Class:12th

Subject: Chemistry

Chapter 3: GROUP IIIA AND GROUP IVA ELEMENTS

💡 Group IIIA & IVA Key Points & Important MCQs

1. Boron occurs in:

(a) Large quantities in earth's crust

(b) Traces and is important for plant growth ✅

(c) Only in oceans

(d) Only in volcanic rocks

2. Which of the following is not a common mineral of boron?

(a) Borax

(b) Colemanite

(c) Orthoboric acid

(d) Bauxite ✅

3. The chemical formula of borax is:

(a) $Na_2B_4O_7 \cdot 10H_2O$ ✅

(b) $Na_2CO_3 \cdot 10H_2O$

(c) $Ca_2BO_3 \cdot 5H_2O$

(d) H_3BO_3

4. The third most abundant element in the earth's crust after oxygen and silicon is:

(a) Iron

(b) Calcium

(c) Aluminium ✅

(d) Sodium

5. Which of the following is a common mineral of aluminium?

(a) Cryolite ✅

(b) Quartz

(c) Graphite

(d) Talc

6. The "inert pair" refers to:

(a) Outer electrons that take part in bonding

(b) Pair of electrons that do not take part in bonding ✅

(c) Electrons in d-orbital

(d) Shared pair of electrons

7. When borax is heated, it:

(a) Changes to a liquid

(b) Swells into a white porous mass ✅

(c) Becomes black

(d) Gives green vapours

8. The borax bead test is used for:

(a) Finding melting point

(b) Identification of coloured salts ✅

(c) Measuring density

(d) Determining pH

9. When aluminium burns in oxygen, it produces:

(a) Dim light

(b) Brilliant light ✅

(c) Blue flame

(d) No visible change

10. Group IVA elements have how many valence electrons?

(a) Two

(b) Three

(c) Four ✅

(d) Five

11. Famous minerals of silicon are:

(a) Feldspar, potash mica and zircon ✅

(b) Bauxite, corundum and cryolite

(c) Quartz, graphite and mica

(d) Talc, clay and gypsum

12. In silica structure, each silicon atom is bonded to:

(a) Two oxygen atoms

(b) Three oxygen atoms

(c) Four oxygen atoms ✅

(d) Six oxygen atoms

13. Compounds like sodium silicate, aluminium silicate, talc and asbestos are known as:

(a) Sulphates

(b) Nitrates

(c) Silicates ✅

(d) Carbonates

14. Methyl silicones are mainly used as:

(a) Fuels

(b) Lubricants and waterproofing materials ✅

(c) Explosives

(d) Fertilizers

15. The oxides of lead are mainly used as:

(a) Fuels

(b) Pigments ✅

(c) Detergents

(d) Fertilizers

🩸 Important MCQs

1. The Group IIIA of the Periodic Table consists of:

(a) Li, Na, K, Rb, Cs

(b) C, Si, Ge, Sn, Pb

(c) N, P, As, Sb, Bi

(d) B, Al, Ga, In, Tl ✅

2. Which element of Group IIIA is non-metallic in nature?

(a) Aluminium

(b) Boron ✅

(c) Gallium

(d) Thallium

3. The abrupt increase in metallic character from boron to aluminium is due to:

(a) Decrease in atomic size

(b) Increase in nuclear charge

(c) Increase in atomic size ✅

(d) Decrease in ionization energy

4. The irregular increase in atomic size in Group IIIA elements is due to:

(a) Presence of p electrons

(b) Presence of d electrons ✅

(c) High ionization energy

(d) Low atomic mass

5. Boron is always found in nature combined with:

(a) Hydrogen

(b) Oxygen ✅

(c) Nitrogen

(d) Sulphur

6. Boron occurs mainly as:

(a) Chlorides

(b) Sulphides

(c) Oxyborate ions ✅

(d) Silicates

7. The main reason for the dissimilarity of boron with other Group IIIA elements is:

(a) Its low atomic number

(b) Its high reactivity

(c) Difference in size and ionization energy ✅

(d) Presence of p orbitals

8. The common oxidation states of boron are:

(a) +1 and +3

(b) +2 and +4

(c) +3 and −3 ✅

(d) +3 and +5

9. Boron does not form ionic compounds because:

(a) It is non-reactive

(b) It cannot form a stable cation ✅

(c) It has high atomic size

(d) It reacts only with hydrogen

10. One of the special features of boron chemistry is:

(a) Formation of ionic compounds

(b) Ability to form molecular addition compounds ✅

(c) Formation of metallic oxides

(d) Formation of halide salts

11. Borax is the sodium salt of:

(a) Metaboric acid

(b) Orthoboric acid

(c) Tetraboric acid ✅

(d) Pyroboric acid

12. The natural mineral from which borax is obtained is called:

(a) Colemanite

(b) Tincal ✅

(c) Gypsum

(d) Dolomite

13. Borax can be prepared by treating boric acid with:

(a) NaOH

(b) Na_2CO_3 (Soda ash) ✅

(c) $CaCO_3$

(d) NaCl

14. The aqueous solution of borax is:

(a) Neutral

(b) Acidic

(c) Basic or alkaline ✅

(d) Amphoteric

15. Borax bead test is used for the:

(a) Detection of non-metals

(b) Detection of metallic cations ✅

(c) Estimation of gases

(d) Identification of acids

16. When borax is heated, it first swells up and then melts to form:

(a) White powder

(b) Transparent glass ✅

(c) Blue solution

(d) Yellow residue

17. In the borax bead test, the blue color with cupric oxide is due to:

(a) Copper sulphate

(b) Cupric borate ✅

(c) Copper hydroxide

(d) Cuprous chloride

18. Borax solution becomes alkaline because of:

(a) Ionization of NaCl

(b) Hydrolysis of $B_4O_7^{2-}$ ✅

(c) Presence of strong acid

(d) Formation of H_2 gas

19. Borax reacts with acids like HCl to form:

(a) Boric acid ✅

(b) Hydrochloric acid

(c) Aluminium chloride

(d) Sodium chloride only

20. Borax when heated with ammonium chloride produces:

(a) Boric acid

(b) Boron nitride ✅

(c) Aluminium nitride

(d) Sodium borate

21. Orthoboric acid is also known as:

(a) Metaboric acid

(b) Boric acid ✅

(c) Tetraboric acid

(d) Pyroboric acid

22. The most stable boric acid among all is:

(a) Orthoboric acid ✅

(b) Metaboric acid

(c) Pyroboric acid

(d) Tetraboric acid

23. Commercially, boric acid is prepared from:

(a) Sodium carbonate

(b) Colemanite ✅

(c) Dolomite

(d) Limestone

24. When boric acid is strongly heated, it finally gives:

(a) Metaboric acid

(b) Boric anhydride ✅

(c) Boron hydride

(d) Aluminium borate

25. Boric acid is a:

(a) Strong acid

(b) Weak monobasic acid ✅

(c) Dibasic acid

(d) Strong tribasic acid

26. The reaction of boric acid with ethyl alcohol gives:

(a) Ethyl borate ✅

(b) Borax

(c) Sodium borate

(d) Ethyl chloride

27. Boric acid turns blue litmus:

(a) Blue

(b) Red ✅

(c) Colorless

(d) Yellow

28. Aluminium becomes corrosion-free due to:

(a) Its low reactivity

(b) A thin layer of Al_2O_3 on its surface ✅

(c) Presence of moisture

(d) Its metallic nature

29. Aluminium reacts with hot concentrated H_2SO_4 to give:

(a) Hydrogen

(b) Sulphur dioxide ✅

(c) Sulphur trioxide

(d) Sulphurous acid

30. Aluminium dissolves in NaOH to form:

(a) Sodium aluminate ✅

(b) Sodium chloride

(c) Aluminium sulphate

(d) Aluminium hydroxide

31. The elements of Group IVA are:

(a) B, Al, Ga, In, Tl

(b) C, Si, Ge, Sn, Pb ✅

(c) N, P, As, Sb, Bi

(d) O, S, Se, Te, Po

32. The non-metallic elements in Group IVA are:

(a) Carbon and Tin

(b) Carbon and Silicon ✅

(c) Silicon and Lead

(d) Germanium and Tin

33. The oxides of carbon and silicon are:

(a) Basic

(b) Amphoteric

(c) Acidic ✅

(d) Neutral

34. The oxides of germanium, tin and lead are:

(a) Acidic

(b) Amphoteric ✅

(c) Basic

(d) Neutral

35. The property of forming long chains of identical atoms is known as:

(a) Ionization

(b) Polymerization

(c) Catenation ✅

(d) Crystallization

36. The element which shows maximum catenation tendency is:

(a) Silicon

(b) Carbon ✅

(c) Germanium

(d) Tin

37. The inert pair effect is most prominent in:

(a) Carbon

(b) Silicon

(c) Tin

(d) Lead ✅

38. The increase in metallic character from carbon to lead is due to:

(a) Decrease in atomic mass

(b) Increase in atomic mass ✅

(c) Decrease in atomic number

(d) Decrease in electropositive character

39. Silicon occurs abundantly in nature as:

(a) Silica and silicates ✅

(b) Chlorides and oxides

(c) Phosphates and sulphates

(d) Carbonates and nitrates

40. Sand is largely composed of:

(a) Sodium chloride

(b) Silicon dioxide ✅

(c) Calcium carbonate

(d) Aluminium oxide

41. Carbon monoxide (CO) is a ______ molecule having a triple bond between the two atoms.

(a) Tetra-atomic

(b) Diatomic ✅

(c) Triatomic

(d) Polyatomic

42. The dipole moment of carbon monoxide (CO) is ______.

(a) 0.512 D

(b) 0.112 D ✅

(c) 1.12 D

(d) Zero

43. The structure of carbon dioxide (CO_2) is ______.

(a) Angular

(b) Linear ✅

(c) Tetrahedral

(d) Trigonal

44. The dipole moment of CO_2 molecule is ______.

(a) 0.5 D

(b) 0.25 D

(c) 0 D ✅

(d) 1 D

45. Silicon dioxide (SiO_2) is commonly known as ______.

(a) Quicklime

(b) Silica ✅

(c) Gypsum

(d) Marble

46. Each silicon atom in silica (SiO_2) is bonded ______.

(a) Linearly to two oxygen atoms

(b) Tetrahedrally to four oxygen atoms ✅

(c) To one oxygen atom

(d) To six oxygen atoms

47. Silica is resistant to all acids except ______.

(a) HCl

(b) HNO_3

(c) H_2SO_4

(d) HF ✅

48. Quartz is the crystalline form of ______.

(a) Silicon carbide

(b) Silicon dioxide ✅

(c) Sodium silicate

(d) Aluminium silicate

49. The molecular structure of silica (SiO_2) forms a ______ network.

(a) Two-dimensional

(b) Continuous giant three-dimensional ✅

(c) Linear

(d) Angular

50. Vitreous silica is also called ______.

(a) Fused quartz ✅

(b) Sodium silicate

(c) Kaolin

(d) Graphite

51. Sodium silicate is commonly known as ______.

(a) Baking soda

(b) Water glass ✅

(c) Soda ash

(d) Lime

52. Sodium silicate (Na_2SiO_3) is prepared by fusing ______.

(a) NaCl and SiO_2

(b) Na_2CO_3 and SiO_2 ✅

(c) NaOH and SiO_2

(d) Na_2SO_4 and SiO_2

53. Sodium silicate solution is ______ in nature.

(a) Acidic

(b) Neutral

(c) Strongly alkaline ✅

(d) Amphoteric

54. Kaolin (pure clay) is used in making ______.

(a) Porcelain and china ware ✅

(b) Cement

(c) Bricks

(d) Marble

55. The yellow or reddish color of ordinary clay is due to ______.

(a) Copper oxide

(b) Iron compounds ✅

(c) Carbon compounds

(d) Lead oxide

56. The reddish color of bricks after heating in a kiln is due to ______.

(a) Ferric oxide ✅

(b) Magnesium oxide

(c) Zinc oxide

(d) Calcium oxide

57. Talc (soapstone) is ______.

(a) Aluminium silicate

(b) Magnesium silicate ✅

(c) Calcium silicate

(d) Sodium silicate

58. Talc is used in cosmetics because it is ______.

(a) Hard

(b) Brittle

(c) Greasy to touch ✅

(d) Transparent

59. Asbestos is a hydrated ______ silicate.

(a) Sodium

(b) Calcium magnesium ✅

(c) Aluminium

(d) Zinc

60. Silicones are synthetic compounds consisting of chains of ______.

(a) Carbon and hydrogen

(b) Silicon and oxygen ✅

(c) Silicon and chlorine

(d) Carbon and nitrogen

61. A semiconductor is a substance that has ______ resistance to the passage of electric current under different conditions.

(a) Constant

(b) Variable ✅

(c) Infinite

(d) Zero

62. Which of the following is not a semiconductor element?

(a) Germanium

(b) Selenium

(c) Iron ✅

(d) Silicon

63. The term “semiconductor” means:

(a) A full conductor

(b) A non-conductor

(c) A half conductor ✅

(d) An insulator

64. The electrical conductivity of a semiconductor ______ with increase in temperature.

(a) Decreases

(b) Increases ✅

(c) Remains constant

(d) Becomes zero

65. Metals and semiconductors behave differently on heating because:

(a) Metals melt, semiconductors do not

(b) Resistance of metals increases, that of semiconductors decreases ✅

(c) Metals expand, semiconductors contract

(d) Both have same resistance behavior

66. Semiconductors conduct electricity better when exposed to:

(a) Darkness

(b) Low temperature

(c) Light ✅

(d) Vacu um

67. Semiconductors are used in:

(a) Photoelectric cells ✅

(b) Plastic manufacturing

(c) Textile industry

(d) Fertilizer plants

68. The junction between two different semiconductor materials forms the basis of:

(a) Bulbs

(b) Transistors ✅

(c) Transformers

(d) Resistors

69. Transistors are used in all the following except:

(a) Radios

(b) Televisions

(c) Computers

(d) Cement mixers ✅

70. The main advantage of transistors over old electronic tubes is that they are:

(a) Larger and cheaper

(b) Smaller and simpler ✅

(c) Heavier and stronger

(d) Harder to make

71. Lead suboxide (Pb_2O) is obtained by heating plumbous oxalate ______.

(a) In the presence of air

(b) In the absence of air ✅

(c) With water

(d) With acid

72. Litharge is another name for:

(a) Pb_2O

(b) PbO ✅

(c) Pb_3O_4

(d) PbO_2

73. Red lead or minium has the formula:

(a) Pb_2O

(b) PbO

(c) Pb_3O_4 ✅

(d) PbO_2

74. White lead is chemically known as:

(a) Basic lead carbonate ✅

(b) Lead sulphate

(c) Lead chromate

(d) Lead oxide

75. Lead chromate ($PbCrO_4$) is used as a pigment known as:

(a) Chrome red

(b) Chrome yellow ✅

(c) White paint

(d) Green oxide

💡 Group IIIA & IVA Key Points & Important Short Questions

1. Where does boron occur in nature and why is it important for plants?

Answer:

👉 Boron occurs in traces in most soils and is essential for the proper growth and development of many plants.

