Hydrolysis with water** : When  $\text{AlCl}_3$  is dissolved in water, it undergoes hydrolysis rapidly to produce  $\text{Al}(\text{OH})_3$  which is a weak base and HCl which is a strong acid. Hence the solution is acidic to litmus.



The complex cation has a high tendency to get dimerised.



#### Uses :

(i) As catalyst for cracking of petroleum.

(ii) As catalyst in Friedel-Crafts reactions.

(iii) For preparing aluminium compounds.



## Solved Examples

**Ex-7.** What happens when :

(write chemical equations only)

- (a) Anhydrous  $\text{AlCl}_3$  is exposed to atmosphere.  
 (b)  $\text{AlCl}_3$  dissolves in aqueous sodium hydroxide (excess)

**Sol.** (a)  $\text{AlCl}_3 + 3\text{H}_2\text{O} \longrightarrow \text{Al}(\text{OH})_3 + 3\text{HCl}$  (HCl fumes in air).

(b)  $\text{AlCl}_3 + 3\text{NaOH} \longrightarrow \text{Al}(\text{OH})_3 \downarrow + 3\text{NaCl}$

$\text{Al}(\text{OH})_3 + \text{OH}^- \longrightarrow [\text{Al}(\text{OH})_4]^-$

**Ex-8.** Anhydrous  $\text{AlCl}_3$  cannot be prepared by heating hydrated salt. Why ?

**Sol.** Gets hydrolysed forming  $\text{Al}_2\text{O}_3$ .



### Alums ; $\text{M}_2\text{SO}_4 \cdot \text{M}'_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$ or $\text{MM}'(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$

Alums are transparent crystalline solids having the above general formula where M is almost any univalent positive cation (except  $\text{Li}^+$  because this ion is too small to meet the structural requirements of the crystal) and  $\text{M}'$  is a trivalent positive cation ( $\text{Al}^{3+}$ ,  $\text{Ti}^{3+}$ ,  $\text{V}^{3+}$ ,  $\text{Cr}^{3+}$ ,  $\text{Fe}^{3+}$ ,  $\text{Mn}^{3+}$ ,  $\text{Co}^{3+}$ ,  $\text{Ga}^{3+}$  etc.). Alums contain the ions  $[\text{M}(\text{H}_2\text{O})_6]^+$ ,  $[\text{M}'(\text{H}_2\text{O})_6]^{3+}$  and  $\text{SO}_4^{2-}$  in the ratio 1 : 1 : 2. Some important alums are :

- (i) Potash alum  $\text{K}_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$       (ii) Chrome alum  $\text{K}_2\text{SO}_4 \cdot \text{Cr}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$   
 (iii) Ferric alum  $\text{K}_2\text{SO}_4 \cdot \text{Fe}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$       (iv) Ammonium alum  $(\text{NH}_4)_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$

Alums are double salts which when dissolved in water produce metal ions (or ammonium ions) and the sulphate ions.

#### Preparation :

A mixture containing solutions of  $\text{M}_2\text{SO}_4$  and  $\text{M}'_2(\text{SO}_4)_3$  in 1 : 1 molar ratio is fused & then the resulting mass is dissolved into water. From the solution thus obtained, alums are crystallised.

#### Uses :

- (i) As a mordant in dye industry. The fabric which is to be dyed is dipped in a solution of the alum and heated with steam.  $\text{Al}(\text{OH})_3$  obtained as hydrolysis product of  $[\text{Al}(\text{H}_2\text{O})_6]^{3+}$  deposits into the fibres and then the dye is absorbed on  $\text{Al}(\text{OH})_3$ .  
 (ii) As a germicide for water purification  
 (iii) As a coagulating agent for precipitating colloidal impurities from water.

## Solved Examples

**Ex-9.** List the cations which are capable of replacing aluminium in alums ?

**Sol.** Cations of about the same size as that of  $\text{Al}^{3+}$  such as  $\text{Ti}^{3+}$ ,  $\text{Cr}^{3+}$ ,  $\text{Mn}^{3+}$ ,  $\text{Fe}^{3+}$  and  $\text{Co}^{3+}$  are capable of replacing aluminium in alums.

### Carbon Halides :

#### $\text{CF}_4$ (Carbon tetrafluoride)

- It is an extraordinarily stable compound.
- Lab preparation :  $\text{SiC} + \text{F}_2 \xrightarrow{\Delta} \text{SiF}_4 + \text{CF}_4$
- No hydrolysis is possible.

#### $\text{CCl}_4$ (Carbon tetrachloride)

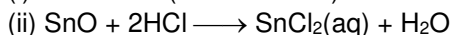
- Common solvent, fairly readily decomposed photo chemically.
- Although it is thermodynamically unstable with respect to hydrolysis, the observe of acceptor orbitals carbon makes the attack very difficult.

#### $\text{CBr}_4$ (Carbon tetrabromide)

- Pale yellow solid at room temperature.
- Insoluble in water, soluble in non-polar solvent.

#### $\text{CI}_4$ (Carbon tetraiodide)

- Bright red, crystalline material.
- odor like that of iodine.

**Stannous Chloride (SnCl<sub>2</sub>·2H<sub>2</sub>O) :****Preparation :**

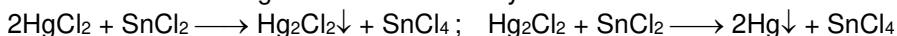
The solution on crystallization gives colourless crystals of SnCl<sub>2</sub>·2H<sub>2</sub>O.

**Properties :**

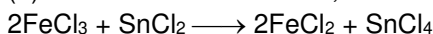
(i) It is a colourless solid soluble in water. It is soluble in alcohol and ether also.

(ii) It is a stronger reducing agent.

(a) Reaction with Hg<sub>2</sub>Cl<sub>2</sub> solution: When SnCl<sub>2</sub> solution is added to an aqueous solution of mercuric chloride, a silky white precipitate of mercurous chloride, Hg<sub>2</sub>Cl<sub>2</sub> is formed which turns black due to further reduction of Hg<sub>2</sub>Cl<sub>2</sub> to black mercury.

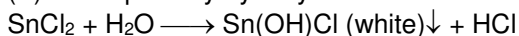


(b) It reduces ferric chloride, FeCl<sub>3</sub> to ferrous chloride, FeCl<sub>2</sub>.



(c) It also reduces CuCl<sub>2</sub> to CuCl (white).

(iii) SnCl<sub>2</sub> partially hydrolyses in water forming the basic chloride, Sn(OH)Cl.



As it produces a weak base and strong acid its aqueous solution is acidic. Its hydrolysis can be prevented by adding concentrated HCl to it during the process of its preparation.

**Uses :**

(i) In dye industry as a reducing agent.

(ii) For the test of mercuric salt.

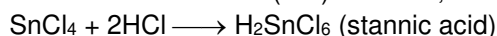
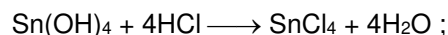
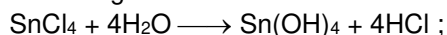
(iii) For the preparation of other stannous compounds.

**Stannic Chloride (SnCl<sub>4</sub>) :****Preparation :****Properties :**

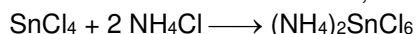
(i) It is a colourless fuming liquid ; boiling point is 114°C.

(ii) Action of moisture: It absorbs moisture and becomes converted into hydrated stannic chlorides, SnCl<sub>4</sub>·3H<sub>2</sub>O, SnCl<sub>4</sub>·5H<sub>2</sub>O, SnCl<sub>4</sub>·6H<sub>2</sub>O and SnCl<sub>4</sub>·8H<sub>2</sub>O. SnCl<sub>4</sub>·5H<sub>2</sub>O is known as "butter of tin" or "oxymercure of tin".

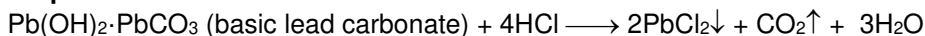
(iii) Hydrolysis with water : It hydrolyses in dilute solution but it is incomplete and can be repressed in presence of halogen acid.



(v) In presence of ammonium chloride, it forms ammonium salt of H<sub>2</sub>SnCl<sub>6</sub> (stannic acid).

**Uses :**

For the preparation of stannic compounds.

**Lead Chloride (PbCl<sub>2</sub>) :****Preparation:****Properties :**

It is a white crystalline solid, insoluble in cold water but soluble in boiling water. It dissolves in concentrated HCl forming a complex ion.

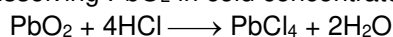
**Uses :**

It is used for making pigments for paints.

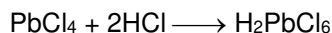
**Lead Tetrachloride (PbCl<sub>4</sub>) :****Preparation :**

It is prepared by the following methods:

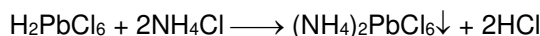
(i) By dissolving PbO<sub>2</sub> in cold concentrated HCl



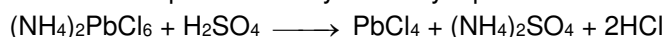
PbCl<sub>4</sub> dissolves in excess of HCl to form a stable solution of H<sub>2</sub>PbCl<sub>6</sub>.



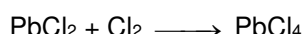
When NH<sub>4</sub>Cl is added to a solution of chloroplumbic acid, a yellow precipitate of ammonium chloroplumbate is formed.



When crystals of ammonium chloroplumbate is added to ice cold concentrated H<sub>2</sub>SO<sub>4</sub>, lead tetrachloride is formed and separates as a yellow oily liquid.

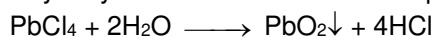


(ii) By the action of Cl<sub>2</sub> on a solution of PbCl<sub>2</sub> in concentrated HCl

**Properties :**

(i) It is a yellow oily liquid which solidifies at -10°C and is soluble in organic solvents like ethanol and benzene.

(ii) Rapid hydrolysis with water forms PbO<sub>2</sub> precipitate

**Uses :**

It is used for making stannic compounds.

**Carbonates (CO<sub>3</sub><sup>2-</sup>) and Bicarbonates (HCO<sub>3</sub><sup>-</sup>)**

Carbonic acid is a dibasic acids giving rise to two series of salts, carbonates (normal salts) and bicarbonates (acid salts) due to successive removal of the replaceable hydrogens from H<sub>2</sub>CO<sub>3</sub>.

**Preparation :**

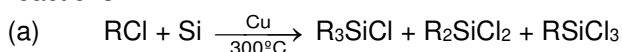
(i) With NaOH :  $2\text{NaOH} + \text{CO}_2 \longrightarrow \text{Na}_2\text{CO}_3$  ;  $\text{Na}_2\text{CO}_3 + \text{H}_2\text{O} + \text{CO}_2 \longrightarrow 2\text{NaHCO}_3$

(ii) By precipitation :  $\text{BaCl}_2 + \text{Na}_2\text{CO}_3 \longrightarrow \text{BaCO}_3 \downarrow + 2\text{NaCl}$

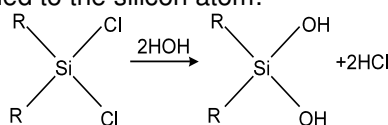
**SiCl<sub>4</sub>, Silicones, Silicates & Zeolites :****Silicones :**

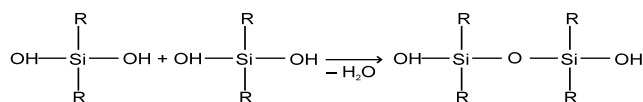
Silicones are synthetic organosilicon compounds having repeated R<sub>2</sub>SiO units held by Si-O-Si linkages. These compounds have the general formula (R<sub>2</sub>SiO)<sub>n</sub> where R = alkyl or aryl group.

The silicones are formed by the hydrolysis of alkyl or aryl substituted chlorosilanes and their subsequent polymerisation. The alkyl or aryl substituted chlorosilanes are prepared by the following reactions.

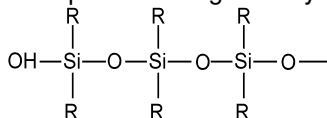


After fractional distillation, the silane derivatives are hydrolysed and the 'hydroxides' immediately condense by intermolecular elimination of water. The final product depends upon the number of hydroxyl groups originally bonded to the silicon atom:





In this manner several molecules may combine to form a long chain polymer whose both the ends will be occupied by  $-\text{OH}$  groups. Such compounds are generally represented from the following formula.

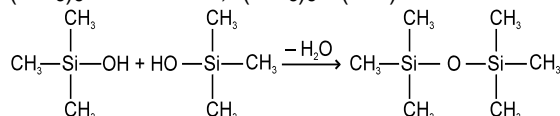
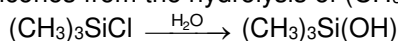


The polymer chain depicted above is terminated by incorporating a small quantity of the monochlorosilane derivative into the hydrolysis mixture.

- Silicones can be prepared from the following types of compounds only.

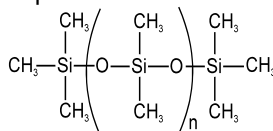
(i)  $\text{R}_3\text{SiCl}$       (ii)  $\text{R}_2\text{SiCl}_2$       (iii)  $\text{RSiCl}_3$

- Silicones from the hydrolysis of  $(\text{CH}_3)_3\text{SiCl}$



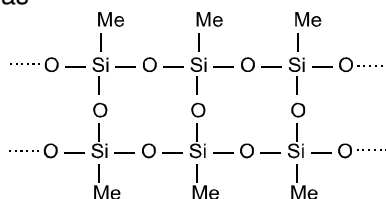
- Silicones from the hydrolysis of a mixture of  $(\text{CH}_3)_3\text{SiCl}$  &  $(\text{CH}_3)_2\text{SiCl}_2$

The dichloro derivative will form a long chain polymer as usual. But the growth of this polymer can be blocked at any stage by the hydrolysis product of mono-chloro derivative.



- Silicones from the hydrolysis of trichloro derivative.

When a compound like  $\text{CH}_3\text{SiCl}_3$  undergoes hydrolysis, a complex cross-linked polymer is obtained as chain can grow in three places as

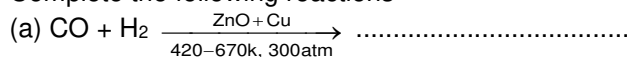


- The hydrocarbon layer along the silicon-oxygen chain makes silicones water-repellent.
- Silicones find a variety of applications because of their chemical inertness, water repelling nature, heat resistance and good electrical insulation property.

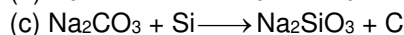
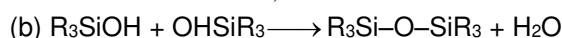
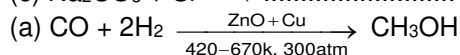
Products having the physical properties of oils, rubbers and resins can be produced using silicones. Silicone varnishes are such excellent insulators and so heat-resistance that insulating wiring with them enabled motors to work over-loads that would have set fire to the insulation formerly used. Silicone fluids are used as hydraulic systems of planes as they are thermally stable and their viscosity alters very little with temperature. Silicone rubbers are used in place of ordinary rubber as they retain their elasticity at much lower temperature than ordinary rubber.

## Solved Examples

**Ex-10.** Complete the following reactions



**Sol.**







## Section (H) : Miscellaneous (Silicones, Silicates, Zeolites & Alums)

### Silicates :

Binary compounds of silicon with oxygen are called silicates but they contain other metals also in their structures.

- (i) Since the electronegativity difference between O & Si is about 1.7, so Si–O bond can be considered 50% ionic & 50% covalent.
- (ii) If we calculate the radius ratio then,  $\frac{r_{\text{Si}^{4+}}}{r_{\text{O}^{2-}}} = 0.29$

It suggests that the coordination number of silicon must be 4 and from VBT point of view we can say that Si is  $sp^3$  hybridized. Therefore silicate structures must be based upon  $\text{SiO}_4^{4-}$  tetrahedral units.

- (iii)  $\text{SiO}_4^{4-}$  tetrahedral units may exist as discrete units or may polymerise into larger units by sharing corners.

### Classification of Silicates :

#### (A) Orthosilicates :

These contain discrete  $[\text{SiO}_4]^{4-}$  units i.e., there is no sharing of corners with one another as shown in figure.

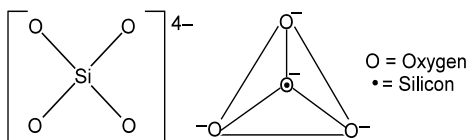


Figure : 2

e.g. Zircon ( $\text{ZrSiO}_4$ ), Forsterite or Olivine ( $\text{Mg}_2\text{SiO}_4$ ), Willemite ( $\text{Zn}_2\text{SiO}_4$ )

#### (B) Pyrosilicate :

In these silicates two tetrahedral units are joined by sharing oxygen at one corner thereby giving  $[\text{Si}_2\text{O}_7]^{6-}$  units.

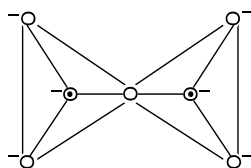


Figure : 3

e.g. Thortveitite ( $\text{Sc}_2\text{Si}_2\text{O}_7$ ), Hemimorphite ( $\text{Zn}_3(\text{Si}_2\text{O}_7) \cdot \text{Zn}(\text{OH})_2 \cdot \text{H}_2\text{O}$ )

○ (–) charge will be present on the oxygen atoms which is bonded with one Si atom.

#### (C) Cyclic silicates :

If two oxygen atoms per tetrahedron are shared to form closed rings such that the structure with general formula  $(\text{SiO}_3^{2-})_n$  or  $(\text{SiO}_3)_n^{2n-}$  is obtained, the silicates containing these anions are called cyclic silicates.  $\text{Si}_3\text{O}_9^{6-}$  and  $\text{Si}_6\text{O}_{18}^{12-}$  anions are the typical examples of cyclic silicates.

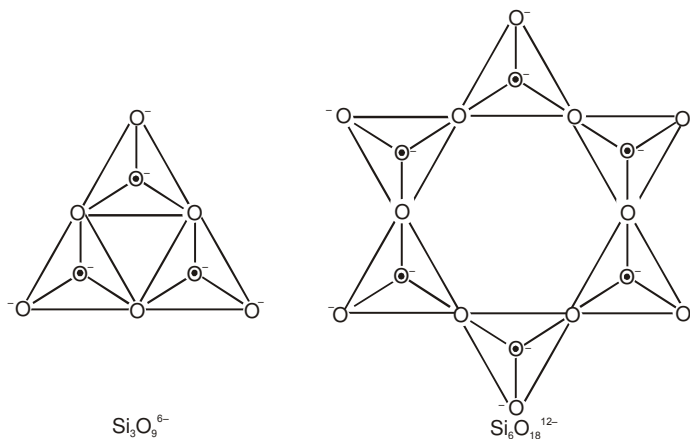


Figure : 4

Figure : 5

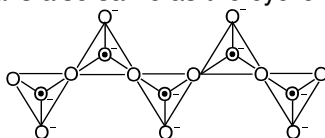




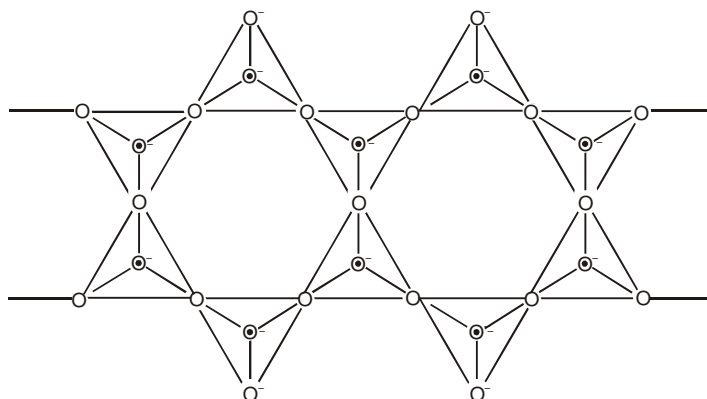
**(D) Chain silicates :**

Chain silicates may be further classified into simple chain & double chain compounds.

In case of simple chains two corners of each tetrahedron are shared & they form a long chain of tetrahedron. Their general formula is also same as the cyclic silicates i.e.  $(\text{SiO}_3)_n^{2n-}$

**Figure : 6**

Similarly, double chain silicates can be drawn in which two simple chains are joined together by shared oxygen. Such compounds are also known as amphiboles. The asbestos mineral is a well known example of double chain silicates. The anions of double chain silicates have general formula  $(\text{Si}_4\text{O}_{11})_n^{6n-}$

**Figure : 7**

e.g., Synthetic silicates  $(\text{Li}_2\text{SiO}_3, \text{Na}_2\text{SiO}_3)$ , Spondumene  $(\text{LiAl}(\text{SiO}_3)_2)$ , Enstatite  $(\text{MgSiO}_3)$ , Diopside  $(\text{CaMg}(\text{SiO}_3)_2)$ , Tremolite  $(\text{Ca}_2\text{Mg}_5(\text{Si}_4\text{O}_{11})_2 (\text{OH})_2)$ , etc.

**(E) Two dimensional sheet silicates :**

In such silicates, three oxygen atoms of each tetrahedral are shared with adjacent  $\text{SiO}_4^{4-}$  tetrahedrals. Such sharing forms two dimension sheet structure with general formula  $(\text{Si}_2\text{O}_5)_n^{2n-}$

e.g. Talc  $(\text{Mg}(\text{Si}_2\text{O}_5)_2 \text{Mg}(\text{OH})_2)$ , Kaolin  $\text{Al}_2(\text{OH})_4 (\text{Si}_2\text{O}_5)$

**(F) Three dimensional silicates :**

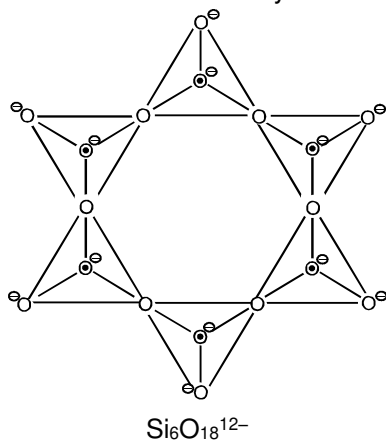
These silicates involve all four oxygen atom in sharing with adjacent  $\text{SiO}_4^{4-}$  tetrahedral units.

e.g. Quartz, Tridymite, Cristobalite, Feldspar, Zeolite and Ultramarines.

## Solved Examples

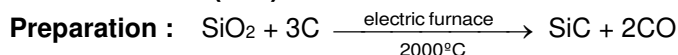
**Ex-11.** Draw the structure of cyclic silicate containing  $\text{Si}_6\text{O}_{18}^{12-}$  ion.

**Sol.**

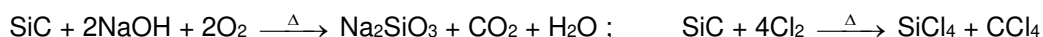


**Zeolites :**

If aluminium atoms replace few silicon atoms in three-dimensional network of silicon dioxide, overall structure known as aluminosilicate, acquires a negative charge. Cations such as  $\text{Na}^+$ ,  $\text{K}^+$  or  $\text{Ca}^{2+}$  balance the negative charge. Examples are feldspar and zeolites. Zeolites are widely used as a catalyst in petrochemical industries for cracking of hydrocarbons and isomerisation, e.g., ZSM-5 (A type of zeolite) used to convert alcohols directly into gasoline. Hydrated zeolites are used as ion exchangers in softening of "hard" water.

**Carborundum (SiC) :****Properties :**

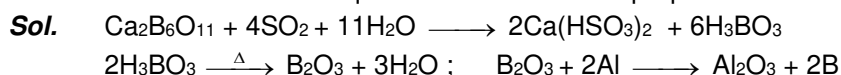
- (i) It is a very hard substance (Hardness = 9.5 Moh)
- (ii) On heating it does not melt rather decomposes into elements.
- (iii) Not attacked by acids. However, it gives the following two reactions at high temperature.



