UNIT – 2 – P-BLOCK ELRMENTS - I

II. Answer the following questions:

1. Write a short note on anamolous properties of the first element of p-block. [SEP-20, AUG-21]

In p-block elements the first member of each group differs from the other elements of the corresponding group. The following factors are responsible for this anomalous behaviour.

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

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

2. Describe briefly allotropism in p- block elements with specific reference to carbon. [FMT-22]

Some elements exist in more than one crystalline or molecular forms in the same physical state. This phenomenon is called allotropism. Most common allotropes of carbon are, Graphite, Diamond, Fullerenes, Carbon nanotubes, Graphene.

3. Give the uses of Borax. [HY-19, AUG-21, HY-23]

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

4. What is catenation? Describe briefly the catenation property of carbon. [MAR, SEP20, JUL,SEP-22, FUT,HY-23]

Catenation is an ability of an element to form a chain of atoms. The conditions for catenation are

- The valency of the element is greater than or equal to two. The element should have the ability to bond with itself. The self-bond must be as strong as its bond with other elements.
- Kinetic inertness of catenated compound towards other molecules.
- Carbon possesses all the above properties and shows catenation.
- Carbon forms a wide range of compounds with itself and with other elements such as H, O, N, S and halogens.

5. Write a note on Fisher tropsch synthesis. [PTA-4, QY-22, MAR-23]

The reaction of carbon monoxide with hydrogen at a pressure of less than 50 atm using metal catalysts at 500-700 K yields saturated and unsaturated hydrocarbons.

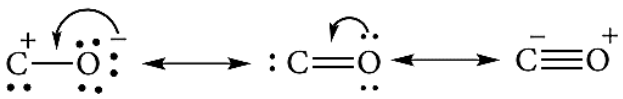
$$nCO + (2n+1)H_2 \longrightarrow C_nH_{(2n+2)} + nH_2O$$

$$nCO + 2nH_2 \longrightarrow C_nH_{2n} + nH_2O$$

6. Give the structure of CO and CO_2.

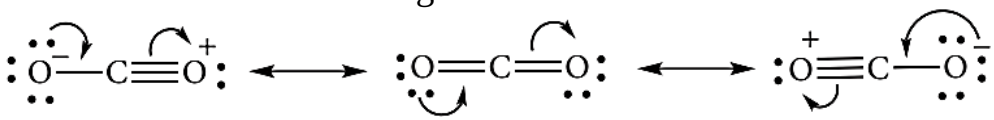
Structure of CO:

- It has a linear structure. In carbon monoxide, three electron pairs are shared between carbon and oxygen.
- The C-O bond distance is 1.128Å. The structure can be considered as the resonance hybrid of the following two canonical forms.



Structure of CO_2:

- Carbon dioxide has a linear structure with equal bond distance for the both C-O bonds.
- In this molecule there is two C-O sigma bond.
- In addition there is 3c-4e bond covering all the three atoms.

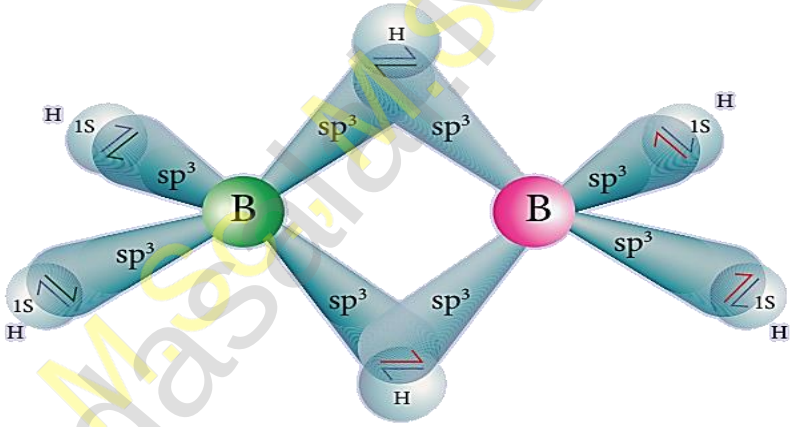


7. Give the uses of silicones. [FMT-22, HY-22, MAR-23, FUT-23]

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

8. Describe the structure of diborane. [PTA-3, FMT-22, MAR-23, FUT-23]

- In diborane two BH_2 units are linked by two bridged hydrogens.
- Therefore, it has eight B-H bonds.
- However, diborane has only 12 valance electrons and are not sufficient to form normal covalent bonds.
- The four terminal B-H bonds are normal covalent bonds (two centre – two electron bond or 2c-2e bond).