2. Name any three common minerals of boron.

Answer:

👉 The common minerals of boron are:

- Borax ($Na_2B_4O_7 \cdot 10H_2O$)
- Colemanite ($Ca_2B_6O_{11} \cdot 5H_2O$)
- Orthoboric acid (H_3BO_3)

3. Which element is the third most abundant in the earth's crust after oxygen and silicon?

Answer:

👉 Aluminium is the third most abundant element in the earth's crust after oxygen and silicon.

4. Define inert pair.

Answer:

👉 The pair of outermost s-electrons that does not readily take part in chemical combination is called an inert pair.

5. What happens when borax is heated?

Answer:

👉 When borax is heated, it fuses, loses its water of crystallization, and swells up into a white porous mass.

6. How is boric acid obtained from borax?

Answer:

👉 When a hot concentrated solution of borax is treated with concentrated H_2SO_4 and then cooled, crystals of boric acid are formed.

7. What happens when aluminium burns in oxygen?

Answer:

👉 When aluminium burns in oxygen, it produces a brilliant white light.

8. How many valence electrons are present in group IVA elements?

Answer:

👉 Group IVA elements have four valence electrons — two in the s-orbital and two in the p-orbital.

9. Name any three important minerals of silicon.

Answer:

👉 The important minerals of silicon are feldspar, potash mica, and zircon.

10. Write two uses of methyl silicones.

Answer:

👉 (1) Methyl silicones are used as lubricants.

👉 (2) They are also used for waterproofing materials.

🩸 Important Short Questions:

1. Name the elements of Group IIIA.

Answer:

👉 The elements of Group IIIA are Boron, Aluminium, Gallium, Indium, and Thallium.

2. Why is boron non-metallic in nature?

Answer:

👉 Boron is non-metallic because of its small atomic size and high nuclear charge.

3. What is the reason for irregular increase in atomic size in Group IIIA?

Answer:

👉 The irregular increase in atomic size is due to poor shielding effect of d-electrons in heavier elements.

4. State the common oxidation states of boron.

Answer:

👉 The common oxidation states of boron are +3 and −3.

5. Why does boron not form ionic compounds?

Answer:

👉 Boron does not form ionic compounds because it cannot form a stable cation.

6. What is borax?

Answer:

👉 Borax is the sodium salt of tetraboric acid with the formula $Na_2B_4O_7 \cdot 10H_2O$.

7. Where does borax occur naturally?

Answer:

👉 Borax occurs naturally as tincal in dried-up lakes of Tibet and California.

8. How is borax manufactured from boric acid?

Answer:

👉 Borax is prepared by treating a hot solution of boric acid with soda ash (Na_2CO_3).

9. Write the chemical equation for the preparation of borax from boric acid.

Answer:

👉 $4H_3BO_3 + Na_2CO_3 \longrightarrow Na_2B_4O_7 + 6H_2O + CO_2$

10. What happens when borax is heated strongly?

Answer:

👉 On heating, borax swells up, loses water, and melts into a transparent glassy mass.

11. Why is borax solution alkaline in nature?

Answer:

👉 Borax undergoes hydrolysis forming a strong base (NaOH) and weak acid (H_3BO_3).

12. What is the borax bead test used for?

Answer:

👉 The borax bead test is used for detecting metallic cations by observing bead color.

13. What happens when borax is treated with hydrochloric acid?

Answer:

👉 It produces boric acid according to:

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

14. Mention two uses of borax.

Answer:

👉 (i) Used in borax bead test.

👉 (ii) Used in manufacturing glass, soaps, and detergents.

15. What is boric acid?

Answer:

👉 Boric acid (H_3BO_3) is a white crystalline weak acid used as an antiseptic and preservative.

16. How is boric acid prepared from borax?

Answer:

👉 By treating hot concentrated borax solution with H_2SO_4 and cooling it to form crystals.

17. Why is boric acid considered a weak acid?

Answer:

👉 Because it ionizes very slightly and acts mainly as a monobasic acid.

18. What happens when boric acid is heated strongly?

Answer:

👉 It first forms metaboric acid, then tetraboric acid, and finally boric anhydride (B_2O_3).

19. Write one use of boric acid.

Answer:

👉 Boric acid is used in eye wash and as an antiseptic in medicines.

20. Why is aluminium said to be corrosion-free?

Answer:

👉 Because a thin oxide layer forms on its surface that prevents further oxidation.

21. Name the elements of Group IVA.

Answer:

👉 Group IVA includes carbon, silicon, germanium, tin, and lead.

22. Write the common properties of Group IVA elements.

Answer:

👉 All elements show a valency of four, form hydrides (MH_4), tetrachlorides (MCl_4), and dioxides (MO_2).

23. Define inert pair effect.

Answer:

👉 The inert pair effect is the tendency of the outermost s-electron pair not to participate in chemical bonding, especially in heavier elements like lead.

24. In which two forms does carbon occur in nature?

Answer:

👉 Carbon occurs in two natural forms: crystalline (diamond, graphite) and amorphous (coal, charcoal).

25. What is meant by catenation?

Answer:

👉 Catenation is the property of an element to form long chains or rings by self-linkage. Carbon shows the maximum tendency for catenation.

26. Name the three oxides of carbon.

Answer:

👉 **The three oxides of carbon are:**

(i) Carbon monoxide (CO)

(ii) Carbon dioxide (CO_2)

(iii) Carbon suboxide (C_3O_2)

27. What type of bond is present in carbon monoxide?

Answer:

👉 Carbon monoxide (CO) is a diatomic molecule having a triple bond between carbon and oxygen atoms.

28. Describe the structure of carbon dioxide (CO_2).

Answer:

👉 Carbon dioxide is a linear molecule in which carbon is doubly bonded to two oxygen atoms (O=C=O). It has zero dipole moment.

29. What is silica and give its important properties?

Answer:

👉 Silicon dioxide (SiO_2), commonly called silica, is the most important compound of silicon.

It is hard, brittle, transparent, and insoluble in water, and is resistant to acids except HF.

30. Why does SiO_2 differ from CO_2?

Answer:

👉 SiO_2 forms a giant covalent network due to larger size of silicon and single Si–O bonds,

while CO_2 forms discrete molecules with double bonds, making it volatile.

31. What are silicates?

Answer:

👉 Compounds derived from silicic acids are called silicates, e.g. sodium silicate (Na_2SiO_3).

32. Write the formula and preparation of sodium silicate.

Answer:

👉 **Formula**: Na_2SiO_3

👉 Prepared by heating sodium carbonate (Na_2CO_3) with sand (SiO_2) in a furnace:

$Na_2CO_3 + SiO_2 \longrightarrow Na_2SiO_3 + CO_2$

33. State two uses of sodium silicate.

Answer:

👉 (i) Used as a filler in soap industry.

👉 (ii) Used as a fireproofing agent in textiles.

34. What is talc and where is it used?

Answer:

👉 Talc ($Mg_2H_2(SiO_3)_4$) is a magnesium silicate, soft and greasy to touch, used in cosmetics and household articles.

35. What are silicones and mention one use.

Answer:

👉 Silicones are synthetic compounds containing silicon-oxygen chains with alkyl side groups (e.g. $-CH_3$).

They are used as lubricants and water-repellent coatings.

36. What is a semiconductor?

Answer:

👉 A semiconductor is a substance whose electrical resistance changes under different conditions. It conducts electricity better than insulators but not as well as metals.

37. Name some examples of semiconductors.

Answer:

👉 Common semiconductors include germanium, selenium, silicon, lead sulphide, silicon carbide, and gallium arsenide.

38. How does temperature affect the resistance of semiconductors?

Answer:

👉 When a semiconductor is heated, its resistance decreases, unlike metals whose resistance increases with heat.

39. How does light affect the conductivity of semiconductors?

Answer:

👉 The conductivity of semiconductors increases with the intensity of light falling on them.

40. What are the uses of semiconductors?

Answer:

👉 Semiconductors are used in photoelectric cells, solar batteries, transistors, radios, televisions, and computers.

41. What is Lead Suboxide (Pb_2O) and how is it obtained?

Answer:

👉 Lead suboxide (Pb_2O) is a black powder obtained by heating plumbous oxalate in the absence of air.

42. What is Litharge (PbO) and where is it used?

Answer:

👉 Litharge is lead monoxide, varying in color from pale yellow to reddish yellow. It is used in making paints, oils, varnishes, and flint glass.

43. What is Red Lead (Pb_3O_4) and what are its uses?

Answer:

👉 Red lead is a bright red crystalline oxide used in storage batteries, anti-corrosion paints, flint glass, matches, and ceramic glazes.

44. What is White Lead and why is it not suitable for use as a good pigment?

Answer:

👉 White lead is basic lead carbonate used as a white pigment. It is unsuitable because it darkens when exposed to hydrogen sulphide in air.

45. What is Lead Chromate and what is its use?

Answer:

👉 Lead chromate ($PbCrO_4$) is used as a pigment known as chrome yellow. It produces yellow, orange, or red colors in paints.

🩸 EXERCISE

Q1. Fill in the blanks:

(i) Boric acid has the chemical formula ______.

Answer: H_3BO_3 ✅

(ii) Aluminium normally occurs as ______ minerals found in the rocks of the outer portion of the earth.

Answer: oxide ✅

(iii) Aluminium gives ______ gas with hot concentrated H_2SO_4.

Answer: sulphur dioxide (SO_2) ✅

(iv) Boron forms ______ bond in its compounds.

Answer: covalent ✅

(v) The chemical formula of white lead is ______.

Answer: $2PbCO_3 \cdot Pb(OH)_2$ ✅

(vi) ______ is the only element with less than four electrons in the outermost shell that is not a metal.

Answer: Boron ✅

(vii) In the Group IIIA of the periodic table, ______ is a semi-metal.

Answer: boron ✅

(viii) Borax that occurs as a natural deposit is called ______.

Answer: tincal ✅

(ix) Cryolite is an important mineral of aluminium and its formula is ______.

Answer: Na_3AlF_6 ✅

(x) A ______ is a substance that has different resistances to the passage of an electric current under different circumstances.

Answer: semiconductor ✅

Q2. Indicate True or False:

(i) Boron always uses all the three of its valence electrons for bonding purposes.

Answer: False ❌

(ii) Diaspore is an ore of carbon.

Answer: False ❌

(iii) Emerald is an ore of aluminium that has the chemical formula $Al_2O_3·2SiO_2·2H_2O$.

Answer: False ❌

(iv) An aqueous solution of borax is feebly acidic in nature.

Answer: False ❌ (It is alkaline in nature)

(v) In case of borax bead test of cupric oxide, the beads are coloured blue in the reducing flame.

Answer: True ✅

(vi) Boric acid can be titrated with sodium hydroxide.

Answer: True ✅

(vii) Carbon and silicon are the only non-metals in Group IVA.

Answer: True ✅

(viii) PbO is commonly known as litharge.

Answer: True ✅

(ix) Basic lead carbonate is a reddish brown pigment.

Answer: False ❌ (It is white pigment)

(x) Aluminium oxide (Al_2O_3) is also called bauxite.

Answer: True ✅

🌟 Q.4. What is the action of an aqueous solution of borax on litmus?

❖ Introduction:

Borax is a naturally occurring compound of boron. Its chemical name is Sodium Tetraborate Decahydrate ($Na_2B_4O_7 \cdot 10H_2O$).

It is a white crystalline solid that dissolves in water to form an alkaline solution. Because of this alkaline nature, borax shows a definite action on litmus paper.

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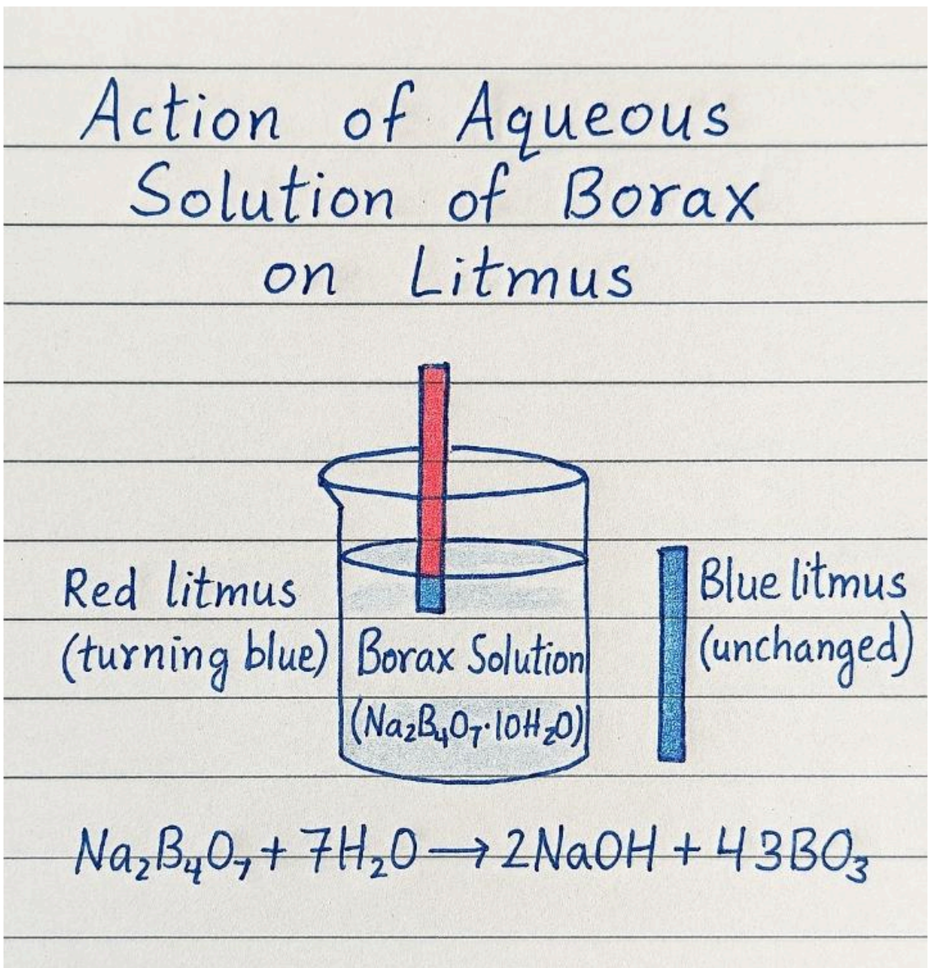

💧 Action on Litmus:

When borax is dissolved in water, the following chemical reaction occurs:

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

- **In this reaction**, sodium hydroxide (NaOH), which is a strong base, and boric acid (H_3BO_3), which is a weak acid, are formed.
- Since NaOH is much stronger than H_3BO_3, the overall solution becomes basic (alkaline) in nature.