- It has a diamond like structure in which each atom is  $\text{sp}^3$  hybridized. Therefore, each atom is tetrahedrally surrounded by 4 atoms of other type.

## Solved Examples

**Ex-12.** Write the chemical equations involved in the preparation of elemental boron from mineral colemanite.

**Uses of boron :**

- (i) Boron is used in the construction of high impact-resistant steel and, since it absorbs neutrons, in reactor rods for controlling atomic reactions.
- (ii) Boron carbide is used as an abrasive.

**Uses of Al :**

It is extensively used :

- (i) for manufacture of cooking and household utensils.
- (ii) as aluminium plating for tanks, pipes, iron bars and other steel objects to prevent corrosion.
- (iii) for manufacture of aluminium cables.
- (iv) for making precision instruments, surgical apparatus, aircraft bodies, rail coaches, motorboats, car.
- (v) Aluminates are important constituents of portland cement.

**Uses of carbon :** Graphite fibres embedded in plastic material form high strength, lightweight composites. The composites are used in products such as tennis rackets, fishing rods, aircraft and canoes. Being good conductor, graphite is used for electrodes in batteries and industrial electrolysis. Crucibles made from graphite are inert to dilute acids and alkalis. Being highly porous and having enormous surface area activated charcoal is used in adsorbing poisonous gases; also used in water filters to remove organic contaminants and in air conditioning system to control odour. Carbon black is used as black pigment in black ink and as filler in automobile tyres. Coke is used as a fuel and largely as a reducing agent in metallurgy. Diamond is a precious stone and used in jewellery. It is measured in carats (1 carat = 200 mg.).

**Uses of silicon :**

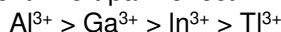
- (i) Ultrapure form of germanium and silicon are used to make transistors and semiconductor devices.
- (ii) Silicon is a very important component of ceramics, glass and cement.



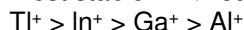
### MISCELLANEOUS SOLVED PROBLEMS (MSPS)

1. Al and Ga are trivalent in their compounds but monovalent compounds are the most stable down the 13th group. Why ?

**Sol.** Down the group (13th), the stability of +3 state decreases and that of +1 state increases due to the prominent "inert pair" effect.

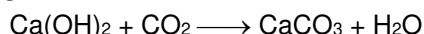


Most stable  $\longrightarrow$  least stable

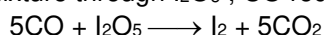


2. If you have a mixture of CO and CO<sub>2</sub>, how would you know about the relative proportions of the two gases in the given mixture ?

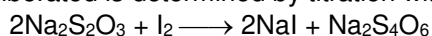
**Sol.** (i) Pass mixture through the Ca(OH)<sub>2</sub> solution; CO<sub>2</sub> is absorbed by Ca(OH)<sub>2</sub>. The residual volume will be that of CO



(ii) Pass mixture through I<sub>2</sub>O<sub>5</sub>; CO reduces I<sub>2</sub>O<sub>5</sub> to I<sub>2</sub>.



I<sub>2</sub> thus liberated is determined by titration with Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>.



This is the quantitative method of estimation of CO.

3. What will happen if borontrifluoride is kept in moist air ?

(A) It will strongly fume.

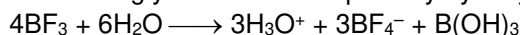
(B) It will partially hydrolyse.

(C) It will completely hydrolyse.

(D) None of these

**Ans.** (A)

**Sol.** In moist air it strongly fume : but it is partially hydrolysed by excess of water.



BF<sub>3</sub> is a colourless gas.

4. What happens when : (write only chemical reactions)

(a) iodine is treated with SnCl<sub>2</sub>.

(b) carbondioxide is passed through a concentrated aqueous solution of sodium chloride saturated with ammonia.

(c) red lead is treated with nitric acid.

(d) dilute nitric acid is slowly reacted with tin.

**Sol.** (a)  $2\text{SnCl}_2 + \text{I}_2 \longrightarrow 2\text{SnCl}_2\text{I}_2 \longrightarrow \text{SnCl}_4 + \text{SnI}_4$

(b)  $\text{NaCl} + \text{NH}_4\text{OH} + \text{CO}_2 \longrightarrow \text{NaHCO}_3 + \text{NH}_4\text{Cl}$

(c)  $\text{Pb}_3\text{O}_4 + 4\text{HNO}_3 \longrightarrow 2\text{Pb(NO}_3)_2 + \text{PbO}_2 + 2\text{H}_2\text{O}$

(d)  $\text{Sn} + 10\text{HNO}_3(\text{dilute}) \longrightarrow 4\text{Sn(NO}_3)_2 + \text{NH}_4\text{NO}_3 + 3\text{H}_2\text{O}$

5. **True / False**

(a) BCl<sub>3</sub> in aqueous solution exists as B<sup>3+</sup> and Cl<sup>-</sup>.

(b) Pure crystalline boron is very unreactive and it is attacked only at high temperatures by strong oxidising agents such as a mixture of hot concentrated H<sub>2</sub>SO<sub>4</sub> and HNO<sub>3</sub>.

(c) AlX<sub>3</sub> (X = Cl, Br) exists as dimer and retains dimer formula in non-polar solvents like ether, benzene etc.

(d) Be<sub>2</sub>C is called acetylide because it reacts with water yielding ethyne.

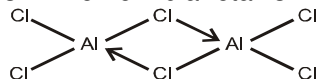
(e) Pb<sub>3</sub>O<sub>4</sub> a double oxide, is obtained by heating lead (II) oxide in air.

**Ans.** (a) False (b) True (c) True (d) False (e) True

**Sol.** (a) Statement is incorrect. BCl<sub>3</sub> hydrolyses in aqueous solution to give boric acid. Because it has large ionisation energies and to make the enthalpy of solution of BCl<sub>3</sub> negative, the enthalpy of hydration of B<sup>3+</sup> should be very high (~ 600 kJ) which is unlikely for the small B<sup>3+</sup> cation.

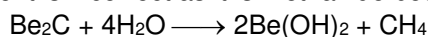
(b)  $2\text{B} + 6\text{HNO}_3(\text{aq.}) \longrightarrow 2\text{H}_3\text{BO}_3(\text{aq.}) + 6\text{NO}_2(\text{g})$

(c) Statement is correct and its dimer structure is as follows. It acquires this structure for attaining an octet of electrons. Dimer formula retains in non-polar solvent like ether, benzene





- (d) Statement is incorrect as it is methanide because it gives methane on reaction with water.



- (e)  $3\text{PbO} + \text{O}_2 \xrightarrow{\Delta} \text{Pb}_3\text{O}_4$

6. **Statement-1** :  $\text{PbO}_2$  is an oxidising agent and reduced to  $\text{PbO}$ .

**Statement-2** : Stability of  $\text{Pb(II)} > \text{Pb(IV)}$  on account of inert pair effect.

- (A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.  
 (B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.  
 (C) Statement-1 is True, Statement-2 is False.  
 (D) Statement-1 is False, Statement-2 is True.

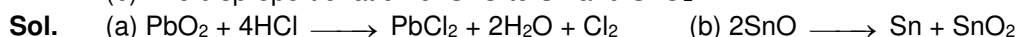
**Ans.** (A)

**Sol.** Both are correct statements and statement-2 is the correct explanation of statement-1.

7. Write the chemical equations to represent the following reactions.

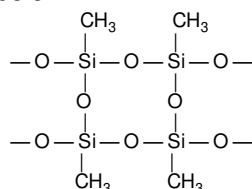
(a) The oxidation of  $\text{HCl}$  (aq) to  $\text{Cl}_2$  (g) by  $\text{PbO}_2$ .

(b) The disproportionation of  $\text{SnO}$  to  $\text{Sn}$  and  $\text{SnO}_2$ .



8. What will happen if we take  $\text{Si}(\text{CH}_3)\text{Cl}_3$  as a starting material for the preparation of commercial silicon polymer?

**Sol.** With  $\text{Si}(\text{CH}_3)\text{Cl}_3$  the chain will grow in three places and we will get cross-linked silicon polymer as shown below :



9. Give three properties of diamond.

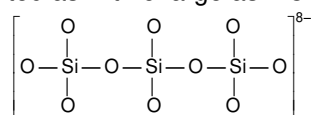
**Sol.** Diamond is very hard, high melting solid. It is an electrical insulator.

10. The silicate anion in the mineral kionite is a chain of three  $\text{SiO}_4$  tetrahedra that share corners with adjacent tetrahedra. The mineral also contains  $\text{Ca}^{2+}$  ions,  $\text{Cu}^{2+}$  ions, and water molecules in a 1:1:1 ratio.

(a) Give the formula and charge of the silicate anion.

(b) Given the complete formula for the mineral.

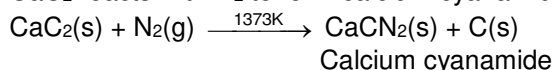
**Sol.** (a) The silicate anion has three  $\text{SiO}_4$  tetrahedra that share corners with adjacent tetrahedra thus silicate is  $\text{Si}_3\text{O}_{10}$ , hence it can be represented as with charge as  $= 3 \times 4n + 10 \times (-2) = -8$



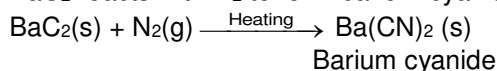
(b)  $\text{Ca}^{2+}$ ,  $\text{Cu}^{2+}$  and  $\text{H}_2\text{O}$  are in the ratio of 1 : 1 : 1 and to balance  $(-8)$  charge of silicate as ion,  $(+8)$  charge is required thus there are two units each of  $\text{Ca}^{2+}$ ,  $\text{Cu}^{2+}$  and  $\text{H}_2\text{O}$  thus, kionoite has formula  $\text{Ca}_2\text{Cu}_2\text{Si}_3\text{O}_{10} \cdot 2\text{H}_2\text{O}$ .

11. In what respect the reaction of  $\text{N}_2$  with (i)  $\text{CaC}_2$  (calcium carbide) & (ii)  $\text{BaC}_2$  (barium carbide) differ from each other.

**Sol.** (i)  $\text{CaC}_2$  reacts with  $\text{N}_2$  to form calcium cyanamide.

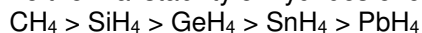


(ii)  $\text{BaC}_2$  reacts with  $\text{N}_2$  to form barium cyanide





12. **Statement-1** : The thermal stability of hydrides of carbon family is in order :



**Statement-2** : E—H bond dissociation enthalpies of the hydrides of carbon family decrease down the group with increasing atomic size.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.

(C) Statement-1 is True, Statement-2 is False.

(D) Statement-1 is False, Statement-2 is True.

**Ans. (A)**

**Sol.** Both are correct statements and statement-2 is the correct explanation of statement-1. Down the group the size of atom increases and thus bond length increases.

13. Which one of the following element does not dissolve in fused or aqueous alkalis?

(A) Boron

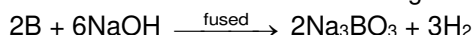
(B) Silicon

(C) Aluminium

(D) None of these

**Ans. (D)**

**Sol.** Boron dissolved in fused alkalis according to the following reaction.



Silicon and aluminium dissolved in both fused and aqueous alkalis.

14. What happens when  $\text{CO}_2$  (g) is passed through sodium meta borate solution ?

**Sol.**  $4\text{NaBO}_2 + \text{CO}_2 \longrightarrow \text{Na}_2\text{B}_4\text{O}_7 + \text{Na}_2\text{CO}_3$

15. Which of the following statement(s) is/are correct ?

(A)  $\text{B}_2\text{O}_3$  and  $\text{SiO}_2$  are acidic in nature and are important constituents of glass.

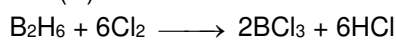
(B) Borides and silicides are hydrolysed by water forming boranes and silanes respectively.

(C) Diborane on reaction with chlorine (g) forms  $\text{B}_2\text{H}_5\text{Cl}$ .

(D)  $\text{SiO}_4^{4-}$  gets hydrolysed by acid or water and form  $\text{Si}_2\text{O}_7^{6-}$ .

**Ans. (A), (B) and (D)**

**Sol.** (A), (B) and (D) are correct statements but (C) is incorrect.

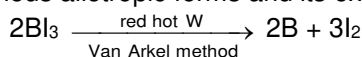


16. Match the following :

	Column-I		Column-II
(A)	Boron	(p)	Forms acidic oxides.
(B)	Carbon	(q)	Pure crystalline form is obtained by Van Arkel method.
(C)	Tin	(r)	Exists in allotropic forms.
(D)	Aluminium	(s)	Hydroxide is amphoteric in nature.

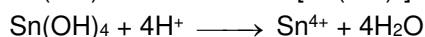
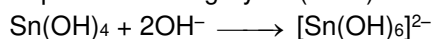
**Ans. (A - p,q,r); (B - p,r); (C - r,s); (D - s)**

**Sol.** (A) Exists in various allotropic forms and its oxide,  $\text{B}_2\text{O}_3$  is acidic in nature.

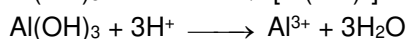
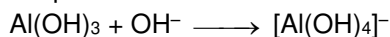


(B) Exists in various allotropic forms like diamond, graphite etc. and its oxide  $\text{CO}_2$  is acidic in nature.

(C) Exists in allotropic forms like grey tin ( $\alpha$ -Sn) and white tin ( $\beta$ -Sn). Hydroxide is amphoteric in nature.



(D) Hydroxide is amphoteric in nature.





## Exercise-1

✎ Marked questions are recommended for Revision.

### PART - I : SUBJECTIVE QUESTIONS

#### Section (A) : General facts about elements

- A-1. Give the main ores of 3<sup>rd</sup> most abundant element?
- A-2. ✎ (i) How amorphous boron of low purity is obtained from borax ?  
(ii) How ultrapure boron can be prepared from  $\text{BI}_3$  or  $\text{BCl}_3$  ?
- A-3. Graphite is used as a lubricant. Explain?

#### Section (B) : Based on Periodic trends

- B-1. Why does not boron form  $\text{B}^{3+}$  ions ?
- B-2. ✎ What do you understand by (a) inert pair effect. (b) catenation ?

#### Section (C) : Based on Chemical Bonding

- C-1. Draw the Lewis dot structure of following :  
(i)  $\text{BF}_3$  (ii)  $[\text{B}(\text{OH})_4]^-$  (iii)  $\text{CO}_2$  (iv)  $\text{CO}$
- C-2. Draw the Lewis dot structure of following :  
(i)  $\text{B}_2\text{H}_6$  (ii) Borax (iii)  $\text{Al}_2\text{Cl}_6$  (iv)  $\text{C}_3\text{O}_2$
- C-3. Give the order of the bond length and bond strength of C–O bond in  $\text{CO}$ ,  $\text{CO}_2$ ,  $\text{CO}_3^{2-}$ .
- C-4. Why B–F bond distance in  $\text{BF}_3$  is shorter than theoretically expected value ?
- C-5. ✎ Identify the nature of following oxides :  
 $\text{CO}$ ,  $\text{CO}_2$ ,  $\text{B}_2\text{O}_3$ ,  $\text{SiO}_2$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{PbO}$

#### Section (D) : Properties of Elements

- D-1. Which of the group-13 element exists in liquid state in nature?
- D-2. ✎ Write the reactions of B, Al, C and Si with air.
- D-3. Give the reactions of group 13 & 14 elements with water ?
- D-4. ✎ Complete the following reaction :  
(a)  $\text{B} + \text{dil. HNO}_3 \longrightarrow$  (b)  $\text{C} + \text{dil. HNO}_3 \longrightarrow$  (c)  $\text{Si} + \text{dil. HNO}_3 \longrightarrow$
- D-5. ✎ Write balanced equation for the following :  
Reaction of aluminium with aqueous sodium hydroxide. [JEE 1997, 1]

#### Section (E) : Oxides, Hydroxides, Oxyacids, Borax

- E-1. ✎ A certain salt X, gives the following results.  
(i) Its aqueous solution is alkaline to litmus.  
(ii) It swells up to a glassy material Y on strong heating.  
(iii) When concentrated  $\text{H}_2\text{SO}_4$  is added to a hot solution of X, white crystal of an acid Z separates out.  
Write equations for all the above reactions and identify X, Y and Z.
- E-2. ✎ (i) A white precipitate (B) is formed when a mineral (A) is boiled with  $\text{Na}_2\text{CO}_3$  solution.  
(ii) The precipitate is filtered and filtrate contains two compounds (C) and (D). The compound (C) is removed by crystallisation and when  $\text{CO}_2$  is passed through the mother liquor left (D) changes to (C).  
(iii) The compound (C) on strong heating gives two compounds (D) and (E).  
(iv) (E) on heating with cobalt oxide produces blue coloured substances (F).  
Identify (A) to (F) and gives chemical equations for the reactions at steps (i) to (iv).



- E-3.** Which of the following can dissolve in HCl (hot or cold) ?  
 $B_2O_3$ ,  $CO_2$ ,  $SiO_2$ ,  $SnO_2$ ,  $PbO_2$
- E-4.** A student of Resonance dissolves the oxides of all the group-13 & 14 elements in both HCl and NaOH one by one in chemistry lab. Oxides of which of the elements will dissolve in both?
- E-5.** In steel industries, haematite ore ( $Fe_2O_3$ ) is made to react with carbon monoxide (CO). Write the reaction involved.

### Section (F) : Hydrides

- F-1.** Arrange the following in increasing order of their thermal stability.  
 $CH_4$ ,  $SiH_4$ ,  $GeH_4$ ,  $SnH_4$ ,  $PbH_4$
- F-2.** Give three reagents with which  $BF_3$  reacts to give  $B_2H_6$ . Also write the reactions involved.
- F-3.** What is inorganic benzene (borazole) and why is it so called ? How will you prepare Borazole from sodium borohydride (in three steps only)
- F-4.** When diborane is hydrolysed by water, a weak monobasic acid is produced which in the presence of sugar or glycerol becomes a strong monobasic acid. Give the reaction?
- F-5.** (a) Diborane reacts with ethyl alcohol to release a gas X. What is X? Also write the reaction involved.  
 (b) Complete the following reaction :  $B_2H_6 + CH_3COOH \longrightarrow ?$

### Section (G) : Halides

- G-1.** Which of the following halide is a good oxidising agent?  
 $SnCl_2$ ,  $PbCl_4$ ,  $PbCl_2$
- G-2.** Complete the following reaction and identify compounds (A) and (B).  

$$B(OH)_3 \xrightarrow[\text{Fusion}]{NH_4HF_2} (A) \xrightarrow[\Delta]{B_2O_3} (B)$$
- G-3.** In a chemistry Lab of university of Berkeley it was observed that Aluminium, Alumina and  $Al(OH)_3$  dissolved in dilute HCl in three separate tests to give a Lewis acid which absorbs water, turns moist blue litmus red, sublimes on heating and is predominantly covalent. Write all the reactions involved.
- G-4.** When  $BCl_3$  is treated with water, it hydrolyses and forms  $[B(OH)_4]^-$  only whereas  $AlCl_3$  in acidified aqueous solution forms  $[Al(H_2O)_6]^{3+}$  ion. Explain what is the hybridisation of boron and aluminium in these species ?
- G-5.** Complete the following reactions :  
 (a)  $BCl_3 + 3H-OH \longrightarrow$       (b)  $4BF_3 + 3H-OH \longrightarrow$       (c)  $COCl_2 + 2H-OH \longrightarrow$   
 (d)  $COF_2 + H-OH \longrightarrow$       (e)  $SiF_4 + 2H-OH \longrightarrow$       (f)  $CF_4 + H-OH \longrightarrow$

### Section (H) : Miscellaneous (Silicones, Silicates, Zeolites & Alums)

- H-1.** If the starting material for the manufacture of silicones is  $RSiCl_3$ , write the structure of the product formed.
- H-2.** What are silicates ? How are they classified ?
- H-3.** Write down hydrolysis of :  
 (i) alkyl substituted chlorosilane      (ii) trialkyl chlorosilane
- H-4.** Define alums and give their general formula. What are some of its important uses ?

## PART - II : ONLY ONE OPTION CORRECT TYPE

### Section (A) : General facts about elements

- A-1.** Which one of the following is most abundant in the earth's crust?  
 (A) B      (B) Al      (C) Ga      (D) In





- A-2.** Which is not the property of diamond ?  
 (A) It is insoluble in all solvents  
 (B) It is oxidised with a mixture of  $K_2Cr_2O_7$  and  $H_2SO_4$  at  $200^\circ C$   
 (C) Being hardest, it is used as an abrasive for sharpening hard tools.  
 (D)  $\Delta_f H^\ominus$  value of diamond is  $1.90 \text{ kJ mol}^{-1}$ .
- A-3.** Relatively most inert form of carbon is :  
 (A) diamond (B) graphite (C) coal (D) charcoal

### Section (B) : Based on Periodic trends

- B-1.** The decrease in stability of higher oxidation state in p-block with increasing atomic number is due to :  
 (A) increase in bond energy as going down the group.  
 (B) the reluctance of s-sub shell electrons to participate in the chemical bonding.  
 (C) both are correct.  
 (D) Noble gas configuration achieved by lower oxidation state.
- B-2.** Carbon and silicon belong to (IV) group. The maximum coordination number of carbon in commonly occurring compounds is 4, whereas that of silicon is 6. This is due to :  
 (A) Large size of silicon (B) More electropositive nature of silicon  
 (C) Availability of low lying d-orbitals in silicon (D) Both (A) and (B)

### Section (C) : Based on Chemical Bonding

- C-1.** Sum of the pair of electron on central atom of following species :  
 $BF_3, CF_4, SiF_4$   
 (A) 0 (B) 1 (C) 2 (D) 3
- C-2.** In diborane the two H—B—H angles are nearly :  
 (A)  $60^\circ, 120^\circ$  (B)  $97^\circ, 120^\circ$  (C)  $95^\circ, 150^\circ$  (D)  $120^\circ, 180^\circ$
- C-3.** Choose the correct option regarding bond enthalpy of following :
- |     | Column-A<br>[bond] |     | Column-B<br>[bond enthalpy (KJ/mol)] |
|-----|--------------------|-----|--------------------------------------|
| (a) | C – C              | (p) | 240                                  |
| (b) | Si – Si            | (q) | 260                                  |
| (c) | Ge – Ge            | (r) | 297                                  |
| (d) | Sn – Sn            | (s) | 348                                  |
- (A) (a – p) ; (b – q) ; (c – r) ; (d – s) (B) (a – s) ; (b – r) ; (c – q) ; (d – p)  
 (C) (a – p) ; (b – r) ; (c – q) ; (d – s) (D) (a – r) ; (b – s) ; (c – q) ; (d – p)
- C-4.** Select the correct option regarding the bond strength of  $C^{14}O^{16}$ ,  $C^{12}O^{16}$ ,  $C^{14}O^{18}$ .  
 (A)  $C^{14}O^{18} > C^{14}O^{16} > C^{12}O^{16}$  (B)  $C^{14}O^{18} < C^{14}O^{16} < C^{12}O^{16}$   
 (C)  $C^{14}O^{18} > C^{14}O^{16} < C^{12}O^{16}$  (D)  $C^{14}O^{18} < C^{14}O^{16} > C^{12}O^{16}$
- C-5.** The stability of dihalides of Si, Ge, Sn and Pb increases steadily in the sequence :  
 (A)  $PbX_2 < SnX_2 < GeX_2 < SiX_2$  (B)  $GeX_2 < SiX_2 < SnX_2 < PbX_2$   
 (C)  $SiX_2 < GeX_2 < PbX_2 < SnX_2$  (D)  $SiX_2 < GeX_2 < SnX_2 < PbX_2$
- C-6.** When borax is dissolved in water :  
 (A)  $B(OH)_3$  is formed only (B)  $[B(OH)_4]^-$  is formed only  
 (C) both  $B(OH)_3$  and  $[B(OH)_4]^-$  are formed (D)  $[B_3O_3(OH)_4]^-$  is formed only
- C-7.** Which of the following is acidic in nature?  
 (A)  $Be(OH)_2$  (B)  $Mg(OH)_2$  (C)  $Al(OH)_3$  (D)  $B(OH)_3$
- C-8.** Boric acid is polymeric due to :  
 (A) its acidic nature (B) the presence of hydrogen bonds  
 (C) its monobasic nature (D) its geometry





