Chapter
3

GROUP IIIA AND GROUP IVA ELEMENTS

GROUP IIIA ELEMENTS

The elements of group IIIA consist of boron, aluminium, gallium, indium and thallium.

Electronic configuration of group IIIA elements

Elements	Symbol	At. Number	Electronic configuration
Boron	B	5	$1s^2, 2s^2, 2p^1$
Aluminium	Al	13	$1s^2, 2s^2, 2p^6, 3s^2, 3p^1$
Gallium	Ga	31	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^{10}, 4p^1$
Indium	In	49	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^{10}, 4p^6, 5s^2, 4d^{10}, 5p^1$
Thallium	Tl	81	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^{10}, 4p^6, 5s^2, 4d^{10}, 5p^6, 6s^2, 4f^{14}, 5d^{10}, 6p^1$

PHYSICAL PROPERTIES OF GROUP IIIA ELEMENTS

(1) **Born is non-metal** while all other members are metals. Boron is non-metal due to its smaller size and high nuclear charge. The abrupt increase in metallic character from B to Al is associated with the increased size of aluminium atom.

(2) **In a group, size of atom increases** from top to bottom but this increase in size is not regular. Atomic sizes of both Al and Ga are almost similar. It is due to the behaviour of 10 electrons present in d orbital. These electrons have poor shielding as compared to s and p electrons. Increase in atomic size from In to Tl is also very small, due to the presence of f electrons which also have poor shielding.

Some properties of group IIIA are given in the table

Property	B	Al	Ga	In	Tl
Atomic number	5	13	31	49	81
Density g/cm^3	2.33	2.7	5.93	7.3	11.85
Melting point (°C)	2300	660	30	157	304
Boiling point (°C)	2550	2467	2403	2080	1457
1st ionization potential kJ/mol	801	577	579	558	589
Atomic radius (pm)	80	125	126	144	148
Ionic radius + 3 ion (pm)	20	52	60	81	95
Electron affinity (kJ/mol)	27	45	29	29	30
Electronegativity	2.0	1.5	1.6	1.7	1.8

(3) Melting points of group IIIA decrease downward in a group due to increase in the size of atoms.

(4) **First ionization energy decreases** downward the group due to increased size of atom. However first IP value increases from Al to Ga due to the poor shielding of d-electron. First I.E. also shows abnormal behaviour from In to Ti due to the presence of f^{14}-electrons. By poor shielding, the force of attraction between nucleus and electronic cloud increases.

OCCURRENCE OF BORON

Boron is not an abundant element. It occurs in traces in most soils and has been found to be essential in very small amounts for the proper growth of many plants.

Boron is always found in nature combined with oxygen, usually as oxyborate ions. Boron occurs principally as salts of various polyboric acids.

Name of minerals of boron	Chemical formula
Borax or tincal	$Na_2B_4O_7.10H_2O$
Colemanite	$Ca_2B_6O_{11}.5H_2O$
Orthoboric acid	H_3BO_3

PECULIAR BEHAVIOUR OF BORON

Boron is the first member of the group IIIA, it shows many dissimilarities with the members of its own group. The difference in the properties of boron and those of the other member of the series is mainly due to the large difference in their sizes and ionization energies.

(1) Boron is the only element in group IIIA which is non-metallic in behaviour.

(2) It is the only element with less than four electrons in the outermost shell which is not a metal.

(3) Boron always uses all the three of its valence electrons for bonding purposes and its common oxidation states are +3 and –3.

(4) One of the outstanding features of the chemistry of boron is its ability to form molecular addition compounds.

(5) Boron does not form ionic compound with sulphate, nitrate or other anions because boron does not form a stable cation.

(6) Boron is black in colour while all other elements are silvery white.

(7) **Oxide** of boron is **acidic**, while aluminium forms amphoteric oxide and rest of elements form basic oxides.

COMPOUNDS OF BORON

Borax or Sodium Tetraborate, $Na_2B_4O_7.10H_2O$:

Borax is sodium salt of tetraboric acid, $H_2B_4O_7$. It is most important than all other borates. Its chemical name is sodium tetraborate decahydrate.

Occurrence of Borax:

Borax occurs as a natural deposit called **tincal** in the dried up lakes of Tibet and California.

Manufacture of Borax:

(1) Formally borax was manufactured by treating a hot solution of boric acid with the proper amount of soda ash.

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

Boric acid Borax

(2) Now-a-days borax is almost exclusive obtained from calcium borate. Finely powered colemanite is boiled with Na_2CO_3 solution, when $CaCO_3$ precipitates out and a mixture of borax and sodium metaborate is formed.

$$Ca_2B_6O_{11} + 2Na_2CO_3 \longrightarrow 2CaCO_3 + Na_2B_4O_7 + 2NaBO_2$$

Colemanite

The clear solution from the top is taken off and is then allowed to crystallize, when crystals of borax separate out. To get more borax, CO_2 is blown through the mother-liquor, the sodium metaborate is decomposed into borax, which separates out in the form of fine crystals.

$$4NaBO_2 + CO_2 \longrightarrow Na_2CO_3 + Na_2B_4O_7$$

Sodium metaborate

(3) Borax may also be obtained from tincal by treating natural tincal with water and subsequently evaporating the clear solution, when crystals of borax separate out.

PROPERTIES OF BORAX

Physical Properties:

(1) Borax is a white crystalline solid.

(2) It is sparingly soluble (very less soluble) in cold water but more soluble in hot water. In 100 g of water at 10°C only 3 g of borax is soluble but at 100°C its solubility is 99.3 grams.

(3) If a saturated solution of borax is allowed to crystallize above 62°C, octahedral crystals of penta hydrate $Na_2B_4O_7.5H_2O$ separates out, but if temperature is below 62°C deca hydrate crystals $Na_2B_4O_7.10H_2O$ are formed.

CHEMICAL PROPERTIES

(1) Hydrolysis:

Aqueous solution of borax is alkaline in nature due to hydrolysis. Hydrolysis is prevented in the presence of glycerin.

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

Strong base Weak acid

Aqueous solution of borax turns red litmus to blue due to the presence of alkali.

Borax when dissolved in water ionizes as:

$$Na_2B_4O_7 \longrightarrow 2Na^+ + B_4O_7^{-2}$$

Hydrolysis of $B_4O_7^{-2}$ ions occurs as follows:

$$B_4O_7^{-2} + 7H_2O \longrightarrow 4H_3BO_3 + 2OH^-$$

So a strong alkali (NaOH) is formed which is highly ionized. On the other hand boric acid (H_3BO_3) ionizes to a little extent so it is a weak acid. Hence, solution of borax as a whole is alkaline in nature.

(2) Effect of Heat:

When borax is heated, it loses water and swells up into a white porous mass due to the expulsion of water. On further heating it melts into a clear transparent glass, which dissolves many metallic oxides forming coloured beads. This reaction forms the basic of borax bead test.

$$Na_2B_4O_7.10H_2O \longrightarrow Na_2B_4O_7 + 10H_2O$$

$$Na_2B_4O_7 \longrightarrow 2NaBO_2 + B_2O_3$$

(3) Reaction with Acids:

It reacts with HCl or H_2SO_4 to form boric acid:

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

Borax Boric acid

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

(4) Reaction with Ammonium Chloride:

When borax is heated with ammonium chloride, boron nitride is produced: BN is also called **Borazole or inorganic graphite**.

$$Na_2B_4O_7 + 2NH_4Cl \longrightarrow 2NaCl + 2BN + B_2O_3 + 4H_2O$$

Boarax Beat Test:

This test is used for identification of colour ions of the salt, i.e., Cu^{2+}, Fe^{+2}, Mn^{2+}, Co^{+2}, Cr^{3+}, Fe^{3+} and Ni^{2+}. We can perform this test as:

Prepare a loop at the end of a platinum wire. Heat the wire and take a little powdered borax on the hot loop. Heat again, borax first swells up and then melts into colourless, glass-like beads on the loop. Now put a few grains of the substance, under examination, on the beads and re-heat it first in the oxidizing flame and then in the reducing flame. Note the colours of the beads.

Chemistry of Borax Bead Test:

Borax, when fused, is decomposed into sodium metaborate and boric anhydride.

$$Na_2B_4O_7 \longrightarrow 2NaBO_2 + B_2O_3$$

The metallic oxide formed from the substance, under examination, combines with B_2O_3 giving the coloured metallic borates. With cupric oxide, the beads are coloured blue in the oxidizing flame because cupric metal borates are blue in colour.

$$CuO + B_2O_3 \longrightarrow Cu(BO_2)_2 \quad \text{(Blue bead)}$$

$$CoO + B_2O_3 \longrightarrow Co(BO_2)_2 \quad \text{(Blue bead)}$$

with CoO, blue bead of cobalt metaborate is formed.

Uses of Borax:

(1) It is used to prepare borate glass, which is heat resistant.

(2) It is used in softening of water.

(3) It is employ in borax bead test, for the detection of metallic cations.

(4) It is used in metallurgical operations.

(5) It is used as a flux in welding and metallurgy.

(6) It is employed in making washing powders.

(7) It is used in leather industry for tanning and dyeing.

(8) It is used in cosmetics, soaps, textiles, paints, medicine, match industry and as a preservative.