👉 **Therefore**, an aqueous solution of borax turns red litmus paper blue.

⚗️ Explanation of Reaction:

1. When borax dissolves in water, it undergoes hydrolysis (reaction with water).

2. During hydrolysis, sodium hydroxide and boric acid are produced.

3. Because NaOH is a strong base, it releases hydroxide ions (OH^-) in solution, which makes the solution alkaline.

4. Due to the presence of OH^- ions, red litmus paper turns blue.

5. Blue litmus paper remains unchanged in borax solution.

🎨 Effect on Indicators:

Red litmus ⟶ Turns blue ✅

Blue litmus ⟶ No change

Phenolphthalein ⟶ Turns pink

Methyl orange ⟶ Turns yellow

✦ Summary:

- When borax ($Na_2B_4O_7 \cdot 10H_2O$) dissolves in water, it forms sodium hydroxide (NaOH) and boric acid (H_3BO_3).
- Since sodium hydroxide is a strong base, the solution becomes alkaline.

Hence, the aqueous solution of borax turns red litmus paper blue because of the formation of hydroxide ions (OH^-).

🌟 Q.5. Give equations to represent the following reactions.

(a) When Borax is Heated with Cobalt(II) Oxide (CoO):

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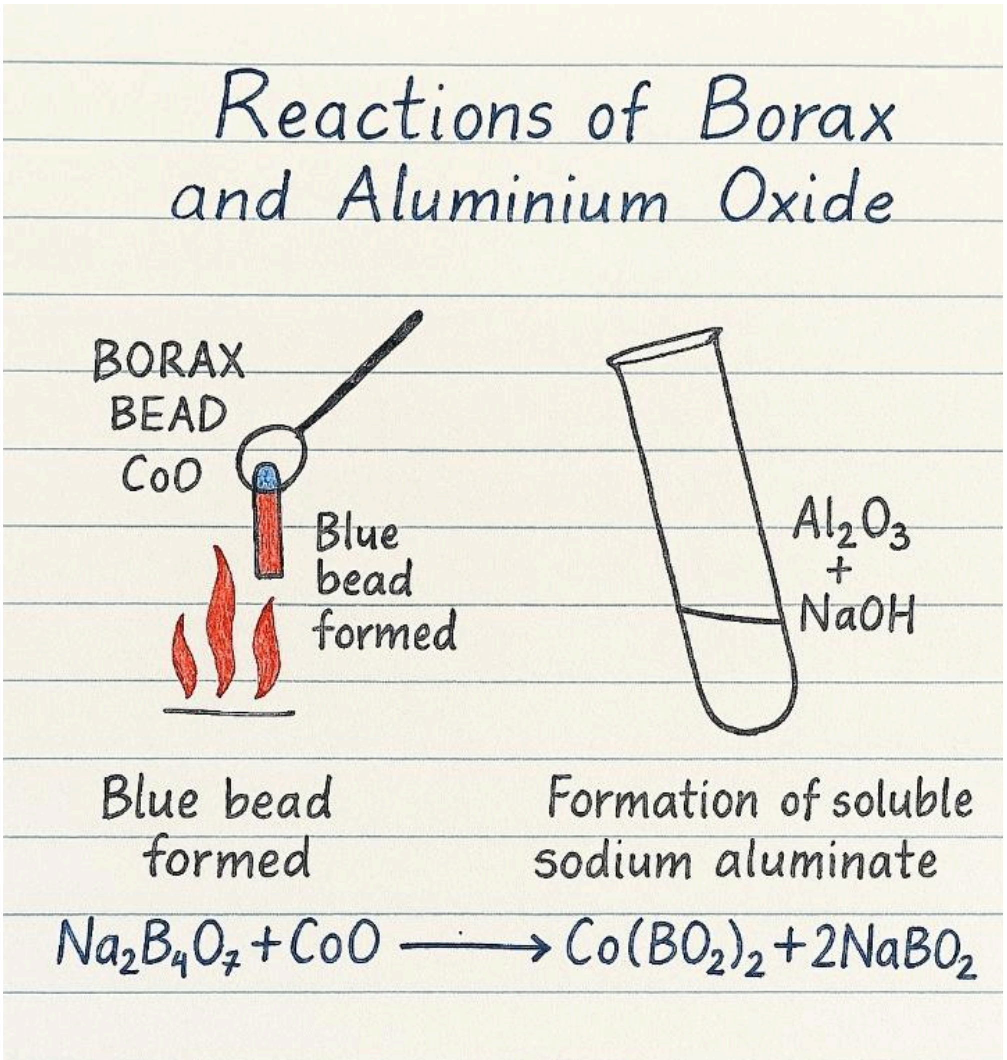

⚗️ Explanation:

- When borax ($Na_2B_4O_7 \cdot 10H_2O$) is heated in a flame, it loses water and forms sodium metaborate ($NaBO_2$) and boric anhydride (B_2O_3).

- This boric anhydride reacts with metallic oxides such as cobalt(II) oxide (CoO) to form a colored borate bead.
- The borax bead test is commonly used to identify metal ions based on the color of the bead formed.

🔹 Reaction:

1. Formation of boric anhydride:

- $Na_2B_4O_7 \longrightarrow 2NaBO_2 + B_2O_3$

2. Reaction with CoO:

- $B_2O_3 + CoO \longrightarrow Co(BO_2)_2$

🎨 Observation:

- In oxidizing flame, the bead is blue in color.
- In reducing flame, the bead remains blue or slightly greenish-blue.

✅ Result:

- This test confirms the presence of cobalt ions (Co^{2+}).
- (b) When Aluminium Oxide (Al_2O_3) is Heated with Sodium Hydroxide ($NaOH$):

⚗️ Explanation:

- Aluminium oxide is amphoteric, meaning it reacts with both acids and bases.
- When it reacts with a strong base like NaOH, it forms a soluble sodium aluminate ($NaAlO_2$) and water.

🔹 **Reaction:**

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

🔥 **Condition:**

This reaction occurs on heating the mixture of Al_2O_3 and NaOH.

✅ **Result:**

A soluble compound (sodium aluminate) is formed, showing that aluminium oxide behaves as an acidic oxide in this reaction.

✦ **Summary:**

1. Borax + CoO ⟶ Forms blue cobalt borate bead (used in bead test).

- $Na_2B_4O_7 + CoO \longrightarrow Co(BO_2)_2 + 2NaBO_2$
- $Al_2O_3 + 2NaOH \longrightarrow 2NaAlO_2 + H_2O$

🌟 **Q.6. Why is aluminium not found as a free element? Explain the chemistry of borax bead test.**

(A) Why Aluminium is Not Found as a Free Element

⚗️ Explanation:

- Aluminium (Al) is a highly reactive metal.
- It has a strong tendency to combine with oxygen, silicon, and other non-metals to form stable compounds such as oxides, silicates, and aluminates.
- Because of this reactivity, aluminium never occurs in its free or metallic state in nature.

🔹 Main Reason:

- Aluminium forms aluminium oxide (Al_2O_3) immediately when exposed to air.
- It also reacts with other elements during geological processes, forming minerals such as bauxite ($Al_2O_3 \cdot 2H_2O$), cryolite (Na_3AlF_6), and xbzfeldspars ($KAlSi_3O_8$).

✅ Conclusion:

Aluminium is found only in combined form in the Earth's crust due to its high chemical reactivity and strong affinity for oxygen.

(B) Chemistry of Borax Bead Test

⚗️ Purpose:

- The borax bead test is a qualitative test used to identify metal ions by observing the color of the bead formed when borax is heated with the metal oxide.

Step 1: Dehydration of Borax

When borax ($Na_2B_4O_7 \cdot 10H_2O$) is heated, it loses water and forms anhydrous borax:

$Na_2B_4O_7 \cdot 10H_2O$ $\mathbf{Na_4O_7}$ + $10H_2O$

Step 2: Formation of !Boric Anhydride

On strong heating, borax decomposes into sodium metaborate ($NaBO_2$) and boric anhydride (B_2O_3):

$Na_2B_4O_7 \longrightarrow 2NaBO_2 + B_2O_3$

Step 3: Reaction with Metallic Oxide

The boric anhydride (B_2O_3) formed reacts with a metallic oxide (MO) to produce a transparent, colored borate bead:

$B_2O_3 + MO \longrightarrow M(BO_2)_2$

Step 4: Color Observation

The color of the bead depends on the metal present and the flame type:

Metal Oxide	Oxidizing Flame	Reducing Flame
CoO (Cobalt oxide)	Blue	Blue
Cr_2O_3 (Chromium oxide)	Green	Green
CuO (Copper oxide)	Blue-green	Red

(Table avoided – listed as text explanation below)

🔹 Explanation Without Table:

- Cobalt oxide gives a blue bead in both oxidizing and reducing flame.
- Chromium oxide gives a green bead.
- Copper oxide gives blue-green in oxidizing and red in reducing flame.

Step 5: Flame Types

- **Oxidizing flame:** More oxygen, used for maximum oxidation.

- **Reducing flame**: Less oxygen, used for reduction of metal ions.

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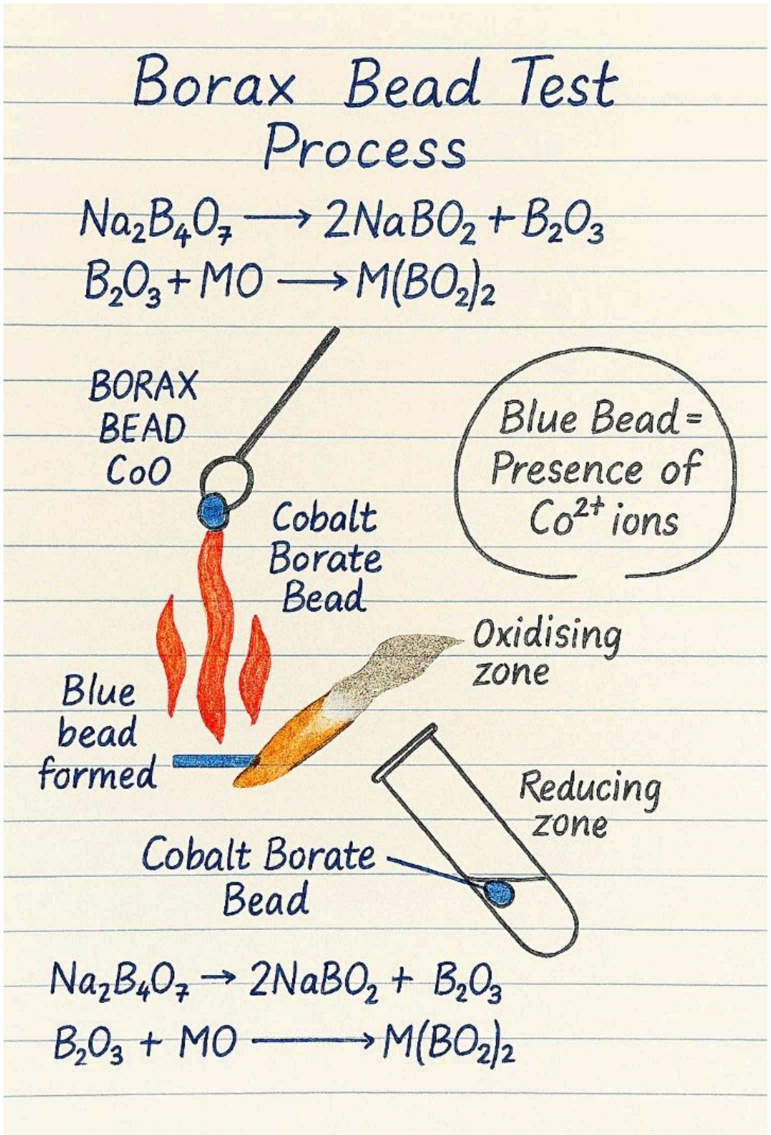

✦ **Summary:**

1. Aluminium is not found free because it is highly reactive and always forms stable compounds like oxides and silicates.

2. In the borax bead test, borax first forms boric anhydride (B_2O_3), which then reacts with metal oxides to form colored borate beads, helping to identify metal ions by their flame color.

🌟 Q.7. How does orthoboric acid react with:

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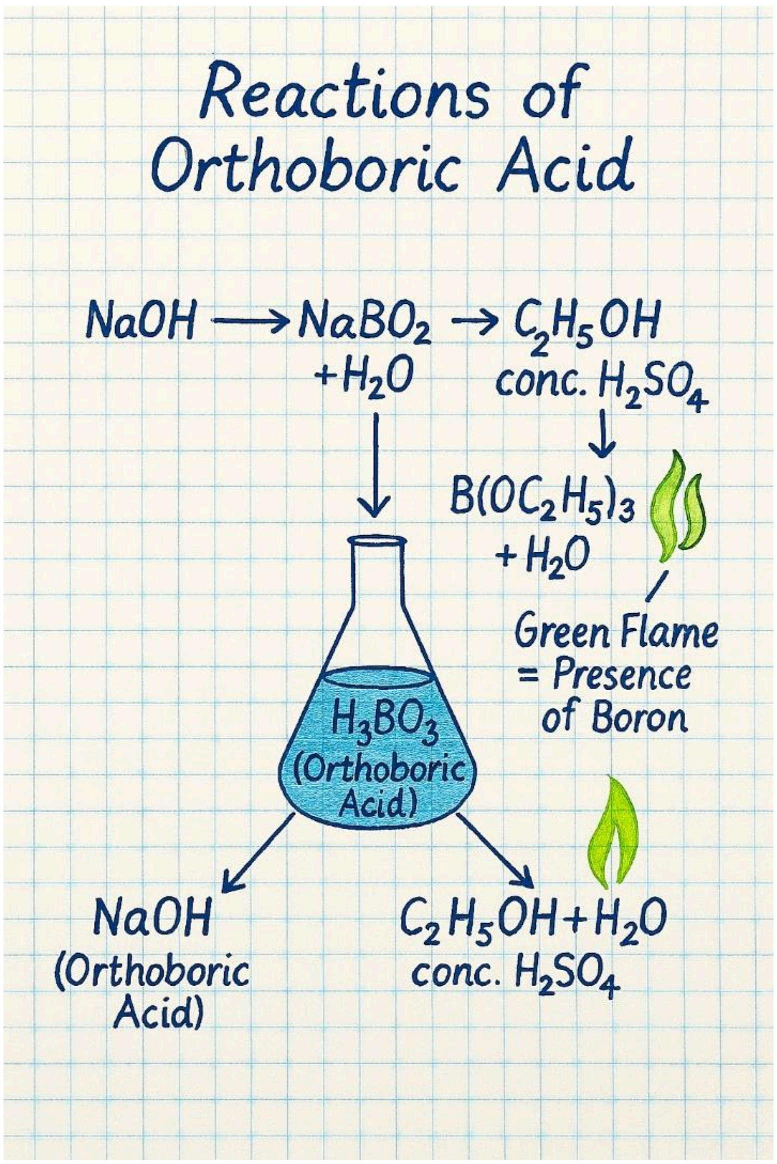

- **(a) Sodium hydroxide (NaOH)**
- **(b) Ethyl alcohol (C_2H_5OH)**

❖ **Answer:**

(A) Reaction of Orthoboric Acid with Sodium Hydroxide

Orthoboric acid (H_3BO_3) is a weak monobasic acid. When it reacts with sodium hydroxide, it does not liberate hydrogen gas. Instead, it forms sodium metaborate ($NaBO_2$) and water.