## Section (D) : Properties of Elements

- D-1.** Thermodynamically the most stable form of carbon is :  
 (A) diamond (B) graphite (C) fullerenes (D) coal
- D-2.** Amorphous boron on burning in air forms :  
 (A)  $B(OH)_3$  (B) Mixture of  $B_2O_3$  and BN  
 (C) Only  $B_2O_3$  (D) Only BN
- D-3.** Aluminium is more reactive than iron. But aluminium is less easily corroded than iron because:  
 (A) aluminium is a noble metal  
 (B) oxygen forms a protective oxide layer on aluminium surface  
 (C) iron undergoes reaction easily with water  
 (D) iron forms both mono and divalent ions
- D-4.** Hot concentrated  $HNO_3$  converts graphite into :  
 (A) graphite oxide (B) benzene hexacarboxylic acid  
 (C) both (A) and (B) (D) none of the above
- D-5.** Silicon reacts with hot solution of NaOH forming :  
 (A)  $Si(OH)_4$  (B)  $Si(OH)_2$  (C)  $SiO_2$  (D)  $Na_2SiO_3$

## Section (E) : Oxides, Hydroxides, Oxyacids, Borax

- E-1.** Borax is prepared by treating colemanite with :  
 (A)  $NaNO_3$  (B) NaCl (C)  $Na_2CO_3$  (D)  $NaHCO_3$
- E-2.** In the following reaction,  $B(OH)_3 + H_2O \longrightarrow [B(OH)_4]^- + H^+$   
 (A)  $B(OH)_3$  is a tribasic acid. (B)  $B(OH)_3$  is a monoacidic Lewis base.  
 (C)  $B(OH)_3$  is a monobasic Lewis acid. (D)  $B(OH)_3$  is amphoteric.
- E-3.** On the addition of mineral acid to an aqueous solution of borax, the compound formed is :  
 (A) borodihydride (B) orthoboric acid (C) metaboric acid (D) pyroboric acid
- E-4.** Which of the following oxides will dissolve in  $H_2SO_4$  ?  
 (A)  $B_2O_3$  (B)  $Al_2O_3$  (C)  $CO_2$  (D)  $SiO_2$
- E-5.** Borax on heating with cobalt oxide forms a blue bead of :  
 (A)  $Co(BO_2)_2$  (B)  $CoBO_2$  (C)  $Co_3(BO_3)_2$  (D)  $Na_3Co(BO_3)_2$
- E-6.**  $B(OH)_3 + NaOH \rightleftharpoons Na[B(OH)_4]$   
 How can this reaction be made to proceed in forward direction ?  
 (A) Addition of cis - 1,2-diol (B) Addition of boron  
 (C) Addition of trans-1,2-diol (D) Addition of  $Na_2HPO_4$
- E-7.** Silica reacts with magnesium to form a magnesium compound (X). (X) reacts with dilute HCl and form (Y), (Y) is :  
 (A) MgO (B)  $MgCl_2$  (C)  $MgSiO$  (D)  $SiCl_4$
- E-8.** Consider the following conversions :  
 $S_1 : H_3BO_3 \xrightarrow{100^\circ C} HBO_2 \xrightarrow{\text{Red heat}} B_2O_3$   
 $S_2 : \text{Borax} + 2HCl \longrightarrow 4H_3BO_3 + 2NaCl + 5H_2O$   
 $S_3 : \text{Colmanite} + 2Na_2CO_3 \longrightarrow 2CaCO_3 \downarrow + \text{Boarx} + 2NaBO_2$   
 $S_4 : \text{Borax} + H_2O \rightleftharpoons 2NaOH + 4H_3BO_3 + 3H_2O$   
 and arrange in the order of True/False :  
 (A) T T F F (B) T F T F (C) F T T F (D) T T T F

## Section (F) : Hydrides

- F-1.** Which one is not a borane ?  
 (A)  $B_5H_9$  (B)  $B_5H_{10}$  (C)  $B_5H_{11}$  (D)  $B_6H_{10}$



- F-2.** In reaction,  $\text{BF}_3 + 3\text{LiBH}_4 \rightarrow 3\text{LiF} + \text{X}$ ; X is :  
 (A)  $\text{B}_4\text{H}_{10}$  (B)  $\text{B}_2\text{H}_6$  (C)  $\text{BH}_3$  (D)  $\text{B}_3\text{H}_8$
- F-3.**  $\text{B (s)} \xrightarrow{\text{Z}} \text{X} \xrightarrow{\text{LiH}} \text{Y} + \text{LiBF}_4$   
 Which of the statement is true for the above sequence of reactions ?  
 (A) Z is hydrogen (B) Y is  $\text{LiBH}_4$   
 (C) Z and Y are  $\text{F}_2$  and  $\text{B}_2\text{H}_6$  respectively (D) Z is potassium hydroxide
- F-4.** The product obtained in the reaction of diborane with excess of ammonia at low temperature is :  
 (A)  $\text{B}_2\text{H}_6 \cdot \text{NH}_3$  (B)  $\text{B}_2\text{H}_6 \cdot 2\text{NH}_3$  (C)  $(\text{BN})_x$  (D) Borazine
- F-5.** Which of the following will give symmetric cleavage of diborane :  
 (A)  $\text{NH}_3$  (B)  $\text{N}(\text{CH}_3)_3$  (C)  $\text{CH}_3\text{—NH}_2$  (D)  $(\text{CH}_2)_2\text{NH}$
- F-6.** Diborane reacts with water to form :  
 (A)  $\text{HBO}_2$  (B)  $\text{H}_3\text{BO}_3$  (C)  $\text{H}_3\text{BO}_3 + \text{H}_2$  (D)  $\text{H}_2$

### Section (G) : Halides

- G-1.** Which one of the following compound is a gas (at  $0^\circ\text{C}$ ) :  
 (A)  $\text{BF}_3$  (B)  $\text{BCl}_3$  (C)  $\text{BBr}_3$  (D)  $\text{BI}_3$
- G-2.**  $\text{Al}_2\text{O}_3$  can be converted to anhydrous  $\text{AlCl}_3$  by heating :  
 (A) hydrated  $\text{Al}_2\text{O}_3$  with  $\text{Cl}_2$  gas (B)  $\text{Al}_2\text{O}_3$  with aqueous  $\text{HCl}$   
 (C)  $\text{Al}_2\text{O}_3$  with  $\text{NaCl}$  in solid state (D) a mixture of  $\text{Al}_2\text{O}_3$  and carbon in dry  $\text{Cl}_2$  gas
- G-3.** Consider the following statements :  
 $\text{S}_1$  : Silicon halides can be prepared by heating wither Si or  $\text{SiC}$  with the appropriate halogen.  
 $\text{S}_2$  : Carbon halides are not hydrolysed under normal conditions because they have no d-orbitals.  
 $\text{S}_3$  : Silicon halides are readily hydrolysed by water to give silicic acid  $[\text{Si}(\text{OH})_4]$ .  
 (A) T F T (B) F F T (C) T F F (D) T T T
- G-4.** Aqueous solution of potash alum is:  
 (A) alkaline (B) acidic (C) neutral (D) soapy
- G-5.**  $\text{CCl}_4$  is inert towards hydrolysis but  $\text{SiCl}_4$  is readily hydrolysed because  
 (A) carbon cannot expand its octet but silicon can expand its octet  
 (B) ionisation potential of carbon is higher than silicon  
 (C) carbon forms double and triple bonds  
 (D) electronegativity of carbon is higher than that of silicon
- G-6.**  $\text{PbF}_4$ ,  $\text{PbCl}_4$  exists but  $\text{PbBr}_4$  and  $\text{PbI}_4$  do not exist because of :  
 (A) Large size of  $\text{Br}^-$  and  $\text{I}^-$  (B) Strong oxidising character of  $\text{Pb}^{+4}$   
 (C) Shpong reducing character of  $\text{Pb}^{+4}$  (D) Low electro negativity of  $\text{Br}^-$  and  $\text{I}^-$

### Section (H) : Miscellaneous (Silicones, Silicates, Zeolites & Alums)

- H-1.** Which silicon compound is used in machinery (with moving parts) in a manner similar to the use of an allotrope of carbon (crystalline) which possesses properties of both a covalent network solid and a molecular solid ?  
 (A) Silica gel (B) Zeolite (C) Silicone (D) Silane
- H-2.** Silicone resins are made by :  
 (A) dissolving a mixture of  $\text{PhSiCl}_3$  and  $(\text{Ph})_2\text{SiCl}_2$  in toluene and then hydrolysis with water.  
 (B) hydrolysing a mixture of  $(\text{CH}_3)_2\text{SiCl}_2$  and  $(\text{CH}_3)_3\text{SiCl}$ .  
 (C) hydrolysis of  $(\text{CH}_3)_2\text{SiCl}_2$   
 (D) none
- H-3.**  $\text{Me}_2\text{SiCl}_2$  on hydrolysis will produce :  
 (A)  $\text{Me}_2\text{Si}(\text{OH})_2$  (B)  $\text{Me}_2\text{Si=O}$   
 (C)  $-\text{O}-(\text{Me})_2\text{Si}-$  (D)  $\text{Me}_2\text{SiClOH}$



- H-4.** Which of the following anions is present in the simple single chain structure of silicate?  
 (A)  $\text{SiO}_4^{4-}$  (B)  $\text{Si}_2\text{O}_7^{6-}$  (C)  $(\text{Si}_2\text{O}_5^{2-})_n$  (D)  $(\text{SiO}_3^{2-})_n$
- H-5.** The structural unit present in pyrosilicates is :  
 (A)  $\text{Si}_3\text{O}_9^{6-}$  (B)  $\text{SiO}_4^{4-}$  (C)  $\text{Si}_2\text{O}_7^{6-}$  (D)  $(\text{Si}_2\text{O}_5^{2-})_n$
- H-6.** Select the incorrect statement.  
 (A) Silicones are hydrophobic in nature.  
 (B) Si–O–Si linkages are moisture sensitive.  
 (C)  $\text{SnI}_4$  is an orange solid on account of high polarization of  $\text{I}^-$ .  
 (D) Silicones are resistant to most chemicals due to high strength of the Si–C bond and stable silica like structure of Si–O–Si–O–Si.
- H-7.** Select incorrect statement :  
 (A) Red lead is  $\text{Pb}_3\text{O}_4$   
 (B)  $(\text{Me})_2\text{SiCl}_2$  on hydrolysis and then on subsequent intermolecular condensation gives cross linked silicones.  
 (C)  $\text{SiO}_4^{4-}$  on hydrolysis with water or acid produces  $\text{Si}_2\text{O}_7^{6-}$   
 (D) None

### PART - III : MATCH THE COLUMN

1. Match the reactions listed in column-I with characteristic(s) / type of reactions listed in column-II.

Column-I	Column-II
(A) $\text{BBr}_3 + \text{H}_2 \longrightarrow \text{B}$	(p) Borax bead test
(B) $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10 \text{H}_2\text{O} + \text{CuSO}_4 \longrightarrow \text{Cu}(\text{BO}_2)_2$	(q) Reduction
(C) $\text{AlCl}_3 + \text{H}_2\text{O} \longrightarrow \text{HCl}$	(r) White fumes
(D) $\text{Cr}_2\text{O}_3 + \text{Al} \longrightarrow \text{Cr}$	(s) Hydrolysis

2. Match the reactions listed in column-I with characteristic(s) / type of reactions listed in column-II.

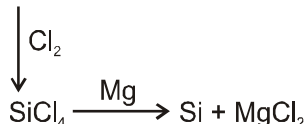
Column-I	Column-II
(A) $\text{Al}_2(\text{C}_2)_3 + \text{H}_2\text{O} \longrightarrow$	(p) One of the products contains both $\sigma$ and $\pi$ bonds
(B) $\text{CH}_2(\text{COOH})_2 + \text{P}_4\text{O}_{10} \longrightarrow$	(q) Hydrolysis
(C) $\text{CH}_3\text{SiCl}_3 + \text{H}_2\text{O} \longrightarrow$	(r) Dehydration
(D) $\text{SnCl}_2 \cdot 2\text{H}_2\text{O} \xrightarrow{\text{on standing}}$	(s) complex crosslinked polymer

## Exercise-2

Marked questions are recommended for Revision.

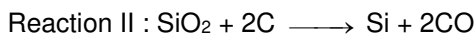
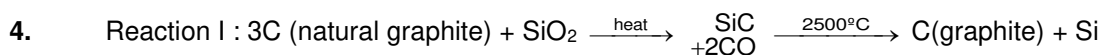
### PART - I : ONLY ONE OPTION CORRECT TYPE

1. Bauxite ( $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$ ) and Aluminosilicate both are ores of aluminium. Bauxite is found on earth but not on Mars whereas Aluminosilicate is found on earth as well as Mars. Possible reason is :  
 (A) No human colony on Mars. (B) No tropical rain forests on Mars.  
 (C) No need of bauxite on Mars (D) Closeness of earth to sun.
2. Isolation of boron in very high purity is extremely difficult because of :  
 (A) Strong tendency of boron to acquire electron rich atoms such as C, N or O  
 (B) High melting point of boron ( $2180^\circ\text{C}$ )  
 (C) Tremendous affinity of liquid Boron towards oxygen.  
 (D) All of these



Identify true statement :

- (A) Excess of  $\text{SiO}_2$  should not be used in above process  
 (B) Produced Si is highly pure  
 (C)  $\text{Cl}_2$  & Mg are oxidising agents.  
 (D) All of these



Reaction I is used in production of synthetic graphite, whereas Reaction II is used in extraction of silicon.

- (A) Reaction I –  $\text{SiO}_2$  in excess ; Reaction II –  $\text{SiO}_2$  in excess  
 (B) Reaction I – C in excess ; Reaction II –  $\text{SiO}_2$  in excess  
 (C) Reaction I –  $\text{SiO}_2$  in excess ; Reaction II – C in excess  
 (D) It does not matter.

5. Catenation tendency in group 14 is :

- (A)  $\text{C} \gg \text{Si} > \text{Ge} \approx \text{Pb}$  due to bond energies  $\text{C-H} > \text{Si-H} > \text{Ge-H} > \text{Sn-H}$   
 (B)  $\text{C} \gg \text{Si} > \text{Ge} \approx \text{Sn} > \text{Pb}$  due to bond energies  $\text{C-C} > \text{Si-C} > \text{Ge-C} > \text{Sn-C}$   
 (C)  $\text{C} \approx \text{Si} \approx \text{Ge} \approx \text{Sn} \approx \text{Pb}$  due to bond energies  $\text{C-H} > \text{Si-H} > \text{Ge-H} > \text{Sn-H}$   
 (D)  $\text{C} \gg \text{Si} > \text{Ge} \approx \text{Sn} > \text{Pb}$  due to bond energies  $\text{C-C} > \text{Si-Si} > \text{Ge-Ge} > \text{Sn-Sn}$

6. Given the order of density : Diamond > Graphite > Fullerene  $\text{C}_{60}$  ; choose the correct order for C–C bond length

(Consider larger bond length if there are two different bond lengths)

- (A) Diamond < graphite < fullerene ( $\text{C}_{60}$ ) (B) Diamond > graphite > fullerene ( $\text{C}_{60}$ )  
 (C) Diamond > fullerene ( $\text{C}_{60}$ ) > graphite (D) Diamond < fullerene ( $\text{C}_{60}$ ) < graphite

7. An element  $\text{E} = \{\text{B, C, Si, Ge}\}$ , predict E on the basis of given conditions :

I : Powdered E reacts with  $\text{O}_2$  to form an oxide.

II : Oxide formed in I reacts with NaOH

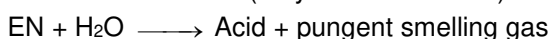
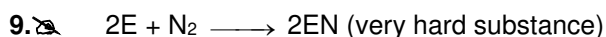
III : E reacts with steam on red heat forming two gaseous products, which can be used as a fuel.

E can be :

- (A) B (B) C (C) Si (D) Ge

8. In limited supply of oxygen C & Si are allowed to react at sufficiently high temperatures in separate vessels, favourable products are :

- (A)  $\text{CO}_2$  &  $\text{SiO}_2$  (B) CO,  $\text{CO}_2$ , SiO &  $\text{SiO}_2$   
 (C) CO,  $\text{CO}_2$  &  $\text{SiO}_2$  (D) CO &  $\text{SiO}_2$



Acid is :

- (A)  $\text{HNO}_3$  (B)  $\text{H}_3\text{BO}_3$  (C)  $\text{HNO}_2$  (D) can be A & B

10. Aluminium vessels should not be washed with materials containing washing soda because :

- (A) washing soda is expensive  
 (B) washing soda is easily decomposed  
 (C) washing soda reacts with aluminium to form soluble aluminate  
 (D) washing soda reacts with aluminium to form insoluble aluminium oxide

11. Aqueous ammonia is used as a precipitating reagent for  $\text{Al}^{3+}$  ions as  $\text{Al(OH)}_3$  rather than aqueous NaOH, because :

- (A)  $\text{NH}_4^+$  is a weak base (B) NaOH is a very strong base  
 (C) NaOH forms soluble  $[\text{Al(OH)}_4]^-$  ions (D) NaOH forms  $[\text{Al(OH)}_2]^+$  ions



12. ✖ Borax is used as a buffer since :  
 (A) Its aqueous solution contains both the weak acid and its salt  
 (B) Its aqueous solution contains  $\text{H}_3\text{BO}_3$ , which is a weak acid  
 (C) Its aqueous solution contains equal amount of strong acid and its salt  
 (D) statement that borax is a buffer, is wrong
13. Which of the following compound is obtained on heating potassium ferrocyanide with concentrated  $\text{H}_2\text{SO}_4$ ?  
 (A)  $\text{CO}_2$  (B) CO (C)  $\text{C}_2\text{H}_2$  (D)  $(\text{CN})_2$
14.  $\text{B}(\text{OH})_3 + \text{NaOH} \longrightarrow \text{Na}[\text{B}(\text{OH})_4] \text{ (aq.)}$ .  
 Then addition of which of the following shifts the reaction in the backward direction.  
 (A) Glycerol (B) Mannitol (C) Catechol (D) Ethanol
15. ✖  $\text{H}_3\text{BO}_3(\text{s}) + \text{aq. NaOH} \xrightarrow{\Delta} (\text{X})$   
 $\text{H}_3\text{BO}_3(\text{s}) + \text{molten NaOH} \xrightarrow{\Delta} (\text{Y})$   
 Compound (X) & (Y) are respectively,  
 (A)  $\text{Na}_3\text{BO}_3$ ,  $\text{Na}_3\text{B}$  (B)  $\text{Na}_3\text{BO}_3$ ,  $\text{NaBO}_2$   
 (C)  $\text{Na}[\text{B}(\text{OH})_4]$ ,  $\text{Na}_3\text{BO}_3$  (D)  $\text{Na}_3\text{BO}_3$ ,  $\text{Na}[\text{B}(\text{OH})_4]$
16. When a solution of sodium hydroxide is added in excess to the solution of potash alum, we obtain :  
 (A) a white precipitate (B) bluish white precipitate  
 (C) a clear solution (D) a crystalline mass
17. ✖ Boron  $\xrightarrow{z}$  x  $\xrightarrow{\text{LiH}}$  y(g) +  $\text{LiBF}_4$   
 $\uparrow$   $\xleftarrow{w}$  y(g)  
 true statement is :  
 (A) z is least reactive non-metal (B) w is cooling  
 (C) y is electron deficient (D) All of these
18.  $\text{B}_2\text{H}_6 + \text{NH}_3 \longrightarrow \text{Addition compound (X)} \xrightarrow{450 \text{ K}} \text{Y} + \text{Z (g)}$   
 In the above sequence Y and Z are respectively :  
 (A) borazine,  $\text{H}_2$  (B) boron,  $\text{H}_2$  (C) boron nitride,  $\text{H}_2$  (D) borazine and hydrogen
19. ✖ Borazine and benzene show striking similarities in their properties. This led to a labeling of borazine as 'inorganic benzene'. However, in contrast to benzene, borazine readily undergoes addition reactions. The appropriate reason for this difference is :  
 (A) Alternate arrangement of B and N atoms in the hexagonal ring.  
 (B) Due to the difference in electronegativity between boron and nitrogen, the cloud (electron density) is more localised on the nitrogen atoms.  
 (C) Aromatic  $\pi$ -clouds of electron density are delocalised over all of the ring atoms.  
 (D) Net dipole moment of borazine molecule is non-zero.
20.  $(\text{SnCl}_4)$  stannic chloride hydrolyses in dilute solution as per given reaction  
 $\text{SnCl}_4 + 4\text{H}_2\text{O} \longrightarrow [\text{Sn}(\text{OH})_4] + 4\text{HCl}$   
 Hydrolysis can be repressed by adding compound "A".  
 $\text{SnCl}_4 + \text{A} \longrightarrow \text{B}$   
 B can be :  
 (A)  $\text{Sn}(\text{OH})_4$  (B)  $\text{SnCl}_2$  (C)  $\text{H}_2\text{SnCl}_6$  (D)  $\text{Sn}(\text{OH})\text{Cl}$
21. ✖ Amphoteric oxide (X) +  $3\text{C} + \text{Cl}_2 \longrightarrow \text{Poisonous gas} + \text{anhydrous chloride (Y)}$   
 Hydrated chloride  $\xrightarrow{\Delta} \text{Z}$   
 Element forming 'Y' other than 'Cl' reacts with concentrated HCl but leads to passivation with conc.  $\text{HNO}_3$ . Select the correct option.  
 (A)  $\text{X} = \text{Z}$  and Y on reacting with LiH forms strong oxidising agent  
 (B)  $\text{X} = \text{Z}$  and Y on reacting with LiH forms strong reducing agent  
 (C)  $\text{X} \neq \text{Z}$  and Y is used as a catalyst in Friedel crafts reaction  
 (D)  $\text{X} \neq \text{Z}$  and Y on reacting with LiH forms strong oxidising agent



22.  $\text{BF}_3$  on hydrolysis forms :  
 (A)  $\text{H}_3\text{BO}_3$  (B)  $\text{HBF}_4$  (C) both (A) and (B) (D) none of these
23. Preparation of organosilicones from  $\text{SiCl}_4$  involves substitution in first step:  
 $\text{SiCl}_4 + x\text{RMgCl} \longrightarrow (\text{R})_x \text{SiCl}_{4-x} + x\text{MgCl}_2$   
 Values of 'x' to obtain chain terminating & chain multiplication parts of chain silicone produced are respectively:  
 (A) 1 & 2 (B) 2 & 1 (C) 2 & 3 (D) 3 & 2
24. To get the silicone  $\text{R}_3\text{Si}-(\text{OSiR}_2)_n-\text{SiR}_3$  having 4Si-O-Si linkage, the unit taken is  
 (A) 4 unit of  $\text{R}_2\text{SiCl}_2$  and 2 unit of  $\text{R}_3\text{SiCl}$  (B) 2 unit of  $\text{R}_2\text{SiCl}_2$  and 2 unit of  $\text{R}_3\text{SiCl}$   
 (C) 3 unit of  $\text{R}_2\text{SiCl}_2$  and 2 unit of  $\text{R}_3\text{SiCl}$  (D) 3 unit of  $\text{R}_3\text{SiCl}$  and 2 unit  $\text{R}_2\text{SiCl}_2$

