PREVIOUS HSE QUESTIONS AND ANSWERS OF THE CHAPTER "THE p-BLOCK ELEMENTS"

1. (i) The allotropic form of carbon which is obtained by heating graphite in an electric arc in presence of an inert gas is _____ .

   (A) Diamond (B) Carbon black (C) Fullerene (D) Charcoal (1)

   (ii) Diamond is hard and a non-conductor of electricity, while graphite is soft and a good conductor of electricity, eventhough both are the different forms of carbon. Justify the statement on the basis of their structure. (3)

   Ans: (i) (C) Fullerene

   (ii) In Diamond, each carbon atom is in sp^3 hybridisation and so it has a three dimensional net-work structure. So it is hard. Due to the absence of free electrons, it is a non- conductor.

   But in graphite, each carbon atom is in sp^2 hybridisation. So it has a layered structure in which there is only a weak van der Waal's force of attraction between different layers. So it is soft. Due to the presence of free electrons, it is a conductor of electricity.

2. (i) Write the industrial production of diborane. (1)

   (ii) Name the final product obtained when diborane is heated with ammonia. (1)

   (iii) Explain the structure of diborane. (2) [December 2021]

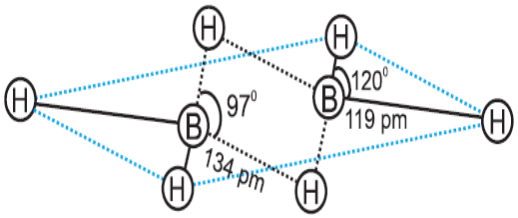
   Ans: (i) Diborane is prepared industrially by the reaction of BF_3 with sodium hydride.

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

   (ii) Borazine ($B_3N_3H_6$)

   (iii) In diborane, each boron atoms is in sp^3 hybridisation. The two boron atoms and 4 hydrogen atoms lie in one plane. These four H atoms are called terminal hydrogen atoms. The other two hydrogen atoms lie one above and one below this plane. These H atoms are called bridging hydrogen atoms. The four terminal B-H bonds are regular two centre-two electron bonds while the two bridge (B-H-B) bonds are three centre-two electron (3c-2e) bonds or banana bonds. Thus diborane is an electron deficient compound.

   Or, draw the structure as follows:



3. (i) What is diborane? (1)

   (ii) Name two types of bonds present in diborane molecule. (1)

   (iii) Name two manmade silicates. (2)

   Ans: (i) Diborane is the simplest boron hydride with molecular formula B_2H_6. It is the dimer of borane (BH_3).

   (ii) 3 centre – 2 electron bond (3c – 2e bond) or banana bond and 2c -2e bond

   Or, B-H-B bonds and B-H bonds.

   (iii) Glass and cement.

4. (i) Carbon monoxide is a poisonous gas. Why? (2)

   (ii) Name any two crystalline allotropes of carbon. (2) [September 2021]

Ans: (i) CO can easily form a stable complex with haemoglobin (carboxy haemoglobin). This prevents haemoglobin in RBC from carrying oxygen round the body. Hence it is poisonous.

(ii) Diamond, graphite and fullerene [any 2 required].

5. A mixture of CO and N_2 is known as …….. (1)

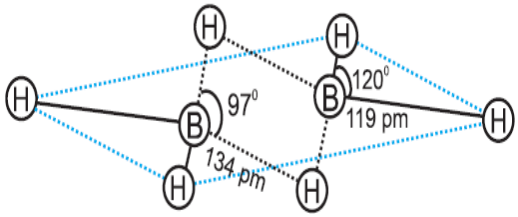
   Ans: Producer gas

6. (a) What is inert pair effect? (1)

   (b) Draw the structure of diborane. (1)

   Ans: (a) It is the reluctance of s-electrons to participate in chemical bonding.

   (b)



7. (a) Name any 2 crystalline allotropes of carbon. (1)

   (b) What are zeolites? Give one example. (1) [December 2020]

   Ans: (a) Diamond and graphite

   (b) Zeolites are aluminosilicates of metals. They are used as catalysts in petrochemical industry.

8. Water gas is a mixture of :

   (a) CO +H_2 (b) CO + N_2 (c) CO_2 + H_2 (d) CO_2 + N_2 (1)

   Ans: CO + H_2

9. (a) What is borax bead test ? (1)

   (b) $SiCl_4$ can be hydrolysed but CCl_4 cannot. Why? (1)

   Ans: (a) When borax is heated with transition metals, metaborates with characteristic colours are formed. This is known as Borax bead test.

   (b) This is due to the absence of vacant d-orbitals in carbon.

