11

The *p*-Block Elements

Facts that Matter

• *p*-Block Elements

Elements belonging to groups 13 to 18 of the periodic table are called *p*-block elements.
General electronic configuration: ns^2np^{1-6} (except for He)

Table 11.1 General Electronic Configuration and Oxidation States of p-Block Elements

Group	13	14	15	16	17	18
General electronic configuration	ns^2np^1	ns^2np^2	ns^2np^3	ns^2np^4	ns^2np^5	ns^2np^6 ($1s^2$ for He)
First member of the group	B	C	N	O	F	He
Group oxidation state	+3	+4	+5	+6	+7	+8
Other oxidation states	+1	+2, –4	+3, –3	+4, +2, –2	+5, +3, +1, –1	+6, +4, +2

• Group 13 Elements: The Boron Family

Outer Electronic Configuration: ns^2np^1
Atomic Radii: The atomic and ionic radii of group 13 elements are smaller than the corresponding elements of alkali and alkaline earth metals.
Reason: On moving from left to right in a period the effective nuclear charge increases and the outer electrons are pulled more strongly towards the nucleus. This results in decrease in atomic size.
On moving down the group, both atomic and ionic radii expected to increase due to the addition of a new electron shell with each succeeding element.
Exception: Atomic radius of Ga is less than that of Al due to the presence of poor sheilding 10d-electrons in gallium.
Ionisation enthalpies: First ionisation enthalpies of the elements of group-13 are less than those of the elements present in group-2 in the same period.
Reason: The removal of *p*-electron is much easier than the *s*-electron and therefore, the first ionisation enthalpies ($\Delta_i H_1$) of the elements of group 13 are lower as compared to the corresponding elements of group 2.

On moving down the group 13 from B to Al the first-ionization enthalpies ($\Delta_i H_1$) decrease due to an increase in atomic size and screening effect which outweigh the effect of increased nuclear charge.

There is discontinuity expected in the ionisation enthalpy values between Al and Ga and between In and Tl due to enability of *d*- and *f*-electrons which have low screening effect to compensate the increase in nuclear charge.

Electronegativity: Down the group, electronegativity first decreases from *B* to Al and then increases.

This is due to discrepancies in the atomic size of the elements.

Physical Properties

(*i*) Due to strong crystalline lattice boron has high melting point.
Rest of the members of this family have low melting point.

(*ii*) Boron is extremely hard and black coloured solid and non metallic in nature.

(*iii*) Other members of this family are soft metals with low melting point and high *electrical conductivity*.

Chemical Properties

Oxidation states: The first two elements boron and aluminium show only +3 oxidation state in the compounds but the other elements of this group gallium, indium and thalium also exhibit +1 oxidation state in addition to +3 oxidation state *i.e.,* they show variable oxidation states.

As we move down the group, the stability of +3 oxidation state decreases while that of +1 oxidation state progressively increases.

• Some Compounds of Boron

(*i*) Borax: Borax is a white crystalline solid.

It contains tetranuclear units. $[B_4O_5(OH)_4]^{2-}$

Its formula is $Na_2[B_4O_5(OH)_4]\cdot 8H_2O$

Borax dissolves in water to give an alkaline solution

$$Na_2B_4O_7 + 7H_2O \longrightarrow 2NaOH + \underset{\text{Orthoboric acid}}{4H_3BO_3}$$

Borax is used as a water softner and cleaning agent.

(*ii*) Orthoboric acid (H_3BO_3) or $B(OH)_3$: Boric acid can be prepared by the acidification of aqueous solution of borax.

$$Na_2B_4O_7 + 2HCl + 5H_2O \longrightarrow 4H_3BO_3 + 2NaCl$$

$$Na_2B_4O_7 + H_2SO_4 + 5H_2O \longrightarrow 4H_3BO_3 + Na_2SO_4$$

It can also be prepared by the hydrolysis of boron compounds.

$$BCl_3 + 3H_2O \longrightarrow H_3BO_3 + 3HCl$$

$$B_2H_6 + 6H_2O \longrightarrow 2H_3BO_3 + 6H_2$$

Physical properties of boric acid:

(*i*) It is a white crystalline solid.

(*ii*) It is soft soapy in touch.

(*iii*) It is sparingly soluble in cold water but fairly soluble in hot water.

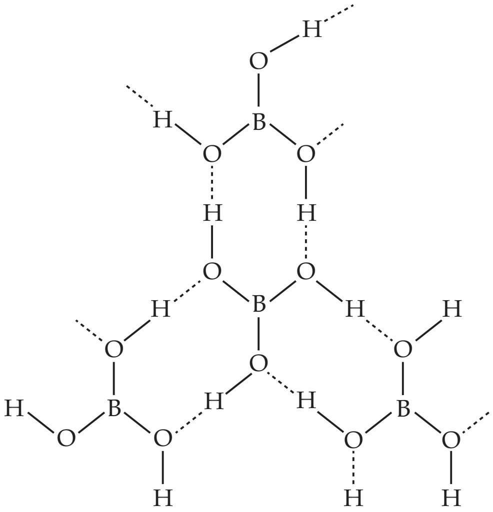
Uses:

(*i*) In the manufacture of heat resistant borosilicate glazes.

(*ii*) As a preservative for milk and food stuffs.

(*iii*) In the manufacture of enamels and glazes in pottery.

Structure of boric acid



Structure of boric acid; the dotted lines represent hydrogen bonds

(***iii***) **Diborane, (B_2H_6):** The series of compounds of boron with hydrogen is known as boranes.

Diborane is prepared by the reduction of boron trifluoride with $LiAlH_4$ in diethyl ether.

$$4BF_3 + 3LiAlH_4 \longrightarrow 2B_2H_6 + 3LiF + 3AlF_3$$

Laboratory method of preparation. In laboratory diborane is prepared by the oxidation of sodium borohydride with iodine.

$$2NaBH_4 + I_2 \longrightarrow B_2H_6 + 2NaI + H_2$$

Industrial method of preparation. On industrial scale, diborane is prepared by reduction of BF_3 with sodium hydride.

$$2BF_3 + 6NaH \xrightarrow{450\text{ K}} B_2H_6 + 6NaF$$

Physical Properties:

(*i*) Diborane is a colourless, highly toxic gas with a b.p. of 180 K.

(*ii*) Diborane catches fire spontaneously upon exposure to air.

(*iii*) Higher boranes are spontaneously flammable in air.

Chemical properties:

(*i*) **Boranes are readily hydrolysed by water to form boric acid**

$$B_2H_6(g) + 6H_2O(l) \longrightarrow 2B(OH)_3(aq) + 6H_2(g)$$

(*ii*) **It burns in oxygen evolving an enormous amount of heat**

$$B_2H_6 + 3O_2 \longrightarrow B_2O_3 + 3H_2O$$

(*iii*) **Reaction with Lewis base:**

Diborane on treatment with lewis bases undergo cleavage reactions to form borane which then reacts with Lewis bases to form adducts.

$$B_2H_6 + 2NMe_3 \longrightarrow 2BH_3\cdot NMe_3$$
$$B_2H_6 + 2CO \longrightarrow 2BH_3\cdot CO$$

• Group 14 Elements: The Carbon Family

Group 14 includes carbon (C), silicon (Si), Germanium (Ge), tin (Sn) and lead (Pb).

General electronic configuration of carbon family is ns^2np^2.

Carbon: Carbon is the seventeenth most abundant element by weight in the earth's crust.

(*i*) It is available as coal, graphite and diamond. In combined state it is present in metal carbonates, hydrocarbons and carbon dioxide gas (0.03%) in air.

(*ii*) Naturally occurring carbon contains two stable iosotopes ^{12}C and ^{13}C and third isotope ^{14}C.