## PART - II : SINGLE AND DOUBLE VALUE INTEGER TYPE

1. How many of the following statements are correct regarding allotropes of carbon :  
 (a) Graphite is not a good conductor of electricity in perpendicular direction of layers at ordinary temperatures.  
 (b) Coke is the impure form of carbon.  
 (c) Anthracite is the purest form of Carbon.  
 (d) Buckminster fullerene contains 12 five membered rings and 20 six-membered rings.  
 (e) Diamond is a good conductor of Heat.  
 (f) Graphite is diamagnetic in nature.  
 (g) Graphite is thermodynamically more stable than diamond
2. For Boron family (B, Al, Ga, In and Tl)  
 x : Number of elements which are solid at  $40^\circ\text{C}$ .  
 y : Period number of element which has greater ionization energy than element just above and below it in periodic table.  
 z : Period number of most abundant element of group 13.  
 Report your answer  $x + 2y + 3z$
3. Consider a prototypical fullerene,  $\text{C}_{60}$ .  
 Let, a = Number of 5-membered rings  
 b = Number of 6-membered rings  
 c = Number of  $\pi$ -bonds in  $\text{C}_{60}$   
 Find the value of  $(3a - 2b + c)$
4. Central atom may exhibit  $\text{sp}^3$  hybridisation in how many of the following species :  
 (a)  $\text{CO}_2$  (b) Graphite (c) Diamond (d) CO  
 (e)  $\text{H}_3\text{BO}_3$  (aq) (f) Zeolites (Si-central) (g) Silicones (Si) (h) Chlorosilane (Si)  
 (i) Borax (Boron) (j)  $\text{Al}_2\text{Cl}_6$  (k)  $\text{B}_2\text{H}_6$  (l)  $\text{SiO}_2$  (solid)  
 (m)  $\text{H}_2\text{CO}_3$  (n)  $\text{COCl}_2$  (o)  $\text{CH}_4$  (p)  $\text{CCl}_4$
5. The number of oxygen atoms in borax which do not form  $\text{p}\pi\text{-p}\pi$  back bond is :
6.  $\text{B} + \text{HNO}_3 \longrightarrow$  (A) + (B)  
 conc. white solid brown gas  
 How many of the following statements are correct regarding products (A) & (B) ?  
 (1) (A) can be prepared by reacting borax with dilute acids.  
 (2) (A) is a weak monobasic lewis acid.  
 (3) (A) behaves like a strong electrolyte when dissolved in water.  
 (4) (A) can be prepared by reacting colemanite,  $\text{SO}_2$  &  $\text{H}_2\text{O}$ .  
 (5) (B) is paramagnetic in nature.  
 (6) (B) is a mixed anhydride.  
 (7) (B) does not forms a dimer  
 (8) (B) reacts with  $\text{NaOH}(\text{aq})$  undergoing disproportionation.  
 (9) Bond angle about central atom is greater in (A) than in (B). (Assume atom forming maximum number of bonds as central atom)





7. Which of the following salts are amphoteric in nature.  
 (a) PbO (b) PbO<sub>2</sub> (c) SnO (d) SnO<sub>2</sub> (e) Al<sub>2</sub>O<sub>3</sub>  
 (f) ZnO (g) BeO (h) Ga<sub>2</sub>O<sub>3</sub> (i) B<sub>2</sub>O<sub>3</sub>
8. How many compounds show amphoteric nature amongst following  
 (a) B<sub>2</sub>O<sub>3</sub> (b) Ti<sub>2</sub>O<sub>3</sub> (c) Al(OH)<sub>3</sub> (d) Ga(OH)<sub>3</sub> (e) Al<sub>2</sub>O<sub>3</sub> (f) Ga<sub>2</sub>O<sub>3</sub>  
 (g) NaAlO<sub>2</sub> (h) Sr(OH)<sub>2</sub> (i) Cr<sub>2</sub>O<sub>3</sub>
9. How many compounds form acidic solution when dissolved in water  
 (a) H<sub>3</sub>PO<sub>4</sub> (b) H<sub>3</sub>BO<sub>3</sub> (c) Na<sub>2</sub>B<sub>4</sub>O<sub>7</sub>·10H<sub>2</sub>O (d) H<sub>3</sub>P<sub>3</sub>O<sub>9</sub>  
 (e) Ba(OH)<sub>2</sub> Ca(OH)<sub>2</sub> (f) PbO, CO
10.  $\text{Mg} + \text{B} \longrightarrow \text{Mg}_x\text{B}_y \xrightarrow{\text{HCl}} \text{Diborane}$   
 Report your answer as (x + y).
11. No of compounds producing gas on hydrolysis (with H<sub>2</sub>O) is .....  
 (a) Al<sub>4</sub>C<sub>3</sub> (b) BaC<sub>2</sub> (c) Mg<sub>2</sub>C<sub>3</sub> (d) SiC (e) B<sub>2</sub>H<sub>6</sub> (f) Fe<sub>3</sub>C
12. How many of the given statements are true for potash Alum.  
 (1) It is a white crystalline solid  
 (2) It swells up on heating  
 (3) It imparts a golden yellow colour to the bunsen flame  
 (4) An aqueous solution of the above gives a white precipitate with BaCl<sub>2</sub> solution soluble only in concentrated sulphuric acid.
13. What is the number of oxygen atoms which are shared between tetrahedrons in Si<sub>3</sub>O<sub>9</sub><sup>6-</sup>.
14. In benitonite (BaTiSi<sub>3</sub>O<sub>9</sub>) number of O atoms shared persilicate tetrahedron is.....
15. The overall charge present on the cyclic silicate anion [Si<sub>6</sub>O<sub>18</sub>]<sup>-n</sup> is “-n”. Report n.
16. The silicate anion in the mineral kinoite is a chain of three SiO<sub>4</sub> tetrahedron that share corners with adjacent tetrahedra. The mineral also contains Ca<sup>2+</sup> and Cu<sup>2+</sup> and As<sup>2+</sup> ion & water molecule in a 1 : 1 : 1 ratio. The formula of mineral is Ca<sub>2</sub>Cu<sub>2</sub>Si<sub>3</sub>O<sub>n</sub>·2H<sub>2</sub>O. Give value of ‘n’

### PART - III : ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

1. Select the correct statement(s).  
 (A) The graphite is diamagnetic and diamond is paramagnetic in nature.  
 (B) Graphite acts as a metallic conductor along the layers of carbon atoms  
 (C) Graphite is less denser than diamond  
 (D) C<sub>60</sub> is called as Buckminster fullerene
2. One of the most fascinating developments in Modern chemistry has been the synthesis of Buckminster fullerene, C<sub>60</sub>. Identify the correct options about C<sub>60</sub>.  
 (A) It consists of fused 5 and 6 membered carbon rings.  
 (B) All atoms are not-equivalent.  
 (C) All bonds are not-equivalent  
 (D) C–C bond lengths at the fusion of two 6-membered rings are shorter with the C–C bond length at the fusion of 5 and 6-membered rings.
3. Graphite and diamond will behave differently in which of the following reactions ?  
 (A) Burning in sufficient air (B) Reaction with hot conc. HNO<sub>3</sub>  
 (C) Reaction with F<sub>2</sub> (D) Reaction with NaOH (aq.)
4. Which statement(s) is/are correct ?  
 (A) Al acts as a reducing agent  
 (B) Al does not react with steam even at higher temperature  
 (C) Al forms a number of alloys with other metals  
 (D) Al is ionic in all its compounds



5. What products are expected from the reaction between colemanite powder and sodium carbonate solution, when they are heated ?  
 (A)  $\text{CaCO}_3$  (B)  $\text{Na}_2\text{B}_4\text{O}_7$  (C)  $\text{NaBO}_2$  (D)  $\text{CaO}$
6. Which of the following forms tetrahydridoborates  
 (A) (Li) (B) Na (C)  $\text{NH}_4^+$  (D)  $\text{Ag}^+$
7. Borax bead test is given by :  
 (A) An aluminium salt (B) A cobalt salt (C) A copper (II) salt (D) A nickel salt
8. Carbon monoxide is prepared by :  
 (A) heating formic acid with conc.  $\text{H}_2\text{SO}_4$  (B) heating potassium ferrocyanide with conc  $\text{H}_2\text{SO}_4$   
 (C) heating malonic acid with  $\text{P}_4\text{O}_{10}$  (D) hydrolysis of  $\text{Mg}_2\text{C}_3$
9. The hydroxide of which metal ion is soluble in excess of sodium hydroxide solution :  
 (A)  $\text{Fe}^{3+}$  (B)  $\text{Cr}^{3+}$  (C)  $\text{Sn}^{2+}$  (D)  $\text{Cu}^{2+}$
10. Which of the following statements is true ?  
 (A) Small amines such as  $\text{NH}_3$ ,  $\text{CH}_3\text{NH}_2$  and  $(\text{CH}_3)_2\text{NH}$  give unsymmetrical cleavage of diborane.  
 (B) Boron hydrides can't be used as high energy fuels.  
 (C) Boron hydrides are readily hydrolysed.  
 (D) Borazine hydrolyses to  $\text{NH}_3$  and boric acid at elevated temperature, if heated with water.
11. Diborane undergoes unsymmetrical cleavage reactions with :  
 (A) dimethylamine (B) ammonia at low temperature  
 (C) methylamine (D) carbon dioxide
12. Select correct statements :  
 (A)  $\text{B}_2\text{H}_6$  is stronger lewis acid than  $\text{BF}_3$  (B)  $\text{BF}_3$  is weaker lewis acid than  $\text{BCl}_3$   
 (C)  $\text{B}_2\text{H}_6$  is not a lewis acid (D) In  $\text{B}_2\text{H}_6$  all 'H' atoms are not in the same plane
13. Which of the following statement(s) is/are correct ?  
 (A) The oxide,  $\text{B}_2\text{O}_3$  and  $\text{B}(\text{OH})_3$  are acidic  
 (B) The halides of B (except  $\text{BF}_3$ ) and Si are hydrolysed.  
 (C) The hydrides of B and Si are volatile, spontaneously flammable and readily hydrolysed.  
 (D) Aluminium hydride is a polymer,  $(\text{AlH}_3)_n$ .
14. Which of the following species exists :  
 (A)  $[\text{BF}_6]^{3-}$  (B)  $[\text{AlF}_6]^{3-}$  (C)  $[\text{GaF}_6]^{3-}$  (D)  $[\text{InF}_6]^{3-}$
15. Which is/are true in case of  $\text{BF}_3$  ?  
 (A) It is volatile liquid even at room temperature (B) It is Lewis acid  
 (C) It has planar geometry (D) It forms adduct with  $\text{NH}_3$
16. Which of the following statements about anhydrous aluminium chloride is/are incorrect ?  
 (A) It exists as  $\text{AlCl}_3$  molecule in gaseous phase (B) It is a strong Lewis base  
 (C) It sublimes at  $100^\circ\text{C}$  under vacuum (D) It is not easily hydrolysed
17. Which of following are correct.  
 (A)  $\text{B}_2\text{H}_6$  is non-planar.  
 (B)  $\text{B}_2\text{H}_6$  undergo symmetrical cleavage with  $\text{PF}_3$ ,  $\text{CO}$  and  $(\text{C}_2\text{H}_5)_3\text{N}$   
 (C)  $\text{B}_2\text{H}_6$  undergo unsymmetrical cleavage with  $\text{NH}_3$ ,  $\text{CH}_3\text{NH}_2$ ,  $(\text{CH}_3)_2\text{NH}$ .  
 (D)  $\text{BeH}_2(\text{s})$ ,  $\text{Ga}_2\text{Me}_6$ ,  $\text{Al}_2\text{Me}_6$  have two type of bonds ( $2\text{C}-2\text{e}$  bond as well as  $3\text{C}-2\text{e}$  bond)
18. A complex cross-linked polymer (silicone) is formed by  
 (A) hydrolysis of  $(\text{CH}_3)_3\text{SiCl}$ .  
 (B) hydrolysis of a mixture of  $(\text{CH}_3)_3\text{SiCl}$  and  $(\text{CH}_3)_2\text{SiCl}_2$   
 (C) hydrolysis of  $\text{CH}_3\text{SiCl}_3$   
 (D) hydrolysis of  $\text{SiCl}_4$ .





19. Select the correct statement (s)
- (A)  $\text{CH}_3\text{SiCl}_3$  undergoes hydrolysis followed by inter molecular elimination of water to form a complex cross - linked polymer (i.e silicone)
- (B) Silicone fluids are thermally stable.
- (C) In sheet silicate, three oxygen atoms of each tetrahedral are shared with adjacent  $\text{SiO}_4^{4-}$  tetrahedrals.
- (D) Silica is attacked by HF and NaOH.

## PART - IV : COMPREHENSION

Read the following comprehension carefully and answer the questions

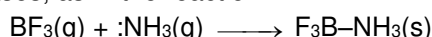
### Comprehension # 1

Compound (A) on reaction with iodine in the solvent diglyme gives a hydride (B) and hydrogen gas. The product (B) is instantly hydrolysed by water or aqueous alkali forming compound (C) and liberating hydrogen gas. The compound (C) in aqueous solution behaves as a weak mono basic acid. But in presence of certain organic polyhydroxy compound behaves as a strong monobasic acid. The hydride (B) in air catches fire spontaneously forming oxide which gives coloured beads with transition metal compounds.

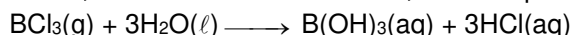
- Which of the following statement is correct for the product (C) ?  
 (A) It is an odd electron molecule. (B) It in water acts as proton donor.  
 (C) It in solid state have hydrogen bonding. (D) It is a useful primary standard for titrating against acids.
- Aqueous solution of product (C) can be titrated against sodium hydroxide using phenolphthalein indicator only in presence of :  
 (A) cis-1, 2 diol (B) trans-1, 2 diol (C) borax (D)  $\text{Na}_2\text{HPO}_4$
- Which of the following statement is correct for hydride (B) ?  
 (A) One mole of it react with two moles of HCl.  
 (B) It reacts with excess of ammonia at low temperature to form an ionic compound.  
 (C) One mole of it reacts with one mole of trimethylamine.  
 (D) It reacts with methyl alcohol to form a trimethyl compound liberating oxygen gas.

### Comprehension # 2

All the boron trihalides except  $\text{BI}_3$  may be prepared by direct reaction between the elements. Boron trihalides consist of trigonal - planar  $\text{BX}_3$  molecules. Unlike the halides of the other elements in the group they are monomeric in the gas, liquid and solid states,  $\text{BF}_3$  and  $\text{BCl}_3$  are gases,  $\text{BBr}_3$  is a volatile liquid and  $\text{BI}_3$  is a solid. Boron trihalides are Lewis acids because they form simple Lewis complexes with suitable bases, as in the reaction :



However, boron chlorides, bromides and iodides are susceptible (sensitive) to protolysis by mild proton sources such as water, alcohols and even amines; for example  $\text{BCl}_3$  undergoes rapid hydrolysis:



It is supposed that the first step in the above reaction is the formation of the complex  $\text{Cl}_3\text{B} \leftarrow \text{OH}_2$  which then eliminates HCl and reacts further with water.

- Which of the following is the best order of Lewis acid strength of  $\text{BF}_3$ ,  $\text{BCl}_3$  and  $\text{BBr}_3$  ?  
 (A)  $\text{BF}_3 > \text{BCl}_3 > \text{BBr}_3$  (B)  $\text{BF}_3 = \text{BCl}_3 = \text{BBr}_3$  (C)  $\text{BF}_3 < \text{BCl}_3 < \text{BBr}_3$  (D)  $\text{BBr}_3 > \text{BF}_3 > \text{BCl}_3$
- Which of the following is the correct prediction about observed B-X bond length, in  $\text{BX}_3$  molecules ?  
 (A) B-F bond length in  $\text{BF}_3$  is found to be less than theoretical value because the electronegativity values of B(2.04) and F(4.0) suggest the bond to be ionic and hence the attraction between oppositely charged ions must decrease the bond length  
 (B)  $\text{BF}_3$  and  $[\text{BF}_4]^-$  have equal B-F bond length  
 (C) The decrease in the B-F bond length in  $\text{BF}_3$  is due to delocalised  $p_\pi-p_\pi$  bonding between vacant '2p' orbital of B and filled '2p' orbital of F.  
 (D) The correct B-X bond length order is  $\text{B-F} > \text{B-Cl} > \text{B-Br} > \text{B-I}$



6. Which is correct about the hydrolysis of  $\text{BX}_3$  ?  
 (A) All  $\text{BX}_3$  undergo hydrolysis to produce  $\text{B(OH)}_3(\text{aq})$  and  $\text{HX(aq)}$ .  
 (B)  $\text{BF}_3$  does not undergo complete hydrolysis due to formation of  $\text{HBF}_4$ .  
 (C)  $\text{BBr}_3$  does not undergo hydrolysis at all because it cannot form H-bonds with water.  
 (D) All the above are correct
7. Which of the following reactions is incorrect ?  
 (A)  $\text{BF}_3(\text{g}) + \text{F}^-(\text{aq}) \longrightarrow [\text{BF}_4]^-(\text{aq})$   
 (B)  $\text{BCl}_3(\text{g}) + 3\text{EtOH}(\ell) \longrightarrow \text{B(OEt)}_3(\ell) + 3\text{HCl}(\text{g})$   
 (C)  $\text{BBr}_3(\ell) + \text{F}_3\text{BN}(\text{CH}_3)_3(\text{s}) \longrightarrow \text{BF}_3(\text{g}) + \text{Br}_3\text{BN}(\text{CH}_3)_3(\text{s})$   
 (D)  $\text{BCl}_3(\text{g}) + 2 \text{C}_5\text{H}_5\text{N}(\ell) \longrightarrow \text{Cl}_3\text{B}(\text{C}_5\text{H}_5\text{N})_2(\text{s})$   
 (excess)

### Comprehension # 3

The small size and high charge of  $\text{Al}^{3+}$  ion gives it a high charge density which is responsible for its tendency to show (a) covalency in its compounds in the gaseous state (b) high hydration energy which stabilizes its compounds in solution, and (c) high lattice energy of its compounds in the solid state. Thus aluminium can form both covalent and ionic bond.

Like halides of boron, halides of aluminium do not show back bonding because of increase in size of aluminium. Actually aluminium atoms complete their octets by forming dimers. Thus chloride and bromide of aluminium exist as dimers, both in the vapour state and in polar-solvents like benzene while the corresponding boron halides exist as monomer. In boron trihalides the extent of back bonding decreases with increase in size of halogens and thus lewis acid character increases. All  $\text{BX}_3$  are hydrolysed by water but  $\text{BF}_3$  shows a different behaviour.

8. The dimeric structure of aluminium chloride disappears when :  
 (A) it dissolves in water (B) it reacts with donor molecules like  $\text{R}_3\text{N}$   
 (C) it dissolves in benzene (D) (A) & (B) both
9. Which one of the following statements is correct ?  
 (A) All boron trihalides are hydrolysed to boric acid.  
 (B) Anhydrous aluminium chloride is an ionic compound  
 (C) Aluminium halides make up the electron deficiency by bridging with halide or alkyl groups  
 (D) None of these
10. Which of the following statements about anhydrous aluminium chloride is correct?  
 (A) It is an ionic compound. (B) It is not easily hydrolysed.  
 (C) It sublimes at  $100^\circ\text{C}$  under vacuum. (D) It is a strong lewis base.
11. Which of the following reaction is incorrect ?  
 (A)  $\text{BF}_3(\text{g}) + \text{F}^-(\text{aq}) \longrightarrow \text{BF}_4^-$   
 (B)  $\text{BF}_3(\text{g}) + 2\text{H}_2\text{O} \longrightarrow [\text{BF}_3\text{OH}]^- + \text{H}_3\text{O}^+$   
 (C)  $\text{BCl}_3(\text{g}) + 3\text{EtOH}(\ell) \longrightarrow \text{B(OEt)}_3(\ell) + 3\text{HCl}$   
 (D)  $\text{BCl}_3(\text{g}) + 2\text{C}_5\text{H}_5\text{N}(\ell) \longrightarrow \text{Cl}_3\text{B}(\text{C}_5\text{H}_5\text{N})_2(\text{s})$



## Comprehension # 4

Answer Q.12, Q.13 and Q.14 by appropriately matching the information given in the three columns of the following table.

Silicates are metal derivatives of silicic acid  $\text{H}_4\text{SiO}_4$  or  $\text{Si}(\text{OH})_4$ . Silicates are formed by heating metal oxide or carbonate with silica. A silicate in general has Si–O bond & possesses a complex network solid having silicate ion  $[\text{SiO}_4]^{4-}$  as the basic structural unit. In silicates each silicon atom is bounded with four oxide ions tetrahedrally. There are following types of silicates  
(1) Orthosilicates (2) Pyrosilicates (3) Cyclic silicates (4) Chain silicates  
(5) 2-D Sheet silicates (6) 3-D sheet silicates

Column-1 (General formula of basic unit)		Column-2 (No. of oxygen atom shared per, $\text{SiO}_4^{4-}$ unit)		Column-3 Examples	
(I)	$\text{SiO}_4^{4-}$	(i)	1	(P)	Kaolin $\text{Al}_2(\text{OH})_4(\text{Si}_2\text{O}_5)$
(II)	$(\text{SiO}_3^{2-})_n$	(ii)	None	(Q)	Benitonite $\text{BaTiSi}_3\text{O}_9$
(III)	$\text{Si}_2\text{O}_7^{6-}$	(iii)	3	(R)	Phenacite $\text{Be}_2\text{SiO}_4$
(IV)	$(\text{Si}_2\text{O}_5)_n^{2n-}$	(iv)	2	(S)	Thortveitite $\text{Sc}_2\text{Si}_2\text{O}_7$

12. For the orthosilicates only correct combination is -  
(A) (I) (ii) (R) (B) (II) (iii) (S) (C) (III) (iv) (R) (D) (IV) (i) (P)
13. For the cyclic or ring silicates only correct combination is-  
(A) (III) (iii) (R) (B) (II) (iv) (Q) (C) (IV) (i) (S) (D) (II) (i) (P)
14. For the two dimensional sheet silicates only correct combination is :  
(A) (III) (iii) (Q) (B) (IV) (ii) (R) (C) (IV) (iii) (P) (D) (II), (i) (S)

## Exercise-3

\* Marked Questions may have more than one correct option.