Chemical Equation:

$H_3BO_3 + NaOH \longrightarrow NaBO_2 + 2H_2O$

In this reaction, boric acid acts as a Lewis acid because it accepts hydroxyl ions from sodium hydroxide. The final product, sodium metaborate, is soluble in water and the reaction mixture becomes slightly basic in nature.

(B) Reaction of Orthoboric Acid with Ethyl Alcohol

When orthoboric acid is heated with ethyl alcohol (C_2H_5OH) in the presence of concentrated sulphuric acid (H_2SO_4), it forms triethyl borate ($B(OC_2H_5)_3$) and water.

Chemical Equation:

$B(OH)_3 + 3C_2H_5OH \longrightarrow B(OC_2H_5)_3 + 3H_2O$

Concentrated sulphuric acid acts as a dehydrating agent and helps in the removal of water to drive the reaction forward. The product, triethyl borate, burns with a bright green flame, which serves as a test for the presence of boron.

✦ Summary:

- When orthoboric acid reacts with sodium hydroxide, it forms sodium metaborate and water.
- When orthoboric acid reacts with ethyl alcohol, it forms triethyl borate, which burns with a green flame, confirming the presence of boron.

Q.8. How will you convert boric acid into borax and vice versa?

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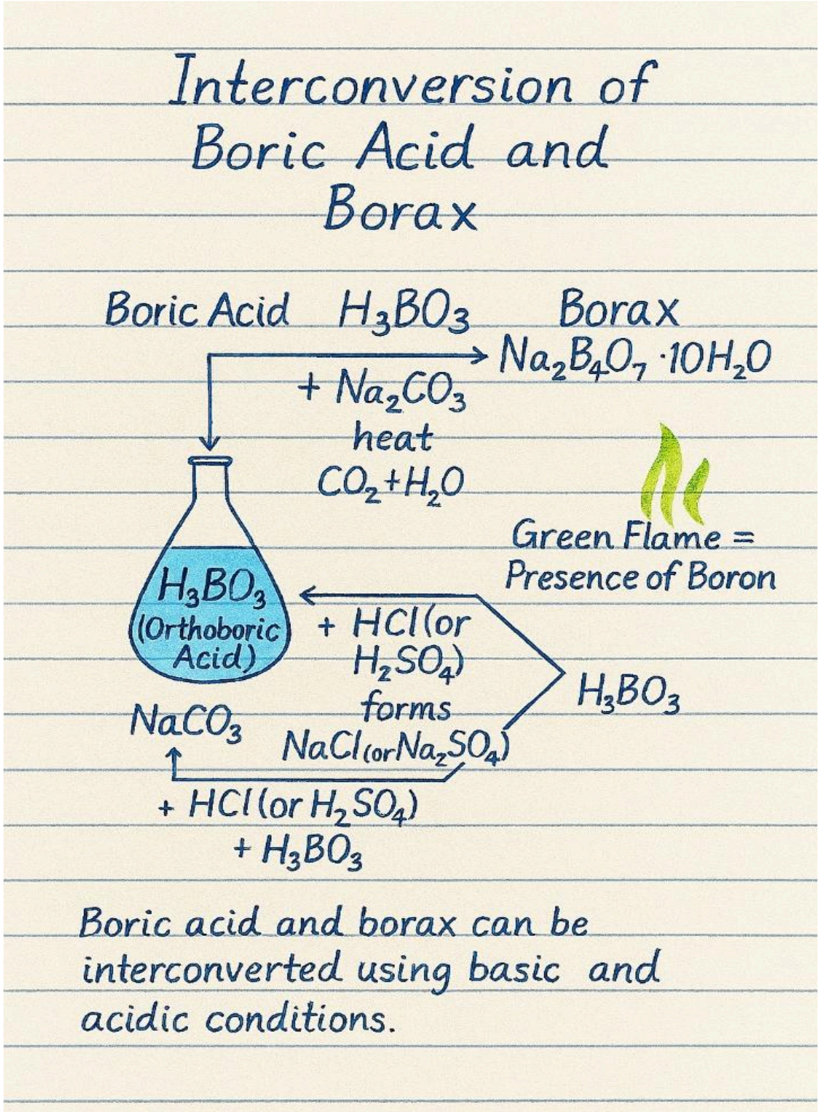

✦ Conversion of Boric Acid into Borax:

- Boric acid (H_3BO_3) can be converted into borax ($Na_2B_4O_7 \cdot 10H_2O$) by heating boric acid with sodium carbonate (Na_2CO_3).
- **During this reaction**, boric acid reacts with sodium carbonate, releasing carbon dioxide (CO_2) and water (H_2O), while borax is formed as the main product.

Chemical Equation:

$4H_3BO_3 + Na_2CO_3 \longrightarrow Na_2B_4O_7 + 6H_2O + CO_2$⬆️

In this process:

- Boric acid acts as a weak acid.
- Sodium carbonate acts as a base providing sodium ions for the formation of borax.
- The reaction mixture on evaporation yields crystals of borax.

✦ Conversion of Borax into Boric Acid:

- Borax can be converted back into boric acid by treating it with a mineral acid such as hydrochloric acid (HCl) or sulphuric acid (H_2SO_4).
- **In this reaction,** borax reacts with the acid to form boric acid and sodium salt of the acid used (NaCl or Na_2SO_4).

Chemical Equations:

With HCl:

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

With H_2SO_4:

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

After reaction, boric acid separates out as a white crystalline solid.

✦ **Summary:**

Boric Acid ⟶ Borax:

Heat boric acid with sodium carbonate ⟶ forms borax, CO_2, and water.

Borax ⟶ Boric Acid:

Treat borax with HCl or H_2SO_4 ⟶ forms boric acid and sodium salt.

🌟 **Q.9. Why are liquid silicones preferred over ordinary organic lubricants?**

❖ **Answer:**

- Liquid silicones (also called silicone oils) are preferred over ordinary organic lubricants such as petroleum oils because of their superior physical and chemical properties.

- They remain stable under extreme temperature conditions, have low volatility, and do not get oxidized easily.

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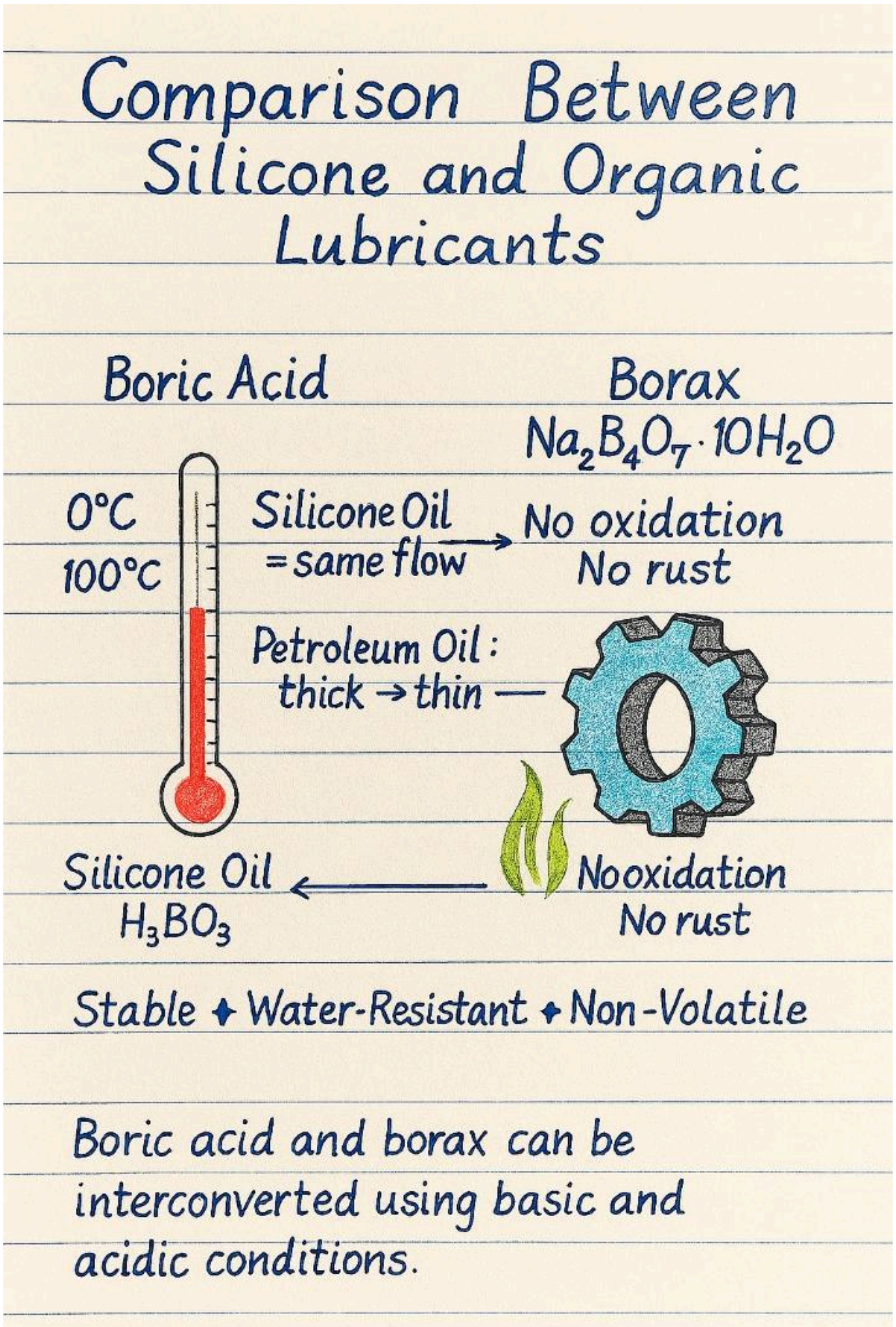

✦ Let's discuss the main reasons in detail 👇

1️⃣ Stability at High and Low Temperatures

- Silicone oils show very little change in viscosity with temperature.
- Even when temperature changes from 0°C to 100°C, their flow property remains almost the same.
- Ordinary oils become thick at low temperatures and thin at high temperatures, which reduces their efficiency.

🧪 Example:

- If petroleum oil's viscosity increases 100 times when cooled, silicone oil increases less than 4 times only.

2️⃣ Resistance to Oxidation and Decomposition

- Silicone oils are highly resistant to air, oxygen, and moisture even at 300°C or more.
- They do not form acids or gums upon oxidation, unlike organic lubricants that easily degrade and lose lubricating power.

3️⃣ Chemical Inertness

- Silicones are chemically inert — they do not react with metals, rubber, or plastics.

- This makes them suitable for use in hydraulic brakes, vacuum systems, and delicate machinery where chemical purity is required.

4️⃣ Water Repellence

- Silicone oils are water-repellent (hydrophobic).
- They prevent rusting of metal surfaces by forming a protective layer, while most organic oils allow slow corrosion.

5️⃣ Non-Volatile and Long-Lasting

- Silicone lubricants have low evaporation rate, which means they last much longer and don't need frequent replacement.

6️⃣ Electrical Insulation

- Silicones are also excellent electrical insulators, so they are used in motors, transformers, and other electrical devices.

✦ **Summary:**

Liquid silicones are preferred over organic lubricants because they:

✅ remain stable over a wide temperature range,

✅ resist oxidation and chemical reaction,

✅ are water-repellent and non-volatile,

✅ provide long-lasting lubrication and electrical insulation.

Hence, silicone oils are more reliable and durable lubricants than ordinary organic oils.

🌟 Q.10. Explain:

(a) CO_2 is non-polar in nature.

(b) CO_2 is acidic in character.

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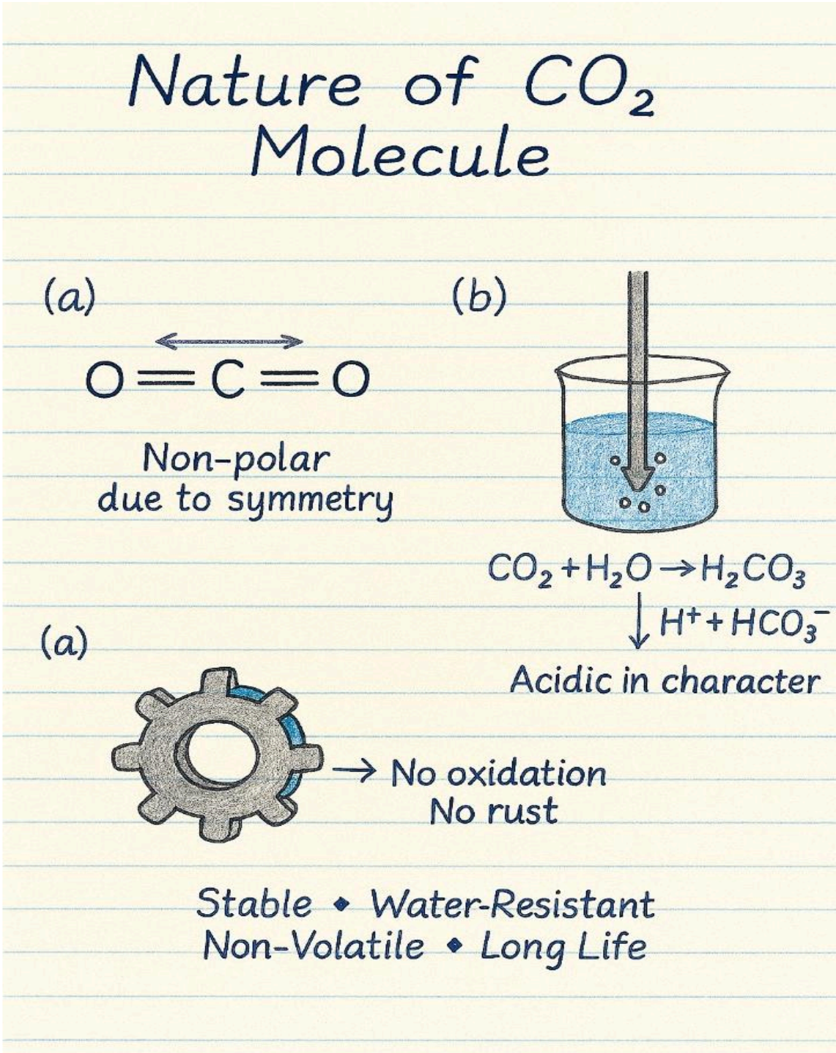

(a) CO_2 is non-polar in nature.