^{14}C is a radioactive isotope with half life 5770 years and is used for radiocarbon dating.

Covalent radius: Covalent radius expected to increase from *C* to *Si*.

From *Si* to *Pb* small increase is found.

Reason: Due to the addition of a new energy shell in each succeeding element. The increase in covalent radii from *Si* to *Pb* is small due to ineffective shielding of the valence electrons by the intervening *d*- and *f*-orbitals.

Ionization Enthalpy: The first ionization enthalpies of group 14 elements are higher than those of the corresponding group 13 elements.

Reason: Because effective nuclear charge increases and size of the atoms becomes smaller. First ionization enthalpy decreases on moving down the group from carbon to tin.

The decrease is very sharp from carbon to silicon while there is slight increase in the first ionization enthalpy of lead as compared to that of tin.

Electronegativity: Group 14 elements are smaller in size as compared to group 13 elements that's why this group are slightly more electronegative than group 13.

From *Si* to *Pb* it is almost same. Small increase in ionization enthalpy from Sn to Pb is due to the effect of increased nuclear charge outweighs the shielding effect due to the presence of additional 4*f*- and 5*d*-electrons.

Physical properties:

(*i*) All the elements of group 14 elements are solids. They are less metallic than group 13.

(*ii*) M.P. and boiling points of group 14 elements are generally high.

Chemical properties:

Carbon and silicon mostly show +4 oxidation state. Germanium forms stable compounds in +4 state and only few compounds in +2 state.

Tin forms compounds in both oxidation states. Lead forms compounds in +2 state are stable and in +4 state are strong oxidising agents.

• Anomalous Behaviour of Carbon

Carbon, differs from the rest of the member of its family. The main reason for the anomalous behaviour is:

(*i*) exceptionally small atomic and ionic size

(*ii*) higher ionization enthalpy

(*iii*) absence of *d*-orbitals in the valence shell.

(*iv*) Higher electronagativity.

It can be explained as follows:

⇒ Since carbon has only *s* and *p*-orbitals it can accommodate only four pairs of electrons other member can expand their covalence due to the presence of *d*-orbitals.

⇒ Carbon can form $P\pi$-$P\pi$ multiple bonds with itself and other atoms having small size and high electronegativity.

For example, $C = C$, $C \equiv C$, $C = O$, $C = S$ and $C \equiv N$

Heavier elements do not form $P\pi$-$P\pi$ bonds because their atomic orbitals are too large and diffuse to have effective overlapping.

⇒ Carbon atoms have the tendency to link with one another through covalent bonds to form chains and rings. This property is called catenation.

Down the group property to show catenation decreases.

The order of catenation is C >> Si > Ge ≈ Sn

Lead does not show catenation.

• Allotropes of Carbon

The property of an element to exist in two or more forms which have different physical properties but identical chemical properties is called allotropy and different forms are called allotropes. Carbon exists in two allotropic forms:

(*i*) Crystalline (*ii*) Amorphous

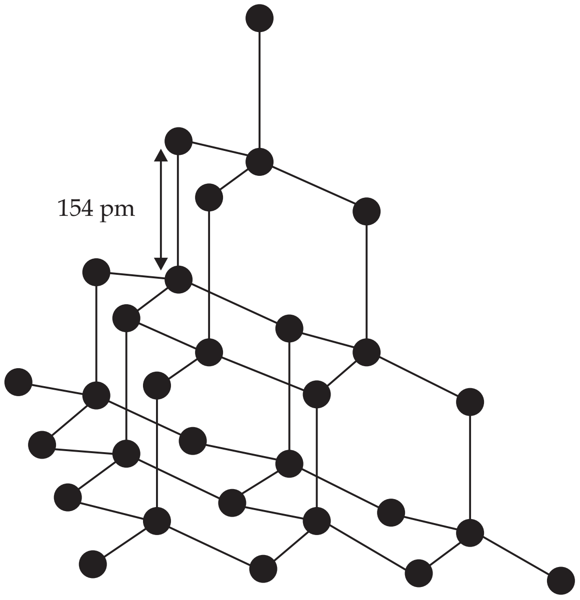
Crystalline form of carbon: Diamond, Graphite, Fullerenes

Diamond: In diamond each carbon atom undergoes sp^3 hybridisation. Each carbon is tetrahedrally linked to four other carbon atoms. The $C-C$ bond length is 154 pm.

Properties:

(*i*) It is the hardest substance on earth.

(*ii*) It is used as an abrasive for sharpening hard tools in making dyes and in manufacture of tungsten filaments.



The structure of diamond

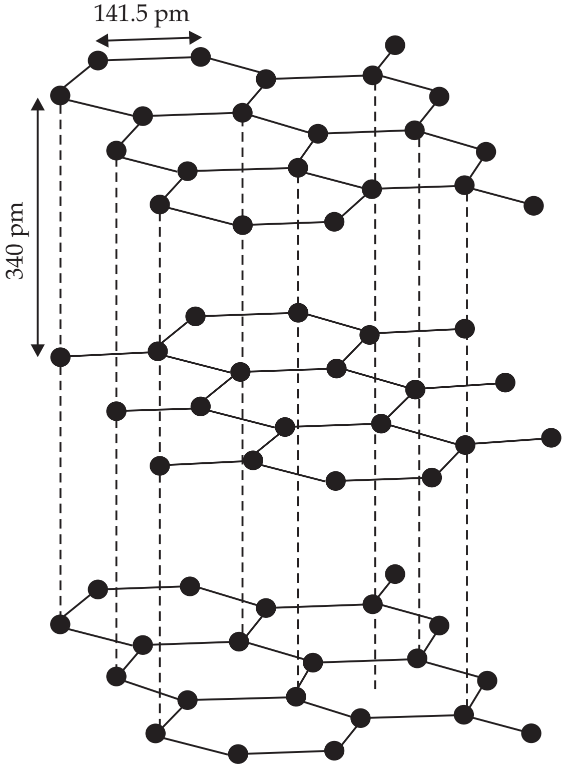
Graphite: In graphite, carbon is sp^2-hybridized. Graphite has a two-dimensional sheet like structure consisting of a number of hexagonal rings fused together. Layers are held by van der Waals forces and distance between two layers is 340 pm.

Properties:

(*i*) Graphite conducts electricity along the sheet.

(*ii*) It is very soft and slippery.

(*iii*) Used as a dry lubricant in machines running at high temperature, where oil cannot be used as a lubricant.



The structure of graphite

Fullerenes: Fullerenes was discovered collectively by three scientists namely E. Smalley, R.F. Curl and H.W. Kroto.

Preparation:

Fullerenes is prepared by heating of graphite in an electric arc in the presence of inert gas such as helium or argon.

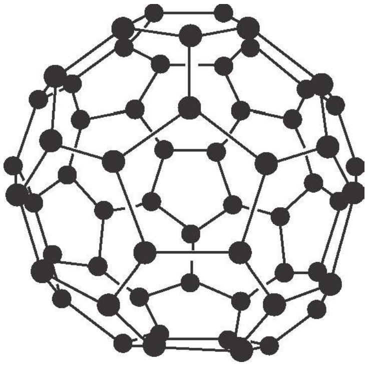
The sooty material formed by the condensation of vapourised C^n small molecules consists of mainly C_{60} with smaller quantity of C_{70} and traces of other fullerenes consisting of even number of carbon atoms upto 350 or above.

Fullerenes are cage like molecules. C_{60} molecule has a shape like soccer ball and called Buckminsterfullerenes. It is the most stable.

It contains 20 six-membered rings and 12 five-membered rings.

Six-membered rings are fused to both the other six-membered rings and five-membered rings but the five-membered rings are connected only to six-membered rings.

All the carbon atoms are equal and they undergo sp^2-hybridization.