### PART - I : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

#### Section (A) : Group 13<sup>th</sup>

- Write the chemical reactions associated with the 'borax bead test' of cobalt (II) oxide.  
[JEE 2000 (M), 3/100]
- Compound (X) on reduction with  $\text{LiAlH}_4$  gives a hydride (Y) containing 21.72% hydrogen along with other products. The compound (Y) reacts with air explosively resulting in boron trioxide. Identify (X) and (Y). Give balanced reactions involved in the formation of (Y) and its reaction with air. Draw structure of (Y).  
[JEE 2001 (M), 5/100]
- Write balanced equations for the reactions of the following compounds with water: [JEE 2002 (M), 5/60]  
(i)  $\text{Al}_4\text{C}_3$  (ii)  $\text{CaNCN}$  (iii)  $\text{BF}_3$  (iv)  $\text{NCl}_3$  (v)  $\text{XeF}_4$
- How is boron obtained from borax ? Give chemical equations with reaction conditions. Write the structure of  $\text{B}_2\text{H}_6$  and its reaction with  $\text{HCl}$ .  
[JEE 2002 (M), 5/60]
- $\text{H}_3\text{BO}_3$  is : [JEE 2003 (S), 3/84]  
(A) monobasic and weak Lewis acid (B) monobasic and weak Bronsted acid  
(C) monobasic and strong Lewis acid (D) tribasic and weak Bronsted acid
- $\text{B}(\text{OH})_3 + \text{NaOH} \longrightarrow \text{Na}[\text{B}(\text{OH})_4] \text{ (aq.)}$   
Then addition of which of the following proceeds the reaction in the forward direction?  
[JEE 2006, 3/184]  
(A) Cis-1, 2 diol (B) Trans 1, 2 diol (C) Borax (D)  $\text{Na}_2\text{HPO}_4$



7. Match the reactions in Column-I with nature of the reactions in column-II.

[JEE 2006, 6/184]

	Column-I		Column-II
(A)	$\text{Bi}^{3+} \rightarrow (\text{BiO})^+$	(p)	Heat
(B)	$[\text{AlO}_2]^- \rightarrow \text{Al}(\text{OH})_3$	(q)	Hydrolysis
(C)	$\text{SiO}_4^{4-} \rightarrow \text{Si}_2\text{O}_7^{6-}$	(r)	Acidification
(D)	$(\text{B}_4\text{O}_7^{2-}) \rightarrow [\text{B}(\text{OH})_3]$	(s)	Dilution by water

8. **Statement-1** : In water, orthoboric acid behaves as a weak monobasic acid, **because**  
**Statement-2** : In water, orthoboric acid acts as a proton donor. [JEE 2007, 3/162]  
 (A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.  
 (B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.  
 (C) Statement-1 is True, Statement-2 is False  
 (D) Statement-1 is False, Statement-2 is True
9. The coordination number of Al in the crystalline state of  $\text{AlCl}_3$  is : [JEE 2009, 4/160]
- 10.\* The correct statement(s) for orthoboric acid is/are [JEE(Advanced) 2014, 3/120]  
 (A) It behaves as a weak acid in water due to self ionization.  
 (B) Acidity of its aqueous solution increases upon addition of ethylene glycol.  
 (C) It has a three dimensional structure due to hydrogen bonding.  
 (D) It is weak electrolyte in water.
11. The increasing order of atomic radii of the following Group 13 elements is: [JEE(Advanced) 2016, 3/124]  
 (A)  $\text{Al} < \text{Ga} < \text{In} < \text{Tl}$  (B)  $\text{Ga} < \text{Al} < \text{In} < \text{Tl}$  (C)  $\text{Al} < \text{In} < \text{Ga} < \text{Tl}$  (D)  $\text{Al} < \text{Ga} < \text{Tl} < \text{In}$
- 12.\* The crystalline form of borax has [JEE(Advanced) 2016, 4/124]  
 (A) tetranuclear  $[\text{B}_4\text{O}_5(\text{OH})_4]^{2-}$  unit  
 (B) all boron atoms in the same plane  
 (C) equal number of  $\text{sp}^2$  and  $\text{sp}^3$  hybridized boron atoms  
 (D) one terminal hydroxide per boron atom
- 13.\* Among the following, the correct statement(s) is(are) [JEE(Advanced) 2017, 4/122]  
 (A)  $\text{Al}(\text{CH}_3)_3$  has the three-centre two-electron bonds in its dimeric structure.  
 (B) The Lewis acidity of  $\text{BCl}_3$  is greater than that of  $\text{AlCl}_3$   
 (C)  $\text{AlCl}_3$  has the three-centre two-electron bonds in its dimeric structure.  
 (D)  $\text{BH}_3$  has the three-centre two-electron bonds in its dimeric structure.

### Section (B) : Group 14<sup>th</sup>

14. Starting from  $\text{SiCl}_4$ , prepare the following in steps not exceeding the number given in parenthesis (give reactions only) : [JEE 2001 (M), 5/100]  
 (i) Silicon (1) (ii) Linear silicone containing methyl groups (4) (iii)  $\text{Na}_2\text{SiO}_3$  (3)
15.  $(\text{Me})_2\text{SiCl}_2$  on hydrolysis will produce : [JEE 2003 (S), 3/84]  
 (A)  $(\text{Me})_2\text{Si}(\text{OH})_2$  (B)  $(\text{Me})_2\text{Si} = \text{O}$   
 (C)  $-\text{[O-(Me)}_2\text{Si-O]}_n-$  (D)  $\text{Me}_2\text{SiCl}(\text{OH})$
16. Which of the following silicate is formed when three oxygen atoms of  $[\text{SiO}_4]^{4-}$  tetrahedral units are shared ? [JEE 2005 (S), 3/84]  
 (A) Sheet silicate (B) Pyrosilicate  
 (C) Three dimensional silicate (D) linear chain silicate
17. **Statement-1** :  $\text{Pb}^{+4}$  compounds are stronger oxidizing agents than  $\text{Sn}^{+4}$  compounds  
**Statement-2** : The higher oxidation states for the group 14 elements are more stable for the heavier members of the group due to 'inert pair effect'. [JEE 2008, 3/162]  
 (A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.  
 (B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.  
 (C) Statement-1 is True, Statement-2 is False  
 (D) Statement-1 is False, Statement-2 is True



- 18.\* In the reaction,  $2X + B_2H_6 \longrightarrow [BH_2(X)_2]^+ [BH_4]^-$   
the amine(s) **X** is(are) : [JEE 2009, 4/160]  
(A)  $NH_3$  (B)  $CH_3NH_2$  (C)  $(CH_3)_2NH$  (D)  $(CH_3)_3N$
19. The value of  $n$  in the molecular formula  $Be_nAl_2Si_6O_{18}$  is : [JEE 2010, 3/163]
20. Three moles of  $B_2H_6$  are completely reacted with methanol. The number of moles of boron containing product formed is : [JEE-Advance 2015, 4/168]
21. Under hydrolytic conditions, the compounds used for preparation of linear polymer and for chain termination, respectively, are : [JEE-Advance 2015, 4/168]  
(A)  $CH_3SiCl_3$  and  $Si(CH_3)_4$  (B)  $(CH_3)_2SiCl_2$  and  $(CH_3)_3SiCl$   
(C)  $(CH_3)SiCl_2$  and  $CH_3SiCl_3$  (D)  $SiCl_4$  and  $(CH_3)_3SiCl$
- 22.\* Among the following, the correct statement(s) is(are) [JEE-Advance 2017, 4/122]  
(A)  $Al(CH_3)_3$  has the three-centre two-electron bonds in its dimeric structure.  
(B) The Lewis acidity of  $BCl_3$  is greater than that of  $AlCl_3$   
(C)  $AlCl_3$  has the three-centre two-electron bonds in its dimeric structure.  
(D)  $BH_3$  has the three-centre two-electron bonds in its dimeric structure.

## PART - II : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

### JEE(MAIN) OFFLINE PROBLEMS

1. Aluminium is extracted by the electrolysis of : [AIEEE 2002, 3/225]  
(1) alumina (2) bauxite  
(3) molten cryolite. (4) alumina mixed with molten cryolite
2. Graphite is a soft solid lubricant extremely difficult to melt. The reason for this anomalous behaviour is that graphite : [AIEEE 2003, 3/225]  
(1) is a non-crystalline substance.  
(2) is an allotropic form of diamond.  
(3) has molecules of variable molecular masses like polymers.  
(4) has carbon atoms arranged in large plates of rings of strongly bound carbon atoms with weak interplate bonds.
3. The soldiers of Napoleon army while at Alps during freezing winter suffered a serious problem as regards to the tin buttons of their uniforms. White metallic tin buttons got converted to grey powder. This transformation is related to : [AIEEE 2004, 3/225]  
(1) a change in the crystalline structure of tin.  
(2) an interaction with nitrogen of the air at very low temperature.  
(3) a change in the partial pressure of oxygen in the air.  
(4) an interaction with water vapour contained in the humid air.
4. Aluminium chloride exists as dimer,  $Al_2Cl_6$  in solid state as well as in solution of non-polar solvents such as benzene. When dissolved in water, it gives : [AIEEE 2004, 3/225]  
(1)  $[Al(OH)_6]^{3-} + 3HCl$  (2)  $[Al(H_2O)_6]^{3+} + 3Cl^-$  (3)  $Al^{3+} + 3Cl^-$  (4)  $Al_2O_3 + 6HCl$
5. In silicon dioxide : [AIEEE 2005, 3/225]  
(1) there are double bonds between silicon and oxygen atoms.  
(2) silicon atom is bonded to two oxygen atoms.  
(3) each silicon atom is surrounded by two oxygen atoms and each oxygen atom is bonded to two silicon atoms.  
(4) each silicon atom is surrounded by four oxygen atoms and each oxygen atom is bonded to two silicon atoms.



6. Heating an aqueous solution of aluminium chloride to dryness will give : [AIEEE 2005, 3/225]  
 (1)  $\text{Al}(\text{OH})\text{Cl}_2$  (2)  $\text{Al}_2\text{O}_3$  (3)  $\text{Al}_2\text{Cl}_6$  (4)  $\text{AlCl}_3$
7. The stability of dihalides of Si, Ge, Sn and Pb increases steadily in the sequence : [AIEEE 2007, 3/120]  
 (1)  $\text{GeX}_2 < \text{SiX}_2 < \text{SnX}_2 < \text{PbX}_2$  (2)  $\text{SiX}_2 < \text{GeX}_2 < \text{PbX}_2 < \text{SnX}_2$   
 (3)  $\text{SiX}_2 < \text{GeX}_2 < \text{SnX}_2 < \text{PbX}_2$  (4)  $\text{PbX}_2 < \text{SnX}_2 < \text{GeX}_2 < \text{SiX}_2$
8. In context with the industrial preparation of hydrogen from water gas ( $\text{CO} + \text{H}_2$ ), which of the following is the correct statement ? [AIEEE 2008, 3/105]  
 (1)  $\text{CO}$  is removed by absorption in aqueous  $\text{Cu}_2\text{Cl}_2$  Solution.  
 (2)  $\text{H}_2$  is removed through occlusion with  $\text{Pd}$ .  
 (3)  $\text{CO}$  is oxidized to  $\text{CO}_2$  with steam in the presence of a catalyst, followed by absorption of  $\text{CO}_2$  in alkali.  
 (4)  $\text{CO}$  and  $\text{H}_2$  are fractionally separated using differences in their densities.
9. Among the following substituted silanes, the one which will give rise to cross linked silicone polymer on hydrolysis is : [AIEEE 2008, 3/105]  
 (1)  $\text{RSiCl}_3$  (2)  $\text{R}_2\text{SiCl}_2$  (3)  $\text{R}_3\text{SiCl}_2$  (4)  $\text{R}_4\text{Si}$
10. Which one of the following is the correct statement ? [AIEEE 2008, 3/105]  
 (1) Beryllium exhibits coordination number of six.  
 (2) Chlorides of both beryllium and aluminium have bridged structures in vapour phase.  
 (3)  $\text{B}_2\text{H}_6 \cdot 2\text{NH}_3$  is known as 'inorganic benzene'.  
 (4) Boric acid is a protonic acid.
11. Boron cannot form which one of the following anions? [AIEEE 2011, 4/120]  
 (1)  $\text{BF}_6^{3-}$  (2)  $\text{BH}_4^-$  (3)  $\text{B}(\text{OH})_4^-$  (4)  $\text{BO}_2^-$

### JEE(MAIN) ONLINE PROBLEMS

1. The gas evolved on heating  $\text{CaF}_2$  and  $\text{SiO}_2$  with concentrated  $\text{H}_2\text{SO}_4$ , on hydrolysis gives a white gelatinous precipitate. The precipitate is : [JEE(Main) 2014 Online (09-04-14), 4/120]  
 (1) hydrofluosilicic acid (2) silica gel  
 (3) silicic acid (4) calciumfluorosilicate
2. In the following sets of reactants which two sets best exhibit the amphoteric character of  $\text{Al}_2\text{O}_3 \cdot x\text{H}_2\text{O}$  ? [JEE(Main) 2014 Online (09-04-14), 4/120]  
 Set 1 :  $\text{Al}_2\text{O}_3 \cdot x\text{H}_2\text{O}$  (s) and  $\text{OH}^-$  (aq) Set 2 :  $\text{Al}_2\text{O}_3 \cdot x\text{H}_2\text{O}$  (s) and  $\text{H}_2\text{O}$  (l)  
 Set 3 :  $\text{Al}_2\text{O}_3 \cdot x\text{H}_2\text{O}$  (s) and  $\text{H}^+$  (aq) Set 4 :  $\text{Al}_2\text{O}_3 \cdot x\text{H}_2\text{O}$  (s) and  $\text{NH}_3$  (aq)  
 (1) 1 and 2 (2) 1 and 3 (3) 2 and 4 (4) 3 and 4
3. Example of a three-dimensional silicate is not : [JEE(Main) 2014 Online (19-04-14), 4/120]  
 (1) Zeolites (2) Ultramarines (3) Feldspars (4) Beryls
4. Match the items in Column I with its main use listed in Column II: [JEE(Main) 2016 Online (09-04-16), 4/120]
- | Column I                                   | Column II                                  |
|--------------------------------------------|--------------------------------------------|
| (A) Silica gel                             | (i) Transistor                             |
| (B) Silicon                                | (ii) Ion-exchanger                         |
| (C) Silicone                               | (iii) Drying agent                         |
| (D) Silicate                               | (iv) Sealant                               |
| (1) (A)-(iii), (B)-(i), (C)-(iv), (D)-(ii) | (2) (A)-(ii), (B)-(i), (C)-(iv), (D)-(iii) |
| (3) (A)-(iv), (B)-(i), (C)-(ii), (D)-(iii) | (4) (A)-(ii), (B)-(iv), (C)-(i), (D)-(iii) |
5. Identify the incorrect statement regarding heavy water : [JEE(Main) 2016 Online (09-04-16), 4/120]  
 (1) It reacts with  $\text{CaC}_2$  to produce  $\text{C}_2\text{D}_2$  and  $\text{Ca}(\text{OD})_2$   
 (2) It is used as a coolant in nuclear reactors.  
 (3) It reacts with  $\text{Al}_4\text{C}_3$  to produce  $\text{CD}_4$  and  $\text{Al}(\text{OD})_3$   
 (4) It reacts with  $\text{SO}_3$  to form deuterated sulphuric acid ( $\text{D}_2\text{SO}_4$ ).





6. Identify the reaction which does not liberate hydrogen : **[JEE(Main) 2016 Online (10-04-16), 4/120]**  
 (1) Allowing a solution of sodium in liquid ammonia to stand.  
 (2) Reaction of zinc with aqueous alkali.  
 (3) Reaction of lithium hydride with  $B_2H_6$ .  
 (4) Electrolysis of acidified water using Pt electrodes.
7. Lithium aluminum hydride reacts with silicon tetrachloride to form : **[JEE(Main) 2018 Online (15-04-18), 4/120]**  
 (1)  $LiCl$ ,  $AlH_3$  and  $SiH_4$  (2)  $LiCl$ ,  $AlCl_3$  and  $SiH_4$   
 (3)  $LiH$ ,  $AlCl_3$  and  $SiCl_2$  (4)  $LiH$ ,  $AlH_3$  and  $SiH_4$
8. A group 13 element 'X' reacts with chlorine gas to produce a compound  $XC l_3$ .  $XC l_3$  is electron deficient and easily reacts with  $NH_3$  to form  $Cl_3X \leftarrow NH_3$  adduct; however,  $XC l_3$  does not dimerize. X is : **[JEE(Main) 2018 Online (16-04-18), 4/120]**  
 (1) B (2) Al (3) In (4) Ga
9. Correct statements amongst a to d regarding silicones are : **[JEE(Main) 2019 Online (09-01-19), 4/120]**  
 (a) They are polymers with hydrophobic character.  
 (b) They are biocompatible.  
 (c) In general, they have high thermal stability and low dielectric strength.  
 (d) Usually, they are resistant to oxidation and used as greases.  
 (1) (a), (b) and (c) only (2) (a) and (b) Only  
 (3) (a), (b) and (d) only (4) (a), (b), (c) and (d)
10. The chloride that CANNOT get hydrolysed is : **[JEE(Main) 2019 Online (11-01-19), 4/120]**  
 (1)  $PbCl_4$  (2)  $SiCl_4$  (3)  $CCl_4$  (4)  $SnCl_4$
11. The relative stability of +1 oxidation state of group 13 elements follows the order : **[JEE(Main) 2019 Online (11-01-19), 4/120]**  
 (1)  $Tl < In < Ga < Al$  (2)  $Ga < Al < In < Tl$  (3)  $Al < Ga < Tl < In$  (4)  $Al < Ga < In < Tl$
12. The element that does NOT show catenation is: **[JEE(Main) 2019 Online (12-01-19), 4/120]**  
 (1) Sn (2) Si (3) Ge (4) Pb





# Answers

## EXERCISE – 1

### PART – I

**A-1.** 3<sup>rd</sup> most abundant element is Aluminium. The main ores of Al are :

- (i) Bauxite ( $\text{Al}_2\text{O}_3 \cdot \text{H}_2\text{O} - \text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ ).
- (ii) Alumosilicate rocks (Feldspars, Mica).
- (iii) Cryolite ( $\text{Na}_3\text{AlF}_6$ ).

**A-2.** (i)  $\text{Na}_2[\text{B}_4\text{O}_5(\text{OH})_4] \cdot 8\text{H}_2\text{O} \xrightarrow{\text{acid}} \text{H}_3\text{BO}_3 \xrightarrow{\text{heat}} \text{B}_2\text{O}_3 \xrightarrow{\text{Mg or Na}} 2\text{B} + 3\text{MgO}$

(ii)  $2\text{BCl}_3 + 3\text{H}_2 \xrightarrow[\text{or Ta filament}]{\text{red hot W}} 2\text{B} + 6\text{HCl}$

Pyrolysis of  $\text{BI}_3$  (Van Arkel Method)

$2\text{BCl}_3 \xrightarrow[\text{Van Arkel Method}]{\text{red hot W or Ta filament}} 2\text{B} + 3\text{I}_2$

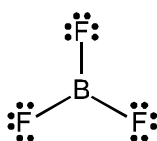
**A-3.** It has layered structure which can be slipped over one another, as the layers are held together by weak van der Waal's forces.

**B-1.** Boron has three electrons in the valence shell. Because of its small and high sum of the first three ionization enthalpies (i.e.,  $\Delta_i H_1 + \Delta_i H_2 + \Delta_i H_3$ ), boron does not lose all its valence electrons to form  $\text{B}^{3+}$  ions.

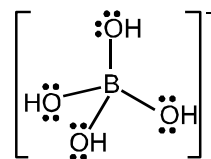
**B-2.** (a) Reluctance of outermost s-orbital electrons to participate in chemical bonding (more pronounced in heavier elements of p-block).

(b) Atoms of elements have the tendency to link with one another through covalent bonds to form chains and rings.

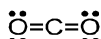
**C-1.** (i)  $\text{BF}_3$



(ii)  $[\text{B}(\text{OH})_4]^-$



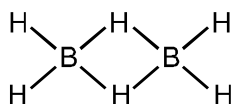
(iii)  $\text{CO}_2$



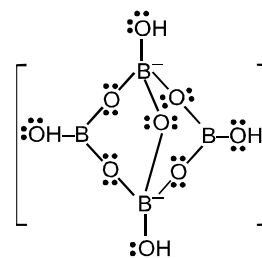
(iv)  $\text{CO}$



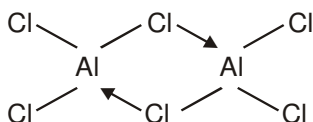
**C-2.** (i)  $\text{B}_2\text{H}_6$



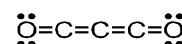
(ii) Borax



(iii)  $\text{Al}_2\text{Cl}_6$



(iv)  $\text{C}_3\text{O}_2$



**C-3.**

CO	CO <sub>2</sub>	CO <sub>3</sub> <sup>2-</sup>
$:\text{C} \equiv \text{O}:$	$\text{O}=\text{C}=\text{O}$	
Bond order = 3	Bond order = 2	Bond order = 4/3

Bond length :  $\text{CO} < \text{CO}_2 < \text{CO}_3^{2-}$

Bond strength :  $\text{CO} > \text{CO}_2 > \text{CO}_3^{2-}$



**C-4.** Due to  $p\pi-p\pi$  back bonding.

**C-5.** CO - Neutral                      SiO<sub>2</sub> - Acidic  
CO<sub>2</sub> - Acidic                      Al<sub>2</sub>O<sub>3</sub> - Amphoteric  
B<sub>2</sub>O<sub>3</sub> - Acidic                      PbO - Amphoteric

**D-1.** Gallium.

**D-2.**

S.No.	Element	Element + O <sub>2</sub>	Element + N <sub>2</sub>
1	B (crystalline)	No reaction	No reaction
	B (amorphous)	B <sub>2</sub> O <sub>3</sub>	BN
2	Al	Al <sub>2</sub> O <sub>3</sub> (at high temp.)	AlN (only at high temp.)
3	C	CO	No reaction
4	Si	SiO <sub>2</sub> (at high temp.)	No reaction

**D-3.** No reaction of group 13 & 14 elements takes place with H<sub>2</sub>O. With Al, the reaction is usually prevented by the deposition of protective layer of Al<sub>2</sub>O<sub>3</sub>.

**D-4.** (a) B + dil. HNO<sub>3</sub> → Poor or No reaction.  
(b) C + dil. HNO<sub>3</sub> → Poor or No reaction.  
(c) Si + dil. HNO<sub>3</sub> → Poor or No reaction.

**D-5.** 2Al + 2NaOH + 2H<sub>2</sub>O → 2NaAlO<sub>2</sub> + 3H<sub>2</sub>

**E-1.** X = Na<sub>2</sub>B<sub>4</sub>O<sub>7</sub>    Y =    Z = H<sub>3</sub>BO<sub>3</sub>

**E-2.** (A) Ca<sub>2</sub>B<sub>6</sub>O<sub>11</sub>.5H<sub>2</sub>O; (B) CaCO<sub>3</sub>; (C) Na<sub>2</sub>B<sub>4</sub>O<sub>7</sub>; (D) NaBO<sub>2</sub>; (E) B<sub>2</sub>O<sub>3</sub>; (F) Co(BO<sub>2</sub>)<sub>2</sub>

**E-3.** SnO<sub>2</sub>, PbO<sub>2</sub>. Because oxides are amphoteric.

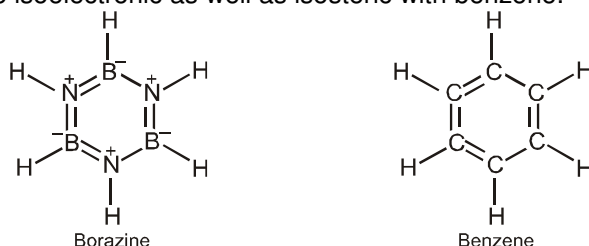
**E-4.** Al, Ga, Sn, Pb.

**E-5.** Fe<sub>2</sub>O<sub>3</sub> (s) + 3CO(g)  $\xrightarrow{\Delta}$  2Fe(s) + 3CO<sub>2</sub> (g)  
CO is a powerful reducing agent which is used in the extraction of many metals from their oxide ores.

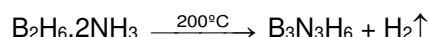
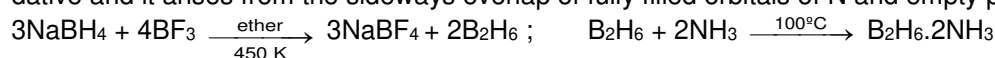
**F-1.** CH<sub>4</sub> > SiH<sub>4</sub> > GeH<sub>4</sub> > SnH<sub>4</sub> > PbH<sub>4</sub>

**F-2.** (i) BF<sub>3</sub> + LiAlH<sub>4</sub> → B<sub>2</sub>H<sub>6</sub> +  $\underbrace{\text{LiF} + \text{AlF}_3}_{\text{Li[AlF}_4\text{]}}$   
(ii) BF<sub>3</sub> + NaH → B<sub>2</sub>H<sub>6</sub> + NaF  
(iii) BF<sub>3</sub> + Na[BH<sub>4</sub>] → B<sub>2</sub>H<sub>6</sub> + Na[BF<sub>4</sub>]

**F-3.** Borazine or borazole (B<sub>3</sub>N<sub>3</sub>H<sub>6</sub>) is known as inorganic benzene.  
It is so called because the structure of borazine is similar to that of benzene.  
It is also isoelectronic as well as isosteric with benzene.

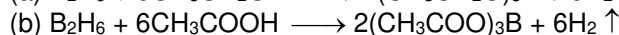
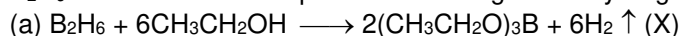


Like carbon in benzene, both N and B in borazine are sp<sup>2</sup>-hybridized. Each N has a p-orbital which is perpendicular to the σ-bonding orbitals and contains a lone pair of electrons. In contrast, each B has an empty p-orbital which is also perpendicular to the plane of the ring. Thus, the π-bonding in borazine is dative and it arises from the sideways overlap of fully filled orbitals of N and empty p-orbitals of B.