- The remaining four electrons have to used for the bridged bonds, i.e. two three centred B-H-B bonds utilise two electrons each. Hence, these bonds are three centre – two electron bonds. The bridging hydrogen atoms are in a plane as shown in the figure. In dibome, the boron is sp^3 hybridised.
- Three of the four sp^3 hybridised orbitals contains single electron and the fourth orbital is empty.
- Two of the half-filled hybridised orbitals of each boron overlap with the two hydrogens to form four-terminal 2c-2e bonds, leaving one empty and one half filled hybridised orbitals on each boron.
- The Three centre – two-electron bonds, B-H-B bond formation involves overlapping the half filled hybridised orbital of one boron, the empty hybridised orbital of the other boron and the half-filled 1s orbital of hydrogen.

9. Write a short note on hydroboration. [JUN-23, FRT-24]

- Diborane adds on to alkenes and alkynes in ether solvent at room temperature.
- This reaction is called as hydroboration and is highly used in synthetic organic chemistry especially for anti-Markovnikov addition.

$$B_2H_6 + 3RCH = CHR \rightarrow B(CH_2 - CH_2R)_3 + 6H_2$$ **[SRT,JUN-23]**

10. Give one example for each of the following: icosogens, tetragen, prictogen, chalcogen

1. Icosogens:	2. Tetragen:	3. Prictogen:	4. Chalcogen:
Boron	Carbon	Oxygen	Fluorine
Aluminium	Silicon	Sulfur	Chlorine
Gallium	Germanium	Selenium	Bromine

11.Write a note on the metallic nature of p-block elements.

- The tendency of an element to form a cation by loosing electrons is known as an electropositive or metallic character. This character depends on the ionisation energy.
- Generally on descending a group the ionisation energy decreases and hence the metallic character increases.
- In p-block, the elements present in lower left part are metals while the elements in the upper right part are non-metals.

GROUP	METALS	NON-METALS	METALLOIDS
13	Al, Ga, In, Tl	-	B
14	Sn, Pb	C	Si, Ge
15	Bi	N, P	As, Sb
16	Po	O, S, Se	Te
17	-	F, Cl, Br, I, At	-
18	-	He, Ne, Ar, Kr, Xe, Rn	-

12.Complete the following reactions:

(a) $B(OH)_3 + NH_3 \rightarrow$ **[HY-22]**
(b) $Na_2B_4O_7 + H_2SO_4 + H_2O \rightarrow$
(c) $B_2H_6 + 2NaOH + 2H_2O \rightarrow$
(d) $B_2H_6 + CH_3OH \rightarrow$
(e) $BF_3 + 9H_2O \rightarrow$
(f) $HCOOH + H_2SO_4 \rightarrow$
(g) $SiCl_4 + NH_3 \rightarrow$ **[QY-19]**
(h) $SiCl_4 + C_2H_5OH \rightarrow$
(i) $B + NaOH \rightarrow$ **[QY-19]**
(j) $H_2B_4O_7 \xrightarrow{\text{Redhot}}$ **[HY-22]**

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

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

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

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

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

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

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

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

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

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

13.How will you identify borate radical?(or) Write ethyl borate test. [PTA-5, GMQ, QY-19, HY-22, MAR-23]

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

$$H_3BO_3 + 3C_2H_5OH \xrightarrow[H_2SO_4]{\text{Conc.}} B(OC_2H_5)_3 + 3H_2O$$

14. Write a note on zeolites. (OR) What are Zeolites? [PTA-2, QY-19, SRT-24]

- Zeolites are three-dimensional crystalline solids containing aluminium, silicon and oxygen in their regular three-dimensional framework.
- They are hydrated sodium alumino silicates with general formula,
  $Na_2O.(Al_2O_3).x(SiO_2)y(H_2O)$ (x = 2 to 10; y = 2 to 6)
- Zeolites have the porous structure in which the monovalent sodium ions and water molecules are loosely held.
- The Si and Al atoms are tetrahedrally coordinated with each other through shared oxygen atoms.
- Zeolites are similar to clay minerals but they differ in their crystalline structure.
- Zeolites structure looks like a honeycomb consisting of a network of interconnected tunnels and cages.
- Water molecules moves freely in and out of these pores but the zeolite framework remains rigid.
- Another special aspect of this structure is that the pore/channel sizes are nearly uniform, allowing the crystal to act as a molecular sieve.
- The removal of permanent hardness of the water can be done using zeolites.