The structure of C_{60}, Buckminster-fullerene:
Note that molecule has the shape of a soccer ball (football).

Properties:

(*i*) Fullerenes being covalent are soluble in organic solvents.
(*ii*) It also forms platinum complexes.

Amorphous allotropic forms of carbon coke: It is a greyish black hard solid and is obtained by destructive distillation.

Wood charcoal: It is obtained by strong heating of wood in a limited supply of air.

Animal charcoal: It is obtained by the destructive distillation of bones.

Uses of carbon:

(*i*) Graphite fibre are used for making superior sports goods such as tennis and badminton rackets, fishing rods.
(*ii*) Being good conductor graphite is used for making electrodes for batteries and industrial electrolysis.
(*iii*) Being highly porous, activated charcoal is used for absorbing poisonous gases in gas masks. It is used to decolourize sugar.
(*iv*) Carbon black is used as black pigment in black ink and as filler in automibile tyres.
(*v*) Coke is extensively used as reducing agent in metallurgy.
(*vi*) Diamond is a precious stone.

• Some Important Compounds of Carbon and Silicon

Carbon Monoxide

Preparation: It is prepared by direct oxidation of *C* in limited supply of oxygen.

$$2C(s) + O_2(g) \xrightarrow{\Delta} 2CO(g)$$

On small scale it is prepared by dehydration of formic acid with Con $\cdot H_2SO_4$ at 373 K.

$$HCOOH \xrightarrow[\text{Con. } H_2SO_4]{373K} H_2O + CO$$

Properties:

(*i*) Carbon monoxide is a colourless and odourless gas.
(*ii*) It is almost insoluble in water.
(*iii*) It is powerful reducing agent and reduces almost all metal oxides except alkali and alkaline earth metal oxides.
(*iv*) In CO molecule there are one σ (sigma) and two π bonds between carbon and oxygen.

$$:C \equiv O:$$

(*v*) It is highly porous in nature. It forms a complex with haemoglobin which is about 300 times more stable than the oxygen-haemoglobin complex. This prevents haemoglobin in the red blood corpuscles from carrying oxygen round the body, there by causing suffocation ultimately leading to death.

Carbon Dioxide

Preparation: It is prepared by complete combustion of carbon and carbon containing fuels in

$$C(s) + O_2(g) \xrightarrow{\Delta} CO_2(g)$$

$$CH_4(g) + 2O_2(g) \xrightarrow{\Delta} CO_2(g) + 2H_2O(g)$$

Properties:

(*i*) It is a colourless and odourless gas.

(*ii*) It is slightly soluble in water. When CO_2 dissolves in water only some of the molecules react with water to form carbonic acid.

(*iii*) It is not poisonous like CO.

But increase in combustion of fossil fuels and decomposition of limestone for cement manufacture increase of CO_2 in the atomosphere is one of the main reasons of green house effect.

Silicon dioxide (SiO_2)

Silicon dioxide, commonly known as silica, occurs in various crystallographic forms.

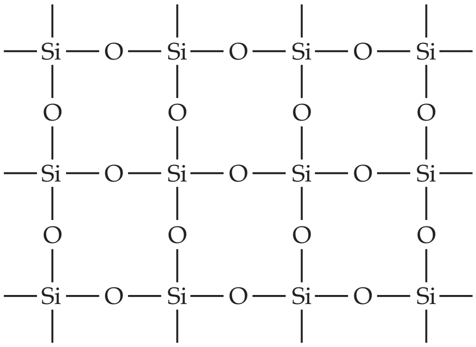
For example, Quartz, Cristobalite and thermite are some of the crystalline forms of silica.

Structure:

Silicon dioxide is a covalent three dimensional network solid.

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 as shown below:



Three dimensional structure of SiO_2

Properties:

(*i*) In normal form silica is very less reactive.

(*ii*) At elevated temperature it does not reacts with halogens, dihydrogen and most of the acids and metals. But it reacts with HF and NaOH.

$$SiO_2 + 2NaOH \longrightarrow Na_2SiO_3 + H_2O$$

$$SiO_2 + 4HF \longrightarrow SiF_4 + 2H_2O$$

Uses:

(*i*) Quartz is extensively used as a piezoelectric material.

(*ii*) Silica gel is used as adsorbent in chromatography.
(*iii*) An amorphous form of silica, kieselghur is used in filtration plants.

Words that Matter

- **P-Block elements:** Contains, metals, non-metals and metalloids.
- **General configuration:** ns^2np^{1-6}
  - Boron is a typical non-metal and the other members are metals.
  - Boron halides are considered to behave like Lewis acids.
  - Boric acid is a Lewis acid.
  - Borax is a white crystalline solide formula is $Na_2\,[B_4O_5(OH)_4]\cdot 8H_2O$
  - Aluminium exhibits +3 oxidation state.
  - **Catenation:** Ability of carbon to form chains or rings not only with *C-C* single bonds but also with multiple bonds ($C = C$ or $C \equiv C$). The tendency of catenation decreases as C >> Si > Ge ≈ Sn
  - **Allotropy:** The important allotropes of carbon are diamond, graphite, and fullerenes.
  - The members of carbon family exhibit +4 and +2 oxidation state. The tendency to show +2 oxidation state increases among heavier elements.
  - Lead in +2 state is stable whereas in +4 oxidation state it is a strong oxidising agent.
  - Carbon monoxide is neutral whereas CO_2 is acidic in nature.
  - Carbon monoxide having lone pair of electrons on *C* forms metal carbonyls.
  - Carbon monoxide forms a haemoglobin complex which is deadly poisonous due to its higher stability.
  - Zeolites are complex aluminium silicates.

NCERT TEXTBOOK QUESTIONS SOLVED

Q1. *Discuss the pattern of variation in the oxidation states of*
(i) B to Tl (ii) C to Pb.

Ans. (*i*) ***B* to *Tl***

Common oxidation states are +1 and +3. The stability of +3 oxidation state decreases from *B* to *Tl*. +1 oxidation state increases from *B* to *Tl*.

(*ii*) ***C* to *Pb***

The common oxidation states are +4 and +2. Stability of +4 oxidation state decreases from *C* to *Pb*.

Details can be seen from the text part.

Q2. *How can you explain higher stability of BCl_3 as compared to $TlCl_3$?*

Ans. BCl_3 is quite stable. Because there is absence of *d*- and *f*-electrons in boron three valence electrons ($2s^2\,2p_{x1}$) are there for bonding with chlorine atom. In *Tl* the valence *s*-electron ($6s^2$) are experiencing maximum inert pair effect. Thus, only $6p^1$ electron is available for bonding. Therefore, BCl_3 is stable but $TlCl_3$ is comparatively unstable.

Q3. *Why does borontrifluoride behave as a Lewis acid?*

Ans. In BF_3, central atom has only six electrons after sharing with the electrons of the *F* atoms. It is an electron deficient compound and thus behaves as a Lewis acid.

Q4. *Consider the compounds, BCl_3 and CCl_4. How will they behave with water justify?*

Ans. In BCl_3, there is only six electrons in the valence shell of *B* atom. Thus, the octet is incomplete and it can accept a pair of electrons from water and hence BCl_3 undergoes hydrolysis. Whereas, in CCl_4, *C* atom has 8 electrons and its octet is complete. That's why it has no tendency to react with water.

$$CCl_4 + H_2O \longrightarrow \text{No reaction}$$

Q5. *Is boric acid a protonic acid? Explain.*

Ans. Boric acid is a Lewis acid, it is not a protonic acid.

Boric acid accepts electrons from hydroxyl ion of H_2O molecule.

$$B(OH)_3 + 2HOH \longrightarrow [B(OH)_4]^- + H_3O^+$$

Q6. *Explain what happens when boric acid is heated.*

Ans. On heating boric acid above 370 K, it forms metaboric acid, HBO_2 which on further heating yields boric oxide B_2O_3.