10. (a) Why $AlCl_3$ exists as dimer? (1)

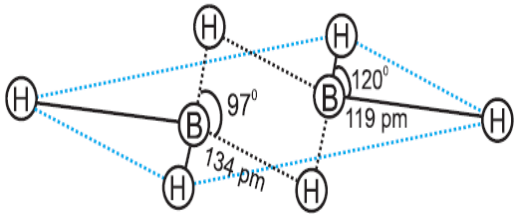
    (b) Write the basic structural unit of silicones and silicates. (1) [March 2020]

    Ans: (a) $AlCl_3$ is electron deficient compound. In order to attain stability, it exists as dimer.

    (b) Basic structural unit of silicones is -R_2SiO- and that of silicates is SiO_4^{4-}.

11. Name the colourless toxic gas that is produced when BF_3 is heated with Sodium hydride (NaH) at 450K. Draw its structure. (2)

    Ans: B_2H_6.



12. Write a short note on (a) Fullerenes and (b) Silicates (4) [July 2019]

    Ans:

    a) Fullerene: These are the cage like spherical molecules of formula C_{60}, C_{70}, C_{76}, C_{84} etc. They are prepared by heating graphite in an electric arc in the presence of inert gases like helium or argon.

The most commonly known fullerene is C_{60}, which is known as Buckminster fullerene. It contains twenty six- membered rings and twelve five membered rings.

b) Silicates: These are compounds of Si in which each silicon atom is bonded to four oxygen atoms in tetrahedral manner. The basic structural unit of silicate is SiO_4^{4-} tetrahedra. They exist in different forms like chain, ring, sheet or three-dimensional structures.

E.g. Zeolites, mica, feldspar, asbestos etc.

13. Draw the structure of Diborane. Write a note on the nature of bonds present in it. (2)

Ans: Refer the answer of the question no. 1

Here the four terminal B-H bonds are regular two centre-two electron bonds while the two bridge (B-H-B) bonds are three centre- two electron (3c-2e) bonds or banana bonds.

14. a) What are silicones? (1)

b) Write the chemical equations showing the steps involved in the manufacture of silicones. (2)

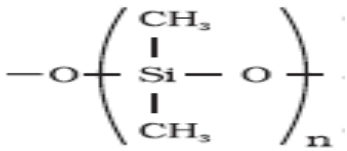
c) How can the chain length of silicones be controlled during their synthesis? (1) [March 2019]

Ans: a) Silicones are organosilicon polymers, which have $(-R_2SiO-)$ as a repeating unit.

b) When methyl chloride reacts with silicon in the presence of copper as a catalyst at 573K temperature, dimethyl dichlorosilane $[(CH_3)_2SiCl_2]$ and other methyl substituted chlorosilanes are formed. Hydrolysis of dichlorosilane followed by condensation gives straight chain polymers.

OR, $2CH_3Cl + Si \xrightarrow{Cu;\ 573K} (CH_3)_2SiCl_2 \xrightarrow{2H_2O} (CH_3)_2Si(OH)_2$

$n(CH_3)_2Si(OH)_2 \xrightarrow{polymerisation}$



c) The chain length of the polymer can be controlled by adding $(CH_3)_3SiCl$ which blocks the ends of the polymer chain.

15. Write the formula of the basic structural unit of silicates. (1)

Ans: SiO_4^{4-}

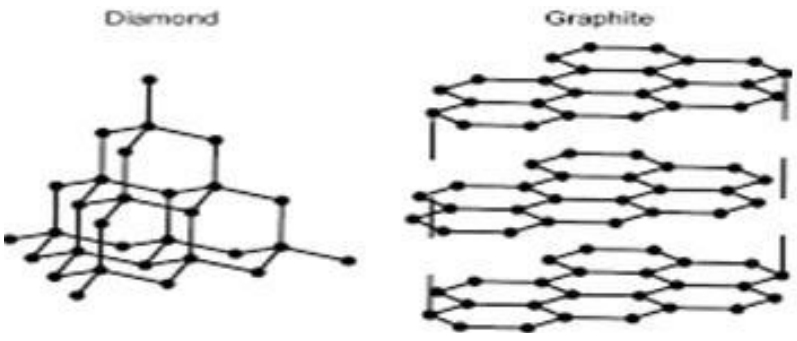
16. What are zeolites? Give any two uses of zeolites. (2)

Ans: Zeolites are aluminosilicates of metals in which Na^+, K^+, Ca^{2+} etc. acts as cations.

They are widely used as a catalyst in petrochemical industries and for removing hardness of water.