BORIC ACIDS

There are three important boric acids. Out of these orthoboric acid is the most important and the stable one. The remaining acids are stable in solid state and change into orthoboric acid in solution:

(1) Metaboric acid, HBO_2 (2) Orthoboric acid, H_3BO_3

(3) Tetraboric acid, $H_2B_4O_7$ (4) Pyroboric acid, $H_6B_4O_9$

$$HBO_2 + H_2O \longrightarrow H_3BO_3$$

Metaboric acid Orthoboric acid

$$H_2B_4O_7 + 5H_2O \longrightarrow 4H_3BO_3$$

Tetraboric acid Orthoboric acid

ORTHOBORIC ACID OR BORIC ACID (H_3BO_3)

It is well crystalline chemical substance (triclinic), sparingly soluble in cold water (2.6% at 40°C) but dissolves readily in hot water (37% at 107°C). This temperature variation in solubility forms the basis for its separation and purification.

PREPARATION OF BORIC ACID ON COMMERCIAL SCALE

(1) Form Colemanite:

On commercial scale boric acid is prepared from a natural calcium borate called colemanite ($Ca_2H_6O_{11}.5H_2O$) by suspending it is boiling water while sulphur dioxide is passed through it. Boric acid crystallizes out from the solution while the other product $CaSO_3$ remains in the solution.

$$Ca_2B_6O_{11} + 2SO_2 + 9H_2O \longrightarrow 2CaSO_3 + 6H_3BO_3$$

(2) From Borax:

A hot concentrated solution of borax is treated with a calculated quantity of conc. H_2SO_4. On cooling, crystals of boric acid formed separate out.

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

Borax — Boric acid

PROPERTIES OF BORIC ACID

(1) Boric acid is a white lustrous crystalline solid having a soft soapy touch, slightly soluble in cold water but fairly soluble in hot.

(2) It is volatile in steam.

(3) It reacts with ethyl alcohol, forming ethyl borate.

$$H_3BO_3 + 3C_2H_5OH \xrightarrow{H_2SO_4} (C_2H_5)_3BO_3\ 3H_2O$$

(4) When heated strongly, it swells to frothy mass losing water molecules. It is first converted into meta boric acid, then to tetra boric acid and finally to boric anhydride.

$$H_3BO_3 \xrightarrow{(100°C)} HBO_2 + H_2O$$

Meta boric acid

$$4HBO_3 \xrightarrow{(140°C)} H_2B_4O_7 + H_2O$$

Tetra boric acid

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

Boric anhydride

(5) It is a very weak acid and ionizes to a very limited extent mainly as a mono basic acid.

$$H_3BO_3 + H_2O \longrightarrow [B(OH)_4]^- + H^+$$

(6) Its solution has no effect on methyl orange although it turns blue litmus red.

(7) It is partially neutralized by caustic soda and gives borax.

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

Borax

(8) When boric acid is neutralized by soda ash Na_2CO_3, borax is obtained.

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

Borax

(9) Boric acid being a weak acid, cannot be titrated with alkalis in the usual manner. In the presence of glycerol, however, it can be titrated against a standard alkali using phenolphthalein as an indicator. In the presence of glycerol, it act as much stronger acid as compared to pure H_3BO_3.

Uses of Boric Acid:

(1) Boric acid is used in medicines as an antiseptic, e.g., dusting powder, boric ointment and boric solution is used as an eye-wash.

(2) It is used in pottery as a glaze because borate glazes are more fusible than silicate glazes and posses a higher coefficient of expansion.

(3) It is also used in candle industry for stiffening of wicks.

OCCURRENCE OF ALUMINIUM

Aluminium is the most abundant element in the Earth's crust (after oxygen and silicon).

It occurs primarily as alumino-silicate minerals found in the rocks of the outer portion of the earth.

Name of minerals of aluminium	Chemical formula
Feldspar	$KAlSi_3O_8$ or $K_2O.Al_2O_3.6SiO_2$
Mica (Muscovite)	$KH_2Al_3(SiO_4)_3$
Kaolin (Clay)	$H_2Al_2(SiO_4)_2.H_2O$ $Al_2O_3.2SiO_2.2H_2O$
Corundum	Al_2O_3
Diaspore	$Al_2O_3.H_2O$
Bauxite	$Al_2O_3.2H_2O$
Gibbsite	$Al_2O_3.3H_2O$ or $Al(OH)_3$
Emerald	$Al_2F_2SiO_4$
Cryolite	Na_3AlF_6

The other elements of group IIIA gallium, indium and thallium are relatively rare and are obtained as by-products during the processing of other metals.

Physical Properties of Aluminium:

(1) It is silvery white metal.

(2) Its density is 2.7 g cm^{-3}. It is light metal.

(3) It is brittle below its M.P (659°C).

(4) It is excellent conductor of heat and electricity.

(5) It is malleable and ductile.

Anodizing:

The thin layer of Al_2O_3 is very useful. The metal is resistant to corrosion due to this layer. Its thickness is purposely increased in the industry by electrolytic process called "Anodizing".

REACTIONS OF ALUMINIUM

(a) Reaction with Air:

Aluminium is a reactive metal. When it is left in air even for a short time, it is coated with a layer of aluminium oxide, Al_2O_3. This oxide protects the aluminium from further attack. This oxide layer is very useful and its thickness is purposely increased in industry by an electrolytic process called anodizing.

(1) Aluminium burns in air at high temperature. The reaction is accompanied with the evolution of heat and intense white light. This property of aluminium is used in flash flight photography.

$$4Al + 3O_2 \longrightarrow 2Al_2O_3 + Heat$$

(2) When aluminium is burnt in air, the product is a mixture of the oxide and equally white aluminium nitride.

$$4Al + 3O_2 \longrightarrow 2Al_2O_3$$

$$2Al + N_2 \longrightarrow 2AlN \qquad \text{(Aluminium nitride)}$$

Because of its ability to combine with both oxygen and nitrogen, the metal is often used to **remove air bubbles** from molten metals. Salt solutions corrode aluminium badly so aluminium and aluminium alloys are not suitable for marine use.

(b) Reaction with Non-metals:

(1) Aluminium of heating with hydrogen forms aluminium hydride.

$$2Al + 3H_2 \xrightarrow{Heat} 2AlH_3$$

(2) When halogens are passed over heated aluminium powdered aluminium halides are produced.

$$3Al + 3X_2 \longrightarrow 2AlX_3$$

$$2Al + 3Cl_2 \longrightarrow 2AlCl_3$$

(c) Reaction with Acids:

Aluminium is attacked rapidly by most acids but remains passive in concentrated nitric acid due to the formation of a protective layer of Al_2O_3. Aluminium dissolves in dilute acids giving out hydrogen:

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

$$2Al + 3H_2SO_4 \longrightarrow Al_2(SO_4)_3 + 3H_2$$

With hot and concentrated sulphuric acid reacts instead of H_2, sulphur dioxide gas is produced.

$$2Al + 6H_2SO_4 \longrightarrow Al_2(SO_4)_3 + 3SO_2 + 6H_2O$$

It is passive with conc. HNO_3.

(d) Reaction with Alkalis:

Aluminium when dissolved in aqueous alkalis producing hydrogen gas and soluble aluminate ion.

$$2Al + 2NaOH + 2H_2O \longrightarrow 2NaAlO_2 + 3H_2$$

Aluminium utensils are not washed with alkali solution. Hydrogen gas is also prepared by this method for filling in balloons.

(e) Thermite Process:

The process in which Al is used as reducing agent is called Alumino-thermite process (discovered by Goldchmidt in 1905).

$$Fe_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Fe$$

$$Cr_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Cr$$

The process is highly exothermic and is used for welding purpose (thermite welding) i.e., welding of tramway rails and heavy machinery.

USES OF ALUMINIUM

(1) It is very light metal (three times less dense than iron) but possess high tensile strength. Due to these properties, it is used in the transport industries, in the construction of aircrafts, ships and cars.

(2) It is good conductor of heat and electricity. It is used as heat exchanger in chemical industry, oil industry and many other industries.

(3) Its smooth surface reflect the radiations. For this reason it is commonly used to insulate buildings, and telescope mirrors. Aluminium foil is also used to jam RADAR.

(4) It is non-magnetic and used in **navigational equipments**.

(5) It is a good reducing agent and thus be used in chemical and steel industry.

(6) It is non-ionic and can be used to make food and brewing equipments and packing materials.

(7) Aluminium readily form alloys with other metals like copper, magnesium, nickel, cobalt and zinc.

(8) Aluminium due to its conductivity and luster, is used for making cooking utensils, window frames and kitchen foil.

(9) Aluminium is used for making petrol and milk storage tanks because it reflects radiations and prevent them of being over-heated in the sun.

GROUP IVA ELEMENTS

Elements of group IVA consist of carbon, silicon germanium, tin and lead.

The electronic configuration of group IVA elements are given below in the table:

Element	Symbol	At. No.	Electronic configuration
Carbon	C	6	$1s^2, 2s^2, 2p^2$
Silicon	Si	14	$1s^2, 2s^2, 2p^6, 3s^2, 3p^2$
Germanium	Ge	32	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^{10}, 4p^2$
Tin	Sn	50	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^{10}, 4p^6, 5s^2, 4d^{10}, 5p^2$
Lead	Pb	82	$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^{10}, 4p^6, 5s^2, 4d^{10}, 5p^6, 6s^2, 4f^{14}, 5d^{10}, 6p^2$

COMMON PROPERTIES OF THE ELEMENT GROUP IVA

(1) The elements of group IVA have four electrons in their valence shells and their valency is four or elements show four oxidation states in their compounds, e.g., CO_2, SiO_2, $PbCl_4$ etc.