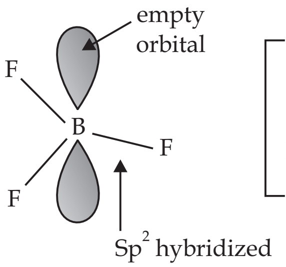
$$H_3BO_3 \xrightarrow{\Delta} HBO_2 \xrightarrow{\Delta} B_2O_3$$

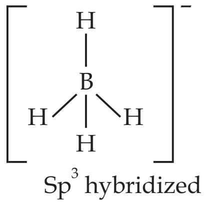
Q7. *Describe the shapes of BF_3 and BH_4^-. Assign the hybridisation of boron in these species.*

Ans. In BF_3, boron is sp^2 hybridized.

$\therefore$ shape of BF_3 = planar.

In $[BH_4]^-$, boron is sp^3 hybridized, thus the shape is tetrahedral.





Q8. *Write reactions to justify amphoteric nature of aluminium.*

Ans. Aluminium reacts with acid as well as base. This shows amphoteric nature of aluminium.

$$2Al(s) + 6HCl(\text{dil.}) \longrightarrow 2AlCl_3(aq) + 3H_2(g)$$

$$2Al(s) + 2NaOH(aq) + 6H_2O(l) \longrightarrow \underset{\text{Sod. tetrahydroxoaluminate (III)}}{2Na^+ [Al(OH)_4]^-(aq)} + 3H_2(g)$$

Q9. *What are electron deficient compounds? Are BCl_3 and $SiCl_4$ electron deficient species? Explain.*

Ans. Electron deficient species are those in which the central atom in their molecule has the tendency to accept one or more electron pairs. They are also known as Lewis acid. BCl_3 and $SiCl_4$ both are electron deficient species.

Since, in BCl_3, *B* atom has only six electrons. Therefore, it is an electron deficient compound.

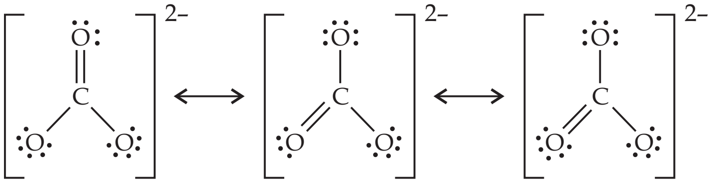
In $SiCl_4$ the central atom has 8 electrons but it can expand its covalency beyond 4 due to the presence of *d*-orbitals.

Thus, $SiCl_4$ should also be considered as electron deficient species.

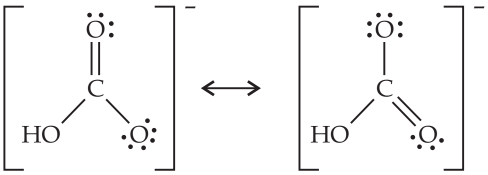
Q10. *Write the resonance structure of CO_3^{2-} and HCO_3^-.*

Ans.

CO_3^{2-}



HCO_3^-



Q11. *What is the state of hybridisation of carbon in*

	(*a*) CO_3^{2-}	(*b*) *diamond*	(*c*) *graphite?*
Ans.	(*a*) CO_3^{2-} (sp^2)	(*b*) Diamond (sp^3)	(*c*) Graphite (sp^2)

Q12. *Explain the difference in properties of diamond and graphite on the basis of their structures.*

Ans. (*i*) Since diamond exists as a three dimensional network solid, it is the hardest substance known with high density and high melting point.

Whereas in graphite, any two successive layers are held together by weak forces of attraction. This makes graphite soft.

(*ii*) In graphite, carbon atom is sp^2 hybridized whereas in diamond, carbon atom is sp^3 hybridized.

(*iii*) Unlike diamond, graphite is good conductor of heat and electricity.

Q13.
- *Rationalise the given statements and give chemical reactions:*
- *Lead (II) chloride reacts with Cl_2 to give $PbCl_4$.*
- *Lead (IV) chloride is highly unstable towards heat.*
- *Lead is known not to form an iodide PbI_4.*

Ans.
- $$PbCl_2 + Cl_2 \longrightarrow PbCl_4.$$
  This is because Pb can show +2 oxidation state more easily than +4 due to inert pair effect.
- $$PbCl_4 \xrightarrow{\text{heat}} PbCl_2 + Cl_2$$
  Because Pb^{2+} is more stable than Pb^{4+} due to inert pair effect.
- PbI_4 does not exist because I^- ion being a powerful reducing agent reduces Pb^{4+} ion to Pb^{2+} ion in solution.
  $$\underset{\text{Pb(IV)}}{Pb^{4+}} + 2I^- \longrightarrow \underset{\text{Pb(II)}}{Pb^{2+}} + I_2$$

Q14. *Suggest reason why the B-F bond lengths in BF_3 (130 pm) and BF_4^- (143 pm) differ.*

Ans. In BF_3 '*B*' is sp^2 hybridised and in BF_4^- '*B*' is sp^3 hybridised. Thus, the difference in bond length is due to the state of hybridisation.

Q15. *If B-Cl bond has a dipole moment, explain why BCl_3 molecule has zero dipole moment.*

Ans. B-Cl bond has dipole moment because of polarity. In BCl_3 since the molecule is symmetrical (planar). Thus the polarities cancel out.

Q16. *Aluminium trifluoride is insoluble in anhydrous HF but dissolves on addition of NaF. Aluminium trifluoride precipitates out of the resulting solution when gaseous BF_3 is bubbled through. Give reason.*

Ans. Since, anhydrous HF is covalent compound and weak acid due to high bond dissociation energy. AlF_3 does not dissolve in HF.

Whereas NaF is ionic compound.

$$3NaF + AlF_3 \longrightarrow Na_3[AlF_6]$$

$$Na_3[AlF_6] + 3BF_3(g) \longrightarrow \underset{\text{Sodium tetrafluoroborate (III)}}{AlF_3 + 3Na^+ [BF_4]^-}$$

Q17. *Suggest a reason as to why CO is poisonous.*

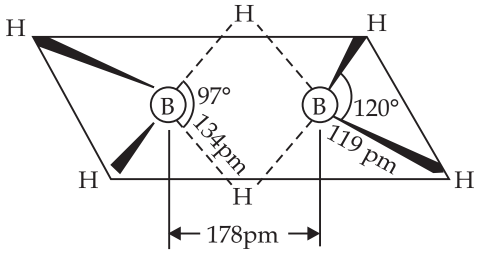
Ans. CO reacts with haemoglobin to form carboxyhaemoglobin which can destroy the oxygen carrying capacity of haemoglobin and the man dies of suffocation.

Q18. *How is excessive content of CO_2 responsible for global warming?*

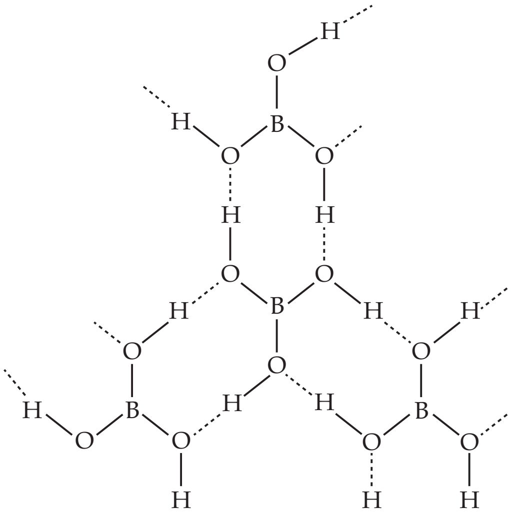
Ans. Excess of CO_2 absorbs heat radiated by the earth. Some of it is dissipated into the atmosphere while the remaining part is radiated back to the earth. As a result, temperature of the earth increases. This is the cause of global warming.

