TOPIC : p-BLOCK ELEMENTS (BORON & CARBON FAMILY) EXERCISE # 1

SECTION (A)

- 1. If is fact.
- 2. Because of their weak metallic bond.
- **3.** Down the group the lower oxidation state of element becomes more stable on account of inert pair effect. Hence the compounds of thallium with +1 oxidation states are stable as compared to +3 oxidation state (i.e.) group valency.
- **4.** Down the group the lower oxidation state of element becomes more stable on account of inert pair effect. Hence the compounds of thallium with +1 oxidation states are stable as compared to +3 oxidation state (i.e.) group valency.
- 5 In the solid state, the B(OH)₃ units are hydrogen bonded together in to two dimensional sheets with almost hexagonal symmetry.



- 6. AICl₃ is covalent when it is anhydrous on account of higher polarising power of Al₃₊.
- 7. Al_2O_3 reacts with alkalis as well as acids forming salts.
- 8. BCl₃ and AlCl₃ are electron deficient compounds because they have six electrons in their valence shells. Hence they act as Lewis acid. Al₃₊ is larger than B₃₊. This leads to poor $p\pi$ – $p\pi$ back bonding in AlCl₃ than BCl₃ and thus BCl₃ is stronger Lewis acid than AlCl₃.
- **9.** Boron trioxide is acidic oxide.
- **10.** It has coordination number six $(AICI_3.6H_2O \text{ or } [AI(H_2O)_6]CI_3)$.
- **11.** GeO₂ is acidic while SnO₂ is amphoteric in nature.

SECTION (B)

- 1. $Na_2B_4O_7 + 5H_2O + H_2SO_4 \rightarrow Na_2SO_4 + 4H_3BO_3$
- 3. BBT gives some transition metal ion eq \rightarrow Mn₊₂, Fe₊₂, Mi₊₂, Co₊₂, Cu₊₂ Eh
- **4.** Cobalt meta borate is a blue coloured bead.

CHEMISTRY FOR NEET

- **5.** These are the uses of borax.
- **6.** CH₃ group being larger can not form a bridge between two small sized boron atoms.
- 7. $B_2H_6 + 6H_2O \rightarrow 2H_3BO_3 + 6H_2$
- 8. $2AI + 2NaOH + 6H_2O \rightarrow 2Na[AI(OH)_4] + 3H_2.$
- 9. Alum is not used as an insecticide and rest all are uses of alum.
- **10.** As boron completes it octet by accepting OH₋ from water molecule. Hence it acts as a Lewis acid.
- **11.** Borax contains tetranuclear units [B₄O₅(OH)₄]₂₋.
- **12.** $[B_4O_5(OH)_4]_{2-} + 5H_2O \longrightarrow 2B(OH)_3 + 2[B(OH)_4]_$ or $[B_4O_7]_{2-} + 7H_2O \longrightarrow 2B(OH)_3 + 2[B(OH)_4]_-$
- **13.** CuO + $B_2O_3 \rightarrow Cu(BO_2)_2$ (blue bead) Copper (II) metaborate
- **14.** BCl₃ + $3H_2O \rightarrow B(OH)_3 + 3HCl$
- 16. It is factual.
- **17.** Alumina is Al₂O₃ which is amphoteric oxide because it dissolves in acids as well as alkalies forming soluble salts.
- **18.** Aluminium oxide is not reduced by chemical reactions since aluminium oxide is highly stable on account of high lattice energy.

SECTION (C)

- 1. Ultrapure Si and Ge are used as semiconductor.
- 2. Inert pair effect increases from Si to Pb and thus stability of M₄₊ ions decreases from Si to Pb.
- 3. C-C = 83 kcal / mol ; Si-Si = 54 kcal / mol ; Ge-Ge = 40 kcal / mol ; Sn-Sn = 37 kcal / mol.
- **4.** Carbon differs from rest of the members of its group in chemical and physical properties due to its smaller size, higher electronegativity, higher ionisation enthalpy and unavailability of d orbitals.
- **5.** They have valence shell electron configuration ns₂ np₂; so two electrons of p sub shell or four electrons of s and p sub shells can participate in chemical bonding.
- 6. The ability of a substance to assume two or more crystalline structures is called polymorphism.
- 7. 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. The order of catenation is C >> Si > Ge \approx Sn.