17. Sketch the structures of graphite and diamond. What is the impact of structure on physical properties of these allotropes? (3) [August 2018]

Ans:



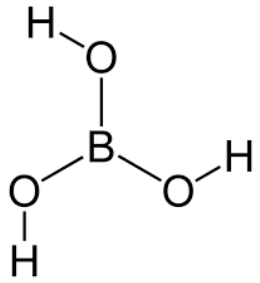
Graphite has a layered structure. Different layers are held by weak van der Waals forces of attraction. So it is very soft and slippery. Diamond has a a rigid three dimensional network of carbon atoms. It is very difficult to break covalent bonds and, therefore, diamond is very hard.

18. The allotrope of carbon with the highest thermodynamic stability is…….. (1)

Ans: Graphite

19. Draw the structure of orthoboric acid. Why it is not a protonic acid? (2)

Ans:



It is non-protic acid since it acts as a Lewis acid by accepting electrons from a hydroxyl ion.

$B(OH)_3 + 2H_2O \rightarrow [B(OH)_4]^- + H_3O^+$

20. Explain any one method of preparation and structure of diborane. (3) [March 2018]

Ans: Diborane is prepared by treating BF_3 with Lithium aluminium hydride ($LiAlH_4$) in ether.

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

Structure: Refer the Answer of the qn. No. 1

21. a) Diborane is an electron deficient compound. Explain the structure of diborane. (2)

b) What is water gas? (1)

c) Inorganic benzene is …… (1) [July 2017]

Ans: a) In diborane, each boron atoms is in sp^3 hybridisation. The two boron atoms and 4 hydrogen atoms lie in one plane. These four H atoms are called terminal hydrogen atoms. The other two hydrogen atoms lie one above and one below this plane. These H atoms are called bridging hydrogen atoms. The four terminal B-H bonds are regular two centre-two electron bonds while the two bridge (B-H-B) bonds are three centre- two electron (3c-2e) bonds or banana bonds. Thus diborane is an electron deficient compound.

Or, Draw the structure as given in the answer of the qn. No. 1

b) A mixture of CO and H_2

c) Borazine ($B_3N_3H_6$)

22. Borax is an important compound of Boron.

a) The solution of borax is alkaline. Give reason. (2)

b) Give any two uses of borax. (1)

c) Diamond has covalent bonding. Yet it has high melting point. Give a reason. (1) [March 2017]

Ans: (a) Borax dissolves in water to give NaOH and orthoboric acid. Since NaOH is a strong alkali and orthoboric acid is weak acid, the solution is basic in nature.

Or, The equation: $Na_2B_4O_7 + 7H_2O \rightarrow 2NaOH + 4H_3BO_3$

(b) Borax is used for the detection of transition elements by Borax bead test. It is used for the manufacture of heat resistant glasses, glass-wool and fibre glass. It is also used as a flux for soldering metals, for heat,

scratch and stain resistant glazed coating to earthenwares and as a constituent of medicinal soaps.

*[**Any one use required**]*

(c) Diamond has a three dimensional network structure with extended covalent bonding. Since it is very difficult to break these covalent binds, it has high m.p.

OR, Due to the tetrahedral (sp^3) hybridisation of carbon atoms in diamond.

23. a) CCl_4 does not undergo hydrolysis but $SiCl_4$ undergoes hydrolysis. Why? (2)
    b) Differentiate between silicates and silicones. (2) [September 2016]

Ans: a) In CCl_4, there is no vacant d-orbitals in carbon. So it cannot accommodate the lone pair of electrons donated by oxygen atom of water molecule.

b) *Refer the Answer of the qn. No. 2 (b) and 4 (a)*

24. Carbon has many allotropes.
    a) Write the name of any two allotropic forms of carbon. (1)
    b) Briefly explain the structure of any one of the above mentioned allotrope. (2)
    c) CCl_4 does not undergo hydrolysis. Give reason. (1)

Ans: a) Diamond and graphite

b) Refer the Answer of the qn. No. 17

c) Refer the Answer of the qn. No. 23 (a)

25. When BF_3 is treated with LiH at 450K, a hydride of boron is formed.
    a) Identify the hydride of boron formed in the above reaction. (1)
    b) Briefly explain the structure of the above mentioned hydride. (2)
    c) Boron compounds behave as Lewis acids. Why? (1) [March 2016]

Ans: a) Diborane (B_2H_6)

b) *Refer the Answer of the qn. No. 2(iii).*

c) Boron compounds are electron deficient. So they behave as Lewis acids.