Q19. *Explain structures of diborane and boric acid.*

Ans. Boric acid contains planar BO_3^{3-} ions which are linked together through hydrogen bonding shown in the fig.



Structure of Diborane (B_2H_6) molecule



Structure of boric acid

Q20. *What happens when*

(a) Borax is heated strongly

(b) Boric acid is added to water

(c) Aluminium is treated with dilute NaOH

(d) BF_3 is reacted with ammonia?

Ans. (*a*) $Na_2B_4O_7 \cdot 10H_2O \xrightarrow[-10H_2O]{\Delta} Na_2B_4O_7 \xrightarrow{\Delta} 2NaBO_2 + B_2O_3$

(*b*) $B(OH)_3 + H_2O \longrightarrow [B(OH)_4]^- + H^+$

(*c*) $2Al + 2NaOH + H_2O \longrightarrow 2NaAlO_2 + 3H_2$

(*d*) $BF_3 + NH_3 \longrightarrow [H_3N \longrightarrow BF_3]$

Q21. *Explain the following reactions.*

(a) Silicon is heated with methyl chloride at high temperature in the presence of copper.

(b) Silicon dioxide is treated with hydrogen fluoride.

(c) CO is heated with ZnO.

(d) Hydrated alumina is treated with aqueous NaOH solution.

Ans. (*a*) A mixture of mono-, di- and trimethyl chlorosilianes along with a small amount of tetramethyl silane is formed.

$$\underset{\text{Methyl chloride}}{CH_3Cl + Si} \xrightarrow[373K]{\text{Cu powder}} CH_3SiCl_3 + (CH_3)_2\,SiCl_2 + (CH_3)_3\,SiCl + (CH_3)_4\,Si$$

(*b*) The initially formed silicon tetrafluoride dissolves in HF to form hydrofluorosilicic acid.

$$SiO_2 + 4HF \longrightarrow SiF_4 + 2H_2O$$
$$SiF_4 + 2HF \longrightarrow H_2SiF_6$$

(*c*) ZnO is reduced to zinc metal

$$ZnO + CO \longrightarrow Zn + CO_2$$

(*d*) Alumina dissolves to form sodium meta-aluminate

$$\underset{\substack{\text{Hydrated alumina}\\ \text{or Bauxite}}}{Al_2O_3 \cdot 2H_2O(s)} + 2NaOH(aq) \xrightarrow{\text{Heat}} \underset{\text{Sod. meta-aluminate}}{2NaAlO_2} + 3H_2O$$

Q22. *Give reasons:*

(i) Conc. HNO_3 can be transported in aluminium container.

(ii) A mixture of dilute NaOH and aluminium pieces is used to open drain.

(iii) Graphite is used as lubricant.

(iv) Diamond is used as an abrasive.

(v) Aluminium alloys are used to make aircraft body.

(vi) Aluminium utensils should not be kept in water overnight.

(vii) Aluminium wire is used to make transmission cables.

Ans. (*i*) Al reacts with conc. HNO_3 to form a very thin film of aluminium oxide on its surface which protects it from further reaction.

$$2Al(s) + 6HNO_3(\text{conc.}) \longrightarrow \underset{\text{Alumina}}{Al_2O_3(s)} + 6NO_2(g) + 3H_2O(l)$$

(*ii*) NaOH reacts with Al to evolve H_2 gas. Thus the pressure of the gas produced can be used for clogged drains.

$$2Al(s) + 2NaOH(aq) + 2H_2O(l) \longrightarrow 2NaAlO_2(aq) + 3H_2(g)$$

(*iii*) Graphite has layered structure which are held by weak van der Waals forces. Thus, graphite cleaves easily between the layers, therefore it is very soft and slippery. That's why it is used as lubricant.

(*iv*) Diamond is used as an-abrasive because it is an extremely hard substance.

(*v*) Alloys of aluminium, like duralumin, is used to make aircraft body due to some of its property like toughness, lightness and resistant to corrosion.

(*vi*) Generally, aluminium metal does not react with water quickly but, when it is kept overnight, it reacts slowly with water in presence of air.

$$2Al(s) + O_2(g) + H_2O(l) \longrightarrow Al_2O_3(s) + H_2(g)$$

a very small amount of (in ppm) Al^{3+} produced in the solution is injurious to health if the water is used for drinking purposes.

(*vii*) Aluminium is generally unaffected by air and moisture and it is also good conductor of electricity. That's why it is used in transmission cables.

Q23. *Explain why is there a phenomenal decrease in ionization enthalpy from carbon to silicon.*

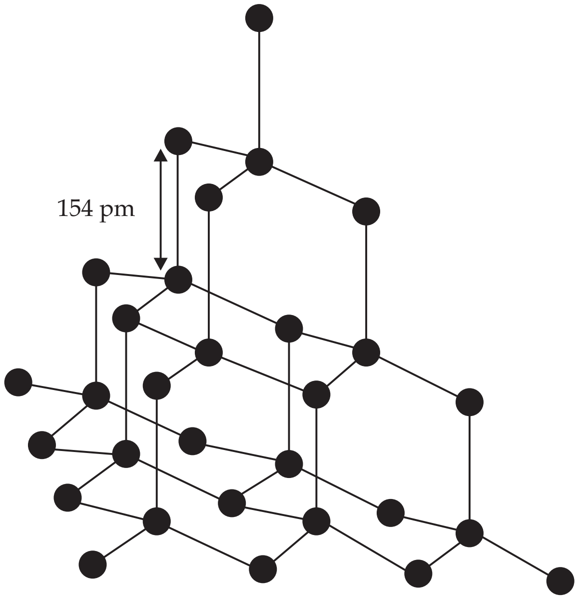
Ans. Because there is increase in atomic size on moving from carbon to silicon, the screening effect increases. Thus the force of attraction of nucleus for the valence electron decreases as compared to carbon. Thus the ionization enthapy decreases from carbon to silicon.

Q24. *How would you explain the lower atomic radius of Ga as compared to Al?*

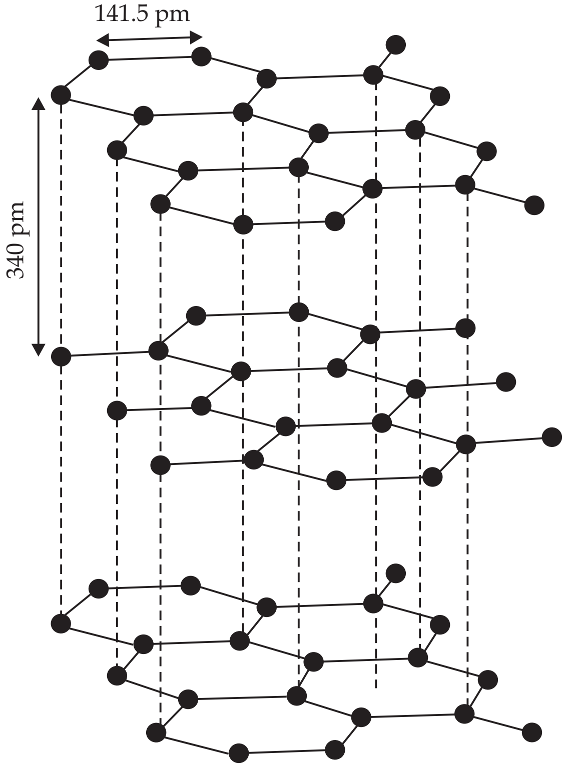
Ans. Due to poor shielding effect of *d*-electrons in Ga, the electrons in gallium experience great force of attraction by nucleus as compared to Al.