(2) All the members of group IVA form hydrides of formula XH_4, e.g., Methane CH_4, Silane SiH_4, Germane GeH_4 etc.

(3) All the members of group IVA form tetra halides e.g., CCl_4, CF_4, $SiCl_4$, $GeCl_4$, $SnCl_4$, $PbCl_4$.

(4) Members of group IVA form dioxides, e.g., CO_2, SiO_2, GeO_2, SnO_2 and PbO_2.

GENERAL TREND OF PROPERTIES IN GROUP IVA

There is a marked change of properties from carbon to lead. Due to this gradation of properties, there are few similarities between extreme members carbon and lead.

(1) Metallic Characters:

Carbon is non-metal, silicon and germanium are semi-metals and tin and lead are good metals. Metallic characters increase from top to bottom in a group.

Table – Physical properties of group IVA elements

Property	C	Si	Ge	Sn	Pb
Atomic number	6	14	32	50	82
Density (g/cm^3)	2.33	2.7	5.93	7.3	11.85
Melting point (°C)	3930	1420	937	232	328
1^{st} ionization energy (kJ/mol)	1086	736	760	707	715
Atomic radius (pm)	77	117	122	140	154
Ionic radius (pm)	20	39	53	71	84

(2) Atomic Radii:

Atomic radii increase from top to bottom in a group, but this increase is very small from Si to Ge due to the presence of d-electrons d^{10} electrons have poor shielding and hold of nucleus on valence electrons increases.

(3) Ionization Energy:

Ionization energy usually decreases in a group from top to bottom. In this group ionization energy increases from Si to Ge due to poor shielding of d^{10}-electrons. This abnormality is also present in Sn to Pb due to poor shield of f^{14}-electrons.

(4) Variable Oxidation State:

The elements of group IVA have four electrons in their valence shell as ns^2, np^2. Carbon and silicon use their four electrons for bonding and have four oxidation state. Ge, Sn and lead have **oxidation +2 and +4**. Lower oxidation states ends with –ous. e.g., Germinous, Stannous and Plumbous, Higher oxidation states ends with –ic. e.g., Germinic, Stannic and Plumbic. In Ge^{2+}, Sn^{2+} and Pb^{2+} only two p-orbitals take part in bond formation. Two s-electron do not involve in bond formation. *"The s-pair of electrons which do not take part in bond formation is called, s-inert pair effect."*

(5) Electropositive Characters:

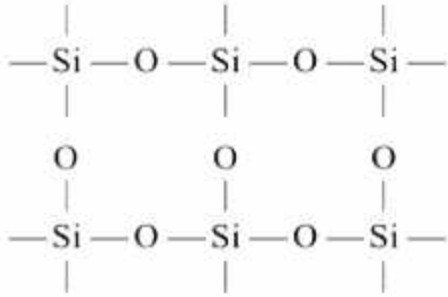
The electropositivity or the tendency to lose electron increases downward in group IVA. This trend is due to the increase in the atomic mass and metallic characters.

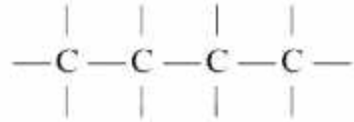
SOME COMMON PROPERTIES OF CARBON AND SILICON

(1) Carbon and silicon both form covalent bonds.

(2) Carbon and silicon both form acidic oxides, whereas oxides of Ge, Sn and Pb are amphoteric.

(3) Carbon and silicon have property of chain formation (catenation). However chain of silicon is alternate with oxygen.





(4) Both carbon and silicon react with hydrogen and halogen to form their hydride and halides respectively. e.g., CH_4, SiH_4, CF_4, SiF_4, etc.

Occurrence of Carbon:

Minerals of carbon	Chemical formula
Limestone (Calcite)	$CaCO_3$
Dolomite	$MgCO_3.CaCO_3$
Magnesite	$MgCO_3$

Occurrence of Silicon:

Minerals of silicon	Chemical formula
Analcite (a zeolite)	$NaAl(SiO_3)_2.H_2O$
Asbestos	$CaMg_3(SiO_3)_4$
Kaolin (pottery clay)	$H_2Al_2(SiO_4)_2.H_2O$
Talc (or soapstone)	$H_2Mg_3(SiO_3)_4$
Zircon	$ZrSiO_4$

Silicon is very abundant, about 25% of the mass of the earth's curst being due to this element.

Silicon, unlike carbon, is not found in free state. Silicon is found as a major constituent of rocks either in the form of silica or silicates. Most minerals other than sulphides, sulphates, phosphates and carbonates contain a high proportion of silicon.

As oxide, it is found as quartz in the following forms:

Rock crystal, amethyst, quartz, smoky quartz, rose quartz and milky quartz.

Sand is largely silicon dioxide (silica). Opal is a hydrated variety of quartz.

PECULIAR BEHAVIOUR OF CARBON

Carbon differs from the remaining members group IV-A in the following respects:

(1) Metallic Character:

Carbon is non-metal while the other members of the family are metalloids or metals.

(2) Catenation or Self-linkage:

Carbon has a tendency to form long chains of identical atoms. The type of linkage of identical atoms with each other is called catenation or self-linkage. The property of catenation decreases on moving down the group from carbon to lead. The maximum tendency of catenation associated with carbon forms the basis of the carbon compounds, which constitute organic chemistry.

(3) Multiple Bonds:

Carbon can form multiple (double or triple) bond with other carbon, atom or with nitrogen oxygen, etc.

For example: $HC \equiv CH$, $CH_2 = CH_2$, $O = C = O$

COMPOUNDS OF CARBON AND SILICON

Structure of Oxides of Carbon:

Three oxides of carbon are known:

CO Carbon monoxide

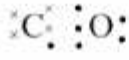
CO_2 Carbon dioxide

C_3O_2 Carbon sub-oxide ($O = C = C = C = O$)

Out of these, the last one is of little importance.

Structure of Carbon Monoxide:

Carbon monoxide is diatomic molecule having triple bond between the two atoms. It is slightly polar. The electronic structure of carbon monoxide can be represented as:



It is usually written as:

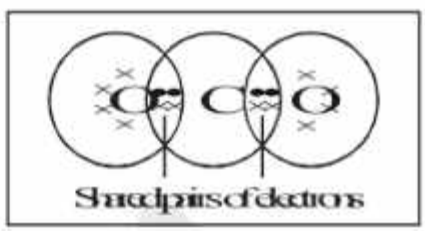
$$:C \equiv O:$$

It might appear from the above structure that the molecule should have a large dipole moment, but in fact the molecule has a small dipole moment (0.112 D).

$$\overset{\delta+}{C} \equiv \overset{\delta-}{O}$$

Structure of Carbon Dioxide:

Carbon dioxide exists in the gaseous state as linear molecules. The observed C–O bond distance is 115 pm and is in agreement with the following structure.



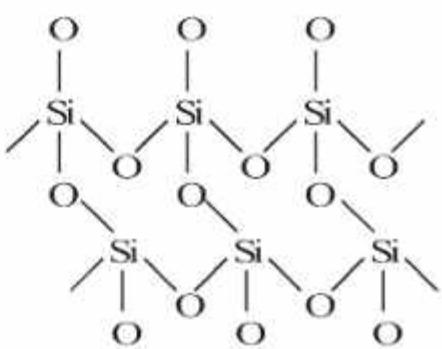
Solid CO_2 (dry ice) has a face-centered cubic structure. Being linear, its dipole moment is zero.

OXIDES OF SILICON

Silicon Dioxide (SiO_2):

Silicon dioxide, SiO_2 called silica, is probably the most common and the most important compound of silicon. In silica every silicon atom is attached tetrahedrally to four oxygen atoms and each oxygen atom has two close silicon neighbours.

The common crystalline form of silicon dioxide, is a hard, brittle, refractor, colourless solid which vary markedly from carbon dioxide.



In SiO_2, each silicon atom is linked with four oxygen atoms in tetrahedral arrangement. Each oxygen atom is covalently bonded with two silicon atoms. It is a three dimensional network covalent bond.

Due to this continuous arrangement, a giant silicon oxygen network extends out to give a massive silicon dioxide crystal. Because each Si is attached with four oxygen and each oxygen is attached with two silicon it has no molecular formula. We can only write the simplest ratio of atoms of silicon and oxygen, which is 1 : 2 or SiO_2.

Silicon-oxygen bond is very strong bond and atoms are firmly placed at their places. SiO_2 does not exist in the form of single molecules like CO_2. It is a macromolecule. Atoms of silicon and oxygen have their complete valence shells and are satisfied but those atoms of Si and O which are present at the surface are not satisfied. Due to this reason silica has high surface activity.

In each of the various crystalline forms of silica, there is a special pattern which is repeated throughout the crystal in a regular definite crystal lattice. The regular tetrahedral arrangement of four oxygen atoms around each silicon persists in each crystalline form but the Si–O–Si bond angles and the rotation about each Si–O bond are different in the different polymorphic species.