Bond	Bond enthalpy (kJ mol₋ı)
C—C	348
Si—Si	297
Ge—Ge	260
Sn—Sn	240

- 8. Silicon is an important constituent of rocks as silicates.
- **9.** Carbon exhibits many allotropic forms; both crystalline as well as amorphous. Diamond and graphite are two well-known crystalline allotropes of carbon as differ in their crystal structures and physical properties.
- **10.** Pb, C and Ge are uneffected by water.

- **11.** SiO₂ is acidic because it reacts with basic oxide like CaO forming salt. CaO + SiO₂ \rightarrow CaSiO₃.
- **12.** Moving down the group with increasing atomic number, the oxidation state two less than the highest group oxidation state becomes more stable in groups 14 due to inert pair effect.
- 13. The common oxidation states exhibited by the elements of 14th group are +4 and +2. In heavier members the tendency to show +2 oxidation state increases in the sequence Ge < Sn < Pb. It is due to the inability of ns₂ electrons of valence shell to participate in bonding (inert pair effect). As a consequence of inert pair effect, the stable oxidation state of Pb is +2 and thus the compounds of Pb(IV) have the tendency to oxidise the compounds and reduced ourselves to Pb(II).
- **14.** C₆₀ molecule has a shape like soccer ball and called Buckminsterfullerene



The structure of C60, Buckminster–fullerene

- **15.** Steric repulsion of large chloride ion increases the energy of the molecule.
- **16.** Graphite has layered structure. Layers are held by van der Waals forces. Each layer is composed of planar hexagonal rings of carbon atoms. Each carbon atom in hexagonal ring undergoes sp₂ hybridisation and makes three sigma bonds with three neighbouring carbon atoms. Fourth electron forms a π bond. The electrons are delocalised over the whole sheet.
- 17. It is a bad conductor of heat because it does not have free π electrons.

SECTION (D)

7.

- **1.** Carbon monoxide is a neutral oxide, it reacts neither with acids nor bases.
- 2. Carbon monoxide burns with a blue flame.
- **3.** $2 C (s) + O_2(g) + 4 N_2(g) \xrightarrow{1273 K} 2 CO (g) + 4 N_2(g) (Producer gas).$
- 4. Mixture of CO and N₂ obtained by passing air over red hot coke is called producer gas.
- 5. SiO₂ + 6HF \rightarrow H₂SiF₆ + 2H₂O.
- **6.** Si + NaOH (hot) \rightarrow Na₄[SiO₄] (silicate)



- 8. Quartz is a crystalline variety of silica (SiO₂).
- 9. $K_4 [Fe(CN)_6] + 6H_2SO_4 + 6H_2O \longrightarrow 2K_2SO_4 + FeSO_4 + 3(NH_4)_2SO_4 + 6CO$

- **10.** $CO + Cl_2 \xrightarrow{hv} COCl_2$
- **11.** $CO_2(g) + H_2O(I) \longrightarrow H_2CO_3(aq)$; $H_2CO_3 \longrightarrow H_4(aq) + HCO_{3-}(aq)$; $HCO_{3-} \longrightarrow H_4(aq) + CO_{32-}(aq)$.
- **12.** In such silicates, three oxygen atoms of each tetrahedral are shared with adjacent SiO₄₄₋ tetrahedrals. Such sharing forms two dimension sheet structure with general formula (Si₂O₅)_{n2n-}
- **13.** If two oxygen atoms per tetrahedron are shared to form closed rings such that the structure with general formula (SiO₃₂₋)ⁿ or (SiO₃)_{n2n-} is obtained, the silicates containing these anions are called cyclic silicates. Si₃O₉₆₋ and Si₆O₁₈₁₂₋ anions are the typical examples of cyclic silicates.