Q25. *What are allotropes? Sketch the structure of two allotropes of carbon namely diamond and graphite. What is the impact of structure on physical properties of two allotropes?*

Ans. **Allotropes:** Allotropes are the different forms of an element which are having same chemical properties but different physical properties due to their structures.



Structure of diamond



Structure of Graphite

In diamond, carbon is sp^3-hybridized. Since, diamond is three dimensional network solid, it is hardest substance with high density whereas graphite has a layered structure. The various layers are formed by van der Waals forces of attraction that's why graphite is soft and slippery.

Q26. (a) *Classify following oxides as neutral, acidic, basic or amphoteric*
CO, B_2O_3, SiO_2, CO_2, Al_2O_3, PbO_2, Tl_2O_3.
(b) *Write suitable equations to show their nature.*

Ans. (*a*) Neutral – CO
Acidic – B_2O_3, SiO_2, CO_2
Basic – Tl_2O_3
Amphoteric – Al_2O_3, PbO_2

(*b*) CO does not react with acid as well as base at room temperature.
Being acidic B_2O_3, SiO_2 and CO_2 reacts with alkalis to form salts.

$$\underset{\text{Boric anhydride}}{B_2O_3} + 2NaOH \longrightarrow \underset{\text{Sod. metaborate}}{2NaBO_2} + H_2O$$

$$SiO_2 + 2NaOH \xrightarrow{\Delta} \underset{\text{Sod. silicate}}{Na_2SiO_3} + H_2O$$

$$CO_2 + 2NaOH \longrightarrow \underset{\text{Sod. carbonate}}{Na_2CO_3} + H_2O$$

Being amphoteric, Al_2O_3, and PbO_2 react with acids and bases.

$$Al_2O_3 + 2NaOH \longrightarrow 2NaAlO_2 + H_2O$$

$$Al_2O_3 + 3H_2SO_4 \longrightarrow Al_2(SO_4)_3 + 3H_2O$$

$$PbO_2 + 2NaOH \longrightarrow Na_2PbO_3 + H_2O$$

$$2PbO_2 + 2H_2SO_4 \longrightarrow 2PbSO_4 + 2H_2O + O_2$$

Being Basic Tl_2O_3 dissolves in acids.

$$Tl_2O_3 + 6HCl \longrightarrow 2TlCl_3 + 3H_2O$$

Q27. *In some of the reactions thallium resembles aluminium, whereas in others it resembles with group 1 metals. Support this statement by giving some evidences.*

Ans. Tl shows both the oxidation state +1 and +3 due to inert pair effect. Tl forms basic oxide like group *I* elements. TlO_2 is strongly basic.

Q28. *When metal X is treated with sodium hydroxide, a white precipitate (A) is obtained, which is soluble in excess of NaOH to give soluble complex (B). Compound (A) is soluble in dilute HCl to form compound (C). The compound (A) when heated strongly gives (D), which is used to extract metal. Identify (X), (A), (B), (C) and (D). Write suitable equations to support their identities.*

Ans.

$$\underset{(X)}{Al} + 3NaOH \longrightarrow \underset{(A)}{Al(OH)_3} \downarrow + 3Na$$

$$\underset{(A)}{Al(OH)_3} + NaOH \longrightarrow \underset{\substack{\text{Soluble} \\ \text{'B'} \\ \text{Sod. tetrahydroxoaluminate} \\ \text{(III)}}}{Na^+[Al(OH)_4]^-}$$

Since *A* is amphoteric in nature.

$$\underset{(A)}{Al(OH)_3} + \text{dil. } HCl \longrightarrow \underset{(C)}{AlCl_3} + 3H_2O$$

$$\underset{(A)}{2Al(OH)_3} \xrightarrow{\Delta} \underset{(D)}{Al_2O_3} + 3H_2O$$

Q29. *What do you understand by (a) inert pair effect (b) allotropy and (c) catenation?*

Ans. (*a*) **Inert pair effect:** The pair of electron in the valence shell does not take part in bond formation is called inert pair effect.

(*b*) **Allotropy:** It is the property of the element by which an element can exist in two or more forms which have same chemical properties but different physical properties due to their structures.

(*c*) **Catenation:** The property to form chains or rings not only with single bonds but also with multiple bonds with itself is called catenation.

For example, carbon forms chains with ($C - C$) single bonds and also with multiple bonds ($C = C$ or $C \equiv C$).

Q30. *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 conc. H_2SO_4 is added to a hot solution of X, white crystal of an acid Z separates out.*

Ans. (*i*)

$$Na_2B_4O_7 + 10H_2O \xrightarrow{\text{water}} 2NaOH + H_2B_4O_7 + 8H_2O$$

(*ii*) $$Na_2B_4O_7 \xrightarrow{\text{heat}} 2NaBO_2 + B_2O_3$$

(*iii*) $$Na_2B_4O_7\cdot 10H_2O + H_2SO_4 \longrightarrow 4H_3BO_3 + Na_2SO_4 + 5H_2O$$

Q31. *Write balanced equations for:*

(i) $BF_3 + LiH \longrightarrow$ *(ii)* $B_2H_6 + H_2O \longrightarrow$ *(iii)* $NaH + B_2H_6 \longrightarrow$

(iv) $H_3BO_3 \xrightarrow{\Delta}$ *(v)* $Al + NaOH \longrightarrow$ *(vi)* $B_2H_6 + NH_3 \longrightarrow$

Ans. (*i*) $$2BF_3 + 6LiH \longrightarrow \underset{\text{Diborane}}{B_2H_6} + 6LiF$$

(*ii*) $$\underset{\text{Diborane}}{B_2H_6} + 6H_2O \longrightarrow \underset{\text{Orthoboric acid}}{2H_3BO_3} + 6H_2$$

(*iii*) $$2NaH + B_2H_6 \longrightarrow \underset{\text{Sod. borohydride}}{2Na^+[BH_4]^-}$$

(*iv*) $$\underset{\text{Orthoboric acid}}{H_3BO_3} \xrightarrow{\Delta} \underset{\text{Metaboric acid}}{HBO_2} + H_2O$$

$$\underset{\text{Metaboric acid}}{4HBO_2} \xrightarrow[-H_2O]{\Delta} \underset{\text{Tetraboric acid}}{H_2B_4O_7} \longrightarrow \underset{\text{Boron trioxide}}{2B_2O_3} + H_2O$$

(*v*) $$2Al + 2NaOH + 6H_2O \longrightarrow \underset{\text{Sod. tetrahydroxoaluminate (III)}}{2Na^+[Al(OH)_4]^-} + 3H_2$$

(*vi*) $$B_2H_6 + 2NH_3 \longrightarrow \underset{\text{Borane-ammonia complex}}{2BH_3\cdot NH_3}$$

Q32. *Give one method for industrial preparation and one for laboratory preparation of CO and* CO_2 *each.*

Ans. Carbon monoxide

Industrial: $$2C(s) + O_2(g) \xrightarrow[\text{air}]{\text{Limited}} 2CO(g)$$

Laboratory: $$\underset{\text{Formic acid}}{HCOOH} \xrightarrow{H_2SO_4} CO + H_2O$$

Carbon dioxide

Industrial: $$C(s) + O_2(g) \xrightarrow[\text{air}]{\text{Excess}} CO_2(g)$$

Laboratory: $CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$

Q33. *An aqueous solution of borax is*

(a) neutral (b) amphoteric (c) basic (d) acidic

Ans. Borax is a salt of a strong base (NaOH) and a weak acid (H_3BO_3), therefore, it is basic in nature, *i.e.*, option (c) is correct.

Q34. *Boric acid is polymeric due to*

(a) its acidic nature *(b) the presence of hydrogen bonds*

(c) its monobasic nature *(d) its geometry*

Ans. Boric acid is polymeric due to the presence of *H*-bonds. Therefore, option (*b*) is correct.