Preparation of Vitreous Silica or Silica Glass:

At 1600°C, silica or quartz melts to give a viscous liquid with a random internal structure. On the average still many molecules of silicon are attached with four oxygen and one oxygen is attached with two silicon atoms. When this liquid silica is cooled, it does not crystallize readily, but usually it under-cools tremendously and eventually becomes rigid without having undergone orientation into a regular crystal pattern. This rigid, highly under-cooled liquid is called vitreous silica or silica glass (frequently incorrectly referred to as fused quartz).

Vitreous silica possesses the following interesting and useful properties:

(1) High transparency to light.

(2) Very refractory (heat resistant), does not soften below 1500 to 1600°C.

(3) Very low thermal expansion (not easily fractured by changing temperature).

(4) Excellent insulator.

(5) Hard, brittle and elastic.

(6) Insoluble in water and inert toward many reagents.

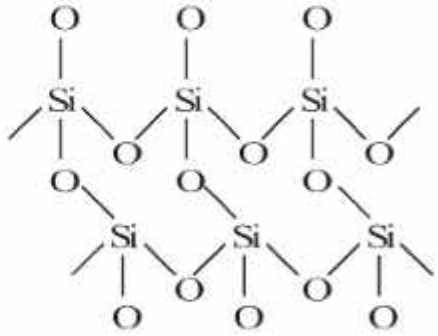
(7) It is resistant towards all acids except HF.

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

CO_2 is Gas while SiO_2 is Solid at Room Temperature:

Both carbon and silicon are the members of group IVA and have four electrons in their valence shell. Size of carbon atom is smaller than the size of silicon atom. In CO_2, each carbon atom forms two double bonds with two oxygen atoms, CO_2 is an independent molecule.

$$\overset{\delta-}{O} = \overset{\delta+}{C} = \overset{\delta-}{O}$$



In case of SiO_2, each silicon atom is covalently bonded with four oxygen atoms and each oxygen atom is attached with two silicon atoms. This networking of bonds is due to bigger size of silicon than carbon. SiO_2 has three dimensional regular arrangement of silicon and oxygen. Due to this network of strong covalent bond atoms of Si and oxygen are present at their fixed position and it exists as solid at room temperature.

SILICATES AND THEIR USES

The compounds derived from silicic acid H_2SiO_3 are known as silicates.

(a) Sodium Silicate Na_2SiO_3 (Water Glass or Soluble Glass):

This is sodium salt of metasilicic acid H_2SiO_3. It is known water glass or soluble glass. It is prepared by fusing sodium carbonate with pure sand. The process is carried out in a furnace called **reverberatory** furnace.

$$Na_2CO_3 + SiO_2 \longrightarrow \underset{\text{Sodium silicate}}{Na_2SiO_3} + CO_2$$

Properties:

Sodium silicate is soluble in water and its solution is strongly alkaline due to hydrolysis.

$$Na_2SiO_3 + 2H_2O \longrightarrow 2NaOH + H_2SiO_3$$

Uses of Sodium Silicate:

(1) It is used as a filler for soap in soap industry.

(2) It is used in textile as fire proof.

(3) It is used as furniture polish.

(4) It is also used in calico printing.

(5) Preservative for eggs.

Chemical Garden:

When crystals of soluble coloured salts like nickel chloride, ferrous sulphate, copper sulphate or cobalt nitrate, etc. are placed in a solution of sodium silicate, they produce a very beautiful growth, like plant, which is called chemical garden.

How to Grow Chemical Garden?

Prepare concentrated solution of Na_2SiO_3 in water and place it in a beaker. Sprinkle some crystals of coloured salt ($NiCl_2$, $FeSO_4$, $CuSO_4$) on the surface of the liquid. Coloured shoots rise up and grow like plant on standing for some time.

(b) Aluminium Silicates:

Aluminium silicates are formed by the chemical **weathering of the rocks**. Clay is an example of aluminium silicate. Clay is formed by disintegration and weathering of rocks.

The melting and freezing of water in the rocks, and the chemical action of water and carbon dioxide, convert these compounds into potassium carbonate, sand and clay. The following reaction explains the weathering of potassium feldspar:

$$\underset{\text{Feldspar}}{K_2O.Al_2O_3.6SiO_2} + H_2CO_3 + H_2O \longrightarrow K_2CO_3 + 4SiO_2 + \underset{\text{Clay}}{Al_2O_3.(SiO_2)_2.2H_2O}$$

PROPERTIES OF KAOLIN OR PURE CLAY

Pure, clay which has the formula shown above, is white and is called kaolin. It is used to make porcelain and china wares. Ordinary clay contains compounds of iron and other metals and it has a yellow or reddish yellow colour.

Impure clays can be more easily fused because they contain oxides of iron, calcium, magnesium and other metals which form easily fusible silicates with sand. Such clays are used to make **bricks, tiles, and stoneware's**. Due to the presence of ferric oxide, the articles of this clay turn reddish when heated in a kiln.

Stoneware is usually glazed to give it a less porous surface by throwing salt upon the articles while they are hot. This treatment produces sodium aluminate $NaAlO_2$ and sodium aluminium silicate, which melts readily and covers the entire surface. When the article cools, the covering solidifies, producing a compact, smooth waterproof surface. **China wares** are made from a mixture of **kaolin, bone ash, and feldspar**; the mixture fuses when heated and fills the pores between the grains of kaolin.

The use of clay in making pottery and other ceramic articles depends upon the **plasticity** of the paste. When soaked in water, the clay progressively hydrates, and the paste becomes more plastic. When the clay is heated, the water of hydration is lost, and a hard rock like mass is formed.

Talc or Soap Stone:

Magnesium silicate $H_2Mg_3(SiO_3)_4$ is commonly known as talc or soapstone. Due to weak force in these layers, they can slide over one another and have slippery touch. Talc is used as bath powder or talcum powder. It is used to make cosmetics.

Asbestos:

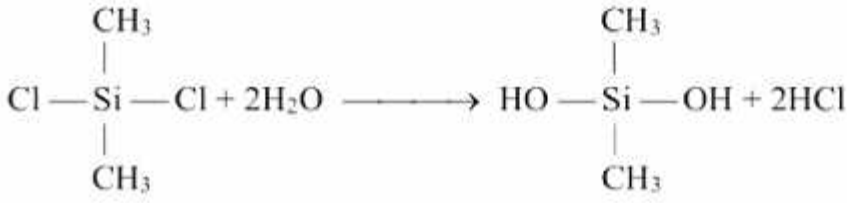
Asbestos is hydrated calcium magnesium silicate $CaMg_3(SiO_3)_4$. It has fibrous nature. Due to its fibrous nature, it is used to make reinforcing fuller in brakes and clutch linings. Because it is fireproof, it is spun and woven into fabrics used in covers. It is used in insulation and sealers in cars, trucks and planes.

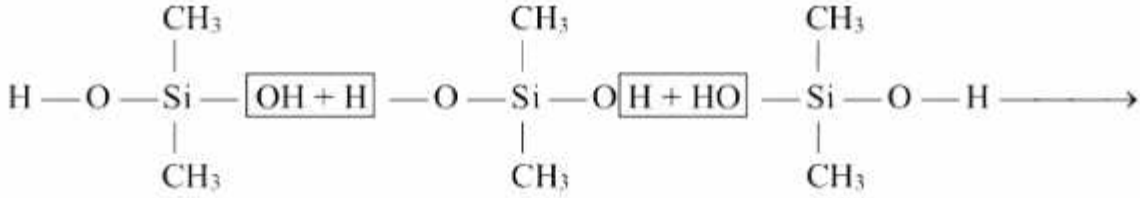
SILICONES

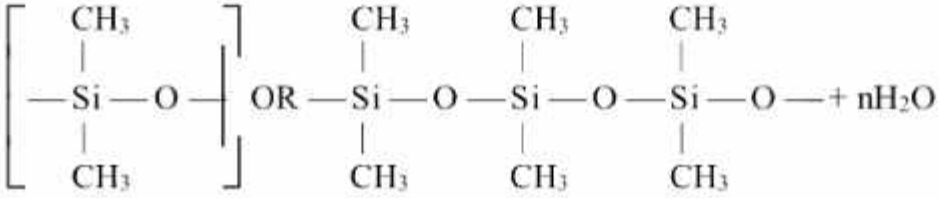
"These are polymeric chain compounds consisting of a backbone of alternatively linked silicon and oxygen atoms alkyl or aryl groups are attacked to the silicon atoms."

Silicones are formed by the hydrolysis of compounds like $(CH_3)_2SiCl_2$. During the formation of silicon polymer, a hydroxyl intermediate is formed which on elimination of water, produces silicones.

PREPARATION







Other alkyl group may also be substituted instead of $-CH_3$ group. Chain of Si–O–Si bond can be made of various length. Due to different chain length and alkyl group, silicones are present as oils, greases of rubber like solids.

PROPERTIES AND USES OF SILICONES

(1) As Lubricants:

Some methyl silicones are only liquids and become more viscous on increasing chain length, are used as lubricant. They are also used in hydraulic brakes and other hydraulic systems. Very small change in viscosity takes place by changing the temperature of silicones. In this respect, silicones are better lubricant than oils.

If the temperature is dropped from 100°C to 0°C, the viscosity of petroleum oil may increase about one hundred folds, whereas that of silicones oil will increase less than four folds. In the presence of **air or oxygen at temperature as high as** 300°C, silicone oils remains free from acid formation, oxidation and similar phenomena, which frequently limit the usefulness of petroleum products and other synthetic organic liquids.