15. How will you convert boric acid to boron nitride? [PTA-3, QY,HY-23, MAR-24]

Fusion of urea with boric acid $B(OH)_3$, in an atmosphere of ammonia at 800 – 1200 K gives boron nitride.

$$B(OH)_3 + NH_3 \xrightarrow{\Delta} BN + 3H_2O$$

16. A hydride of 2nd period alkali metal (A) on reaction with compound of Boron (B) to give a reducing agent (C) identify A, B and C. [PTA-1, JUL-20, SRT-23]

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

$$B_2H_6 + 2LiH \xrightarrow{\text{Ether}} 2LiBH_4$$

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

17. A double salt which contains fourth-period alkali metal (A) on heating at 500K gives (B) Aqueous solution of (B) gives white precipitate with $BaCl_2$ and gives a red colour compound with alizarin. Identify A and B.

- A double salt which contains fourth-period alkali metal (A) is potash alum
  $K_2SO_4.Al_2(SO_4)_3.24H_2O$
- On heating potash alum (A) 500K give anhydrous potash alum (or) burnt alum (B).

$$K_2SO_4.Al_2(SO_4)_3.24\,H_2O \xrightarrow{500\,K} K_2SO_4.Al_2(SO_4)_3 + 24\,H_2O$$

- Aqueous solution of burnt alum, has sulphates ion, potassium ion and aluminium ion. Sulphate ion reacts with $BaCl_2$ to form white precipitate of Barium Sulphate

$$(SO_4)_2 + BaCl_2 \rightarrow BaSO_4 + 2Cl^-$$

- Aluminium ion reacts with alizarin solution to give a red colour compound.

18. CO is a reducing agent. Justify with an example. [PTA-6, FMT-22, SRT-24]

- CO_2 Thermodynamically, CO_2 is much more stable than CO, thus carbon monoxide has a relatively high tendency to be oxidised to form carbon di oxide. As it is oxidised it reduces the other substance in the reaction.
- When CO is used to reduce a metal oxide, it gets oxidized to form CO_2

$$CO + Fe_2O_3 \rightarrow 2Fe + 3CO_2$$

EVALUATE YOURSELF

1. Why group 18 elements are called inert gases? Write the general electronic configuration of group 18 elements.

- The group-18 consists of 6 elements, helium, neon, argon, krypton, xenon and radon. All these are gases have completely filled s and p orbitals, hence they are more stable and have least reactivity.
- Therefore group-18 elements are called inert gases. ns^2np^6 is the general electronic configuration of group elements.

GOVERNMENT EXAM QUESTION PAPER

1. How is Potash Alum prepared? What happens when it is heated to 500K? (or) Write the preparation of potash alum? [HY-19, JUN-20, QY-22]

The alunite the alum stone is the naturally occurring form and it is $K_2SO_4.Al_2(SO_4)_3.4Al(OH)_3$. When alum stone is treated with excess of sulphuric acid, the aluminium hydroxide is converted to aluminium sulphate. A calculated quantity of potassium sulphate is added and the solution is crystallised to generate potash alum. It is purified by recrystallisation.

$$K_2SO_4.Al_2(SO_4)_3.4Al(OH)_3 + 6H_2SO_4 \longrightarrow K_2SO_4 + 3Al_2(SO_4)_3 + 12\,H_2O$$

$$K_2SO_4 + Al_2(SO_4)_3 + 24\,H_2O \longrightarrow K_2SO_4.Al_2(SO_4)_3.24\,H_2O$$

Potash alum is heating at 500 K loses water of hydration and swells up. The swollen mass is known as **burnt alum**.

$$K_2SO_4.Al_2(SO_4)_3.24\,H_2O \xrightarrow{500\ K} K_2SO_4.Al_2(SO_4)_3 + 24\,H_2O$$

2. Although Graphite and Diamond are allotropes of carbon, graphite is soft whereas diamond is hard. Why? [QY-19]

- Carbon alone forms the familiar substances graphite and diamond. Both graphite and diamond are made only of carbon atoms.
- Graphite is very soft and slippery while Diamond is the hardest substance.
- While there are strong covalent bonds between carbon atoms in each layer, there are only weak forces between layers. This allows layers of carbon to slide over each other in graphite.
- On the other hand, in diamonds, each carbon atom is the same distance from each of its neighboring carbon atoms. they are bonded by strong covalent bonds
- Diamond is hard because it has four carbon atoms which form a strong covalent bond in tetrahedral structure whereas graphite is arranged in layer form through weak wander walls force hence is slippery in nature.