Q35. *The type of hybridisation of boron in diborane is*

(a) sp (b) sp^2 (c) sp^3 (d) dsp^2

Ans. In B_2H_6, *B* is sp^3-hybridized. Therefore, *option (c) is correct.*

Q36. *Thermodynamically the most stable form of carbon is*

(a) diamond (b) graphite (c) fullerenes (d) coal

Ans. Thermodynamically the most stable form of carbon is graphite, *i.e., option (b) is correct.*

Q37. *Elements of group 14*

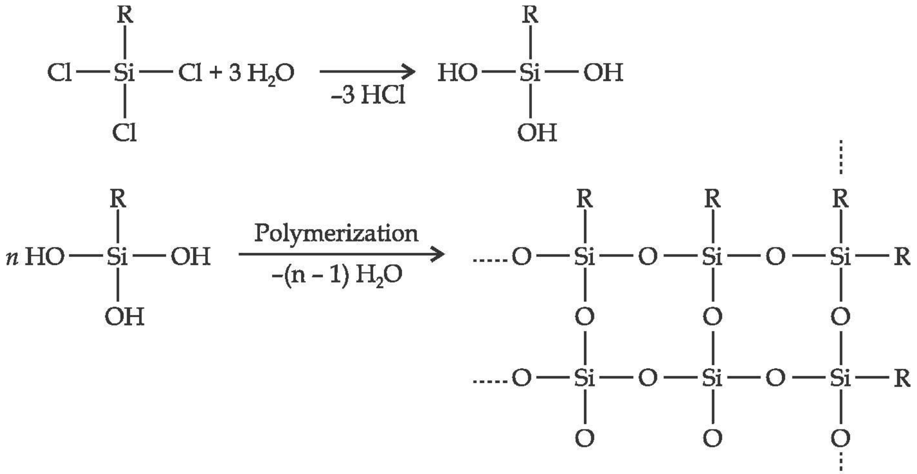
(a) exhibit oxidation state of +4 only (b) exhibit oxidation state of +2 and +4

(c) form M^{2-} and M^{4+} ion (d) form M^{2+} and M^{4+} ions.

Ans. Due to inert pair effect, elements of group 14 exhibit oxidation states of +2 and +4. Thus, *option (b) is correct.*

Q38. *If the starting material for the manufacture of silicons is $RSiCl_3$, write the structure of the product formed.*

Ans. Hydrolysis of alkyltrichlorosilanes gives cross-linked silicons.



$$RSiCl_3 + 3H_2O \xrightarrow[-3HCl]{} RSi(OH)_3$$

$$n\,RSi(OH)_3 \xrightarrow[-(n-1)H_2O]{\text{Polymerization}} \text{Cross-linked silicone}$$

Cross-linked silicone

MORE QUESTIONS SOLVED

I. VERY SHORT ANSWER TYPE QUESTIONS

Q1. *Why is boron used in nuclear reactions?*

Ans. Because Boron can absorb neutrons.

Q2. *Why does boron form stable electron deficient compounds?*

Ans. Boron has three electrons in its valence shell that boron show three electrons with other elements and form an electron deficient compound.

Q3. *By giving a balanced equation show how $B(OH)_3$ behaves as an acid in water.*

Ans. $B(OH)_3 + 2HOH \longrightarrow [B(OH)_4]^- + H_3O^+$.

Q4. *What is dry ice? Why is it so called?*

Ans. Carbon dioxide can be obtained as a solid in the form of dry ice by allowing the liquified CO_2 to expand rapidly.

Unlike ordinary ice it does not melt and hence does not wet the surface on which it is kept. Thus it is called dry ice.

Q5. *Name the element of group 14 which exhibits maximum tendency for catenation.*

Ans. Carbon.

Q6. *What is the basic building unit of all silicates?*

Ans. SiO_4^{4-} is the basic unit of all silicates.

Q7. *Why do boron halides form addition compounds with* NH_3*?*

Ans. Boron halides are lewis acids and can accept a pair of electrons from amines to form addition product.

Q8. *What happens when* $NaBH_4$ *reacts with iodine?*

Ans. $2NaBH_4 + I_2 \longrightarrow B_2H_6 + 2NaI + H_2$.

Q9. *Out of* CCl_4 *and* $SiCl_4$ *which one react with water and why?*

Ans. Due to the presence of *d*-orbitals in Si, $SiCl_4$ reacts with water. CCl_4 does not react with water due to the absence of *d*-orbitals in *C* atom.

Q10. *Which oxide of carbon is regarded as anhydride of carbonic acid?*

Ans. CO_2 is regarded as anhydride of carbonic acid.

$$H_2CO_3 \longrightarrow H_2O + CO_2$$

Q11. *What happens when boric acid is heated?*

Ans.
$$H_3BO_3 \xrightarrow{\Delta} HBO_2 \xrightarrow{\Delta} B_2O_3$$

Q12. CO_2 *is gas while* SiO_2 *is solid at room temperature. Give reason.*

Ans. The molecules of CO_2 are held together by weak van der Waals forces of attraction which can be easily overcome by collisions of the molecules at room temperature. Consequently CO_2 is a gas.

On the other hand silicon atom forms four single covalent bonds with O-atom which are tetrahedrally arranged and form a three-dimensional structure. Thus SiO_2 is a high melting solid.

Q13. *What is producer gas?*

Ans. Producer gas is a mixture of CO and N_2 in the ratio of 2 : 1.

Q14. *Write the state of hybridisation of 'B' in* BF_3.

Ans. Hybridisation of '*B*' in BF_3 is sp^2.

Q15. *Mention the state of hybridisation of B in* BH_4^-.

Ans. sp^3.

II. SHORT ANSWER TYPE QUESTIONS

Q1. *What is meant by catenation? Why does 'C' show the property of catenation to maximum extent?*

Ans. It is the phenomenon of an atom to form a strong covalent bond with the atoms of itself. Carbon shares the property of catenation to maximum extent because it is small in size and can form $P\pi$-$P\pi$ multiple bonds to itself.

Q2. *Give the chemical reactions as an evidence for each of the following observations.*

(i) Tin (II) is a reducing agent whereas lead (II) is not.

(ii) Gallium (I) undergoes disproportionation reaction.

Ans. (*i*) Due to inert pair effect Pb^{2+} is more stable than Pb^{4+}. Whereas Sn^{4+} is more stable than Sn^{2+}.

Thus Sn^{2+} is a good reducing agent and Pb^{2+} is not.

(*ii*) $3Ga^+ \longrightarrow 2Ga + Ga^{3+}$

This is because Ga^{3+} is more stable than Ga^+.

Q3. *Describe two similarities and two dissimilarities between B and Al.*

Ans. Similarities:

(*i*) Both have same number of valence electrons.

(*ii*) Both have similar electronic configuration.

Dissimilarities:

(*i*) B is a non-metal where Al is a metal.

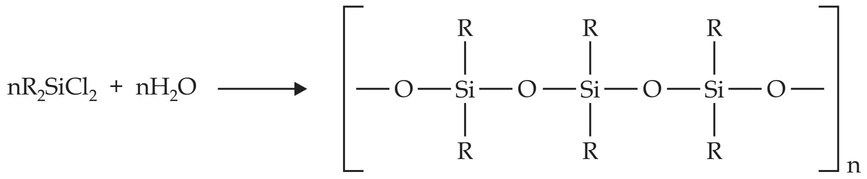
(*ii*) B forms acidic oxide whereas Al forms amphoteric oxides.

Q4. *(a) What is general formula of silicons?*

(b) How are linear silicons obtained?