(2) As Rubber:

Methyl silicones of high molecular mass resemble rubber and are used in making rubber like tubing and sheets.

(3) Electrical Insulator:

Silicone molecules can be made in such a way that bridges, or cross linkages bind one long molecule to another, at several points along the chain. These compounds have resinous properties and are extensively used in electrical insulator.

(4) Water Repellent:

Another interesting and important application of silicones is their use in the treatment of various surfaces to make them water repellent. A silicones film covers the surface, and repels water like a grease film. Much of the leakage of electricity through moisture film on ceramic electrical insulators can be prevented by a silicone film; cloth, plastics, asbestos, glass, leather and paper, even filter paper and blotting paper become strongly water repellent when covered with silicone film.

SEMICONDUCTORS

"A semiconductor is a solid, crystalline material with an electrical conductivity intermediate between that of metals and that of insulators."

The conductivity of metal decreases by increasing temperature while conductivity of semimetals increases by increasing temperature. Semiconductors have different resistance to passage of electric current in different conditions. Some common semiconductor materials are given below in the table:

Elements	III-V compounds	II-VI compounds
Si	AIP – Aluminium phosphide	CdS – Cadmium sulphide
Ge	GaP – Gallium phosphide	ZnS – Zinc sulphide
Se	GaAs – gallium arsenide	CdTe – Cadmium Telluride
	InAs – Indium arsenide	
	In Sb – Indium antimonide	

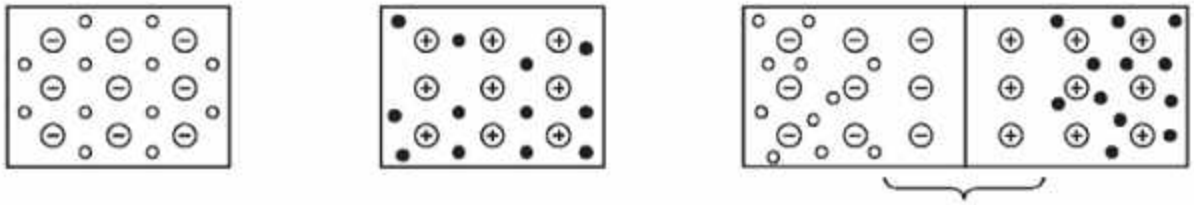
Semiconductors are of two types:

N-type Semiconductor:

Semiconductor in which mobile phase is electrons and stationary phase is positive ions.

P-type Semiconductor:

The semiconductor in which mobile phase are holes and stationary phase is negative ions.



p-type semiconductor with mobile holes and stationary negative ions

n-type semiconductor with mobile electrons and stationary positive ions

p-n junction

Formation of a p-n junction

PROPERTIES OF SEMICONDUCTORS

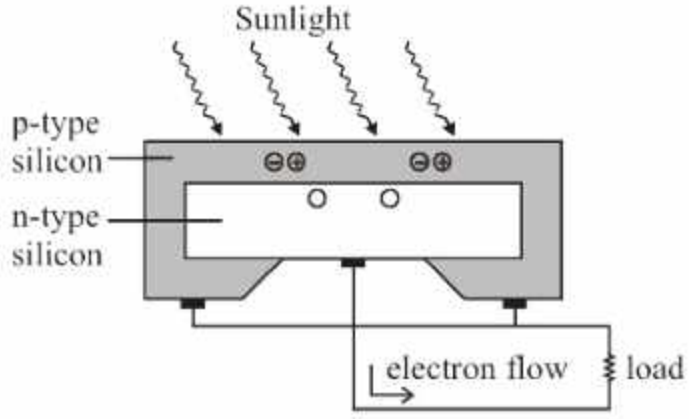
(1) Electrical Conductivity:

Semiconductors conduct electricity better than insulators, but not as well as good conductors like metals. This gives them their name, which means "Half conductors". How well they conduct electricity depends upon their temperature. When a metal is heated, its resistance increases, when a semiconductor is heated its resistance decreases.

(2) Light Sensitivity:

Semiconductors are also sensitive to light. The greater the intensity of the light that shines on them, the better they conduct electricity. The effects that light and heat energy have on semiconductors make them extremely useful. They are used in **photoelectric cells** and in a **solar batteries**.

The electrons of semiconductors do not carry electric current as readiiy as the electrons of good electric conductors like metals. However, when the atoms of the material absorb heat or light, the electrons become less tightly bound to their atoms. They can now conduct electricity.



A photovoltaic (solar) cell using silicon-based semiconductors

(3) Use in Transistors:

Another special property of semiconductors is the way they behave when they are joined to another material, which may be a metal or a different semiconductor. The junction between the different materials forms a boundary. It allows electricity to pass more properly and is used in transistors. Transistors are much smaller and less complicated than old fashioned electronic tubes. They are used in radio, television, computers and calculators.

USES OF LEAD COMPOUNDS IN PAINTS

Different oxides of lead, basic lead carbonate and lead chromate are used in paints.

(1) Lead Suboxide Pb_2O:

It is black powder, obtained on heating plumbous oxalate in the absence of air.

$$2PbC_2O_4 \xrightarrow{\text{Heat}} Pb_2O + 3CO_2 + CO$$

$$Pb_2O \xrightarrow{\Delta} PbO + Pb$$

Pb_2O is decomposed by heat into Pb and PbO. Oxidation state of lead is +1. Other than pigment, it is also used in the manufacture of lead storage batteries.

(2) Lead Monoxide (Litharge, Massicot), PbO:

(i) Litharge varies in colour from pale yellow to reddish yellow, possibly due to the existence of two forms, a rhombic (yellow) and a tetragonal (red).

(ii) It is slightly soluble in water.

(iii) It is amphoteric oxide.

(iv) It combines with acids and bases to form salt and water.

$$PbO + 2HCl \longrightarrow PbCl_2 + H_2O$$

$$PbO + 2NaOH \longrightarrow Na_2PbO_2 + H_2O$$

Uses of Lead Monoxide:

(1) It is usually used in preparing flint glass and paints.

(2) If litharge is boiled with water and olive oil, lead oleate is formed which is a sticky adhesive mass.

(3) A paste of litharge and glycerine harden on standing and yield a cement that is stable towards water and is often employed to seal drain pipes of sinks.

(4) It is also used as glaze for decorating ceramic objects.

(3) Red Lead, Pb_3O_4 or Minimum (Sindhur):

It is a combination of plumbous and plumbic oxide.

($PbO.PbO_2.PbO$)

Preparation:

When lead is heated in air at about 340°C, it absorbs oxygen and forms a bright scarlet crystalline powder of red lead or **minimum**.

$$3Pb + 2O_2 \longrightarrow Pb_3O_4$$

It decomposes at 470°C:

$$2Pb_3O_4 \xrightarrow{470°C} 6PbO + O_2$$

Uses:

(1) It is used for manufacture of lead storage batteries.

(2) It is used as red pigment in paints.

(3) Mixture of linseed oil and red lead is applied to steel and iron to prevent corrosion.

(4) It is an important ingredient for the manufacture of flint glass, matches and ceramic glazes.

(4) Lead Oxide, Plumbic Oxide, PbO_2:

When red lead is treated with concentrated nitric acid, it is decomposed into lead nitrate and lead dioxide:

$$Pb_3O_4 + 4HNO_3 \longrightarrow 2Pb(NO_3)_2 + PbO_2 + H_2O$$

Lead dioxide is a reddish brown powder. It is slightly soluble in water, but it does dissolve in alkaline water to yield soluble plumbates. It is not affected by dilute acids. It is poisonous in nature. It decomposes on heating at 43°C to form red lead.

$$2PbCO_3.Pb(OH)_2 \xrightarrow{43°C} Pb_3O_4 + CO + CO_2 + H_2O$$

(5) White Lead $2PbCO_3.Pb(OH)_2$:

Basic lead carbonate $2PbCO_3.Pb(OH)_2$ is an amorphous white pigment. It mixes readily with linseed oil and has a good covering power. If improperly prepared, it becomes crystalline and its covering power is reduced.

White lead is not suitable for use as a good pigment since it is darkened by the hydrogen sulphide, which is frequently present in the atmosphere.

(6) Lead Chromate, Chrome Yellow $PbCrO_4$:

It is prepared by reacting K_2CrO_4 with $Pb(CH_3COO)_2$.

$$K_2CrO_4 + Pb(CH_3COO)_2 \longrightarrow \underset{\text{Yellow ppts}}{PbCrO_4} + 2CH_3COOK$$

It is used as a pigment under the name of **chrome yellow**. Orange or red basic lead chromates are formed when lead chromate is boiled with dilute alkali hydroxide and are used as pigments. The stable yellow modification of lead chromate is monoclinic. Mixture of lead chromate with lead sulphate or barium sulphate are also used as yellow pigments.

EXERCISE

Q.1 Fill in the blanks:

(i) ———— acid has the chemical formula HBO_2.

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

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

(iv) Boron forms ———— bond in its compounds.

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

(vi) ———— is the only element with less than four electrons in the outer most shell that is not a metal.

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

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

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

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

ANSWERS

(i)	metaboric acid	**(ii)**	alumino-silicate	**(iii)**	SO_2
(iv)	three	**(v)**	$2PbCO_3 . Pb(OH)_2$	**(vi)**	boron
(vii)	boron	**(viii)**	tincal	**(ix)**	Na_3AlF_6
(x)	semiconductor				

Q.2 Indicate True or False:

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

(ii) Diaspore is an ore of carbon.