Answer:

- Carbon dioxide (CO_2) molecules are non-polar even though the C–O bonds are polar.
- This is because of its linear structure and symmetrical arrangement of atoms.
- The molecule has two polar bonds (C=O and C=O).

- Oxygen is more electronegative than carbon, so each C–O bond has a dipole moment.
- **However**, the two dipoles are equal and opposite in direction.
- Due to the linear geometry (180° bond angle), these dipoles cancel each other, resulting in zero net dipole moment.

👉 **Therefore**, CO_2 is non-polar even though it contains polar covalent bonds.

🧪 Representation:

O = C = O

⬆️ ⬇️

Dipoles cancel out ⟶ Non-polar molecule

(b) CO_2 is acidic in character.

Answer:

- Carbon dioxide (CO_2) is acidic in nature because it reacts with water to form carbonic acid (H_2CO_3), a weak acid.

🧪 Chemical Equation:

$CO_2 + H_2O \longrightarrow H_2CO_3$

- Carbonic acid then ionizes partially in water to produce hydrogen ions (H^+) and bicarbonate ions (HCO_3^-).

$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$

- This shows that CO_2 behaves like an acid anhydride (acid-forming oxide).
- It also reacts with alkalis to form carbonates and bicarbonates, confirming its acidic nature.

🧪 Examples:

- $CO_2 + 2NaOH \longrightarrow Na_2CO_3 + H_2O$
- $CO_2 + NaOH \longrightarrow NaHCO_3$

✦ Summary:

Point	Explanation
CO_2 is non-polar	Because it is linear and symmetrical; dipole moments cancel each other.
CO_2 is acidic	Because it reacts with water to form carbonic acid and reacts with alkalis to form carbonates.

🌟 Q.11. Why is CO_2 a gas at room temperature while SiO_2 is a solid?

❖ Answer:

- Carbon dioxide (CO_2) and silicon dioxide (SiO_2) both belong to Group IVA (Group 14) elements, yet they exist in different physical states at room temperature.
- This difference arises from the type of bonding and structure each compound possesses.

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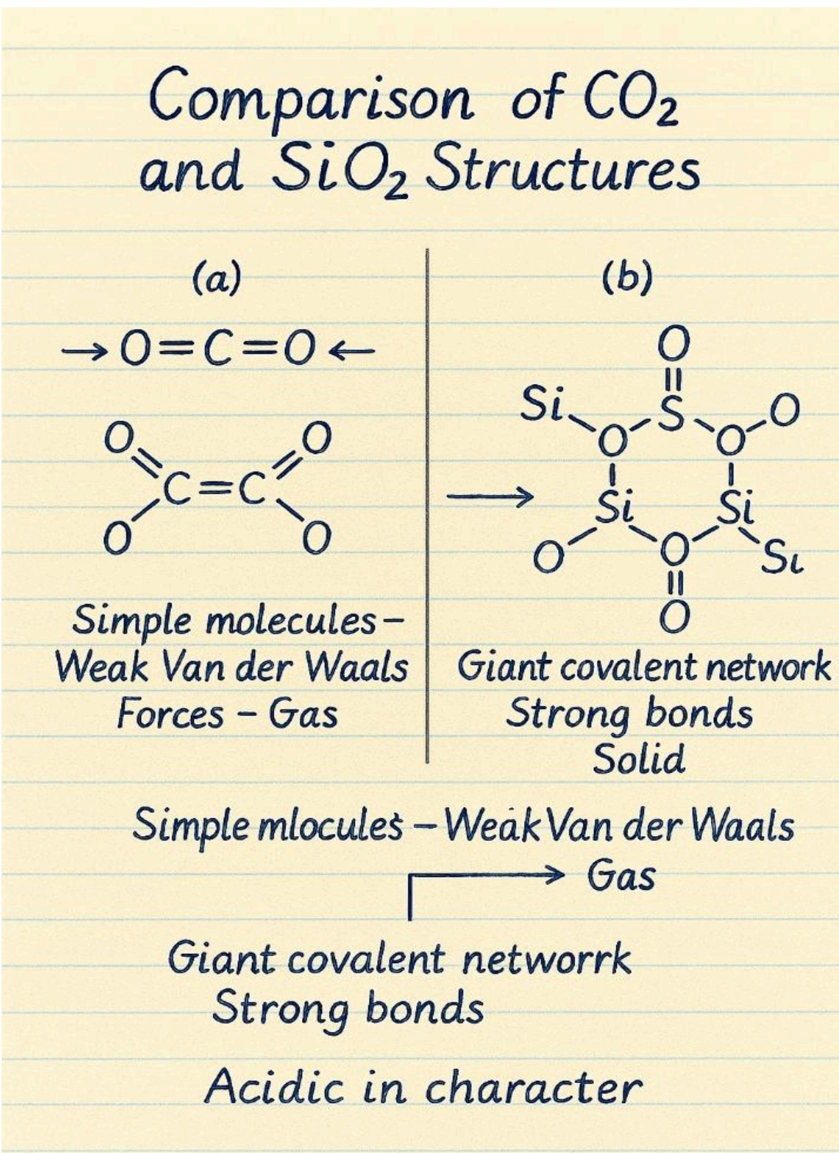

1️⃣Bonding and Structure of CO_2:

- CO_2 is a molecular compound.
- Each molecule consists of one carbon atom double-bonded to two oxygen atoms.
- The bonding is covalent, and the molecules are held together by weak Van der Waals forces.
- These weak intermolecular forces can be easily broken, so CO_2 exists as a gas at room temperature.

🧪 Structure:

O = C = O

- Weak intermolecular attraction
- Low melting and boiling points

2️⃣Bonding and Structure of SiO_2:

- SiO_2 (silicon dioxide) has a giant covalent (network) structure.
- Each silicon atom is tetrahedrally bonded to four oxygen atoms, and each oxygen is shared between two silicon atoms.
- The entire structure forms a three-dimensional network of strong Si–O–Si bonds.
- Breaking this giant structure requires a large amount of energy, so SiO_2 exists as a hard solid (like quartz or sand).

🧱 Structure:

- 3D covalent lattice
- Very strong Si–O bonds
- High melting and boiling points

3️⃣ Comparison:

Property	CO_2	SiO_2
Type of structure	Simple molecular	Giant covalent
Type of forces	Weak Van der Waals forces	Strong Si–O covalent bonds
Melting & boiling point	Very low	Very high
Physical state at room temperature	Gas	Solid

✦ Summary:

- CO_2 has weak intermolecular forces, so it remains a gas.
- SiO_2 has strong covalent bonds in a giant network, so it remains a solid.

👉 **Hence**, the difference in bonding and structure is the reason for their different physical states.

🌟 Q.12. Give the names and formulas of different acids of boron.

❖ Answer:

Boron forms a series of oxy-acids which differ from each other in the amount of water combined with boric oxide (B_2O_3). The most important acids of boron are as follows:

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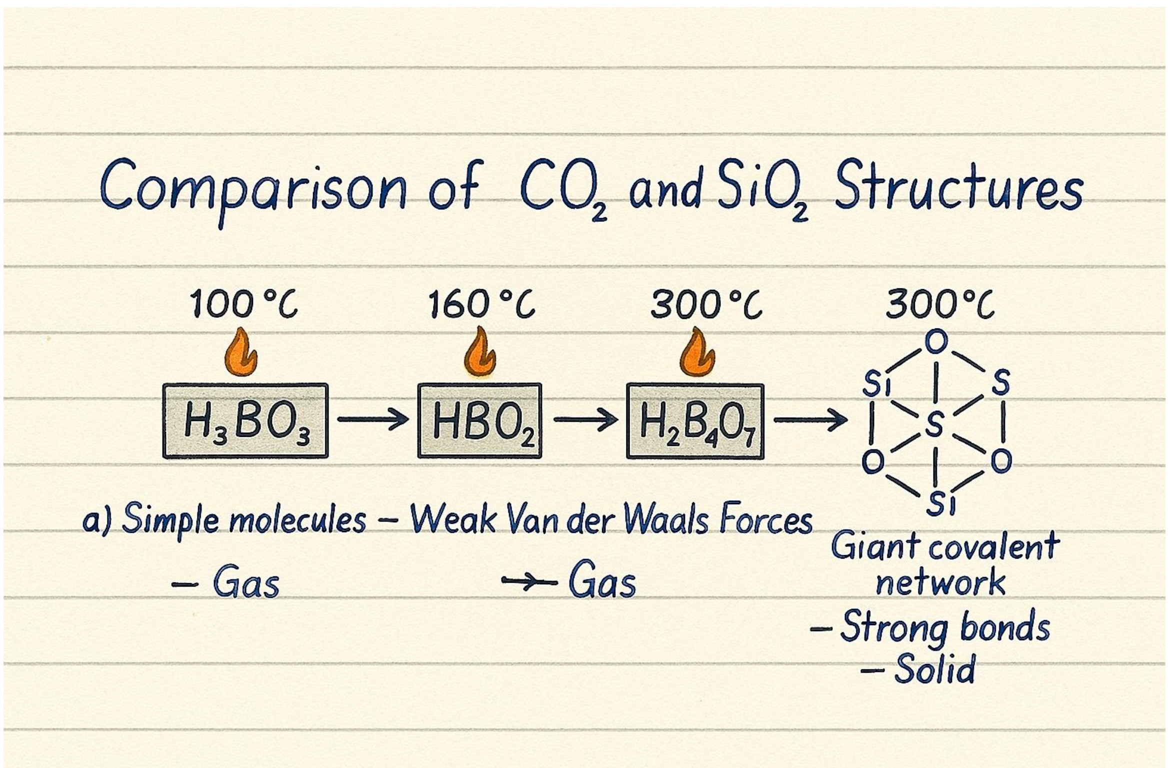


(1) Orthoboric Acid (Boric Acid)

👉 **Formula:** H_3BO_3

- It is obtained by dissolving boron trioxide in water.

Equation:

$B_2O_3 + 3H_2O \longrightarrow 2H_3BO_3$

(2) Metaboric Acid

👉 **Formula:** HBO_2

It is formed when orthoboric acid is heated at about 100°C.

Equation:

$H_3BO_3 \longrightarrow HBO_2 + H_2O$

(3) Tetraboric Acid (Pyroboric Acid)

👉 **Formula**: $H_2B_4O_7$

It is formed by further heating of orthoboric acid at 160°C.

Equation:

$4H_3BO_3 \longrightarrow H_2B_4O_7 + 5H_2O$

(4) Boric Anhydride (Boron Trioxide)

👉 **Formula**: B_2O_3

It is formed when tetraboric acid is heated strongly at 300°C.

Equation:

$H_2B_4O_7 \longrightarrow 2B_2O_3 + H_2O$

Explanation:

- When boric acid is heated gradually, it loses water molecules step by step, forming different acids.
- Each new acid is a dehydrated form of the previous one.

✦ **Summary:**

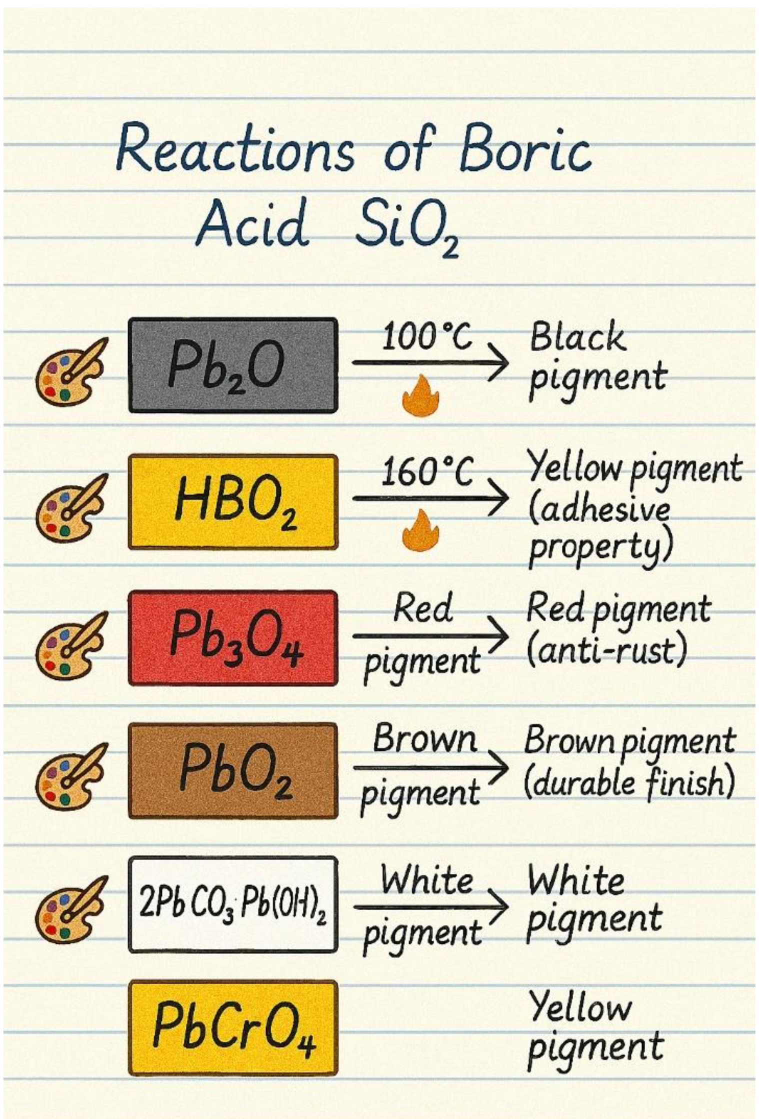
- Orthoboric acid (H_3BO_3) on heating gives metaboric acid (HBO_2).
- On stronger heating, tetraboric acid ($H_2B_4O_7$) is produced.
- At still higher temperature, boric anhydride (B_2O_3) is obtained.

🌟 **Q.13. What is the importance of oxides of lead in paints?**

❖ **Answer:**

Lead oxides play a very important role in the paint industry because they act as pigments, corrosion preventers, and drying agents. Their bright colors and protective properties make them highly valuable for coating surfaces like metals, wood, and walls.