26. Orthoboric acid is an important compound of boron. Prepare a short note on orthoboric acid highlighting the following aspects.
    - Method of preparation * Acidic nature *Action of heat *structure (4) [October 2015]

Ans: It is prepared by acidifying an aqueous solution of borax.

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

It is a weak monobasic non-protic acid. It acts as a Lewis acid by accepting electrons from a hydroxyl ion.

$B(OH)_3 + 2H_2O \rightarrow [B(OH)_4]^- + H_3O^+$

On heating above 370K, it forms metaboric acid (HBO_2) which on further heating gives boric oxide (B_2O_3).

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

Structure: Refer the Answer of the qn. No. 9

27. a) Thermodynamically, the most stable allotrope of carbon is …….. (1)
    b) Carbon is the first member of group 14 in the periodic table.
    i) Why does carbon differ from the rest of the members of its group? (1)
    ii) Write any two anomalous properties of carbon. (2) [March 2015]

Ans: a) Graphite

b) i) Due to its small size, high electronegativity and unavailability of vacant d-orbitals

ii) The anomalous properties shown by C are:

- *The maximum covalency of C is four. While other elements of group 14 can extend their covalency beyond 4 due to the presence of vacant d-orbitals.*
- *Carbon has unique ability to form pπ– pπ multiple bonds with itself and with other atoms .*

28. Give reason for the following:
    a) CO_2 is a gas while SiO_2 is a solid. (1)
    b) CCl_4 cannot be hydrolyzed but $SiCl_4$ can be hydrolyzed. (1)
    c) Borax bead test can be used to identify metaborates in the laboratory. (1)
    d) Graphite is used as a lubricant in machines. (1) [August 2014]

    Ans: a) In CO_2 molecule has a linear shape and hence it exists as discrete (separate) molecules. So it is a gas. But in silica (SiO_2), each Si atom is tetrahedrally surrounded by 4 oxygen atoms. So it has a three dimensional network structure and hence it is a solid.

    b) Due to the absence of vacant d-orbitals in C.

    c) Since the metaborates of most of the transition metals are coloured.

    d) Because of its layered structure and slippery nature.

29. a) What is dry ice? (1)
    b) Why does BF_3 behave as a Lewis acid? (1)
    c) Carbon forms millions of compounds due to its self-linking property to form long chains and big rings.
    i) Name the above property of carbon. (1)
    ii) Give the reason for the above property of carbon. (1) [March 2014]

    Ans: a) Solid CO_2.

    b) Because of the presence of vacant d-orbitals in Boron.

    c) i) Catenation

    ii) This is because C – C bonds are very strong.

30. a) i) Boric acid (H_3BO_3) is considered as a weak acid. Why? (1)
    ii) Carbon monoxide is highly poisonous. Why? (1)
    b) What are zeolites? What is its use? (2) [September 2013]

    Ans: a) i) Boric acid is a weak Lewis acid since it accepts electrons from a hydroxyl ion of water molecule.

    ii) CO can easily form a stable complex with haemoglobin (carboxy haemoglobin). This prevents haemoglobin in RBC from carrying oxygen round the body. Hence it is poisonous.

    b) Refer the Answer of the qn. No. 16

31. The group 14 elements have four electrons in the outermost shell.
    a) $SiCl_4$ can be easily hydrolyzed by water while CCl_4 cannot be hydrolyzed. Why? (1)
    b) How are fullerenes prepared? (1)
    c) Distinguish between silicones and silicates? (2)` [March 2013]

    Ans: a) Refer the Answer of the qn. No. 23 (a)

    b) Fullerenes are prepared by heating graphite in an electric arc in the presence of inert gases like helium or argon.

    c) *Silicones are organosilicon polymers containing -R_2SiO- as repeating unit. While silicates are compounds of Si in which SiO_4^{4-} tetrahedra as basic structural unit.*

32. a) Diborane is an electron deficient compound.
    i) Name the special bonds that present in Diborane. (1)
    ii) How will you convert Diborane into inorganic benzene? (1)

b) What are silicones? Write its general formula. (2) [September 2012]

Ans: a)

i) 3 centre-2 electron (3C-2e) bond or banana bond

ii) When diborane is heated with ammonia, we get Borazine commonly called inorganic benzene.

b) Silicones are organosilicon polymers containing -R_2SiO- as repeating unit. General formula is (-R_2SiO-)$_n$.