14. Glass and cement are man-made silicates.

EXERCISE # 2

- **1.** ΔH_{IE(l)} In kJ/mole : B = 801, AI = 577; Ga = 579; In = 558; TI = 589
- 2. Down the group, due to poor shielding, effective nuclear charge holds ns electrons tightly (responsible for inert pair effect) and thereby, restricting their participation in bonding. As a result of this only p-orbital electron may be involved in bonding. The relative stability of + 1 oxidation state progressively increases for heavier elements: Al < Ga < In < Tl. In thallium +1 oxidation state is predominant and + 3 oxidation state is highly oxidising in character.</p>
- **3.** Poor shielding of d- and f-orbital increases the effective nuclear charge down the group and this increased nuclear charge holds ns electrons tightly. Thus only p-orbitals participate in chemical bonding and not s-orbital. This is called inert pair effect.
- 4. Down the group, due to poor shielding, effective nuclear charge holds ns electrons tightly (responsible for inert pair effect) and thereby restricting their participation in bonding. As a result of this, only p-orbital electron may be involved in bonding. The relative stability of + 1 oxidation state progressively increases for heavier elements : Al < Ga < In < Tl. In thallium, +1 oxidation state is predominant and + 3 oxidation state is highly oxidising in character.</p>
- 5. Being electro positive in nature, it is used as reducing agent in many metallurgical procsses.

$$Cr_2O_3 + AI \xrightarrow{a} Cr + Al_2O_3$$

- **6.** Na₂CO₃ + H₂O \rightarrow 2NaOH + CO₂ ; 4OH₋ + Al \rightarrow [Al(OH)₄]- (soluble complex)
- **7.** Aluminium is more reactive than iron. But aluminium is less easily corroded than iron because oxygen forms a protective oxide layer on aluminium surface.
- **8.** In TII₃, TI₃₊ is highly oxidising in character and I₋ is highly reducing in nature.
- **9.** [B₄O₅(OH)₄]₂₋ + 5H₂O = 2B(OH)₃ (weak acid) + 2[B(OH₄)]₋ (salt)

10. It is a weak monobasic acid and in aqueous solution the boron atom completes its octet by accepting OH₋ from water molecules:

 $B(OH)_3(aq) + 2H_2O(I) = [B(OH)_4]_-(aq) + H_3O_+(aq).$ pK = 9.25. It, therefore, functions as a Lewis acid and not as a proton donor like most acids.

11. In the solid state, the B(OH)₃ units are hydrogen bonded together into two dimensional sheets with almost hexagonal symmetry.



12. H₃BO₃ (aq) + H₂O (ℓ) [B(OH)₄]- (aq) + H₊ (aq)



- **14.** Al₂O₃ is amphoteric oxide because it dissolves in acids as well as alkalies forming soluble salts.
- **15.** (1) boron trioxide acidic oxide.

13.

- (2) Al₂O₃ and Ga₂O₃ amphoteric oxide.
- (3) In_2O_3 and Tl_2O_3 basic oxides.
- **16.** BH_3 being electron deficient dimerises to B_2H_6 .
- **17.** Acidic strength of Boron trihalide increases in the order of $BF_3 < BCI_3 < BBr_3 < BI_3$ as from F(2p) to I(5p), the energy level difference between boron and halides increases and thus $p\pi$ - $p\pi$ back bonding becomes less effective.



Hence basic due to formation of NaOH which is a stronger base.

CHEMISTRY FOR NEET

Excess NH,

22. B₂H₆ + 2NH₃ low harpenature B₂H₆.2NH₃ or [H₂B(NH₃)₂]₊ [BH₄]₋ (ionic compound).

- **23.** Borazine, B₃N₃H₆ is known as "inorganic benzene" in view of its ring structure with alternate BH and NH groups.
- **24.** As $AI(OH)_3$ is amphoteric in nature and thus form $[AI(H_2O)_2(OH)_4]_-$.