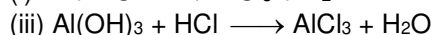
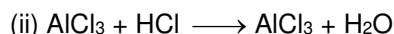
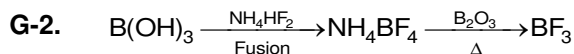




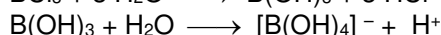
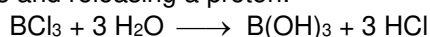
**F-5.**  $\text{B}_2\text{H}_6$  reacts with all the species containing acidic hydrogen and releases  $\text{H}_2$ .



**G-1.**  $\text{PbCl}_4$  is a good oxidising agent whereas  $\text{SnCl}_2$  is a good reducing agent and  $\text{PbCl}_2$  is neither.

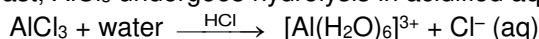


**G-4.** When  $\text{BCl}_3$  reacts with water, it first undergoes hydrolysis to form boric acid,  $\text{B}(\text{OH})_3$ . Due to small size and high electronegativity of B,  $\text{B}(\text{OH})_3$  polarizes  $\text{H}_2\text{O}$  molecule accepting an  $\text{OH}^-$  ion to form  $[\text{B}(\text{OH})_4]^-$  species and releasing a proton:



Since B lies in the 2nd period, it has only one s- and three p- orbitals but no d- orbitals. In other words, at the maximum, it can have four pairs of electrons in the valence shell. i.e., its maximum coordination number is 4. That is why, it accepts one  $\text{OH}^-$  ion forming  $[\text{B}(\text{OH})_4]^-$  in which boron is  $\text{sp}^3$ -hybridized.

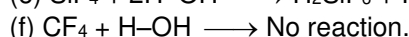
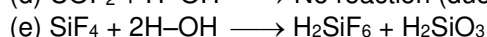
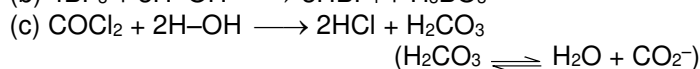
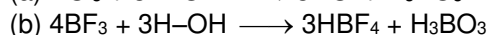
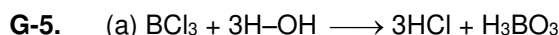
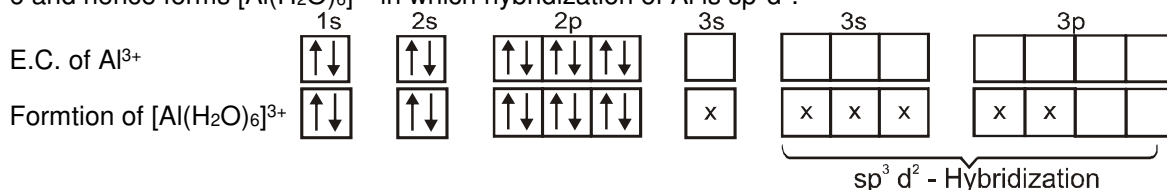
In contrast,  $\text{AlCl}_3$  undergoes hydrolysis in acidified aqueous solution to form  $[\text{Al}(\text{H}_2\text{O})_6]^{3+}$ .



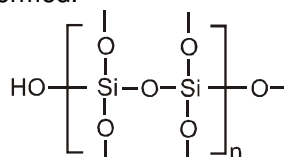
This may be explained as follows:

(i) In acidic medium, the conc. of  $\text{OH}^-$  ions is much lower than that of  $\text{H}^+$  ions, therefore,  $\text{Al}^{3+}$  ions coordinate with  $\text{H}_2\text{O}$  molecules and not with  $\text{OH}^-$  ions.

(ii) Due to the presence of vacant d-orbitals in  $\text{Al}^{3+}$  ions, it can expand its coordination number from 4 to 6 and hence forms  $[\text{Al}(\text{H}_2\text{O})_6]^{3+}$  in which hybridization of Al is  $\text{sp}^3\text{d}^2$ .



**H-1.** Three dimensional silicone will be formed.



**H-2.** Binary compounds of silicon with oxygen are called silicates but they contain other metals also in their structures.

**(i) Orthosilicates :** These contain discrete  $[\text{SiO}_4]^{4-}$  units i.e., there is no sharing of corners with one another.

**(ii) Pyrosilicate :** In these silicates two tetrahedral units are joined by sharing oxygen at one corner thereby giving  $[\text{Si}_2\text{O}_7]^{6-}$  units.

**(iii) Cyclic silicates :** If two oxygen atoms per tetrahedron are shared to form closed rings such that the structure with general formula  $(\text{SiO}_3^{2-})_n$  or  $(\text{SiO}_3)_n^{2n-}$  is obtained, the silicates containing these anions are called cyclic silicates.  $\text{Si}_3\text{O}_9^{6-}$  and  $\text{Si}_6\text{O}_{18}^{12-}$  anions are the typical examples of cyclic silicates.

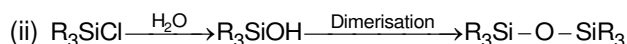
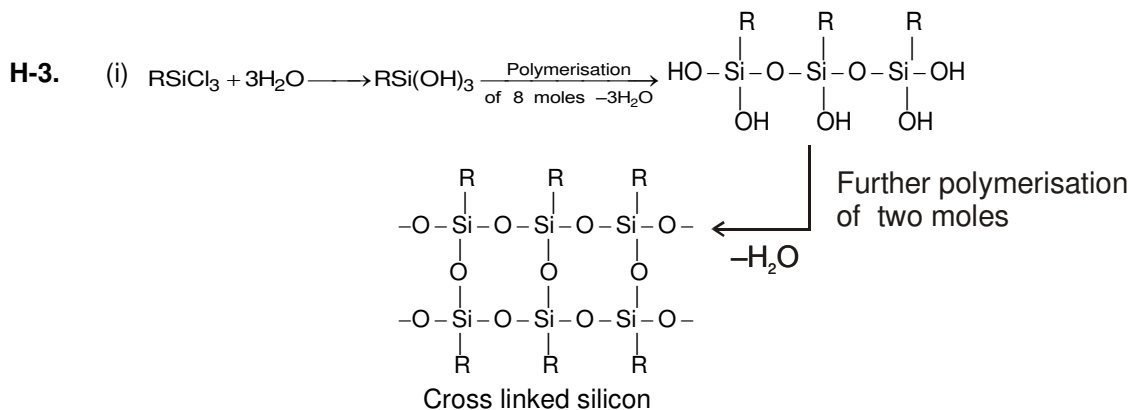


**(iv) Chain silicates** : Chain silicates may be further classified into simple chain & double chain compounds.

In case of simple chains two corners of each tetrahedron are shared & they form a long chain of tetrahedron. Their general formula is also same as the cyclic silicates i.e.  $(\text{SiO}_3)_n^{2n-}$

**(v) Two dimensional sheet silicates** : In such silicates, three oxygen atoms of each tetrahedral are shared with adjacent  $\text{SiO}_4^{4-}$  tetrahedrals. Such sharing forms two dimension sheet structure with general formula  $(\text{Si}_2\text{O}_5)_n^{2n-}$

**(vi) Three dimensional silicates** : These silicates involve all four oxygen atom in sharing with adjacent  $\text{SiO}_4^{4-}$  tetrahedral units.



**H-4.** Alums are transparent crystalline solids having the general formula  $\text{M}_2\text{SO}_4 \cdot \text{M}'_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$  or  $\text{MM}'(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$  where M is almost any univalent positive cation (except  $\text{Li}^+$  because this ion is too small to meet the structural requirements of the crystal) and  $\text{M}'$  is a trivalent positive cation ( $\text{Al}^{3+}$ ,  $\text{Ti}^{3+}$ ,  $\text{V}^{3+}$ ,  $\text{Cr}^{3+}$ ,  $\text{Fe}^{3+}$ ,  $\text{Mn}^{3+}$ ,  $\text{Co}^{3+}$ ,  $\text{Ga}^{3+}$  etc.). Alums contain the ions  $[\text{M}(\text{H}_2\text{O})_6]^+$ ,  $[\text{M}'(\text{H}_2\text{O})_6]^{3+}$  and  $\text{SO}_4^{2-}$  in the ratio 1 : 1 : 2. Some important alums are :

(i) Potash alum  $\text{K}_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$

(ii) Chrome alum  $\text{K}_2\text{SO}_4 \cdot \text{Cr}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$

(iii) Ferric alum  $\text{K}_2\text{SO}_4 \cdot \text{Fe}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$

(iv) Ammonium alum  $(\text{NH}_4)_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$

It is used :

- as a mordant in dye industry. The fabric which is to be dyed is dipped in a solution of the alum and heated with steam.  $\text{Al(OH)}_3$  obtained as hydrolysis product of  $[\text{Al}(\text{H}_2\text{O})_6]^{3+}$  deposits into the fibres and then the dye is absorbed on  $\text{Al(OH)}_3$ .
- as a germicide for water purification.
- as a coagulating agent for precipitating colloidal impurities from water.

## PART – II

<b>A-1.</b> (B)	<b>A-2.</b> (B)	<b>A-3.</b> (A)	<b>B-1.</b> (B)	<b>B-2.</b> (C)
<b>C-1.</b> (A)	<b>C-2.</b> (B)	<b>C-3.</b> (B)	<b>C-4.</b> (A)	<b>C-5.</b> (D)
<b>C-6.</b> (C)	<b>C-7.</b> (D)	<b>C-8.</b> (B)	<b>D-1.</b> (B)	<b>D-2.</b> (B)
<b>D-3.</b> (B)	<b>D-4.</b> (B)	<b>D-5.</b> (D)	<b>E-1.</b> (C)	<b>E-2.</b> (C)
<b>E-3.</b> (B)	<b>E-4.</b> (B)	<b>E-5.</b> (A)	<b>E-6.</b> (A)	<b>E-7.</b> (B)
<b>E-8.</b> (D)	<b>F-1.</b> (B)	<b>F-2.</b> (B)	<b>F-3.</b> (C)	<b>F-4.</b> (B)
<b>F-5.</b> (B)	<b>F-6.</b> (C)	<b>G-1.</b> (A)	<b>G-2.</b> (D)	<b>G-3.</b> (D)
<b>G-4.</b> (B)	<b>G-5.</b> (A)	<b>G-6.</b> (B)	<b>H-1.</b> (C)	<b>H-2.</b> (A)
<b>H-3.</b> (C)	<b>H-4.</b> (D)	<b>H-5.</b> (C)	<b>H-6.</b> (B)	<b>H-7.</b> (B)

## PART – III

- (A – q) ; (B – p) ; (C – r, s) ; (D – q).
- (A – p, q) ; (B – p, r) ; (C – q, s) ; (D – q, r)



## EXERCISE – 2

### PART – I

- |         |         |         |         |         |
|---------|---------|---------|---------|---------|
| 1. (B)  | 2. (D)  | 3. (B)  | 4. (B)  | 5. (D)  |
| 6. (C)  | 7. (B)  | 8. (D)  | 9. (B)  | 10. (C) |
| 11. (C) | 12. (A) | 13. (B) | 14. (D) | 15. (C) |
| 16. (C) | 17. (C) | 18. (D) | 19. (B) | 20. (C) |
| 21. (B) | 22. (C) | 23. (D) | 24. (C) |         |

### PART – II

- |                                |                              |                               |
|--------------------------------|------------------------------|-------------------------------|
| 1. 6 (Except (c))              | 2. 21 (x = 4, y = 4, z = 3)  |                               |
| 3. 26 (a = 12, b = 20, c = 30) | 4. 11 (Except a, b, d, m, n) | 5. 3                          |
| 6. 7 (Except 3 and 7)          | 7. 8 (Except (i))            |                               |
| 8. 5 (Except (a, b, g, h))     | 9. 3 (a, b, d)               | 10. 5      11. 4 (a, b, c, e) |
| 12. (1, 2, 4)                  | 13. 3                        | 14. 2      15. 12      16. 10 |

### PART – III

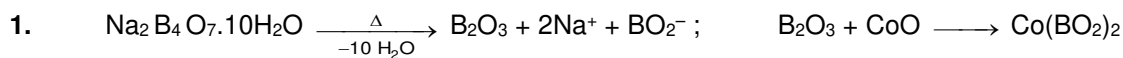
- |           |            |            |            |           |
|-----------|------------|------------|------------|-----------|
| 1. (BCD)  | 2. (ABCD)  | 3. (BC)    | 4. (ABC)   | 5. (ABC)  |
| 6. (AB)   | 7. (BCD)   | 8. (AB)    | 9. (BC)    | 10. (ACD) |
| 11. (ABC) | 12. (BD)   | 13. (ABCD) | 14. (BCD)  | 15. (BCD) |
| 16. (ABD) | 17. (ABCD) | 18. (C)    | 19. (ABCD) |           |

### PART – IV

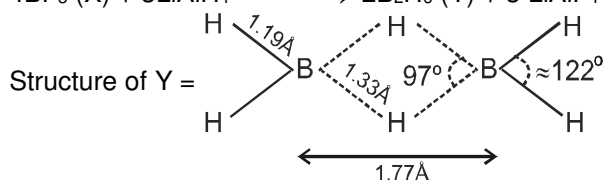
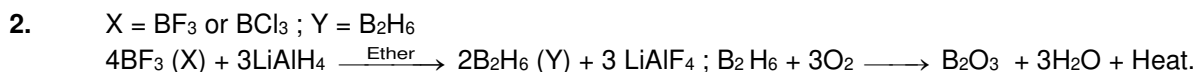
- |         |         |         |         |         |
|---------|---------|---------|---------|---------|
| 1. (C)  | 2. (A)  | 3. (B)  | 4. (C)  | 5. (C)  |
| 6. (B)  | 7. (D)  | 8. (D)  | 9. (C)  | 10. (C) |
| 11. (D) | 12. (A) | 13. (B) | 14. (C) |         |

## EXERCISE - 2

### PART – I



Blue bead



- |                                                                                                                             |                                                                                                            |
|-----------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|
| 3. (i) $\text{Al}_4\text{C}_3 + \text{H}_2\text{O} \longrightarrow 4\text{Al}(\text{OH})_3 + 3\text{CH}_4 \uparrow$         | (ii) $\text{CaNCN} + 3\text{H}_2\text{O} \longrightarrow \text{CaCO}_3 \downarrow + 2\text{NH}_3 \uparrow$ |
| (iii) $4\text{BF}_3 + 6\text{H}_2\text{O} \longrightarrow \text{H}_3\text{BO}_3 + 3[\text{BF}_4]^- + 3\text{H}_3\text{O}^+$ | (iv) $\text{NCl}_3 + 3\text{H}_2\text{O} \longrightarrow \text{NH}_3 + 3\text{HOCl}$                       |
| (v) $6\text{XeF}_4 + 12\text{H}_2\text{O} \longrightarrow 4\text{Xe} + 2\text{XeO}_3 + 24\text{HF} + 3\text{O}_2$           |                                                                                                            |





## Additional Problems for Self Practice (APSP)

*This Section is not meant for classroom discussion. It is being given to promote self-study and self testing amongst the Resonance students.*

### PART - I : PRACTICE TEST-1 (IIT-JEE (MAIN Pattern))

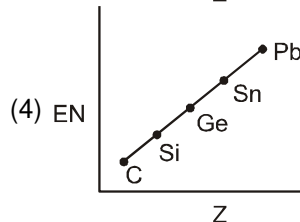
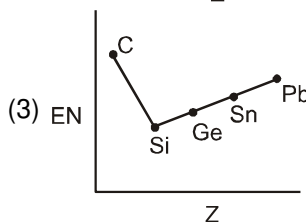
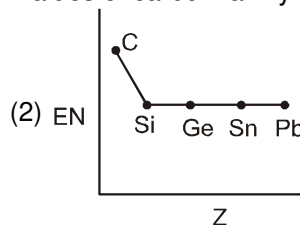
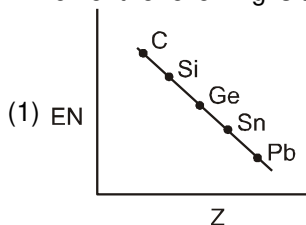
Max. Time : 1 Hr.

Max. Marks : 120

#### Important Instructions

- The test is of **1 hour** duration.
- The Test Booklet consists of **30** questions. The maximum marks are **120**.
- Each question is allotted **4 (four)** marks for correct response.
- Candidates will be awarded marks as stated above in Instructions No. 3 for correct response of each question.  $\frac{1}{4}$  (**one fourth**) marks will be deducted for indicating incorrect response of each question. No deduction from the total score will be made if no response is indicated for an item in the answer sheet.
- There is only one correct response for each question. Filling up more than one response in any question will be treated as wrong response and marks for wrong response will be deducted accordingly as per instructions 4 above.

1. Which of the following is the correct graph for EN values of carbon family :

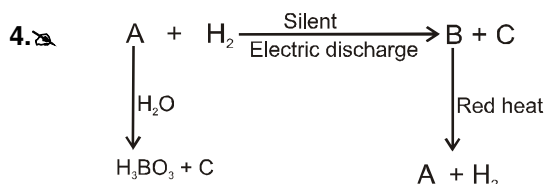


2. Select the incorrect statement :

- Silicon does not form an allotrope like graphite because of its no tendency of multiple bond formation.
- Catenation tendency is greater in C than in Si.
- CO is stable in nature but SiO does not
- None of these

3. Which of the following statement about Si is correct.

- Si predominantly forms covalent compounds with oxidation number as +4.
- Ionisation enthalpy of Si is more than that of carbon.
- Electron affinity of Si is less than that of carbon.
- Si can't show coordination number more than 4.



Identify correct statement.

- C is a weak lewis acid
- B is a weak lewis base
- C is a strong acid
- D reacts with NaOH to produce C





5.  $4\text{BCl}_3 + 3\text{LiAlH}_4 \longrightarrow \text{A} + 3\text{AlCl}_3 + 3\text{LiCl}$   
When A reacts with NaOH it produces a colourless combustible gas and another compound 'B'. Select incorrect statement about 'B'.  
(1) Its aqueous solution turns red litmus blue (2) It shows anionic hydrolysis  
(3) It shows cationic hydrolysis (4) It can also produce by reaction of boron with NaOH
6. When heating white lead then find out released gas (A) and (B)  
 $2\text{PbCO}_3 \cdot \text{Pb(OH)}_2 \xrightarrow{\Delta} \text{Pb}_3\text{O}_4 + (\text{A}) + (\text{B}) + \text{H}_2\text{O}$   
(white lead)  
(1) CO, O<sub>2</sub> (2) CO<sub>2</sub>, O<sub>2</sub> (3) CO<sub>2</sub>, CH<sub>4</sub> (4) CO, CO<sub>2</sub>
7. Amorphous boron is extracted from borax by following step  
Borax  $\xrightarrow{\text{(A)}}$  H<sub>3</sub>BO<sub>3</sub>  $\xrightarrow{\text{Heat}}$  B<sub>2</sub>O<sub>3</sub>  $\xrightarrow{\text{(B)}}$  Boron  
Then (A) and (B) are :  
(1) H<sub>2</sub>SO<sub>4</sub>, Al (2) HCl, carbon (3) H<sub>2</sub>SO<sub>4</sub>, Mg (4) HCl, Fe
8. The role of addition of Me<sub>3</sub>SiCl during the hydrolysis followed by condensation of Me<sub>2</sub>SiCl<sub>2</sub> is.  
(1) To catalyze the reaction.  
(2) To terminate the chain and hence controlling the molecular weight.  
(3) For obtaining a proper cross linking.  
(4) All of the above
9. Given type of silicones are called [P]
- $$\begin{array}{c}
 \text{Me} \quad \text{Me} \\
 | \quad | \\
 \text{Me}-\text{Si}-\text{O}-\text{Si}-\text{Me} \\
 | \quad | \\
 \text{O} \quad \text{O} \\
 | \quad | \\
 \text{Me}-\text{Si}-\text{O}-\text{Si}-\text{Me} \\
 | \quad | \\
 \text{Me} \quad \text{Me}
 \end{array}$$
- [P] is prepared by controlled hydrolysis of [Q]. [P] & [Q] are respectively.  
(1) Linear silicone, CH<sub>3</sub>SiCl<sub>3</sub> (2) branched silicone, (CH<sub>3</sub>)<sub>3</sub>SiCl  
(3) Cyclic silicone, (CH<sub>3</sub>)<sub>2</sub>SiCl<sub>2</sub> (4) Cyclic silicone, CH<sub>3</sub>SiCl<sub>3</sub>
10. Which of the following is not a property of silicones ?  
(1) They are combustible  
(2) They are water - repellant  
(3) They are polymeric liquids or solids  
(4) Their viscosity does not change significantly with rise in temperature.
11. Tourmalene is a class of cyclosilicates with general formula.  
(Ca, K, Na) (Al, Fe, Li, Mg, Mn)<sub>3</sub> (Al, Cr, Fe, V)<sub>6</sub> (BO<sub>3</sub>)<sub>3</sub> (Si, Al, B)<sub>6</sub>O<sub>18</sub> (OH, F)<sub>4</sub>  
Which of the following is not a correct example of tourmalene ?  
(1) CaAl<sub>3</sub>Fe<sub>6</sub>(BO<sub>3</sub>)<sub>3</sub> Si<sub>6</sub>O<sub>18</sub>F<sub>4</sub> (2) Ca<sub>2</sub>Li<sub>3</sub>V<sub>6</sub>(BO<sub>3</sub>)<sub>3</sub> Si<sub>6</sub>O<sub>18</sub>(OH)<sub>4</sub>  
(3) KMg<sub>3</sub>Cr<sub>6</sub>(BO<sub>3</sub>)<sub>3</sub> Si<sub>6</sub>O<sub>18</sub>(OH)<sub>4</sub> (4) CaAl<sub>9</sub>(BO<sub>3</sub>)<sub>3</sub> Si<sub>6</sub>O<sub>18</sub>(OH)<sub>4</sub>
12. The silicate anion in the mineral kinoite is a chain of three SiO<sub>4</sub> tetrahedra, that share corners with adjacent tetrahedra. The charge of the silicate anion is :  
(1) -4 (2) -8 (3) -6 (4) -2
13. The dehydration of malonic acid CH<sub>2</sub>(COOH)<sub>2</sub> with P<sub>4</sub>O<sub>10</sub> gives :  
(1) carbon monoxide (2) carbon suboxide (3) carbon dioxide (4) all three
14. Borax on heating with cobalt oxide forms a blue bead of :  
(1) Co(BO<sub>2</sub>)<sub>2</sub> (2) CoBO<sub>2</sub> (3) Co<sub>3</sub>(BO<sub>3</sub>)<sub>2</sub> (4) Na<sub>3</sub>Co(BO<sub>3</sub>)<sub>2</sub>
15. The dissolution of Al(OH)<sub>3</sub> by a solution of NaOH results in the formation of :  
(1) [Al(H<sub>2</sub>O)<sub>4</sub>(OH)]<sup>2+</sup> (2) [Al(H<sub>2</sub>O)<sub>2</sub>(OH)<sub>4</sub>]<sup>-</sup> (3) [Al(H<sub>2</sub>O)<sub>3</sub>(OH)<sub>3</sub>] (4) [Al(H<sub>2</sub>O)<sub>6</sub>(OH)<sub>3</sub>]