For example:

1. The slippery nature of graphite is attributed to the pencil lead.
2. The hardness of a diamond is used to drill, grind or cut materials.
3. Graphite is a good conductor because of the free electrons present in it

3. Give the uses of Potash alum. [QY-19, QY-23]

- It is used for purification of water. It is also used for water proofing and textiles
- It is used in dyeing, paper and leather tanning industries
- It is employed as a styptic agent to arrest bleeding.

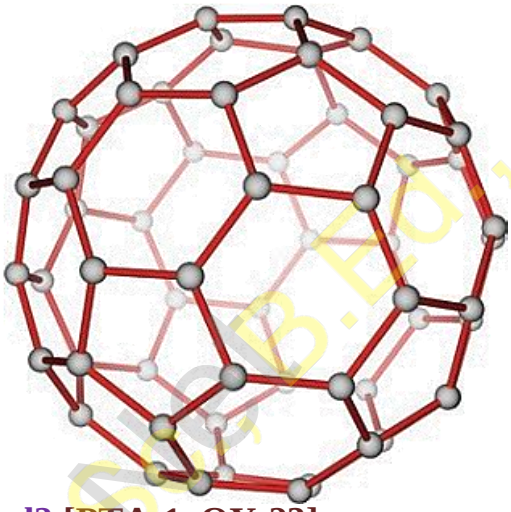
4. There is only a marginal difference in decrease in ionisation enthalpy from Aluminium to Thallium – Explain why? [MAR-20]

The reason for decrease in ionisation enthalpy from Aluminium to Thallium is due to the presence of inner d and f-electrons which has poor shielding effect compared to s and p-electrons.

5. What are the uses of boric acid? [MAY,JULY-22, SRT-24, MAR-24]

- Boric acid is used in the manufacture of pottery glases, enamels and pigments.
- It is used as an antiseptic and as an eye lotion.
- It is also used as a food preservative.

6. What are fullerenes? [FMT-22]



Fullerenes are newly synthesised allotropes of carbon. Unlike graphite and diamond, these allotropes are discrete molecules such as C_{32}, C_{50}, C_{60}, C_{70}, C_{76} etc., these molecules have cage like structures as shown in the figure. The C60 molecules have a soccer ball like structure and is called buckminster fullerene or buckyballs. It has a fused ring structure consists of 20 six membered rings and 12 five membered rings. Each carbon atom is sp^2 hybridised and forms three σ bonds & a delocalised π bond giving aromatic character to these molecules. The C-C bond distance is 1.44 Å and C=C distance 1.38 Å.

7. Which is known as Inorganic benzene? How it is prepared? [PTA-1, QY-23]

Borozole or **Borazine** is known as Inorganic benzene. When treated with excess ammonia at low temperatures diborane gives diboranediammonate. On heating at higher temperatures it gives inorganic benzene (borazole).

$$3B_2H_6 + 6NH_3 \xrightarrow{-153\ K} 3(B_2H_6.2NH_3)\ (or)\ 3[BH_2(NH_3)_2]^+[BH_4]^-$$

$$3B_2H_6 + 2NH_3 \xrightarrow[\text{Clossed vessel}]{\text{High temp}} 2B_3N_3H_6 + 12H_2$$

(Borazole or Borazine - Inorganic benzene)

8. What are amphiboles? Give example. [PTA-1,]

Double chain silicates (or amphiboles): These silicates contains $[Si_4O_{11}]_n^{6n-}$ ions. In these silicates there are two different types of tetrahedra : (i) Those sharing 3 vertices (ii) those sharing only 2 vertices.

Examples:

1) **Asbestos:** These are fibrous and non-combustible silicates. Therefore they are used for thermal insulation material, brake linings, construction material and filters. Asbestos being carcinogenic silicates, their applications are restricted.