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

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

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

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

(vii) Carbon and silicona re the only non-metals in group IVA.

(viii) PbO is commonly known as litharge.

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

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

ANSWERS

(i)	True	**(ii)**	False	**(iii)**	False	**(iv)**	False	**(v)**	False
(vi)	False	**(vii)**	True	**(viii)**	True	**(ix)**	False	**(x)**	False

Q.3 Multiple choice questions. Encircle the correct answer:

(i) Which metal is used in the thermit process because of its activity:

(a) Iron **(b)** Copper

(c) Aluminium **(d)** Zinc

(ii) Aluminium oxide is:

(a) Acidic oxide **(b)** Basic oxide

(c) Amphoteric oxide **(d)** None of these

(iii) Chemical composition of colemanite is:

(a) $Ca_2B_6O_{11} \cdot 5H_2O$ **(b)** $CaB_4O_7 \cdot 4H_2O$

(c) $Na_2B_4O_7 \cdot 4H_2O$ **(d)** $CaNaB_5O_9 \cdot 8H_2O$

(iv) Which element forms ion with charge +3:

(a) Beryllium **(b)** Alluminium

(c) Carbon **(d)** Silicon

(v) Which electronic configuration corresponds to an element of group-IIIA of the periodic table:

(a) $1s^2, 2s^2, 2p^6, 3s^2, 3p^1$ **(b)** $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2$

(c) $1s^2, 2s^2, 2p^6$ **(d)** $1s^2, 2s^2, 2p^6, 3s^2, 3p^3$

(vi) Which element among the following belongs to group IVA of the periodic table:

(a) Barium **(b)** Iodine

(c) Lead **(d)** Oxygen

(vii) Boric acid cannot be used:

(a) As antiseptic in medicine **(b)** For washing eyes

(c) In soda bottles **(d)** For enamels and glazes

(viii) Which of the following elements is not present abundantly in earth's crust:

(a) Silicon **(b)** Aluminium

(c) Sodium **(d)** Oxygen

(ix) Tincal is a mineral of:

(a) Al **(b)** B

(c) Si **(d)** C

(x) The chief ore of aluminium is:

(a) Na_3AlF_6 **(b)** $Al_2O_3 . 2H_2O$

(c) Al_2O_3 **(d)** $Al_2O_3 . H_2O$

ANSWERS

(i)	(c)	**(ii)**	(c)	**(iii)**	(a)	**(iv)**	(b)	**(v)**	(a)
(vi)	(c)	**(vii)**	(c)	**(viii)**	(c)	**(ix)**	(b)	**(x)**	(b)

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

Ans. The aqueous solution of borax is alkaline in nature due to the formation of strong alkali (NaOH)

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

Therefore, in the solution of borax litmus becomes blue.

Q.5 Give equations to represent the following reactions.

Ans.

(a) Borax is heated with CoO:

$$Na_2B_4O_7 + CoO \longrightarrow Co(BO_2)_2 + 2NaBO_2$$

(b) Al_2O_3 is heated with NaOH solution:

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

Q.6 (i) Why is aluminum not found as a free element?

(ii) Explain the chemistry of borax bead test.

Ans.

(i) Aluminum does not exist in free state because it is a highly reactive metal. It is third most abundant element of earth crust and mostly found in the form of alumino—silicates.

(ii) See text for detailed answer.

Q.7 How does orthoboric acid react with?

Ans.

(a) Sodium hydroxide:

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

(b) Ethyl alochol:

$$H_3BO_3 + 3C_2H_5OH \longrightarrow (C_2H_5)_3BO_3 + 3H_2O$$

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

Ans.

(i) Boric acid into borax:

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

(Borax)

(ii) Borax into boric acid:

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

(Boric acid)

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

Ans. Liquid silicones are preferred aver ordinary organic lubricants because with the change of temperature, small change in viscosity takes place. In the presence of air or oxygen at high temperature, silicone oils remain free from acid formation and oxidation whereas these phenomena limit the usefulness of ordinary lubricants.

Q.10 Explain:

(a) CO_2 is non-polar in nature.

(b) CO_2 is acidic in character.

Ans.

(a) See Q.8 of Short Questions.

(b) CO_2 is a non-metal oxide. When CO_2 is dissolved in water it changes into carbonic acid and hence CO_2 is acidic in nature.

$$H_2O + CO_2 \longrightarrow H_2CO_3 \quad \text{(carbonic acid)}$$

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

Ans. See Q.9 of Short Questions.

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

Ans. **Acids of Boron:**

(i) Metaboric acid HBO_2

(ii) Orthoboric acid H_3BO_3

(iii) Tetraboric acid $H_2B_4O_7$

(iv) Pyroboric acid $H_6B_4O_9$

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

Ans. For details see text book.

Q.14 Give the names, electronic configurations and occurrence of group-III A elements of the periodic table.

Ans. Detailed question see text book.

Q.15 Discuss the peculiar behaviour of boron with respect to the other members of group-III A elements.

Ans. Descriptive question. See text book for details.

Q.16 (a) What is borax?

(b) Describe its commercial preparation.

(c) Outline the principal uses of borax.

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

Ans. For answer of (a), (b) and (c) see text book.

(d) Hardness in water is because of Ca^{2+} and Mg^{2+}. Borax ahs ability to remove Ca^{2+} and Mg^{2+} ions from water as calcium tetra-borate and magnesium tetra-borate and hence borax can be used as water softening agent.

$$Ca^{2+} + Na_2B_4O_7 \longrightarrow CaB_4O_7 + 2Na^+$$

$$Mg^{2+} + Na_2B_4O_7 \longrightarrow MgB_4O_7 + 2Na^+$$

Q.17 (a) What is boric acid?

(b) How is boric acid prepared in laboratory?

(c) Give properties and uses of boric acid.

Ans. Descriptive question. See text book for details.

Q.18 (a) Give the names along with the formulas of three important area of aluminum.

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

(i) Oxygen (ii) Hydrogen (iii) Halogens

(iv) Acids (v) Alkalies

Ans.

(a) Three Ores of Aluminum:

Bauxite $Al_2O_3 . 2H_2O$

Cryolite Na_3AlF_6

Gibbsite $Al_2O_3 . 3H_2O$

(b) (i) Reaction with O_2:

$$4Al + 3O_2 \longrightarrow 2Al_2O_3 + Heat$$

(ii) Reaction with H_2:

$$2Al + 3H_2 \longrightarrow 2AlH_3$$

(iii) Reaction with Halogens:

$$2Al + 3X_2 \longrightarrow 2AlX_3$$

$$2Al + 3Cl_2 \longrightarrow 2AlCl_3$$

(iv) Reaction with Acids:

$$2Al + 6HCl \xrightarrow{dil.} 2AlCl_3 + 3H_2$$

$$2Al + 3H_2SO_4 \xrightarrow{dil.} Al_2(SO_4)_3 + 3H_2$$

(v) Reaction with Alaklies:

$$2Al + 2NaOH + 2H_2O \longrightarrow 2NaAlO_2 + 3H_2$$

Q.19 Give the names, electronic configurations, and occurrence of group IV a elements of the periodic table.

Ans. Descriptive question. See text book for details.

Q.20 Discuss the peculiar behaviour of carbon with respect to the other members of group-IV A of the periodic table.

Ans. Descriptive question. See text book for details.

Q.21 (a) What are silicones?

(b) Give a brief summary of the principal properties of silicones.

(c) Out live the uses of silicones.

(d) What are silicates?

(e) Describe the important uses of silicates.

Ans.

(a) Silicones: Long chain compounds of alternating Si and O (oxygen) atom in which alkyl radical is attached to Si.

For the answer of (b) and (c) consult text book.

(d) Silicates: The compounds which are derived from metasilicis is acid (H_2SiO_3) e.g.,

Asbestos : $CaMg(SiO_3)_4$

Talc : $H_2Mg_3(SiO_3)_4$

(e) (i) Sodium Silicate:

* Used as a filler for soap in soap industry.
* Used in textile as a fire proof.
* Used as furniture polish.
* Used in calico printing.

(ii) Aluminum Silicate:

* Used in making pottery and ceramic material.
* Used in making porcelain and chinaware.
* Making of tiles and bricks.
* Glazing of tiles.

(iii) Talc or Soapstone:

* Used in making cosmetics.
* Making household articles.

(iv) Asbestos:

* Used in making incombustible fabrics.
* Used in making hard board.
* Insulation and sealer for cars.

DO YOU KNOW?

(1) Borax occurs as natural deposit called tincal. It is found in dried lakes of Tibet and California.

(2) Borax bead test is used for basic coloured radicals like Cu^{+2}, Fe^{+3}, Mn^{+2}, Co^{+2}, Cr^{+3} and Ni^{+2}.

(3) Formula of copper metaborate is $Cu(BO_2)_2$.

(4) H_3BO_3 is mono basic acid.

(5) The process in which Al is used as reducing agent is called "Thermite Process". For example

$$Fe_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Fe$$

$$Cr_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Cr$$

(6) Aluminum foil is used to jam radar.

(7) Sodium silicate is called water glass or soluble glass.

(8) PbO is called litharge.

(9) Formula of red lead is Pb_3O_4.

(10) $PbCrO_4$ is called chrome yellow.