25.

34.

 S_1 : C_1 C_1 C_2 C_1 in solid state; C_1 C_1 C_1 in vapour state; C_1 C_2 C_1 in vapour state;

 $\mathbf{S}_2: \mathsf{B}(\mathsf{OH})_3 + 2\mathsf{H}_2\mathsf{O} \longrightarrow [\mathsf{B}(\mathsf{OH})_4]_- + \mathsf{H}_3\mathsf{O}_+$

- **S**₃ : Na₂B₄O₇ + H₂SO₄ + 5H₂O \rightarrow Na₂SO₄ + 4H₃BO₃
- **26.** Coal gas contains H₂, saturated and unsaturated hydrocarbons, CO, CO₂, N₂ and O₂.
- **27.** (1) and (2) are correct statements.
- **28.** Only tin decomposes the steam to form SnO₂ and H₂.

 $Sn + 2H_2O \longrightarrow SnO_2 + 2H_2$

- 29. Iodine and bromine are unable to oxidise Pb to Pb₄₊. On account of inert pair effect the stable oxidation state of Pb is +2. So Pb₄₊ acts as oxidising agent and oxidises I₋ and Br₋ to I₂ and Br₂ respectively and itself reduced to Pb₂₊.
- **30.** Silicon and diamond have similar crystal structure.

31.
$$C(s) + H_2O(g) \xrightarrow{d} CO(g) + H_2(g)$$
; $2C(s) + O_2 + N_2 \xrightarrow{d} 2CO + 4N_2$

- **32.** Ni + 4CO ^{25*C} > [Ni(CO)₄] volatile compound.
- **33.** Three oxygen atoms of each SiO₄₄- tetrahedra are shared with adjacent SiO₄₄- tetrahedra. Such sharing forms two dimension sheet structure with general formula (Si₂O₅)_{n2n}-.



In this manner several molecules may combine to form a long chain polymer i.e. linear polymer.

35. As chain can grow in three places as





37.

- **38.** SiF₄ gets hydrolysed giving Si(OH)₄. SiF₄ + 4H₂O \longrightarrow Si(OH)₄ + 4HF.
- **39.** SiCl₄ + 4H₂O \rightarrow H₄SiO₄ + 4HCl
- **40.** Carbide of silicon is called carborundum.

EXERCISE # 3

PART - I

 A bond length is the average distance between the centres of nuclei of two bonded atoms. A multiple bond (double or triple bond) always shorter than the corresponding single bond. The C-atom in CO₃₂₋ is sp₂-hybridised as shown

The C-atom in CO₂ is sp-hybridised with bond distance carbon oxygen is 122 pm.

 $O=C=O \iff +O \equiv C - \stackrel{\bigcirc}{\Box} \iff \stackrel{\bigcirc}{\Box} -C \equiv +O$ The C-atom in CO is sp-hybridised with C–O bond distance is 110 pm. $:C\equiv O^{*}:$ So, the correct order is $CO < CO_{2} < CO_{32-}$

- **2.** In peroxides, the oxidation state of O is -1 and they give H₂O₂, with dilute acids, and have peroxide linkage.
- 3. As the size of halogen atom increases, the acidic strength of boron halides increases. Thus, BF₃ is the weakest Lewis acid. This is because of the pπ pπ back bonding between the fully-filled unutilised 3p orbitals of F and vacant 2p orbitals of boron which makes BF₃ less electron deficient. Such back donation is not possible in case of BCl₃ or BBr₃ due to larger energy difference between their orbitals. Thus, these are more electron deficient. Since on moving down the group the energy difference increases, the Lewis the acid character also increases. Thus, the tendency to behave as Lewis acid follows the order BBr₃ > BCl₃ > BF₃
- **4.** BF₄₋ hybridisation sp₃, tetrahedral structure. NH₄₊ hybridisation sp₃, tetrahedral structure.