16. Select the incorrect statement about the boron.
- (1) Pure form of the elements are obtained by the reduction of  $\text{BCl}_3$  with zinc at  $900^\circ\text{C}$ .
  - (2) Crystalline boron is attacked only by hot concentrated oxidising agents.
  - (3) Amorphous boron and ammonia at white heat gives  $(\text{BN})_x$ , a slippery white solid with a layer structure resembling that of graphite.
  - (4) Boron does form  $\text{B}^{3+}$  cation easily.
17. Aqueous solution containing 1 mol of borax reacts with 2 mol of acids. This is because of :
- (1) formation of 2 mol of  $\text{B}(\text{OH})_3$  only
  - (2) formation of 2 mol of  $[\text{B}(\text{OH})_4]^-$  only
  - (3) formation of 1 mol each of  $\text{B}(\text{OH})_3$  and  $[\text{B}(\text{OH})_4]^-$
  - (4) formation of 2 mol each of  $[\text{B}(\text{OH})_4]^-$  and  $\text{B}(\text{OH})_3$ , of which only  $[\text{B}(\text{OH})_4]^-$  reacts with acid
18. Match List I (Fuels) with List II (composition) and select the correct answer using the codes given below the lists :
- | List I (Fuels)   |     |     |     |     | List II (Composition)                                               |     |     |     |     |
|------------------|-----|-----|-----|-----|---------------------------------------------------------------------|-----|-----|-----|-----|
| (1) Water gas    |     |     |     |     | i. A mixture of CO and $\text{N}_2$                                 |     |     |     |     |
| (2) Producer gas |     |     |     |     | ii. Methane                                                         |     |     |     |     |
| (3) Coal gas     |     |     |     |     | iii. A mixture of CO and $\text{H}_2$                               |     |     |     |     |
| (4) Natural gas  |     |     |     |     | iv. A mixture of CO, $\text{H}_2$ , $\text{CH}_4$ and $\text{CO}_2$ |     |     |     |     |
|                  | (1) | (2) | (3) | (4) |                                                                     | (1) | (2) | (3) | (4) |
| (1)              | iii | i   | iv  | ii  | (2)                                                                 | iii | i   | ii  | iv  |
| (3)              | i   | iii | iv  | ii  | (4)                                                                 | iii | ii  | iv  | i   |
19. Water transported through lead pipes becomes poisonous due to the formation of:
- (1)  $\text{PbO}$
  - (2)  $\text{PbO}_2$
  - (3)  $\text{Pb}(\text{OH})_2$
  - (4)  $\text{Pb}_3\text{O}_4$
20. When steam is passed over red hot coke, the outgoing gas contains –
- (1) Producer gas
  - (2) Water gas
  - (3) Coal gas
  - (4) None of the above
21. In  $\text{BF}_3$ , the B-F bond length is  $1.30 \text{ \AA}$ , when  $\text{BF}_3$  is allowed to be treated with  $\text{Me}_3\text{N}$ , it forms an adduct,  $\text{Me}_3\text{N} \rightarrow \text{BF}_3$ . The bond length of B-F in the adduct is :
- (1) Greater than  $1.30 \text{ \AA}$
  - (2) Smaller than  $1.30 \text{ \AA}$
  - (3) Equal to  $1.30 \text{ \AA}$
  - (4) None of these
22. Aluminium is extracted by the electrolysis of :
- (1) alumina
  - (2) bauxite
  - (3) molten cryolite.
  - (4) alumina mixed with molten cryolite
23. A compound of boron X reacts at  $200^\circ\text{C}$  temperature with  $\text{NH}_3$  to give another compound Y which is called as inorganic benzene. The compound Y is a colourless liquid and is highly light sensitive. Its melting point is  $-57^\circ\text{C}$ . The compound X with excess of  $\text{NH}_3$  and at a still higher temperature gives boron nitride  $(\text{BN})_n$ . The compounds X and Y are respectively :
- (1)  $\text{BH}_3$  and  $\text{B}_2\text{H}_6$
  - (2)  $\text{NaBH}_4$  and  $\text{C}_6\text{H}_6$
  - (3)  $\text{B}_2\text{H}_6$  and  $\text{B}_3\text{N}_3\text{H}_6$
  - (4)  $\text{B}_4\text{C}_3$  and  $\text{C}_6\text{H}_6$
24. For given processes, choose the correct order of purity of silicon obtained.
- $\text{SiO}_2 + 2\text{C} \longrightarrow \text{Si} + 2\text{CO}$
  - $\text{Si}(\text{pure}) + 2\text{Cl}_2 \longrightarrow \text{SiCl}_4$   
 $\text{SiCl}_4 + 2\text{Mg} \longrightarrow \text{Si} + \text{MgCl}_2$
  - $\text{Na}_2[\text{SiF}_6] + 4\text{Na} \longrightarrow 6\text{NaF} + \text{Si}$  Zone refined Si
- (1) I > II > III
  - (2) III > II > I
  - (3) I = II = III
  - (4) II > I > III
25. E represents an element belonging to boron family.
- $$2\text{E} + 3\text{X}_2 \longrightarrow 2\text{EX}_3 \quad (\text{X} = \text{F}, \text{Cl}, \text{Br}, \text{I})$$
- (1) Oxidation state of E in all  $\text{EX}_3$  is +3
  - (2) All  $\text{EX}_3$  are predominantly ionic
  - (3) Tl does not form  $\text{TlX}_3$  as  $\text{Tl}^{+1}$  is more stable than  $\text{Tl}^{+3}$
  - (4) There exists some  $\text{EX}_3$  for which E shows +1 oxidation state.



26. ~~26.~~ E represents an element belonging to carbon family.  
 $E + 2X_2 \longrightarrow EX_4$  (X = F, Cl, Br, I)  
 (1) Stability of  $EX_4$  decreases down the 14<sup>th</sup> group  
 (2)  $PbI_4$  does not exist  
 (3) Ge & Pb forms  $EX_2$  as well.  
 (4) All are correct
27. When Al is added to KOH solution  
 (1) No action takes place (2) Oxygen is evolved  
 (3) Water is produced (4) Hydrogen is evolved
28. Which of the following reactions lead to chemical inertness :  
 (1) Lead with dilute  $H_2SO_4$  (2) Lead with conc. HCl  
 (3) Aluminium with oxygen (4) All of above reactions
29. Which of the following statements regarding ortho boric acid ( $H_3BO_3$ ) is false ?  
 (1) It acts as a weak monobasic acid (2) It is soluble in hot water  
 (3) It has a planar structure (4) It acts as a tribasic acid
30. Which of the following is a correct match :  
 I : Potash alum –  $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$   
 II : Chrome alum –  $K_2SO_4 \cdot Cr_2(SO_4)_3 \cdot 24H_2O$   
 III : Potash alum  $K_2SO_4 \cdot Fe_2(SO_4)_3 \cdot 24H_2O$   
 IV : Ammonium alum –  $(NH_4)_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$   
 (1) I, II, III & IV (2) I, II & III (3) I, II & IV (4) Only II & IV

### Practice Test-1 (IIT-JEE (Main Pattern))

#### OBJECTIVE RESPONSE SHEET (ORS)

Que.	1	2	3	4	5	6	7	8	9	10
Ans.										
Que.	11	12	13	14	15	16	17	18	19	20
Ans.										
Que.	21	22	23	24	25	26	27	28	29	30
Ans.										

### PART - II : NATIONAL STANDARD EXAMINATION IN CHEMISTRY (NSEC) STAGE-I

1. Carborundum is the commercial name of : [NSEC-2000]  
 (A)  $H_3PO_4$  (B)  $Ca(H_2PO_4)_2$  (C)  $Al_2O_3$  (D) SiC
2. Which of the following is used in making printer's ink, black varnish and shoe polish ? [NSEC-2000]  
 (A) gas black (B) carbon black (C) bone black (D) lamp black
3. Graphite is used in nuclear reactor : [NSEC-2000]  
 (A) for reducing the speed of neutrons (B) as a fuel  
 (C) as a lubricant  
 (D) for lining the inner surface of the reactor which will work as an insulator.
4. Which Group IIIA element is expected to have physical and chemical properties least similar to other members of that group ? [NSEC-2000]  
 (A) Ga (B) Al (C) B (D) Ln
5. Select the group of oxides that cannot be reduced by carbon to give the respective metals. [NSEC-2000]  
 (A) CaO,  $K_2O$  (B)  $Fe_2O_3$ , ZnO (C)  $Cu_2O$ ,  $K_2O$  (D)  $PbO$ ,  $Fe_2O_3$



6.  $\text{SnCl}_2$  acts as a reducing agent because [NSEC-2003]  
 (A)  $\text{SnCl}_2$  can accept electrons readily (B)  $\text{Sn}^{3+}$  is more stable than  $\text{Sn}^{2+}$   
 (C)  $\text{Sn}^{4+}$  is more stable than  $\text{Sn}^{2+}$  (D)  $\text{Sn}^{2+}$  can be readily converted to metallic tin.
7. The acidic hydroxide is [NSEC-2003]  
 (A)  $\text{Ca}(\text{OH})_2$  (B)  $\text{Al}(\text{OH})_3$  (C)  $\text{B}(\text{OH})_3$  (D)  $\text{TlOH}$ .
8. Carbon dioxide is gaseous, while  $\text{SiO}_2$  is solid because [NSEC-2003]  
 (A)  $\text{CO}_2$  is a linear molecule, while  $\text{SiO}_2$  is an angular one  
 (B) the van der Waal's forces are very strong in  $\text{SiO}_2$   
 (C)  $\text{CO}_2$  is covalent, while  $\text{SiO}_2$  is ionic  
 (D) unlike C, Si cannot form stable bonds with O, hence Si has to form a 3D lattice.
9. The metal that can be extracted from its oxide by reduction with carbon is [NSEC-2003]  
 (A) sodium (B) calcium (C) iron (D) aluminium.
10. Aluminium oxide exists in nature as gems with different colours. The reason for the difference in colour is that [NSEC-2003]  
 (A) the oxidation states of aluminium in these gems are different  
 (B) the extent of crystallinity in these gems is different  
 (C) the Al–O bonding is different in these gem structures  
 (D) there are different transition metal ions present as impurities in these gems.
11. White lead is [NSEC-2004]  
 (A)  $\text{PbCO}_3$  (B)  $\text{PbCO}_3 \cdot \text{PbO}$  (C)  $2\text{PbCO}_3 \cdot \text{Pb}(\text{OH})_2$  (D)  $2\text{PbSO}_4 \cdot \text{PbO}$ .
12. Boron nitride is isoelectronic with [NSEC-2004]  
 (A)  $\text{LiF}$  (B)  $\text{CO}$  (C)  $(\text{CN})^-$  (D)  $\text{AlN}$ .
13. Which of the following carbides on treatment with water evolves methane? [NSEC-2005]  
 (A)  $\text{CaC}_2$  (B)  $\text{Al}_4\text{C}_3$  (C)  $\text{B}_4\text{C}$  (D)  $\text{SiC}$ .
14. In borax bead test, the borax used is  $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ . However, the species that is responsible for the test is [NSEC-2006]  
 (A)  $\text{Na}_3\text{BO}_3$  (B)  $\text{B}_2\text{O}_3$  (C)  $\text{Na}[\text{B}(\text{OH})_4]$  (D)  $\text{Na}[\text{BO}]_4$ .
15. Thallium forms stable chloride,  $\text{TlCl}$ , unlike Aluminum which forms chloride  $\text{AlCl}_3$ . This is because: [NSEC-2007]  
 (A) inert pair effect makes  $\text{Tl}^+$  more stable than  $\text{Tl}^{3+}$   
 (B) Tl is not a group 13 element.  
 (C) Tl–X bond is covalent while Al–Cl bond is ionic.  
 (D) Tl–X bond is ionic while Al–Cl bond is covalent.
16. Silicones are water repelling in nature because- [NSEC-2007]  
 (A) they have highly covalent Si–O–Si linkages.  
 (B) they have organic groups forming hydrophobic exterior.  
 (C) they are polymeric in nature.  
 (D) they have Si–H bonds as in hydrocarbons.
17. The correct balanced chemical equation for the reaction between Al and S is : [NSEC-2009]  
 (A)  $16\text{Al} + 3\text{S}_8 \longrightarrow 8\text{Al}_2\text{S}_3$  (B)  $12\text{Al} + \text{S}_8 \longrightarrow 4\text{Al}_3\text{S}_2$   
 (C)  $8\text{Al} + \text{S}_8 \longrightarrow 8\text{AlS}$  (D)  $4\text{Al} + \text{S}_8 \longrightarrow 4\text{AlS}_2$
18. The silicates formed from  $[\text{SiO}_4]^{4-}$  tetrahedral units by sharing three oxygen atoms are : [NSEC-2009]  
 (A) Sheet silicates (B) Pyrosilicates  
 (C) Linear Chain silicates (D) Three dimensional silicates
19. The change in hybridization of aluminium when  $\text{Al}_2\text{Cl}_6$  decomposes in the gas phase is : [NSEC-2010]  
 (A)  $\text{sp}^2 \rightarrow \text{sp}^3$  (B)  $\text{sp} \rightarrow \text{sp}^2$  (C)  $\text{sp} \rightarrow \text{sp}^3$  (D)  $\text{sp}^3 \rightarrow \text{sp}^2$
20. Pure germanium is an example of- [NSEC-2010]  
 (A) an intrinsic semiconductor (B) a n-type semiconductor  
 (C) a p-type semiconductor (D) a n-p type semiconductor



21. Lead dissolves most readily in dilute (A) acetic acid (B) sulphuric acid (C) phosphoric acid (D) sodium hydroxide [NSEC-2011]
22. The most abundant element in the earth's crust is : (A) aluminium (B) oxygen (C) silicon (D) iron [NSEC-2011]
23. In chlorides, the common oxidation states of aluminium and thallium are +3 and +1 respectively because. [NSEC-2017]  
(A) Tl-Cl bond is ionic and Al-Cl bond is covalent  
(B) 6s electrons of Tl are bound more strongly than the 3s electron of Al  
(C) Tl-Cl bond is stronger than Al-Cl bond  
(D) 3s electrons of Al are bond strongly than the 6s electrons of Tl
24.  $\text{Sn}^{2+}$  compounds like  $\text{SnO}$  and  $\text{SnCl}_2$  are well known reducing agents, while  $\text{PbO}_2$  acts as an oxidizing agent. Which of the following statements support these reactivities? [NSEC-2017]  
I.  $\text{SnO}$  is more stable than  $\text{SnO}_2$  II.  $\text{Sn}^{4+}$  is more stable than  $\text{Sn}^{2+}$   
III.  $\text{Pb}^{4+}$  is more stable than  $\text{Pb}^{2+}$  IV.  $\text{Pb}^{2+}$  is more stable than  $\text{Pb}^{4+}$   
(A) I and III (B) I, III and IV (C) II and IV (D) I, II and IV
25. The gaseous product obtained on reaction of  $\text{BF}_3$  with  $\text{LiH}$  is (A) HF (B)  $\text{H}_2$  (C)  $\text{B}_2\text{H}_6$  (D)  $\text{F}_2$  [NSEC-2018]
26. Which one of the following is *not* used as a monomer for the synthesis of a high molecular weight silicone polymer ? [NSEC-2018]  
(A)  $\text{MeSiCl}_3$  (B)  $\text{Me}_2\text{SiCl}_2$  (C)  $\text{Me}_3\text{SiCl}$  (D)  $\text{PbSiCl}_3$
27. Which of the following is a strong oxidizing agent ? [NSEC-2018]  
(A)  $\text{AlCl}_3$  (B)  $\text{TlCl}_3$  (C)  $\text{NF}_3$  (D)  $\text{PCl}_3$
28. During World War II, soldiers posted at high altitudes experienced crumbling of the tin buttons of their uniforms into a grey powder. This can be attributed to [NSEC-2018]  
(A) oxidation of tin (B) interaction with nitrogen in the air at low pressure  
(C) change in the crystal structure of tin (D) reaction of tin with water vapour in the air

### PART - III : HIGH LEVEL PROBLEMS (HLP)

#### ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

1. Boron can be obtained by :  
(A) reduction of  $\text{B}_2\text{O}_3$  by C.  
(B) reduction of  $\text{BCl}_3$  with  $\text{H}_2$  at 1270 K.  
(C) thermal decomposition of boron halides at 1173 K.  
(D) electrolytic reduction of  $\text{KBF}_4$  in  $\text{KF}$  at 1073 K.
2. Aluminium can be prepared by :  
(A) Electrolytic reduction of alumina in presence of Cryolite & fluorspar.  
(B) Reduction of  $\text{AlCl}_3(\text{s})$  by potassium amalgam.  
(C) Reduction of aqueous solution of  $\text{Al}_2(\text{SO}_4)_3$  (aq) by zinc metal.  
(D) Thermal decomposition of aluminium oxide.
3. Which of the following can produce silicon.  
(A) Reduction of  $\text{SiO}_2$  by carbon (B) Reduction of  $\text{SiO}_2$  by Silicon carbide  
(C) Thermal decomposition of  $\text{SiH}_4$  (D) Thermal decomposition of  $\text{SiC}$
4. Which of the following facts regarding boron and silicon is/are true ?  
(A) Boron is used to make boron steel or boron carbide control rods for nuclear reactor.  
(B) Boron and silicon form halides which are not hydrolysed.  
(C) Boron and silicon react with magnesium to form magnesium boride and magnesium silicide which are decomposed by acids to give volatile borane and silane, respectively.  
(D) Both boron and silicon react with alkali to form borates and silicates containing  $\text{BO}_3^{3-}$  and  $\text{SiO}_4^{4-}$  tetrahedral units, respectively.



5. Which of the following statements are true.  
 (A) Red lead ( $\text{Pb}_3\text{O}_4$ ) is diamagnetic and contains both  $\text{Pb}^{+2}$  and  $\text{Pb}^{+4}$  ions.  
 (B) Both  $\text{PbO}$  and  $\text{PbO}_2$  are amphoteric in nature.  
 (C) Stannate and plumbate ions results in  $\text{SnO}_2$  and  $\text{PbO}_2$  with acidic solution.  
 (D) Concentrated Nitric acid oxidises red lead into lead dioxide.
6. Which is/are incorrect about permutit or zeolite :  
 (A) By it both temporary and permanent hardness of water can not be removed.  
 (B) Its formula is  $\text{Na}_2\text{Al}_2\text{Si}_3\text{O}_8 \cdot x\text{H}_2\text{O}$   
 (C) It softens hard water by exchanging its  $\text{Na}^+$  ions with  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  present in hard water.  
 (D) Exhausted zeolite can be regenerated by passing conc. solution of  $\text{NaCl}$  through it.

## PART - IV : PRACTICE TEST-2 (IIT-JEE (ADVANCED Pattern))

Max. Time : 1 Hr.

Max. Marks : 69

### Important Instructions

#### A. General :

- The test is of 1 hour duration.
- The Test Booklet consists of 23 questions. The maximum marks are 69.

#### B. Question Paper Format

- Each part consists of five sections.
- Section 1 contains 8 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which ONE is correct.
- Section 2 contains 5 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which ONE OR MORE THAN ONE are correct.
- Section 3 contains 6 questions. The answer to each of the questions is a single-digit integer, ranging from 0 to 9 (both inclusive).
- Section 4 contains 1 paragraphs each describing theory, experiment and data etc. 3 questions relate to paragraph. Each question pertaining to a particular passage should have only one correct answer among the four given choices (A), (B), (C) and (D).
- Section 5 contains 1 multiple choice questions. Question has two lists (list-1 : P, Q, R and S; List-2 : 1, 2, 3 and 4). The options for the correct match are provided as (A), (B), (C) and (D) out of which ONLY ONE is correct.

#### C. Marking Scheme

- For each question in Section 1, 4 and 5 you will be awarded 3 marks if you darken the bubble corresponding to the correct answer and zero mark if no bubble is darkened. In all other cases, minus one (– 1) mark will be awarded.
- For each question in Section 2, you will be awarded 3 marks. If you darken all the bubble(s) corresponding to the correct answer(s) and zero mark. If no bubbles are darkened. No negative marks will be answered for incorrect answer in this section.
- For each question in Section 3, you will be awarded 3 marks if you darken only the bubble corresponding to the correct answer and zero mark if no bubble is darkened. No negative marks will be awarded for incorrect answer in this section.

### SECTION-1 : (Only One option correct Type)

This section contains 8 multiple choice questions. Each questions has four choices (A), (B), (C) and (D) out of which Only ONE option is correct.

1. Which of the following statements is false.  
 (A)  $\text{PbO}$ ,  $\text{PbO}_2$  are amphoteric,  $\text{CO}$  is neutral and  $\text{CO}_2$ ,  $\text{SiO}_2$  are acidic.  
 (B) Carbon shows oxidation number from –4 to +4 in its various compounds.  
 (C)  $\text{B}_2\text{O}_3$  is acidic,  $\text{SnO}$  is amphoteric and  $\text{Ga}_2\text{O}_3$ ,  $\text{GeO}_2$  are acidic.  
 (D) Boron is non metal, Ge, Ga are metalloids and Pb, Sn, In are metals.





2. Which of the following are the correct matches :

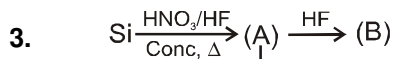
**Mineral**

- (i) Kernite
- (ii) Carbonandum
- (iii) Colemanite
- (iv) Mica
- (v) Carnalite

**Element present**

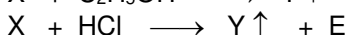
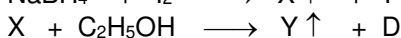
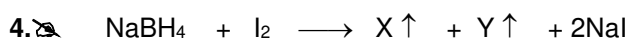
- Boron
- Aluminium
- Calcium
- Silicon
- Boron

- (A) (ii), (i)      (B) (i), (ii), (iv)      (C) (i), (iii), (iv)      (D) none of these



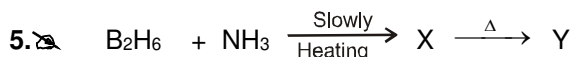
Select the correct option :

- (A) (A) is  $\text{SiF}_4$       (B) (B) is  $\text{H}_2\text{SiF}_6$       (C) (C) is  $\text{H}_4\text{SiO}_4$       (D) All of these



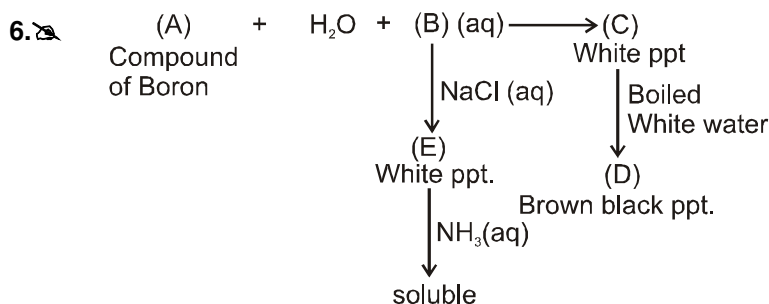
D gives following colour with flame

- (A) Red      (B) Green      (C) Blue      (D) No colour



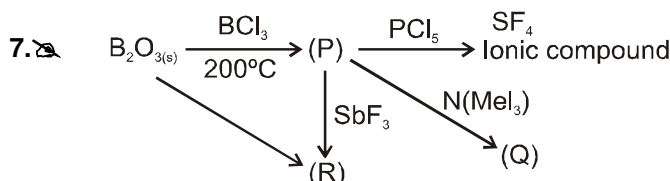
Which of the following around X is correct.

- (A) X is ionic in nature, Hybridisation state of B in both cationic and anionic part is same.  
 (B) X is ionic in nature, hybridisation state of B in cationic and anionic part are different.  
 (C) Y is covalent and hybridisation state of all B is not same.  
 (D) Y is ionic and hybridisation state of all B are same.



(C) & (D) are respectively.

- (A)  $\text{Mn}(\text{BO}_2)_2$ ,  $\text{MnO}_2$       (B)  $\text{AgNO}_2$ ,  $\text{Ag}_2\text{O}$       (C)  $\text{Cu}(\text{BO}_2)_2$ ,  $\text{CuO}$       (D) none of these



Select the correct option ?