✦ **Diagram:**



✦ Let's discuss their importance in detail 👇

1️⃣ Lead Suboxide (Pb_2O)

- **Color**: Black powder
- **Use**: Besides batteries, it is used as a pigment in certain paints.

It gives a dull black shade and adds protective covering to metallic surfaces.

Equation (formation):

$2PbC_2O_4 \longrightarrow Pb_2O + 3CO_2 + CO$

2️⃣ Lead Monoxide (PbO) — Litharge or Massicot

Color: Pale yellow to reddish-yellow

Importance:

- Used in making flint glass and paints.
- When boiled with oil, it forms lead oleate, a sticky mass that improves adhesion of paints.
- Used in oils and varnishes to make paints dry quickly and spread smoothly.

3️⃣ Red Lead (Pb_3O_4) — Triplumbic Tetraoxide

Color: Bright scarlet red

Importance:

- Used as a red pigment in anti-rust paints for steel and iron.
- Protects metallic structures from corrosion.
- Also used in making flint glass, matches, and ceramic glazes.

Equation:

$3Pb + 2O_2 \; Pb_3O_4$

4️⃣ Lead Dioxide (PbO_2)

Color: Reddish-brown powder

Importance:

- Used as a pigment and oxidizing agent.
- Adds durability and shine to paints.
- Resists weathering and gives a smooth, glossy finish.

5️⃣ White Lead ($2PbCO_3 \cdot Pb(OH)_2$)

Color: Pure white

Importance:

- One of the oldest and most important white pigments.
- Has good covering power and mixes easily with oil to make smooth paint.
- Gives an opaque, bright finish to walls and wood.

However, it is avoided now because of lead toxicity.

6️⃣ Lead Chromate ($PbCrO_4$)

Color: Chrome yellow (bright yellow)

Importance:

- Used as yellow pigment in decorative paints.
- When boiled with alkali, it gives orange or red shades.
- Gives vibrant and long-lasting color to paints.

✦ Summary:

Lead oxides are important in paints because they:

- Provide bright and durable colors
- Protect metal surfaces from rust and corrosion
- Improve adhesion and smoothness of paints
- Are used in the manufacture of glass, ceramics, and matches

🌟 **Q.14. Give the names, electronic configurations, and occurrence of Group IIIA elements of the periodic table.**

❖ **Answer:**

- Group IIIA (or Group 13) of the periodic table is also known as the Boron Group.
- It consists of five elements — Boron (B), Aluminium (Al), Gallium (Ga), Indium (In), and Thallium (Tl).
- All of these elements have three valence electrons in their outermost shell with a general electronic configuration ns^2np^1.

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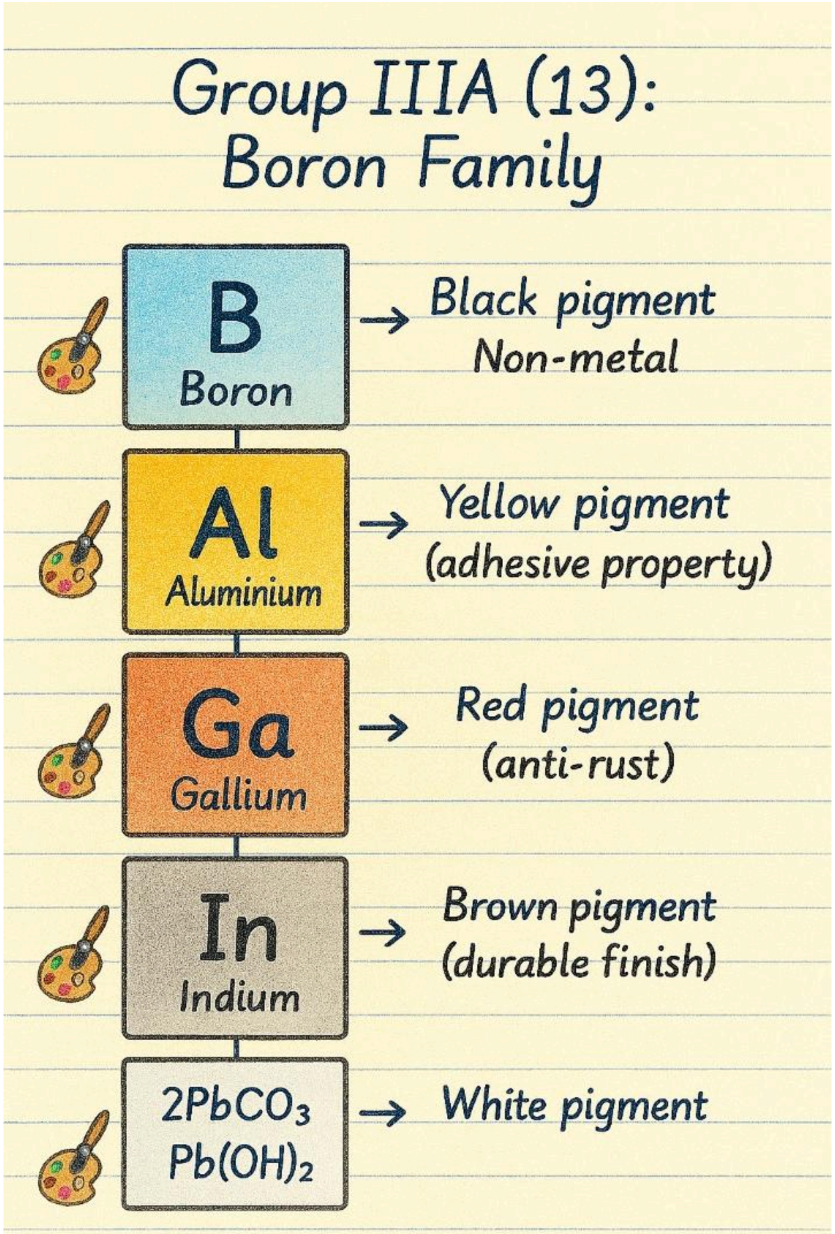


1️⃣ Boron (B)

Atomic number: 5

- Electronic configuration: $1s^2, 2s^2, 2p^1$

Occurrence:

- Boron does not occur in the free state due to its reactivity.
- It is found in the form of borax ($Na_2B_4O_7 \cdot 10H_2O$), colemanite ($Ca_2B_6O_{11} \cdot 5H_2O$), and boric acid ($H_3BO_3$).
- Commonly found in volcanic regions and dried-up lake beds.

2 Aluminium (Al)

Atomic number: 13

- Electronic configuration: $1s^2, 2s^2, 2p^6, 3s^2, 3p^1$

Occurrence:

- Aluminium is the most abundant metal in the Earth's crust.
- Found in minerals like bauxite ($Al_2O_3 \cdot 2H_2O$), cryolite (Na_3AlF_6), and corundum (Al_2O_3).
- It never occurs freely because it is highly reactive and forms stable oxides and silicates.

3 Gallium (Ga)

Atomic number: 31

- Electronic configuration: [Ar] $3d^{10}$ $4s^2$ $4p^1$

Occurrence:

- Found in trace amounts in bauxite and zinc blende (ZnS) ores.
- It is also obtained as a by-product in the extraction of aluminium and zinc.
- Gallium is a rare element but has great importance in electronics (semiconductors).

4️⃣ Indium (In)

Atomic number: 49

- Electronic configuration: [Kr] $4d^{10}$ $5s^2$ $5p^1$

Occurrence:

- Found in small amounts in zinc blende (ZnS), iron pyrites (FeS_2), and tin ores.
- Extracted as a by-product during zinc refining.
- It is a soft metal with applications in alloys and semiconductors.

5️⃣ Thallium (Tl)

Atomic number: 81

- Electronic configuration: [Xe] $4f^{14}\ 5d^{10}\ 6s^2\ 6p^1$

Occurrence:

- Occurs in trace quantities in lead, zinc, and copper sulphide ores.
- Mostly obtained as a by-product during lead refining.
- Thallium is a toxic metal used in thermometers, optical lenses, and electronics.

✦ **Summary:**

- All Group IIIA elements have three valence electrons (ns^2np^1).
- They show a gradual transition from non-metallic (Boron) to metallic (Thallium) character.
- Boron is a metalloid, while Aluminium, Gallium, Indium, and Thallium are metals.

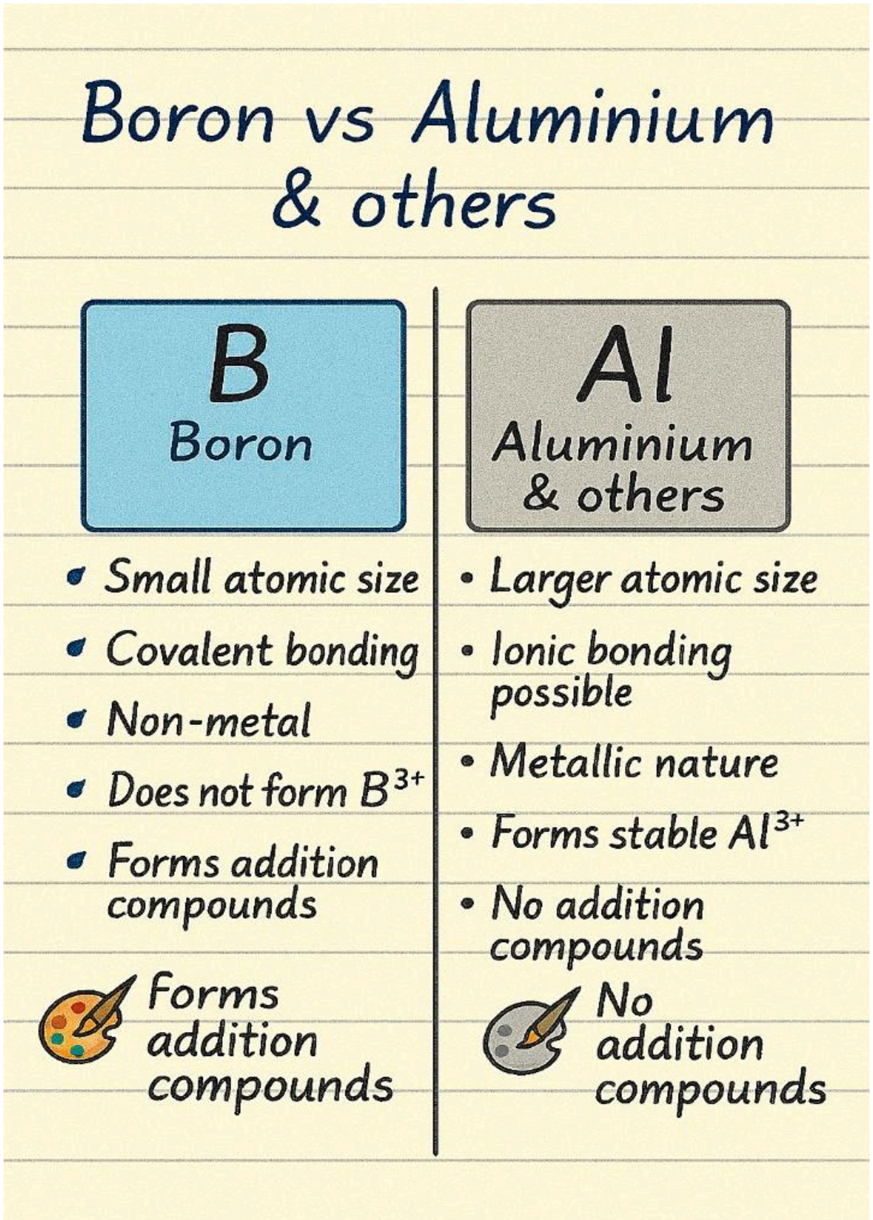
🌟 **Q.15. Discuss the peculiar behaviour of boron with respect to the other members of Group IIIA elements.**

Answer:

- Boron is the first element of Group IIIA (Group 13) in the periodic table and shows distinct chemical and physical properties compared to the other members of its group (Aluminium, Gallium, Indium, and Thallium).

- These differences arise mainly because of its small atomic size, high ionization energy, high electronegativity, and absence of d-orbitals.

✦ **Digram:**



1️⃣ Non-Metallic Nature

👉 Boron is the only non-metal in Group IIIA.

👉 All other members — Aluminium, Gallium, Indium, and Thallium — are metals.

👉 Due to its small size and high ionization potential, boron cannot lose electrons easily, so it forms covalent compounds, not metallic bonds.

2️⃣ Absence of Metallic Character

👉 Unlike aluminium and other heavier elements, boron does not conduct electricity and lacks metallic luster.

👉 It exists in a hard, brittle crystalline form, while others are soft metals.

3️⃣ Covalent Bond Formation

👉 Boron always forms purely covalent bonds because it has a small atomic radius and high ionization energy.

👉 Other elements like aluminium and gallium can form ionic compounds in addition to covalent ones.

Example:

- Boron trichloride (BCl_3) is covalent,
- Aluminium chloride ($AlCl_3$) is partly ionic in nature.

4️⃣ No Formation of Stable Cations

👉 Boron cannot form B^{3+} ions because the removal of three electrons requires very high energy.

👉 Therefore, boron never forms ionic compounds with anions like nitrate (NO_3^-) or sulphate (SO_4^{2-}).

👉 Other members, like aluminium, form stable cations (e.g., Al^{3+}).

5️⃣ Formation of Molecular Addition Compounds

👉 One of the most peculiar characteristics of boron is its ability to form molecular addition compounds due to its electron-deficient nature.

👉 It can accept lone pairs of electrons from donor molecules to complete its octet.

Example:

$BF_3 + NH_3 \longrightarrow F_3B \longrightarrow NH_3$

Here, boron trifluoride reacts with ammonia to form an adduct compound.

6️⃣ Oxidation States

👉 Boron exhibits only the +3 oxidation state in its compounds.

👉 Other elements like thallium can show both +1 and +3 oxidation states because of the inert pair effect (non-participation of s-electrons in bonding).

7️⃣ Structural Complexity

👉 Boron forms many complex and network structures such as borates and boranes (e.g., $B_{10}H_{14}$).

👉 These types of compounds are not formed by other members of the group.

✦ **Summary:**

Boron differs significantly from its heavier group members.

The main reasons for this are:

✅ Small atomic size

✅ High ionization energy

✅ High electronegativity

✅ Absence of d-orbitals

Therefore, boron is non-metallic, covalent, and electron-deficient, while other elements of Group IIIA are metallic and electropositive.

🌟 **Q.16. Explain**:

(a) What is Borax?

(b) Describe its commercial preparation.

(c) Outline the principal uses of borax.

(d) How does borax serve as a water softening agent?