33. Borax, orthoboric acid and diborane are some useful compounds of boron.
    a) Write the chemical formula of borax. (1)
    b) Boric acid is not a protonic acid but acts as a Lewis acid. Justify. (1)
    c) Explain the structure of diborane using a diagram. (2) [March 2012]

Ans: a) $Na_2B_4O_7$. $10H_2O$ or $Na_2[B_4O_5(OH)_4].8H_2O$.

b) *Refer the Answer of the qn. No. 19*

c) *Refer the Answer of the qn. No. 2(iii).*

34. a) Some elements can exist in different crystalline forms and are called allotropes.
    i) What are the important allotropic forms of carbon? (1)
    ii) Which allotropic form of carbon is used as a dry lubricant in machines running at high temperature? (1)
    b) When sodium borohydride ($NaBH_4$) is treated with iodine (I_2), two gaseous products were obtained. One is hydrogen and the other is a highly toxic gas X, which catches fire upon exposure to air. When the gas X is heated with ammonia for a long time, a compound Y of ring structure is obtained. Identify X and Y. (Name and molecular formula are expected) (2) [October 2011]

Ans: a)

i) Diamond, Graphite and Fullerene are the important crystalline allotropes of carbon.

ii) Graphite

b) X is diborane (B_2H_6) and Y is Borazine ($B_3N_3H_6$)

35. Two important compounds of carbon are carbon monoxide and carbon dioxide.
    a) Why carbon monoxide is called a poisonous gas? (1)
    b) How is CO_2 responsible for global warming? (1½)
    c) What are producer gas and water gas? Mention their uses? (1½) [March 2011]

Ans: a)

a) *Refer the Answer of the qn. No. 30 (a) ii*

b) CO_2 absorbs earth radiation which results in increase in temperature of the atmosphere.

c) Producer gas is a mixture of carbon monoxide and nitrogen while water gas is a mixture of carbon monoxide and hydrogen. Both are used as industrial fuels.

36. Match the following:

A	B	C
1. Inorganic benzene	a) Allotrope	i) Aluminium
2. Glass like beads	b) Borax	ii) Carbon
3. Fullerene	c) Borazine	iii) B_2H_6
4. Zeolites	d) Dry ice	iv) $B_3N_3H_6$
	e) Softening of hard water	v) $Na_2[B_4O_5(OH)_4].8H_2O$

(4) [September 2010]

Ans: a)

A	B	C
1. Inorganic benzene	d) Borazine	iv) $B_3N_3H_6$
2. Glass like beads	b) Borax	v) $Na_2[B_4O_5(OH)_4].8H_2O$
3. Fullerene	a) Allotrope	ii) Carbon
4. Zeolites	e) Softening of hard water	i) Aluminium

37. Boron, Aluminium, Gallium, Indium and Thalium belong to group 13 of the periodic table of elements.
    a) How can you explain the higher stability of BCl_3 as compared to $TlCl_3$? (1)
    b) While Aluminium can be form the ion $[AlF_6]^{3-}$, Boron is unable to form $[BF_6]^{3-}$ ion. Explain. (1)
    c) State whether the compound BCl_3 is acidic or basic. (1)
    d) Write the hybridization state of B in BF_3 and BH_4^-. (1) [March 2010]

    Ans: a) Due to inert pair effect Tl mainly shows +1 oxidation state. $TlCl_3$ is less stable.
    b) Due to the lack of vacant d-orbitals in B.
    c) Acidic. Since it contains vacant orbitals, BCl_3 can act as Lewis acid.
    d) $BF_3 – sp^2$ hybridisation, $BH_4^- – sp^3$ hybridisation.

38. a) Briefly describe the structure of diborane. (2)
    b) What is inorganic benzene? Why is it so called? (2) [March 2009]

    Ans: a) Refer the Answer of the qn. No. 2(iii).
    b) Borazine ($B_3N_3H_6$). It is called inorganic benzene since its structure is similar to that of benzene.

39. Some elements show allotropy.
    a) Define allotropy. (1)
    b) Diamond is hard and non-conducting, while graphite is soft and conducting. Explain. (2) [June 2008]

    Ans: a) The existance of an element in two or more forms with same chemical properties but with different physical properties is known as allotropy.
    b) Diamond has a three dimensional net-work structure and there is no free electron. So it is hard and non- conducting. But graphite has a layered structure in which there is only a weak van der Waal's force of attraction between different layers. Also it contains free electrons. So it is soft and conducting.

40. Carbon and silicon belong to the same group and have many similarities. But …….
    a) CO_2 is a gas while SiO_2 is a solid. Explain (2)
    b) CCl_4 cannot be hydrolysed, but $SiCl_4$ can be. Why? (1) [February 2008]

    Ans: a) Refer the Answer of the qn. No. 28 (a)
    b) Refer the Answer of the qn. No. 23 (a)