Ans. (*a*) R_2SiO

(*b*) Linear silicons are obtained by the hydrolysis of R_2SiCl_2 (chlorosilanes).



$$nR_2SiCl_2 + nH_2O \longrightarrow \left[-O-\underset{R}{\overset{R}{Si}}-O-\underset{R}{\overset{R}{Si}}-O-\underset{R}{\overset{R}{Si}}-O- \right]_n$$

Linear silicons

Q5. *What happens when*

(i) Quick lime is heated with coke?

(ii) Carbon monoxide reacts with Cl_2*?*

Ans. (*i*) $CaO + 3C \longrightarrow CaC_2 + CO$

(*ii*) $CO + Cl_2 \longrightarrow \underset{\text{(phosgene)}}{COCl_2}$

Q6. *What are Fullerenes? How are they prepared?*

Ans. Fullerenes are the allotropes of carbon. Its structure is like a soccer ball.

They are prepared by heating graphite in electric arc in presence of inert gases such as helium or argon.

Q7. *Give reason.*

(i) C and Si are always tetravalent but Ge, Sn, Pb show divalency.

(ii) Gallium has higher ionization enthalpy than Al. Explain.

Ans. (*i*) Ge, Sn and Pb show divalency due to inert pair effect, Pb^{2+} is more stable than Pb^{4+}.

(*ii*) Due to poor shielding effect of *d*-electrons in Ga, effective nuclear charge increases as compared to Al. Thus the I.E of Ga is higher than Al.

Q8. *Give reason why boron and aluminium tend to form covalent compounds.*

Ans. Sum of the three ionization enthalpies of both the elements are very high. Thus they have no tendency to lose electrons to form ionic compound. Instead they form covalent compounds.

III. LONG ANSWER TYPE QUESTIONS

Q1. *Explain the differences in properties of diamond and graphite based upon their structures.*

Ans.

Diamond	*Graphite*
(*i*) Diamond is the hardest substance on earth.	(*i*) Graphite is soft and slippery
(*ii*) In diamond carbon is sp^3 – hybridised	(*ii*) In Graphite carbon is sp^2 – hybridized.
(*iii*) Since all the electrons in diamond are firmly held in *C* – *C*, 6 bonds there are no free electrons in diamond crystal. Therefore diamond is bad conductor of electricity.	(*iii*) Since only three electrons of each carbon are used in making hexagonal rings of graphite, fourth valence electron is free to move thus graphite is a good conductor of electricity.
(*iv*) Because of high refractive index diamond can reflect and refract the light.	(*iv*) Graphite is a black substance and possess a metallic lustre.

Q2. *Give reasons:*

(*a*) *Why do Boron halides form addition compound with* NH_3*?*

(*b*) *The tendency for catenation decreases down the group in Group 14.*

(*c*) PbO_2 *is a stronger oxidising agent than* SnO_2.

Ans. (*a*) It is because BX_3 is an electron deficient compound and NH_3 is an electron rich compound.

(*b*) As we move down the group 14, the atomic size increases and thus the strength of the element decreases down the group thus the bond dissociation enthalpy decreases steadily consequently the tendency for catenation decreases down the group.

(*c*) PbO_2 and SnO_2 both are present in +4 oxidation state. But due to stronger inert pair effect Pb^{2+} ion is more stable than Sn^{2+} ion.

In other way Pb^{4+} ions is more easily reduced to Pb^{2+} ions. Thus PbO_2 acts as a stronger oxidising agent than SnO_2.

Q3. *How is boron obtained from borax? Give chemical equations with reaction conditions.*

Ans.

$$\underset{\text{Borax}}{Na_2B_4O_7 \cdot 10H_2O} + H_2SO_4\ (\text{conc.}) \longrightarrow Na_2SO_4 + H_2B_4O_7 + 10H_2O$$

$$H_2B_4O_7 + 5H_2O \longrightarrow \underset{\text{Boric acid}}{4H_3BO_3}$$

$$2H_3BO_3 \xrightarrow{\text{Heat}} \underset{\text{Boric oxide}}{B_2O_3} + 3H_2O$$

$$B_2O_3 + 3Mg \xrightarrow{\Delta} 2B + 3MgO$$

IV. MULTIPLE CHOICE QUESTIONS

1. Boron has an extremely high melting point because of

(*a*) its ionic crystal structure

(*b*) the strong binding forces in the covalent polymer

(*c*) atomic size
(*d*) allotropy

2. Which of the following compound is an important catalyst as well as a Lewis acid?

(*a*) Al_2S_2 (*b*) BF_3 (*c*) S_4N_4 (*d*) N_2H_4

3. Carbon-60 contains

(*a*) 20 pentagons and 12 hexagons (*b*) 12 pentagons and 20 hexagons
(*c*) 30 pentagons and 30 hexagons (*d*) 24 pentagons and 36 hexagons

4. The diamond molecule contains

(*a*) sp^2-hybridized carbon atoms connected by single bonds
(*b*) sp^2-hybridized carbon atoms connected by double bonds
(*c*) sp^3-hybridized carbon atoms connected by single bonds
(*d*) sp^3-and sp^2-hybridized carbon atoms connected by single bonds

5. Which of the following is the most ionic?

(*a*) CCl_4 (*b*) $PbCl_2$ (*c*) $PbCl_4$ (*d*) $SiCl_4$

6. Silicon carbide (SiC) is known as

(*a*) quartz (*b*) tridynite (*c*) corundum (*d*) carborundum

7. Which of the following is a purely acidic oxide?

(*a*) SiO_2 (*b*) SnO_2 (*c*) PbO (*d*) MnO_2

8. Silicones are a group of organosilicon polymers containing

(*a*) Si – O – Si linkages (*b*) O – Si – O linkages
(*c*) Si – C – Si linkages (*d*) Si – Si – O linkages

9. Which of the following molecules have zero dipole moment?

(*a*) CS_2 (*b*) CO_2 (*c*) CCl_2 (*d*) CH_2Cl_2

10. Silicon shows a diagonal relation with

(*a*) magnesium (*b*) phosphorous (*c*) carbon (*d*) boron

Ans. 1. (*b*) 2. (*d*) 3. (*b*) 4. (*c*) 5. (*b*)
6. (*d*) 7. (*a*) 8. (*a*) 9. (*a*) and(*b*) 10. (*d*)

V. HOTS QUESTIONS

Q1. *Give reason for the following observations:–*

(a) The tendency for catenation decrease down the group in Group 14.
(b) The decreasing stability of +3 oxidations state with increasing atomic number in group 13.
(c) Molten aluminium bromide is a poor conductor of electricity.

Ans. (*a*) It is due to decrease in bond dissociation energy which is due to increase in atomic size.

C-C > Si-Si > Ge-Ge > Sn-Sn > Pb-Pb

(*b*) It is due to inert pair effect.

(*c*) Molten $AlBr_3$ is poor conductor of electricity because it is covalent compound.

Q2. *(a) Why do Boron halides form addition compound with NH_3?*

(b) Assign appropriate reason for each of the following observations:–

(i) Anhydrous $AlCl_3$ is used as a catalyst in many organic reactions.

(ii) No form of elemental silicon is comparable to graphite.

Ans. (*a*) It is because BX_3 is electron deficient whereas NH_3 is electron rich.

(*b*) (*i*) It is Lewis acid.

(*ii*) It cannot form pπ – pπ bond due to large size.

Q3. *Give the chemical reaction as an evidence for each of the following observations.*

(*i*) Tin (II) is a reducing agent whereas lead (II) is not.

(*ii*) Gallium (I) undergoes disproportionation reaction.

Ans. (*i*) Due to inert pair effect Pb^{2+} is more stable than Pb^{4+}. Whereas Sn^{4+} is more stable than Sn^{2+}.

(*ii*) $3Ga^+ \rightarrow 2Ga + Ga^{3+}$

This is because Ga^{3+} is more stable than Ga^+.

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