9. How does boric acid reacts with NaOH?

It reacts with sodium hydroxide to form sodium metaborate and sodium tetraborate.

$$H_3BO_3 + NaOH \rightarrow NaBO_2 + 2H_2O$$

$$4H_3BO_3 + 2NaOH \rightarrow Na_2B_4O_7 + 7H_2O$$

10. What happens when Boric acid is heated? [QY-23]

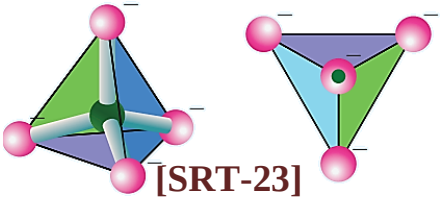
Boric acid when heated at 373 K gives metaboric acid and at 413 K, it gives tetraboric acid. When heated at red hot, it gives boric anhydride which is a glassy mass.

$$4H_3BO_3 \xrightarrow{373\ K} 4HBO_2 + 4H_2O$$

$$4HBO_2 \xrightarrow{413\ K} H_2B_4O_7 + H_2O$$

$$H_2B_4O_7 \xrightarrow{\text{Red hot}} 2B_2O_3 + H_2O$$

11.Write about orthosilicates. [FRT-24]



The simplest silicates which contain discrete $[SiO_4]^{4-}$ tetrahedral units are called **ortho silicates** or **neso silicates**.

12.$AlCl_3$ is more stable where as $TlCl_3$ is highly unstable. Why? [SRT-23]

- Aluminium (III) chloride is stable whereas thallium (III) chloride is highly unstable and disproportionates to thallium (I) chloride and chlorine gas.
- This shows that in thallium the stable lower oxidation state corresponds to the loss of *np* electrons only and not *ns* electrons.
- Thus in heavier post-transition metals, the outer *s* electrons (*ns*) have a tendency to remain inert and show reluctance to take part in the bonding, which is known as inert pair effect.

13.What are Silicates? [MAR-24]

The mineral which contains silicon and oxygen in tetrahedral $[SiO_4]^{4-}$ units linked together in different patterns are called silicates. Nearly 95 % of the earth crust is composed of silicate minerals and silica. The glass and ceramic industries are based on the chemistry silicates.

How will you prepare chlorine in the laboratory?

14.Write about McAfee process. [FRT-24]

Aluminium chloride is obtained by heating a mixture of alumina and coke in a current of chlorine.

$$2Al_2O_3 + 3C + 6Cl_2 \longrightarrow 4AlCl_3 + 3CO_2$$

On industrial scale it is prepared by chlorinating aluminium around 1000 K

$$2Al + 3Cl_2 \xrightarrow{1000\ K} 2AlCl_3$$

15.What is water gas equilibrium? [FMT-22]

The equilibrium involved in the reaction between carbon dioxide and hydrogen, has many industrial applications is called water gas equilibrium.

$$CO_2 + H_2 \rightleftharpoons CO + H_2O$$

16.What is the action of heat on Borax? [SAT-22]

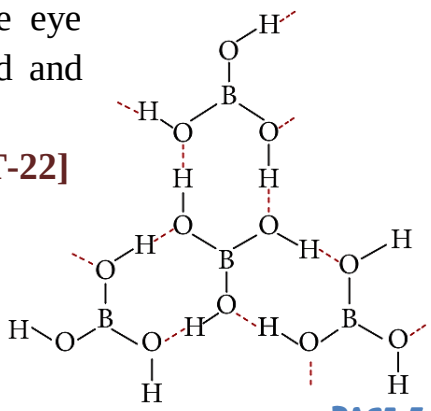
On heating it forms a transparent borax beads.

$$Na_2B_4O_7.10H_2O \xrightarrow[-10H_2O]{\Delta} Na_2B_4O_7 \longrightarrow 2NaBO_2 + B_2O_3$$

17.Mention the uses of boron. [SAT-22]

- Boron has the capacity to absorb neutrons. Hence, its isotope $^{10}B_5$ is used as moderator in nuclear reactors.
- Amorphous boron is used as a rocket fuel igniter. Boron is essential for the cell walls of plants.
- Compounds of boron have many applications. For example eye drops, antiseptics, washing powders etc., contains boric acid and borax. In the manufacture of Pyrex glass, boric oxide is used.

18.Draw the structure of Boric acid and mention its uses [SAT-22]



- Boric acid is used in the manufacture of pottery glases, enamels and pigments.
- It is used as an antiseptic and as an eye lotion.
- It is also used as a food preservative.

19.How is dibonane prepared?

Diborane can also be obtained in small quantities by the reaction of iodine with sodium borohydride in diglyme.

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

On heating magnesium boride with HCl a mixture of volatile boranes are obtained.

$$2Mg_3B_2 + 12HCl \longrightarrow 6MgCl_2 + B_4H_{10} + H_2$$

$$B_4H_{10} + H_2 \longrightarrow 2B_2H_6$$