- |                             |                        |                                          |
|-----------------------------|------------------------|------------------------------------------|
| (P)                         | (Q)                    | (R)                                      |
| (A) $\text{B}_2\text{Cl}_4$ | $\text{B}_2\text{F}_2$ | $\text{B}_2\text{Cl}_4 (\text{NMe}_3)_2$ |
| (B) $\text{B}_4\text{Cl}_4$ | $\text{B}_2\text{F}_4$ | $\text{B}_2\text{Cl}_4 (\text{MMe}_3)_4$ |
| (C) $\text{B}_2\text{Cl}_4$ | $\text{B}_2\text{F}_4$ | $\text{B}_2\text{Cl}_4 (\text{NMe}_3)_2$ |
| (D) $\text{B}_4\text{Cl}_4$ | $\text{B}_2\text{F}_6$ | $\text{B}_2\text{Cl}_2 (\text{NMe}_3)_2$ |

8. Thortretite,  $\text{Sc}_2\text{Si}_2\text{O}_7$  is :

- (A) a orthosilicate      (B) a pyrosilicate      (C) a sheet silicate      (D) a cyclic silicate




**Section-2 : (One or More than one options correct Type)**

This section contains 5 multipole choice questions. Each questions has four choices (A), (B), (C) and (D) out of which ONE or MORE THAN ONE are correct.

9. Which of the following are the ores of Boron  
(A) Tincal (B) Kernite (C) Colemanite (D) Bauxite
10. When an inorganic compound X having electron deficient bonding (banana bonding) react with ammonia gas at certain temperature gives a compound (Y), isostructural with benzene. Compound (X) with ammonia at a high temperature produces a substance (Z).  
(A) X is  $B_2H_6$  (B) Y is  $B_3N_3H_6$   
(C) Z is hard substance (D) compound X contain 3C-2e and 2C-2e bond.
11. Which of the following statement is/are correct ?  
(A) All III A group elements forms trihalide  
(B) Only Al react directly with  $N_2$  at high temperature and form AlN  
(C) Al Passivated by concentrated  $HNO_3$   
(D) All IV A ( $14^{th}$ ) group elements forms trihalide
12. Which of the following is/are true about silicones.  
(A) Silicones contain repeated  $R_2SiO$  units  
(B)  $RSiCl_3$  gives a complex cross linked silicones  
(C)  $(CH_3)_2SiCl_2$  gives a chain silicone.  
(D) When silicone undergo combustion, it form solid white powder as one of the products.
13. Cation exchanger zeolite  $Na_{12}Al_{12}Si_{17}O_{58} \cdot 27H_2O$  can exchange cation with which of the following in aqueous solution ?  
(A)  $Mg(HCO_3)_2$  (B)  $K_2SO_4$  (C)  $CaCl_2$  (D)  $NH_4NO_3$

**Section-3 : (One Integer Value Correct Type.)**

This section contains 6 questions. Each question, when worked out will result in one integer from 0 to 9 (both inclusive)

14. How many of the following parameters/properties are greater for diamond as compared to graphite? Density, Electrical resistivity, Thermal conductivity, Stability, % s-character for hybridised orbitals, Hardness, Bond angle, C-C (bond length), Standard enthalpy of formation.
15.  $Na_2B_4O_7 \xrightarrow{\Delta} NaBO_2 + B_2O_3$   
 $NaBO_2 + H_2O_2 + H_2O \longrightarrow \text{compound A(aq)}$   
The compound A the sum of oxidation states of all the oxygen atoms is X. Then the value of |X| is
16. A Boron mineral have pentaborate anion whose molecular formula is  $[B_5O_6(OH)_4]^-$ . The number of B-O-B linkage present are.....
17. Consider the following sequence of reactions :  
 $B_2O_3 + CaF_2 + H_2SO_4 \longrightarrow (A) + (B) + H_2O$   
 $(A) + LiAlH_4 \longrightarrow (C)(g) + (D) + LiF$   
 $(C) + H_2O \xrightarrow{\Delta} (D) + H_2\uparrow$   
 $(D) + Na_2CO_3 \longrightarrow (E) + NaBO_2 + CO_2\uparrow$   
 $(E) + NH_4Cl \longrightarrow (F) + B_2O_3 + NaCl + H_2O$   
What is the empirical formula mass of compound (F) ?
18. How many of the following statement are correct ?  
(1)  $CF_4$  can be prepared by reaction between SiC and  $F_2$ .  
(2) In  $SiF_4$  Si-F observed bond length is shorter than actual Si-F bond length  
(3)  $(C_2F_4)_n$  is known as PTFE.  
(4)  $CCl_4$  react with Anhydrous HF, gives Chloro Fluoro carbon ( $CCl_2F_2$ )  
(5)  $CCl_4$  can hydrolysis under super heating condition.  
(6) Hydrolysis of  $SiF_4$  is not complete of  $SiF_4$  is partially hydrolysis.



19. How many of the following may react with  $\text{SiCl}_4$  to produce a non-polar product ?  
 $\text{NaH}$ ,  $\text{CH}_3\text{MgCl}$ ,  $\text{H}_2\text{O}$ ,  $\text{LiAlH}_4$ ,  $\text{H}_2\text{SO}_4(\text{l})$ ,  $\text{NH}_3$ ,  $\text{Be}$

#### SECTION-4 : Comprehension Type (Only One options correct)

This section contains 1 paragraphs, each describing theory, experiments, data etc. 3 questions relate to the paragraph. Each question has only one correct answer among the four given options (A), (B), (C) and (D)

#### Paragraph For Questions 20 to 22

- (i)  $\text{P} + \text{C}(\text{carbon}) + \text{Cl}_2 \longrightarrow \text{Q} + \text{CO}\uparrow$  (ii)  $\text{Q} + \text{H}_2\text{O} \longrightarrow \text{R} + \text{HCl}$   
 (iii)  $\text{BN} + \text{H}_2\text{O} \longrightarrow \text{R} + \text{NH}_3\uparrow$  (iv)  $\text{Q} + \text{LiAlH}_4 \longrightarrow \text{S} + \text{LiCl} + \text{AlCl}_3$   
 (v)  $\text{S} + \text{H}_2 \longrightarrow \text{R} + \text{H}_2\uparrow$  (vi)  $\text{S} + \text{NaH} \longrightarrow \text{T}$   
 (P, Q, R, S and T do not represent their chemical symbols)

20. Compound Q has :  
 (I) zero dipole moment (II) a planar trigonal structure  
 (III) an electron deficient compound (IV) a Lewis base  
 Choose the correct code  
 (A) I, IV (B) I, II, IV (C) I, II, III (D) I, II, III, IV
21. Compound T is used as a/an :  
 (A) oxidising agent (B) complexing agent (C) bleaching agent (D) reducing agent
22. Compound S is :  
 (I) an odd- $e^-$  compound (II)  $(2C - 3e^-)$   
 (III) an electron deficient compound (IV) a  $\text{sp}^2$  hybridized compound  
 Choose the correct code :  
 (A) III (B) I, III (C) II, III, IV (D) I, II, IV

#### SECTION-5 : Matching List Type (Only One options correct)

This section contains 1 questions, each having two matching lists. Choices for the correct combination of elements from List-I and List-II are given as options (A), (B), (C) and (D) out of which one is correct

23. Choose the correct match :

	Silicates		Number of oxygen atoms shared per tetrahedron
(a)	Ortho silicate	(p)	4
(b)	Pyro silicate	(q)	1
(c)	Cyclic silicate	(r)	0
(d)	3-D silicate	(s)	2

- (A) a - p, b - q, c - r, d - s (B) a - r, b - q, c - s, d - p  
 (C) a - s, b - r, c - q, d - p (D) a - r, b - s, c - q, d - p

### Practice Test-2 ( IIT-JEE (ADVANCED Pattern))

#### OBJECTIVE RESPONSE SHEET (ORS)

Que.	1	2	3	4	5	6	7	8	9	10
Ans.										
Que.	11	12	13	14	15	16	17	18	19	20
Ans.										
Que.	21	22	23							
Ans.										



# APSP Answers

## PART - I

1.	(2)	2.	(4)	3.	(1)	4.	(3)	5.	(3)
6.	(4)	7.	(3)	8.	(2)	9.	(3)	10.	(1)
11.	(1)	12.	(2)	13.	(2)	14.	(1)	15.	(2)
16.	(4)	17.	(4)	18.	(1)	19.	(3)	20.	(2)
21.	(1)	22.	(4)	23.	(3)	24.	(2)	25.	(4)
26.	(4)	27.	(4)	28.	(4)	29.	(4)	30.	(3)

## PART - II

1.	(D)	2.	(B)	3.	(A)	4.	(C)	5.	(A)
6.	(C)	7.	(C)	8.	(D)	9.	(C)	10.	(D)
11.	(C)	12.	(A)	13.	(B)	14.	(D)	15.	(A)
16.	(B)	17.	(A)	18.	(A)	19.	(D)	20.	(A)
21.	(A)	22.	(B)	23.	(B)	24.	(C)	25.	(C)
26.	(C)	27.	(B)	28.	(C)				

## PART - III

1.	(BCD)	2.	(AB)	3.	(ABC)	4.	(ACD)	5.	(ABC)
6.	(AB)								

## PART - IV

1.	(C)	2.	(C)	3.	(D)	4.	(B)	5.	(A)
6.	(B)	7.	(C)	8.	(B)	9.	(ABC)	10.	(ABCD)
11.	(ABC)	12.	(ABCD)	13.	(AC)	14.	6	15.	24
16.	6	17.	25	18.	6	19.	4	20.	(C)
21.	(D)	22.	(A)	23.	(B)				



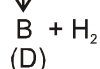
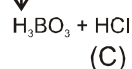
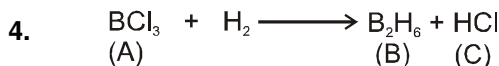


# APSP Solutions

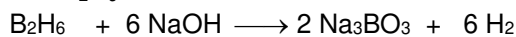
## PART - I

1. The EN values of Carbon family are :

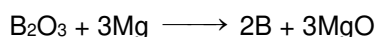
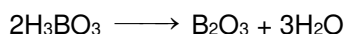
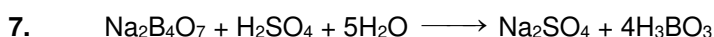
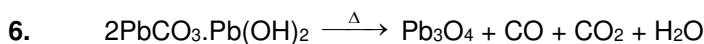
Element	C	Si	Ge	Sn	Pb
EN	2.5	1.8	1.8	1.8	1.9



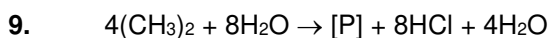
5. A is  $\text{B}_2\text{H}_6$



B is  $\text{Na}_3\text{BO}_3$  a salt of SBWA.



8. Being containing one halogen atom it is utilized for terminating the chain.



10. It is a fact.

11. You are not expected to have a prior knowledge of tourmaline. It is simply a common-sense based question based on adding all the charges.

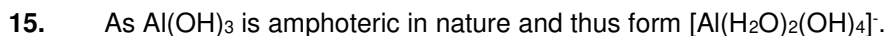
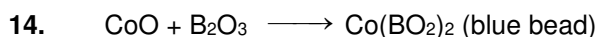
(1)  $+2 + 3 \times 3 + x \times 6 - 3 \times 3 + 4 \times 6 - 2 \times 18 - 1 \times 4 = 6 \times -14 \neq 0$  for  $x = +2$  or  $+3$  (possible on Fe)

(2)  $+2 \times 2 + 1 \times 3 + 3 \times 6 - 3 \times 3 + 6 \times 4 - 18 \times 2 - 1 \times 4 = 0$

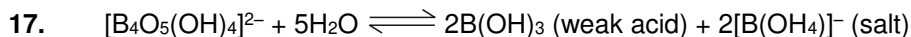
It fits, so it is possible

(3)  $+1 \times 1 + 2 \times 3 + 3 \times 6 - 3 \times 3 + 4 \times 6 - 2 \times 18 - 1 \times 4 = 0$

(4)  $+2 \times 1 + 9 \times 3 - 3 \times 3 + 6 \times 4 - 2 \times 18 - 1 \times 4 = 0$

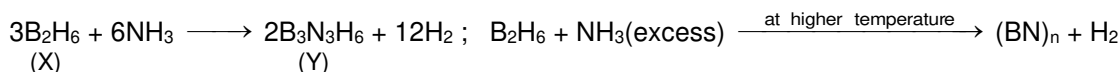


16. Due to small size of boron, the sum of its first three ionization enthalpies is very high. This prevents it to form  $+3$  ions.



22. Alumina is mixed with cryolite, in molten state which make alumina good conductor and lowers the fusion temperature also.

23. The reactions involved are



Y is borazole which is isosteric with benzene.





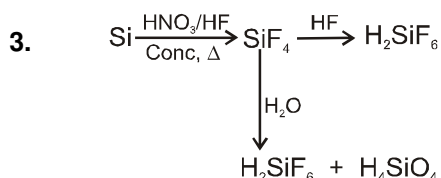
28. (1)  $\text{Pb} + \text{H}_2\text{SO}_4 \longrightarrow \text{PbSO}_4 (\text{layer}) + \text{H}_2 \uparrow$   
 (2)  $\text{Pb} + \text{Conc. HCl} \longrightarrow \text{PbCl}_2 (\text{Coating}) + \text{H}_2 \uparrow$   
 (3)  $2\text{Al} + 3/2 \text{O}_2 \longrightarrow \text{Al}_2\text{O}_3 (\text{s})$
29.  $\text{B}(\text{OH})_3 + 2\text{HOH} \rightleftharpoons [\text{B}(\text{OH})_4]^- + \text{H}_3\text{O}^+$ .  
 In aqueous solution the boron completes its octet by accepting  $\text{OH}^-$  from water molecules. It therefore function as a weak monobasic lewis acid.

### PART - III

1. (B)  $2\text{BCl}_3 + 3\text{H}_2 \xrightarrow{1270 \text{ K}} 2\text{B} + 6\text{HCl}$   
 (C)  $2\text{BCl}_3 \xrightarrow{1173 \text{ K}} \text{B} + 3\text{Cl}_2$   
 (D)  $\text{K}^+ [\text{BF}_4]^- \xrightleftharpoons{1073 \text{ K}} \text{K}^+ + [\text{BF}_4]^-$   
 $[\text{BF}_4]^- + \text{e}^- \longrightarrow \text{B} + 2\text{F}_2$  (At anode)  
 $\text{K}^+ + \text{e}^- \longrightarrow \text{K}$  (At cathode)
3.  $\text{SiO}_2 + 2 \text{C} \xrightarrow{\Delta} \text{Si} + 2 \text{CO} \uparrow$   
 $\text{SiO}_2 + \text{SiC} \xrightarrow{\Delta} \text{Si} + 2 \text{CO} \uparrow$   
 $\text{SiH}_4 \xrightarrow{\Delta} \text{Si} + 2 \text{H}_2 \uparrow$
4. (B)  $\text{BCl}_3 + 3\text{H}_2\text{O} \xrightarrow{\text{Hydrolysis}} \text{H}_3\text{BO}_3 + 3\text{HCl}$  ;  $\text{SiCl}_4 + 3\text{H}_2\text{O} \xrightarrow{\text{Hydrolysis}} \text{H}_2\text{SiO}_3 + 4\text{HCl}$   
 (C)  $\text{B} + \text{Mg} \longrightarrow \text{Mg}_3\text{B}_2 + \text{H}_3\text{PO}_4 \longrightarrow \text{Mix of boranes} \xrightarrow{\Delta} \text{B}_2\text{H}_6$   
 (D)  $2\text{B} + 6\text{NaOH} \longrightarrow 2\text{Na}_3\text{BO}_3 + 3\text{H}_2$  ;  $\text{Si} + 4\text{NaOH} \longrightarrow \text{Na}_4\text{SiO}_4 + 2\text{H}_2$
6. (A) Both hardness can be removed by it.  
 (B) Zeolite :  $\text{Na}_2\text{Al}_2\text{Si}_2\text{O}_8 \cdot x\text{H}_2\text{O}$

### PART - IV

1. Statements (A), (B), (D) are true.  
 Statement (C)  $\text{SnO}_2$  is amphoteric,  $\text{Ga}_2\text{O}_3$  is amphoteric.



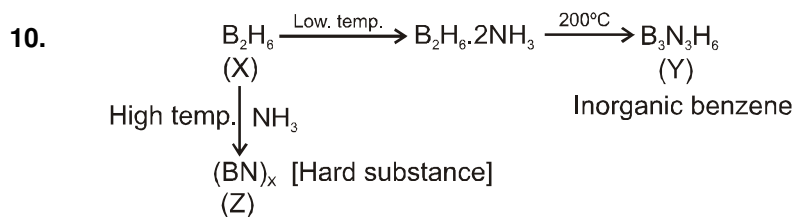
4. X :  $\text{B}_2\text{H}_6$                       Y :  $\text{H}_2$   
 $\text{NaBH}_4 + \text{I}_2 \longrightarrow \text{B}_2\text{H}_6 \uparrow + \text{H}_2 \uparrow + 2\text{NaI}$   
 $\text{B}_2\text{H}_6 + \text{C}_2\text{H}_5\text{OH} \longrightarrow \text{H}_2 \uparrow + \text{B}(\text{OC}_2\text{H}_5)_3$   
 $\text{B}_2\text{H}_6 + \text{HCl} \longrightarrow \text{H}_2 \uparrow + \text{B}_2\text{H}_5\text{Cl}$
5.  $\text{B}_2\text{X}_6 + 2\text{NH}_3 \longrightarrow [\text{H}_3\text{N} \rightarrow \overset{+}{\text{B}}\text{H}_2 \leftarrow \text{NH}_3] [\text{BH}_4]^-$   
 $\downarrow \Delta$   
 $\text{B}_3\text{N}_3\text{H}_6$   
 x  
 y

In X hybridisation state of both B is  $\text{sp}^3$ .

6.  $\text{Na}_2\text{B}_4\text{O}_7 + \text{AgNO}_3 (\text{aq}) + \text{H}_2\text{O} \longrightarrow \text{AgBO}_2 \downarrow + \text{NaNO}_3 + \text{H}_3\text{BO}_3 \xrightarrow{\text{Boiled with water}} \text{Ag}_2\text{O} \downarrow + \text{H}_3\text{BO}_3$
8.  $\text{Sc}_2\text{Si}_2\text{O}_7$  contains  $\text{Si}_2\text{O}_7^{6-}$  units



9. Borax or Tincol :  $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$  Kernite :  $\text{Na}_2\text{B}_4\text{O}_7 \cdot 4\text{H}_2\text{O}$   
Colemanite :  $\text{Ca}_2\text{B}_6\text{O}_{11}$  Bauxite :  $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$

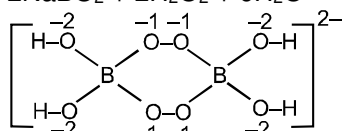
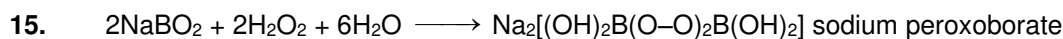


11. (A) All 13th group elements forms trihalide even  $\text{Ti}^+$  as  $\text{TiI}_3$   $\text{BX}_3$   $\text{AlCl}_3$ ,  $\text{GaCl}_3$   $\text{InCl}_3$   $\text{Ti}^+$  ( $\text{I}_3$ )<sup>-</sup> tri iodide ion.  
(B) At high temperature only Al react directly with  $\text{N}_2$  and gives  $\text{AlN}$   
(C) Conc.  $\text{HNO}_3$  is oxidising agent, It forms an oxide layers on Al surface, this makes Al passive towards conc.  $\text{HNO}_3$ .  
(D) Except Pb, all 14<sup>th</sup> group element forms  $\text{MX}_4$  tetrahalides.

12. Combustion of silicone produces solid silica.

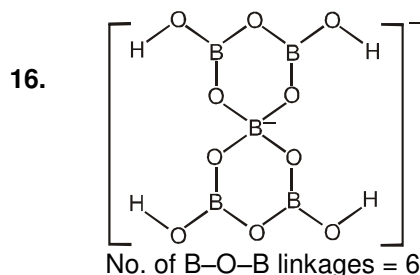
13. Zeolites can exchange cation to release more soluble cation in aqueous solution.

14. Density, Electrical resistivity, Thermal conductivity, Hardness, C – C (bond length),  $\Delta H_f^\circ$ .

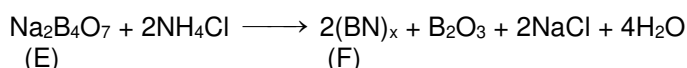
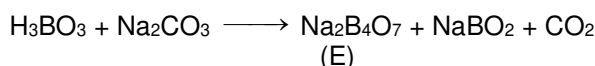
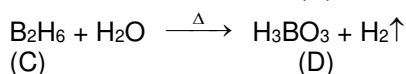
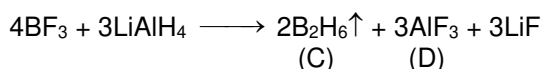
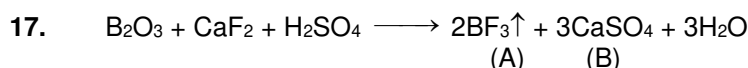


$$X = [(-2) \times 4 + (-1) \times 4] = -12$$

$$\text{Hence } |X| = 12$$



No. of B–O–B linkages = 6



Empirical formula mass of BN = 10.8 + 14 = 24.8  $\approx$  25

18. (1)  $\text{SiC} + \text{F}_2 \rightarrow \text{SiF}_4 + \text{CF}_4$  (2) Because of  $d\pi-p\pi$  back bonding in  $\text{SiF}_4$ .  
(3) PTFE = Poly tetra fluoro ethane (4)  $\text{CCl}_4 + \text{HF} \rightarrow \text{CCl}_2\text{F}_2 + \text{HCl}$   
(5)  $\text{CCl}_4 \xrightarrow[\text{Super heating (steam)}]{+\text{H}_2\text{O}} \text{COCl}_2 + \text{HCl}$   
(6)  $\text{SiF}_4 + \text{F}^- \rightarrow [\text{SiF}_6]^{-2}$  ( $\text{F}^-$  form in 1<sup>st</sup> stage hydrolysis of  $\text{SiF}_4$ )



19.  $4\text{NaH} + \text{SiCl}_4 \longrightarrow 4\text{NaCl} + \text{SiH}_4 \uparrow$  (non-polar)  
 $\text{CH}_3\text{MgCl} + \text{SiCl}_4 \longrightarrow \text{MgCl}_2 + \text{Si}(\text{CH}_3)_4$  (non-polar)  
 $3\text{H}_2\text{O} + \text{SiCl}_4 \longrightarrow \text{H}_2\text{SiO}_3 + 4\text{HCl}$   
 $\text{LiAlH}_4 + \text{SiCl}_4 \longrightarrow \text{LiCl} + \text{AlCl}_3 + \text{SiH}_4$  (non-polar)  
 $\text{H}_2\text{SO}_4(\ell) + \text{SiCl}_4 \longrightarrow$  no reaction  
 $\text{NH}_3 + \text{SiCl}_4 \longrightarrow$  Polymeric substance  
 $2\text{Be} + \text{SiCl}_4 \longrightarrow 2\text{BeCl}_2 + \text{Si}$  (non-polar)

(20 to 22)

- (i)  $\text{B}_2\text{O}_3$  (P) +  $3\text{C} + 3\text{Cl}_2 \longrightarrow 2\text{BCl}_3$  (Q) +  $3\text{CO} \uparrow$   
(ii)  $\text{BCl}_3$  (Q) +  $3\text{H}_2\text{O} \longrightarrow \text{H}_3\text{BO}_3$  (R) +  $3\text{HCl}$   
(iii)  $\text{BN} + 3\text{H}_2\text{O} \longrightarrow \text{H}_3\text{BO}_3$  (R) +  $\text{NH}_3$   
(iv)  $4\text{BCl}_3$  (Q) +  $3\text{LiAlH}_4 \longrightarrow 2\text{B}_2\text{H}_6$  (S) +  $3\text{LiCl} + 3\text{AlCl}_3$   
(v)  $\text{B}_2\text{H}_6 + 6\text{H}_2\text{O} \longrightarrow 2\text{H}_3\text{BO}_3$  (R) +  $6\text{H}_2 \uparrow$   
(v)  $\text{B}_2\text{H}_6$  (S) +  $2\text{NaH} \longrightarrow 2\text{NaBH}_4$  (T)