5.t≥ (BH₃)₂ or (B₂H₆)

It contains two 3 centre-2 electron bonds.

6. SO₂ is used as a food preservatives but NO₂ does not.

7. $H_{3}BO_{3} + H_{2}O = B(OH)_{4}^{-} - H^{+}$

H3BO3 is Lewis acid and accept OH_{-} from H_2O and releases H_{+} .

- 8. AIF₃ + KF \xrightarrow{HF} K₃[AIF₆] (maximum C.N. of Al₊₃ is six so it form AIF₆₃₋).
- 9. Order of stability

Sn₂₊ < Sn₄₊

 $Pb_{2^+} > Pb_{4^+}$

So Sn_{2+} reacts as a reducing agent and Pb_{4+} reacts as an oxidising agent.

- **10.** The correct order of atomic radii in group 13 elements is : B < Ga < Al < In < TI
- **11.** Boron not shows expand its octet.
- 12. [SiCl₆]⁻² is not stable due to steric hinderence develop by large size CI atom on small size Si atom
- **13.** Silicones are used in cosmetic surgery.

PART - II

1. Structure of diborane is as follows :



Thus the H–B–H angles are nearly 97°, 120°.

- **2.** Fullerene consists of 12 five-membered rings and 20 six-membered rings. So it has five membered rings less than six membered rings.
- **3.** The electronegativity of N (3.0) is much higher than P (2.1). In P expansion of octet is possible.
- 5. K_2SO_4 . $Cr_2(SO_4)_3$ 24H₂O chrome alum can form.

PART - III

- **1.** Alumina is mixed with cryolite, in molten state which make alumina good conductor and lowers the fusion temperature also.
- **2.** Graphite has a two-dimensional sheet like structure and each carbon atom makes a use of sp₂ hybridisation.

The above layer structure of graphite is less compact than that of diamond. Further, since the bonding between the layers involving only van der Waal's forces is weak, these layers can slide over each other. This gives softness, greasiness and lubricating character to graphite.

- **3.** White metallic tin i.e. (β -Sn) changes to another allotrope, grey (α -Sn) at low temperature (T < 13.2°C).
- 4. AICI₃ + 6H₂O = [AI(H₂O)₆]₃₊ + 3CI₋

CHEMISTRY FOR NEET

p-Block Elements

Silicon dioxide exhibits polymorphism. It is a network solid in which each Si atom is surrounded 5. tetrahedrally by four oxygen atoms.



2AICI3 + 6H20 Hydrolysis AI2O3 + 6HCI + 3H2O 6.

7.

11.

13.

- $:C_{\frac{2\pi}{2\pi}}^{\text{fo}}C:$
- 8. Calcium carbide is ionic carbide having [: $C \equiv C$:]₂₋



2p-orbital 9.

> Decrease in B – F bond length which results in the higher bond dissociation energy of B – F in BF₃ is due to delocalised $p\pi-p\pi$ bonding between filled p-orbital of F atom and vacant p-orbital of B atom.

10. Due to the inert pair effect (the reluctance of ns_2 electrons of outermost shell to participate in bonding), the stability of M₂₊ ions (of group IV elements) increases as we go down the group.

$$CO + H_2O(g)$$

 $CO_2 + H_2; CO_2 + 2KOH \longrightarrow K_2CO_3 + H_2C$

12. When a compound like CH₃SiCl₃ undergoes hydrolysis, a complex cross-linked polymer is obtained as chain can grow in three places.



- 14. Due to non-availability of d-orbitals, boron is unable to expand its octet. Therefore, the maximum covalence of boron cannot exceed 4.
- "C" in CCl₄ does not have vacant orbital required for hydrolysis. 16.
- Concentration tendency order : C >> Si > Ge ~ Sn > Pb 17.