(11) $PbCrO_4.PbO$ is called chrome red.

(12) PbO is amphoteric oxide.

(13) Alum $K_2SO_4.Al_2(SO_4)_3.24H_2O$ is double salt.

(14) PbO has two forms:

(a) Rhombic which is yellow in colour.

(b) Tetragonal which is red in colour.

(15) **Mordanting:** Alum and aluminium salts are used as mordants. $Al(OH)_3$ absorbs the dye and fixes it firmly on the fabric. It is called "Mordanting".

CHAPTER 3

GROUP IIIA AND GROUP IVA ELEMENTS

MULTIPLE CHOICE QUESTIONS

1. Which metal is used in thermite process because of its activity:

(a) Fe (b) Cu

(c) Al (d) Zn

2. Aluminum oxide is:

(a) Acidic (b) Basic

(c) Amphotric (d) None of these

3. Which element form an ion with change +3:

(a) Be (b) Al

(c) C (d) Si

4. Which of the following element is not present abundantly in earth's crust:

(a) Si (b) Al

(c) Na (d) O

5. Which of the following radicals give blue colour (in cold and hot state) in oxidizing flame when subjected to Borax Bead test:

(a) Cu^{-2} (b) Co^{+2}

(c) Cr^{-3} (d) Ni^{-2}

6. Sulphur is not present in:

(a) Onion (b) Garlic

(c) Egg (d) Fat

7. Which is the formula of clay:

(a) $Al_2O_3 . SiF_4$ (b) Al_2O_3

(c) $Na_2O_3 . 2H_2O$ (d) $Al_2O_3 . 2SiO_2 . 2H_2O$

8. BF_3 acts as Lewis acid because it behaves as:

(a) Free radical (b) Cationic specie

(c) Electrophile (d) Nucleophile

9. Which of the following gas will turns lime water milky:

(a) Cl_2 (b) NO_2

(c) CO (d) CO_2

10. Elements which exhibits maximum catenation property:

(a) C (b) Pb_3O_4

(c) Ge (d) PbO_2

11. Chrome yellow is:

(a) $PbMoO_4$ (b) $K_2Cr_2O_7$

(c) $PbCrO_4$ (d) K_2CrO_4

12. Which one of the following is the formula of litharge:

(a) PbO (b) PbO_2

(c) Pb_3O_4 (d) Pb_2O_3

13. A gas which burn with blue flame is:

(a) CO_2 (b) N_2

(c) CO (d) NO

14. Which compound of silicon used as filler in soap to make it heavy:

(a) SiO_2 (b) Na_2SiO_3

(c) H_2SiO_3 (d) Silicones

15. Pb_3O_4 has chemical name of:

(a) Litharge (b) Massicot

(c) Sandhur (d) Halite

16. Stable shape in which $PbCrO_4$ exist:

(a) Triclinic (b) Monoclinic

(c) Rhomleric (d) None of these

17. Chief ore of Al is:

(a) Na_3AlF_6 (b) $Al_2O_3 . 2H_2O$

(c) Al_2O_3 (d) $Al_2O_3 . H_2O$

18. Tincal is a mineral of:

(a) Al **(b)** B

(c) Si **(d)** C

19. What is the nature of solution of Borax:

(a) Neutral **(b)** Alkaline

(c) Acidic **(d)** Corrosive

20. Which of the following is the correct number of lone-pair with oxygen in CO:

(a) 1 **(b)** 2

(c) 3 **(d)** 4

answers

1.	(c)	**2.**	(c)	**3.**	(b)	**4.**	(c)	**5.**	(b)
6.	(d)	**7.**	(d)	**8.**	(c)	**9.**	(d)	**10.**	(a)
11.	(c)	**12.**	(a)	**13.**	(c)	**14.**	(b)	**15.**	(c)
16.	(b)	**17.**	(b)	**18.**	(b)	**19.**	(b)	**20.**	(a)

solved EXERCISE

Q.1 Fill in the blanks:

(i) ———— acid has the chemical formula HBO_2.

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

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

(iv) Boron forms ———— bond in its compounds.

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

(vi) ———— is the only element with less than four electrons in the outer most shell that is not a metal.

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

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

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

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

answers

(i)	metaboric acid	**(ii)**	alumino-silicate	**(iii)**	SO_2
(iv)	three	**(v)**	$2PbCO_3 . Pb(OH)_2$	**(vi)**	boron
(vii)	boron	**(viii)**	tincal	**(ix)**	Na_3AlF_6
(x)	semiconductor				

Q.2 Indicate True or False:

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

(ii) Diaspore is an ore of carbon.

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

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

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

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

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

(viii) PbO is commonly known as litharge.

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

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

answers

(i)	True	**(ii)**	False	**(iii)**	False	**(iv)**	False	**(v)**	False
(vi)	False	**(vii)**	True	**(viii)**	True	**(ix)**	False	**(x)**	False

Q.3 Multiple choice questions. Encircle the correct answer:

(i) Which metal is used in the thermit process because of its activity:

(a) Iron **(b)** Copper

(c) Aluminium **(d)** Zinc

(ii) Aluminium oxide is:

(a) Acidic oxide **(b)** Basic oxide

(c) Amphoteric oxide **(d)** None of these

(iii) Chemical composition of colemanite is:

(a) $Ca_2B_6O_{11} \cdot 5H_2O$ **(b)** $CaB_4O_7 \cdot 4H_2O$

(c) $Na_2B_4O_7 \cdot 4H_2O$ **(d)** $CaNaB_5O_9 \cdot 8H_2O$

(iv) Which element forms ion with charge +3:

(a) Beryllium **(b)** Aluminium

(c) Carbon **(d)** Silicon

(v) Which electronic configuration corresponds to an element of group-IIIA of the periodic table:

(a) $1s^2, 2s^2, 2p^6, 3s^2, 3p^1$ **(b)** $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2$

(c) $1s^2, 2s^2, 2p^6$ **(d)** $1s^2, 2s^2, 2p^6, 3s^2, 3p^3$

(vi) Which element among the following belongs to group IVA of the periodic table:

(a) Barium **(b)** Iodine

(c) Lead **(d)** Oxygen

(vii) Boric acid cannot be used:

(a) As antiseptic in medicine **(b)** For washing eyes

(c) In soda bottles **(d)** For enamels and glazes

(viii) Which of the following elements is not present abundantly in earth's crust:

(a) Silicon **(b)** Aluminium

(c) Sodium **(d)** Oxygen

(ix) Tincal is a mineral of:

(a) Al **(b)** B

(c) Si **(d)** C

(x) The chief ore of aluminium is:

(a) Na_3AlF_6 **(b)** $Al_2O_3 . 2H_2O$

(c) Al_2O_3 **(d)** $Al_2O_3 . H_2O$

answers

(i)	(c)	**(ii)**	(c)	**(iii)**	(a)	**(iv)**	(b)	**(v)**	(a)
(vi)	(c)	**(vii)**	(c)	**(viii)**	(c)	**(ix)**	(b)	**(x)**	(b)

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

Ans. The aqueous solution of borax is alkaline in nature due to the formation of strong alkali (NaOH)

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

Therefore, in the solution of borax litmus becomes blue.

Q.5 Give equations to represent the following reactions.

Ans.

(a) Borax is heated with CoO:

$$Na_2B_4O_7 + CoO \longrightarrow Co(BO_2)_2 + 2NaBO_2$$

(b) Al_2O_3 is heated with NaOH solution:

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

Q.6 (i) Why is aluminum not found as a free element?

(ii) Explain the chemistry of borax bead test.

Ans.

(i) Aluminum does not exist in free state because it is a highly reactive metal. It is third most abundant element of earth crust and mostly found in the form of alumino—silicates.

(ii) See text for detailed answer.

Q.7 How does orthoboric acid react with?

Ans.

(a) Sodium hydroxide:

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

(b) Ethyl alochol:

$$H_3BO_3 + 3C_2H_5OH \longrightarrow (C_2H_5)_3BO_3 + 3H_2O$$

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

Ans.

(i) Boric acid into borax:

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

(Borax)

(ii) Borax into boric acid:

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

(Boric acid)

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

Ans. Liquid silicones are preferred over ordinary organic lubricants because with the change of temperature, small change in viscosity takes place. In the presence of air or oxygen at high temperature, silicone oils remain free from acid formation and oxidation whereas these phenomena limit the usefulness of ordinary lubricants.

Q.10 Explain:

(a) CO_2 is non-polar in nature.

(b) CO_2 is acidic in character.

Ans.

(a) See Q.8 of Short Questions.

(b) CO_2 is a non-metal oxide. When CO_2 is dissolved in water it changes into carbonic acid and hence CO_2 is acidic in nature.

$$H_2O + CO_2 \longrightarrow H_2CO_3 \quad \text{(carbonic acid)}$$

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

Ans. See Q.9 of Short Questions.

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

Ans. **Acids of Born:**

(i) Metaboric acid HBO_2

(ii) Orthoboric acid H_3BO_3

(iii) Tetraboric acid $H_2B_4O_7$

(iv) Pyroboric acid $H_6B_4O_9$

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

Ans. For details see text book.

Q.14 Give the names, electronic configurations and occurrence of group-III A elements of the periodic table.

Ans. Detailed question see text book.

Q.15 Discuss the peculiar behaviour of boron with respect to the other members of group-III A elements.