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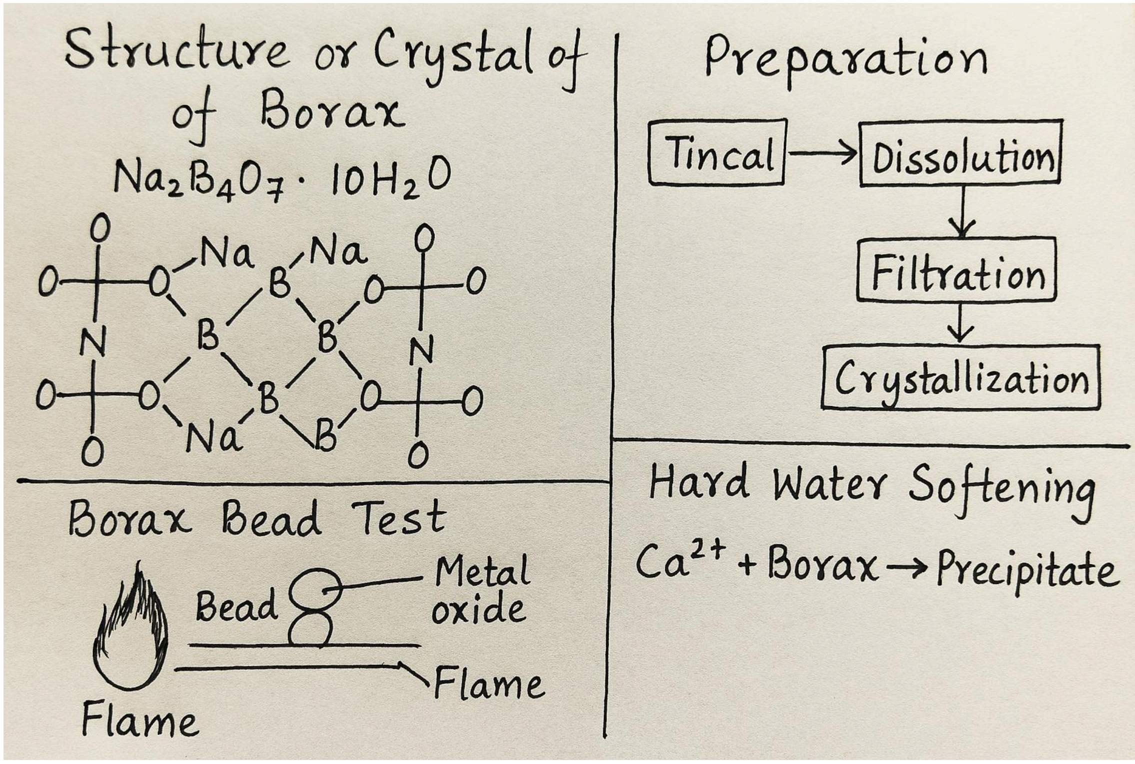

(a) What is Borax?

👉 **Definition:**

- Borax is a sodium salt of boric acid having the chemical formula $Na_2B_4O_7 \cdot 10H_2O$.
- It is also known as sodium tetraborate decahydrate.

👉 **Appearance:**

- It is a white crystalline substance which is soluble in water and has a slightly alkaline reaction.

👉 **Natural Occurrence:**

- It occurs naturally as a mineral called tincal in the beds of dried-up lakes in regions like Tibet, California, and India.

(b) Commercial Preparation of Borax

- Borax is commercially prepared from tincal (a natural form of impure borax) or from boric acid.

Method 1: From Tincal

1. Dissolution:

- The crude tincal is dissolved in hot water to form a clear solution.

2. Filtration:

- Insoluble impurities such as clay and sand are removed by filtration.

3. Crystallization:

- The clear solution is cooled, and borax crystals ($Na_2B_4O_7 \cdot 10H_2O$) are obtained.

Chemical Concept:

Tincal mainly consists of $Na_2B_4O_7 \cdot 10H_2O$, which upon purification gives pure borax crystals.

Method 2: From Boric Acid

1. Reaction with Sodium Carbonate (Na_2CO_3):

- When boric acid (H_3BO_3) is heated with sodium carbonate, borax is formed along with the evolution of carbon dioxide gas.

Chemical Equation:

$$4H_3BO_3 + Na_2CO_3 \longrightarrow Na_2B_4O_7 + 6H_2O + CO_2\uparrow$$

2. Crystallization:

- On cooling, crystals of borax separate out from the solution.

(c) Principal Uses of Borax

👉 **1. In Glass and Enamel Industry:**

- Used to manufacture heat-resistant glass (borosilicate glass) and ceramic glazes.
- Gives glass a smooth, glossy appearance and increases thermal stability.

👉 **2. In Welding and Soldering:**

- Acts as a flux by removing oxide layers from metal surfaces, making them clean and ready for joining.

👉 **3. In Medicine:**

- Used as a mild antiseptic and eye wash solution in medical preparations.

👉 **4. In Laboratory Work:**

- Used in the borax bead test for identifying metallic radicals (such as copper, cobalt, etc.).

👉 **5. In Detergents and Cleaning Agents:**

- Used as an ingredient in washing powders and cleansing creams because of its alkaline and softening properties.

👉 **6. As a Preservative:**

- Borax is used in the preservation of wood and textiles to protect them from insects and fungi.

(d) Borax as a Water Softening Agent

👉 **Explanation:**

- Hard water contains calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions which react with soap and form insoluble scum, reducing soap's effectiveness.

👉 **When borax** is added to hard water, it reacts with these ions to form insoluble borates of calcium and magnesium, thereby removing hardness from the water.

Chemical Equations:

$Na_2B_4O_7 + CaSO_4 \longrightarrow CaB_4O_7$⬇️ $+ Na_2SO_4$

$Na_2B_4O_7 + MgCl_2 \longrightarrow MgB_4O_7$ ⬇️ $+ 2NaCl$

👉 As a result, soft water is obtained which forms lather easily with soap.

✦ **Summary:**

- Borax is a sodium salt of boric acid ($Na_2B_4O_7 \cdot 10H_2O$).
- It is prepared from tincal or boric acid.
- Used in glass, medicine, metallurgy, and detergents.
- Acts as a water softening agent by removing Ca^{2+} and Mg^{2+} ions from hard water.

🌟 Q.17. (a) What is Boric Acid? (b) How is Boric Acid prepared in the laboratory? (c) Give properties and uses of Boric Acid.

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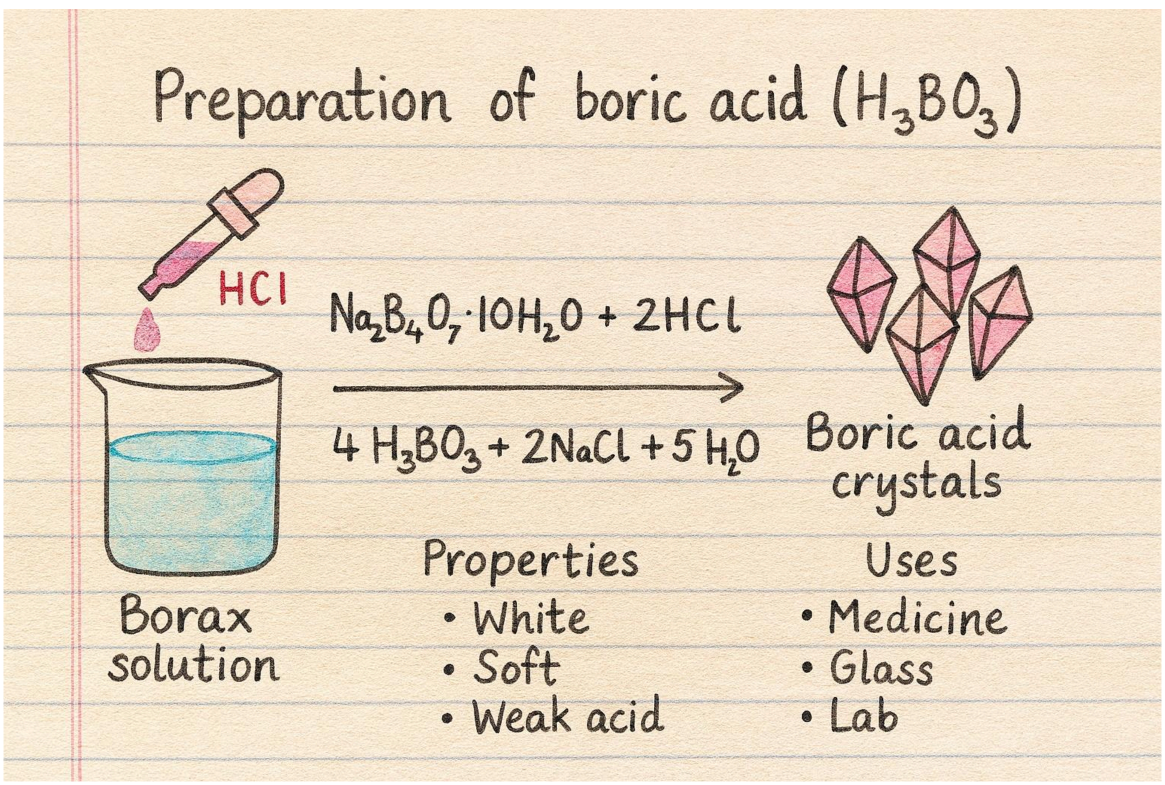

(a) What is Boric Acid?

👉 Definition:

- Boric acid is a weak monobasic acid of boron with the chemical formula H_3BO_3 (also written as $B(OH)_3$).

👉 **Nature and Appearance:**

- It is a white, crystalline solid, soft to the touch, and soluble in water.

👉 **Classification:**

- It is also called orthoboric acid and is sometimes obtained from borax by acidification.

(b) Preparation of Boric Acid in the Laboratory

- Boric acid is prepared from borax by the action of a mineral acid like hydrochloric acid (HCl) or sulphuric acid (H_2SO_4).

Chemical Reaction:

$$Na_2B_4O_7 \cdot 10H_2O + 2HCl \longrightarrow 4H_3BO_3 + 2NaCl + 5H_2O$$

Explanation of the Process:

1. Dissolution:

- Borax is dissolved in hot water in a beaker.

2. Addition of Acid:

- Dilute hydrochloric acid is added to the hot solution of borax with constant stirring.

3. Crystallization:

- On cooling, crystals of boric acid (H_3BO_3) separate out from the solution.

4. Filtration and Drying:

- The crystals are filtered, washed with cold water, and dried on filter paper.

👉 Thus, pure boric acid is obtained.

(c) Properties of Boric Acid

1. Physical Properties:

- It is a white, crystalline solid.
- Soluble in hot water, slightly soluble in cold water.
- Has a soapy feel when touched.

- Odorless and tasteless.

2. Chemical Properties:

(i) Weak Acid:

- Boric acid is not a true proton donor but acts as a Lewis acid by accepting hydroxide ions (OH^-) from water.

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

Thus, it behaves as a weak monobasic acid.

(ii) Reaction with Alkalis (NaOH):

- When boric acid reacts with sodium hydroxide, it forms sodium borate and water.

$H_3BO_3 + NaOH \longrightarrow NaBO_2 + 2H_2O$

(iii) Reaction with Ethyl Alcohol (C_2H_5OH):

- On heating with ethyl alcohol and concentrated sulphuric acid, triethyl borate is formed, which burns with a green-edged flame.

$B(OH)_3 + 3C_2H_5OH \longrightarrow B(OC_2H_5)_3 + 3H_2O$

(iv) Action on Litmus:

- An aqueous solution of boric acid is weakly acidic and turns blue litmus paper slightly red.

(d) Uses of Boric Acid

👉 **1. In Medicine:**

- Used as a mild antiseptic for eye wash, skin lotions, and antiseptic powders.

👉 **2. In Glass and Enamel Industry:**

- Used to make borosilicate glass, heat-resistant glass, and ceramic glazes.

👉 **3. In Laboratory:**

- Used in the borax bead test and for preparing borax.

👉 **4. In Textile and Leather Industry:**

- Used as a flame retardant and preservative for fabrics and leather goods.

👉 5. In Manufacturing of Borates:

- Serves as a raw material for the preparation of sodium borate, boron carbide, and boron halides.

✦ Summary:

- Boric acid (H_3BO_3) is a weak acid of boron.
- Prepared in the lab from borax and hydrochloric acid.
- White crystalline solid, weakly acidic, and acts as a Lewis acid.
- Used in medicine, glass industry, and laboratory tests.

🌟 Q.18. (a) Give the names along with the formulas of three important ores of aluminium.

(b) How and under what conditions does aluminium react with the following:

(i) Oxygen

(ii) Hydrogen

(iii) Halogens

(iv) Acids

(v) Alkalies

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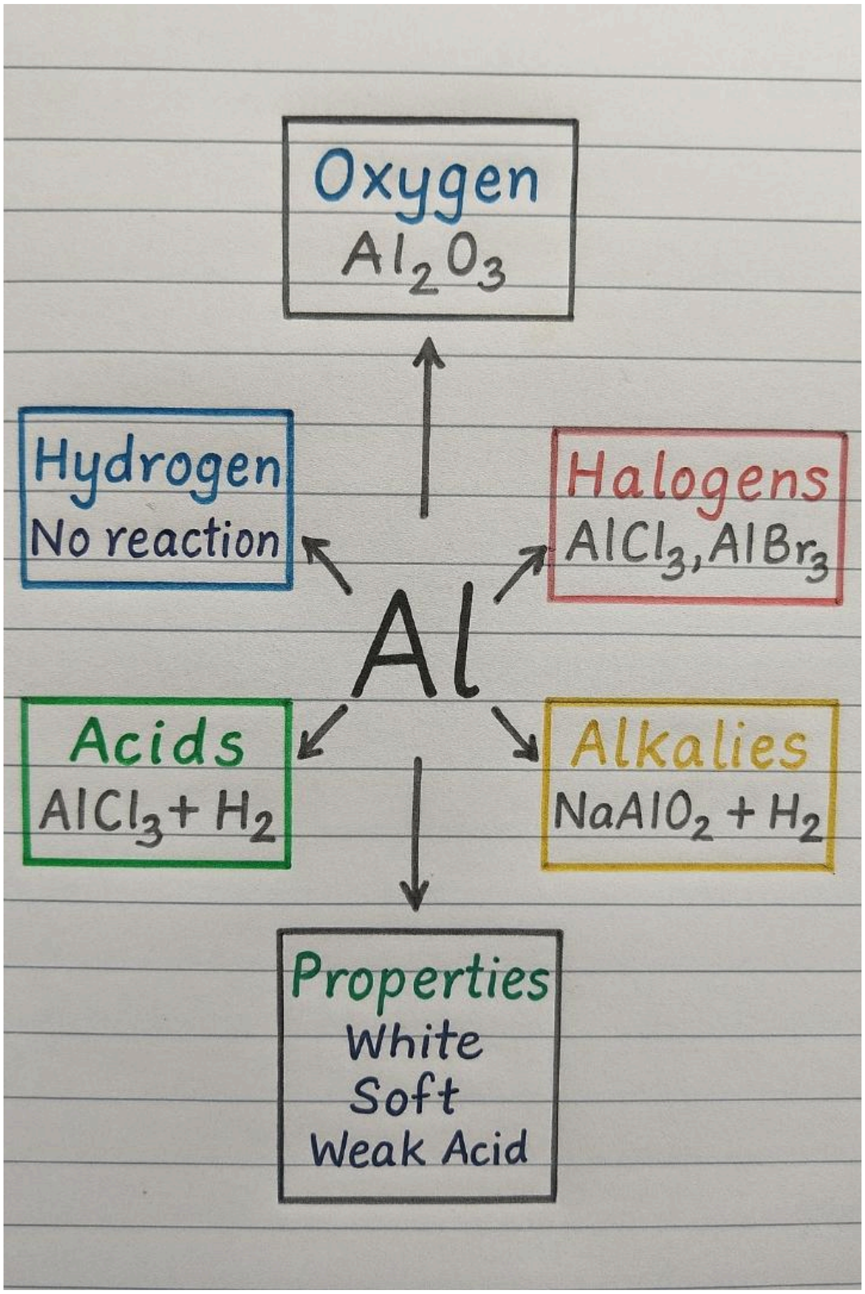

(a) Important Ores of Aluminium

- Aluminium is a very abundant metal in the Earth's crust but it is never found free due to its strong affinity for oxygen. It occurs in the form of oxides, silicates, and hydroxides.

👉 **The three most important ores of aluminium are:**

1. Bauxite — $Al_2O_3·2H_2O$

➢ It is the chief ore of aluminium.

➢ Mainly contains hydrated aluminium oxide.

➢ Found in red, brown, or yellow earthy masses.

2. Cryolite — Na_3AlF_6

➢ It is a double fluoride of sodium and aluminium.

➢ Mainly used in the electrolytic extraction of aluminium as a flux to lower melting point.

3. Corundum — Al_2O_3

➢ It is a natural crystalline form of aluminium oxide.

➢ Extremely hard and used as an abrasive (e.g., emery paper).

(b) Reactions of Aluminium with Different Substances

- Aluminium is an amphoteric metal, meaning it reacts with both acids and bases.
- Its behavior in chemical reactions depends on temperature and environmental conditions.

(i) Reaction with Oxygen (O_2)

👉 **At room temperature:**

- Aluminium forms a thin, protective oxide film (Al_2O_3) on its surface, which prevents further oxidation.

👉 **At high temperature:**

- When heated strongly in oxygen, aluminium burns with a brilliant white flame, forming aluminium oxide.

Equation:

$4Al + 3O_2 \longrightarrow 2Al_2O_3$

💡 **Note**: This oxide layer makes aluminium resistant to corrosion.

(ii) Reaction with Hydrogen (H_2)

👉 Aluminium does not react directly with hydrogen,

even at high temperature, because hydrogen is not reactive enough to displace aluminium from its compounds.

Hence:

❌ No direct reaction occurs between aluminium and hydrogen.

(iii) Reaction with Halogens

👉 Aluminium reacts vigorously with halogens (like chlorine, bromine, iodine, etc.) forming aluminium halides.

Example:

$2Al + 3Cl_2 \longrightarrow 2AlCl_3$

Products formed:

- Aluminium chloride ($AlCl_3$) – white crystalline solid
- Aluminium bromide ($AlBr_3$)
- Aluminium iodide (AlI_3)

💡 These halides are covalent compounds and easily hydrolyzed in water.

(iv) Reaction with Acids

👉 Aluminium reacts with dilute acids such as HCl or H_2SO_4, forming aluminium salts and hydrogen gas.

Equation:

$2Al + 6HCl \longrightarrow 2AlCl_3 + 3H_2$⬆️

💡 The reaction shows that aluminium is electropositive, easily displacing hydrogen from acids.

However, the oxide film must first be removed for the reaction to start.

(v) Reaction with Alkalies

👉 Aluminium dissolves in aqueous sodium hydroxide (NaOH) forming sodium aluminate ($NaAlO_2$) and hydrogen gas.

Equation:

$2Al + 2NaOH + 6H_2O \longrightarrow 2NaAl(OH)_4 + 3H_2$⬆️

At high temperature:

- Sodium aluminate decomposes to give sodium aluminate ($NaAlO_2$).

$2NaAl(OH)_4 \longrightarrow 2NaAlO_2 + 4H_2O$

💡 This reaction shows the amphoteric nature of aluminium — it reacts with both acids and bases.

🌟 Q.19. Give the names, electronic configurations and occurrence of Group-IVA elements of the periodic table.

❖ Introduction:

- Group IVA elements belong to the carbon family in the periodic table. These elements include Carbon (C), Silicon (Si), Germanium (Ge), Tin (Sn) and Lead (Pb).
- Each element in this group has four electrons in its outermost shell ($ns^2\ np^2$). Because of this configuration, these elements generally show tetravalency (+4) and sometimes divalency (+2) due to the inert pair effect.

- As we move down the group, the metallic character increases — carbon is a non-metal, silicon and germanium are metalloids, while tin and lead are metals.

🧪 Names and Electronic Configurations:

1. Carbon (C)

- **Atomic Number**: 6
- **Electronic Configuration:** $1s^2\ 2s^2\ 2p^2$
- **Nature**: Non-metal

2. Silicon (Si)

- **Atomic Number**: 14
- **Electronic Configuration:** $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$
- **Nature**: Metalloid

3. Germanium (Ge)

- **Atomic Number**: 32
- **Electronic Configuration**: $[Ar]\ 3d^{10}\ 4s^2\ 4p^2$
- **Nature**: Metalloid

4. Tin (Sn)

- **Atomic Number**: 50
- **Electronic Configuration**: $[Kr]\ 4d^{10}\ 5s^2\ 5p^2$
- **Nature**: Metal

5. Lead (Pb)

- **Atomic Number**: 82
- **Electronic Configuration:** [Xe] $4f^{14}$ $5d^{10}$ $6s^2$ $6p^2$
- **Nature**: Metal

🌍 Occurrence of Group IVA Elements:

1. Carbon (C)

- Carbon occurs both in free and combined states.
- In free state, it is found as diamond, graphite, and coal.
- In combined form, it occurs as carbon dioxide (CO_2) in air, and in minerals such as calcium carbonate ($CaCO_3$) and magnesium carbonate ($MgCO_3$).
- It also forms the basis of organic compounds present in all living organisms.

2. Silicon (Si)

- Silicon is the second most abundant element in the Earth's crust, making up about 27% by weight.
- It never occurs in free state but is found in combined form as silica (SiO_2) in sand and quartz.
- It also occurs in silicates such as mica, feldspar, and clay, which form a major portion of rocks.

3. Germanium (Ge)

- Germanium occurs in small quantities and is mainly obtained as a by-product in the refining of zinc ores.
- It is found in minerals such as Germanite (Cu_3GeS_3) and Argyrodite (Ag_8GeS_6).
- Germanium is an important semiconductor material used in transistors and electronic devices.

4. Tin (Sn)

- Tin is mainly obtained from cassiterite (SnO_2), which is its chief ore.
- It is found in countries like Malaysia, Indonesia, and Bolivia.
- Tin is used for tin plating, making alloys like bronze, and in solders.

5. Lead (Pb)

- Lead occurs mainly in Galena (PbS), which is its principal ore.
- Other ores include Cerussite ($PbCO_3$) and Anglesite ($PbSO_4$).
- Lead is used in batteries, paints, pipes, cables, and radiation shields.

⚙️ Trends in the Group:

- The metallic character increases from carbon to lead.
- The atomic size increases down the group.

- The covalent character decreases, and ionic character increases.
- The oxidation states commonly shown are +4 and +2.
- Carbon and silicon form covalent compounds, while tin and lead tend to form ionic compounds.

✦ **Summary:**

- Group IVA elements — carbon, silicon, germanium, tin, and lead — have four valence electrons ($ns^2\ np^2$).
- Carbon is a non-metal, silicon and germanium are metalloids, and tin and lead are metals.
- They occur widely in nature in the form of oxides, silicates, and ores.
- Their properties gradually change from non-metallic to metallic down the group.

🌟 **Q.20. Discuss the peculiar behaviour of carbon with respect to the other members of Group-IVA of the periodic table.**

❖ **Introduction:**

- Carbon is the first and smallest element of Group IVA (the carbon family).
- Although it belongs to the same group as silicon, germanium, tin, and lead, its properties are quite different from them.
- This unusual difference in its behavior is known as the peculiar behaviour of carbon.

- The main reasons for this distinct behavior are its small atomic size, high electronegativity, absence of d-orbitals, and strong catenation property.

⚛️ Reasons for Peculiar Behaviour of Carbon:

1. Small Atomic Size

- Carbon has a very small atomic radius, which allows it to form strong covalent bonds with other atoms such as hydrogen, oxygen, and nitrogen.
- **Because of this,** carbon can form a large number of stable compounds — more than any other element in the periodic table.

Example:

C forms strong bonds in compounds like CH_4 (methane), CO_2 (carbon dioxide), and C_2H_6 (ethane).

2. High Electronegativity

- Carbon has a relatively high electronegativity (2.5) compared to other elements of its group.
- This makes carbon less metallic and more capable of forming covalent compounds rather than ionic compounds.
- Other group members, like tin and lead, are metallic and form ionic compounds more easily.

3. Absence of d-Orbitals

- Carbon lacks d-orbitals in its valence shell, so it cannot expand its valency beyond four.
- In contrast, heavier elements such as silicon and tin have vacant d-orbitals and can show higher coordination numbers (like 6).

Example:

- Carbon shows maximum valency of 4 (in CH_4).
- Silicon can show valency 6 (in SiF_6^{2-}).

4. Strong Catenation Property

- Catenation means the ability of an element to form chains of atoms bonded together.
- Carbon shows exceptional catenation due to strong C–C bonds, which are stable under normal conditions.
- Other group elements like Si, Ge, Sn, and Pb also show catenation but to a much smaller extent because their M–M bonds are weaker.

Example:

- Carbon forms long chains and rings in hydrocarbons, alcohols, sugars, and proteins.

5. Ability to Form Multiple Bonds

- Carbon can form double and triple bonds with other elements (C=C, C≡C, C=O, C≡N, etc.) because of its small size and strong bonding ability.
- Other elements of the group rarely form such multiple bonds.

Example:

- Ethylene (C_2H_4) → double bond
- Acetylene (C_2H_2) → triple bond
- Silicon or tin do not form such compounds easily.

6. Formation of Allotropes

- Carbon shows allotropy, meaning it exists in different physical forms having the same chemical properties.
- Its main allotropes are Diamond, Graphite, and Amorphous Carbon.
- Other members of the group do not show such distinct and stable allotropic forms.

Example:

- **Diamond:** Hardest natural substance.
- **Graphite:** Good conductor of electricity.

7. Formation of a Vast Number of Compounds (Organic Chemistry)

- Carbon forms millions of compounds, especially organic compounds, because of its catenation and bonding ability.
- No other element in the group shows such versatility.
- This is the reason carbon chemistry is studied separately as Organic Chemistry.

✦ Summary:

Carbon behaves differently from the other members of Group IVA due to the following main reasons:

- It has small atomic size and high bond strength.
- It has high electronegativity and forms strong covalent bonds.
- It lacks d-orbitals, so cannot expand its valency.
- It shows strong catenation and forms multiple bonds.
- It exhibits allotropy and forms a vast number of organic compounds.

Because of these properties, carbon stands unique among all Group IVA elements.

🌟 Q.21. Explain:

(a) What are Silicones?

- Silicones are synthetic compounds of silicon in which silicon atoms are linked to oxygen atoms in a chain-like structure, and organic groups (like methyl or ethyl groups) are attached to silicon.
- **General formula:** $[R_2SiO]_n$ where R is an alkyl group (like CH_3).

They are sometimes called polysiloxanes.

- Silicones are chemically similar to silicates, but the oxygen atoms in silicates are part of a mineral lattice, while in silicones, they are part of a flexible chain.

Example: Methyl silicone – $Si(CH_3)_2$–O–$Si(CH_3)_2$–O...

(b) Principal Properties of Silicones

1. Silicones are thermally stable and resist decomposition at high temperatures.

2. They are insoluble in water but soluble in organic solvents.

3. Liquid silicones have very low change in viscosity with temperature, unlike ordinary oils.

4. High molecular weight silicones resemble rubber and have elasticity.

5. They are chemically inert, resistant to oxidation and acids.

6. Can form cross-linked structures to make resins with high strength and durability.

7. Water-repellent and can form protective coatings.

(c) Uses of Silicones

1. Lubricants – as oils or greases for machinery, bearings, and gears.

2. Hydraulic systems – used in brakes and hydraulic equipment.

3. Electrical insulation – silicone resins are excellent insulators.

4. Water-repellent coatings – applied on cloth, plastics, paper, glass, and leather.

5. Rubber-like materials – high molecular weight silicones used in tubing, sheets, and medical implants.

6. Heat-resistant coatings – used on surfaces exposed to high temperatures.

(d) What are Silicates?

- Silicates are compounds containing silicon and oxygen, often with metals like aluminum, sodium, calcium, or magnesium.

They are derived from silicic acids.

Example: Sodium silicate (Na_2SiO_3) and Aluminium silicate (Al_2SiO_5).

(e) Uses of Silicates

1. Sodium silicate (Water glass) – used in soaps, textile printing, and furniture polish.

2. Aluminium silicate (Kaolin clay) – used in porcelain, china wares, bricks, tiles, and stoneware.

3. Talc ($Mg_3Si_4O_{10}(OH)_2$) – used in cosmetics and household articles.

4. Asbestos ($CaMg(SiO_4)_2 \cdot nH_2O$) – used in fireproof fabrics and boards.

5. Silicates are also used in cement, ceramics, and construction materials due to their thermal and chemical stability.

✦ Summary:

Silicones: synthetic, flexible chains of silicon-oxygen with organic groups; water-repellent, heat-resistant, inert, used in lubricants, insulation, and rubber-like materials.

Silicates: natural compounds of silicon-oxygen with metals; used in construction, ceramics, paints, cosmetics, and industrial applications.

Note:

This chapter is designed to provide a solid foundation of knowledge, with the goal of deepening understanding and encouraging further exploration of the subject. The content has been carefully selected to support effective learning and inspire students to engage with the topic more deeply.

Author: Muhammad Asghar

Purpose: To contribute to education by offering insightful, valuable content that enhances learning and understanding.