Ans. Descriptive question. See text book for details.

Q.16 (a) What is boroax?

(b) Describe its commercial preparation.

(c) Outline the principal uses of boarax.

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

Ans. For answer of (a), (b) and (c) see text book.

(d) Hardness in water is because of Ca^{2+} and Mg^{2+}. Borax has ability to remove Ca^{2+} and Mg^{2+} ions from water as calcium tetra-borate and magnesium tetra-borate and hence borax can be used as water softening agent.

$$Ca^{2+} + Na_2B_4O_7 \longrightarrow CaB_4O_7 + 2Na^+$$

$$Mg^{2+} + Na_2B_4O_7 \longrightarrow MgB_4O_7 + 2Na^+$$

Q.17 (a) What is boric acid?

(b) How is boric acid prepared in laboratory?

(c) Give properties and uses of boric acid.

Ans. Descriptive question. See text book for details.

Q.18 (a) Give the names along with the formulas of three important area of aluminum.

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

(i) Oxygen (ii) Hydrogen (iii) Halogens

(iv) Acids (v) Alkalies

Ans.

(a) Three Ores of Aluminum:

Bauxite $Al_2O_3 . 2H_2O$

Cryolite Na_3AlF_6

Gibbsite $Al_2O_3 . 3H_2O$

(b) (i) Reaction with O_2:

$$4Al + 3O_2 \longrightarrow 2Al_2O_3 + Heat$$

(ii) Reaction with H_2:

$$2Al + 3H_2 \longrightarrow 2AlH_3$$

(iii) Reaction with Halogens:

$$2Al + 3X_2 \longrightarrow 2AlX_3$$

$$2Al + 3Cl_2 \longrightarrow 2AlCl_3$$

(iv) Reaction with Acids:

$$2Al + 6HCl \xrightarrow{dil.} 2AlCl_3 + 3H_2$$

$$2Al + 3H_2SO_4 \xrightarrow{dil.} Al_2(SO_4)_3 + 3H_2$$

(v) Reaction with Alaklies:

$$2Al + 2NaOH + 2H_2O \longrightarrow 2NaAlO_2 + 3H_2$$

Q.19 Give the names, electronic configurations, and occurrence of group IV a elements of the periodic table.

Ans. Descriptive question. See text book for details.

Q.20 Discuss the peculiar behaviour of carbon with respect to the other members of group-IV A of the periodic table.

Ans. Descriptive question. See text book for details.

Q.21 (a) What are silicones?

(b) Give a brief summary of the principal properties of silicones.

(c) Out live the uses of silicones.

(d) What are silicates?

(e) Describe the important uses of silicates.

Ans.

(a) Silicones: Long chain compounds of alternating Si and O (oxygen) atom in which alkyl radical is attached to Si.

For the answer of (b) and (c) consult text book.

(d) Silicates: The compounds which are derived from metasilicic acid (H_2SiO_3) e.g.,

Asbestos : $CaMg_3(SiO_3)_4$

Talc : $H_2Mg_3(SiO_3)_4$

(e) (i) Sodium Silicate:

* Used as a filler for soap in soap industry.
* Used in textile as a fire proof.
* Used as furniture polish.
* Used in calico printing.

(ii) Aluminum Silicate:

* Used in making pottery and ceramic material.
* Used in making porcelain and china ware.
* Making of tiles and bricks.
* Glazing of tiles.

(iii) Talc or Soapstone:

* Used in making cosmetics.
* Making household articles.

(iv) Asbestos:

* Used in making incombustible fabrics.
* Used in making hard board.
* Insulation and sealer for cars.

DO YOU KNOW?

1. Borax occurs as natural deposit called tincal. It is found in dried lakes of Tibet and California.
2. Borax bead test is used for basic coloured radicals like Cu^{+2}, Fe^{+3}, Mn^{+2}, Co^{+2}, Cr^{+3} and Ni^{-2}.
3. Formula of copper metaborate is $Cu(BO_2)_2$.
4. H_3BO_3 is mono basic acid.
5. The process in which Al is used as reducing agent is called "Thermite Process". For example

$$Cr_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Cr$$

6. Aluminum foil is used to jam radar.
7. Sodium silicate is called water glass or soluble glass.
8. PbO is called litharge.
9. Formula of red lead is Pb_3O_4.
10. $PbCrO_4$ is called chrome yellow.
11. $PbCrO_4$. PbO is called chrome red.

SHORT QUESTIONS

Q.1 What is the action of an aqeous solution of borax on litmus?

Ans. Red litmus becomes blue in aqeous solution of borax. Borax hydrolysis changes to alkali and weak acid (ortho-boric acid).

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

Q.2 Why the aluminum vessels are not washed with alkalies?

Ans. Dilute solution of alkalies react with aluminum to form sodium aluminate and hydrogen, so aluminum vessels are not washed with alkalies.

$$2Al + 2NaOH + 2H_2O \longrightarrow 2NaAlO_2 + 3H_2$$

Q.3 What is effect of heat on borax?

Ans. Borax on heating loses its water of crystallization and swells up into a white porous mass due to expulsion of water. On further heating it melts into a clear transparent glassy mass.

$$2Na_2B_4O_7 \cdot 10H_2O \longrightarrow Na_2B_4O_7 + 10H_2O$$

$$Na_2B_4O_7 \xrightarrow{\Delta} 2NaBO_2 + B_2O_3$$

Q.4 How borax bead test is performed?

Ans. Prepare a loop of platinum wire. Heat the loop on flame and touch it with borax powder. Some powder will melt and adhere with the loop. Now heat the borax upto glassy mass. Put some crystals of substance, which is under examination on the loop, and heat it again. Observe the colour of bead on oxidising and reducing flame.

Q.5 What is effect of heat on orthoboric acid?

Ans. Orthoboric acid on heating changes to metaboric acid, which on further heating, changes to tetraboric acid. Tetraboric acid on strong heating changes to boric anhydride.

$$H_3BO_3 \xrightarrow{100^\circ C} HBO_2 + H_2O$$

$$4HBO_2 \xrightarrow{140^\circ C} H_2B_4O_7 + H_2O$$

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

Q.6 How aluminum metal is used to remove air bubbles from molten metals or molten iron?

Ans. At high temperature some aluminum is added to the molten metals. Al reacts with N_2 and O_2 of air to form AlN and Al_2O_3 respectively and air bubbles are removed.

$$2Al + N_2 \longrightarrow 2AlN$$

$$4Al + 3O_2 \longrightarrow 2Al_2O_3$$

Q.7 Write down two similar behaviours in carbon and silicon.

Ans. (i) Both C and Si have catenation or chain formation properties.

(ii) Oxides of both C and Si are acidic in nature.

Q.8 Why CO_2 molecule is non-polar in nature?

Ans. CO_2 molecule has linear structure.

$$\overset{-\delta}{O} \leftarrow \overset{+\delta}{C} \rightarrow \overset{-\delta}{O}$$

Polarity of the molecule is cancelled out because two vectors are in opposite direction with same magnitude. Its dipole moment is zero.

Q.9 CO_2 is gas while SiO_2 is solid, although both are oxides of group IV-A.

Ans. CO_2 molecule has independent existence and has weak intermolecular forces in them. SiO_2 is not an independent molecule. SiO_2 has network covalent structure. It is giant molecule or macromolecule. In SiO_2 each silicon atom is linked with four oxygen atoms and one oxygen is linked with two silicon atoms.

Q.10 What is chemical garden?

Ans. When crystals of coloured salts like $NiSO_4$, $FeSO_4$, $CuSO_4$, $Co(NO_3)_2$ etc., are placed in the solution of sodium silicate, they produce a very beautiful growth, like plants, which is called chemical garden.

Q.11 What are silicones?

Ans. Silicon are inorganic polymers. Silicones are formed by the hydrolysis of $(CH_3)_2SiCl_2$ and then dehydration of that hydrolytic product.

$$Cl-\overset{\overset{CH_3}{|}}{\underset{\underset{CH_3}{|}}{Si}}-Cl + 2H_2O \longrightarrow HO-\overset{\overset{CH_3}{|}}{\underset{\underset{CH_3}{|}}{Si}}-OH + 2HCl$$

$$n\ HO-\overset{\overset{CH_3}{|}}{\underset{\underset{CH_3}{|}}{Si}}-OH \longrightarrow \left[O-\overset{\overset{CH_3}{|}}{\underset{\underset{CH_3}{|}}{Si}}-\right]_n + 2HCl$$

Q.12 Silicones are better lubricants as compared to petroleum oil, why?

Ans. In silicones, very small change in viscosity takes place by changing temperature as compared to mobile oil. If the temperature is dropped from 100°C – 0°C the viscosity of petroleum oil may increase about one hundred fold, whereas that of silicon oil will increase less than four folds. At high temperature, silicones do not react with air oxygen and remains free from acids, petroleum oil cannot be used at high temperature due to air oxidation and cracking of the molecules.

Q.13 How does borax serve as a water-softening agent?

Ans. Borax can be used to remove Ca^{+2} ions and Mg^{+2} ions from hard water. These ions react with borax and settle down as precipitates.

$$Ca^{+2} + Na_2B_4O_7 \longrightarrow CaB_4O_7 + 2Na^+$$

$$Mg^{+2} + Na_2B_4O_7 \longrightarrow MgB_4O_7 + 2Na^+$$

Q.14 Write the formula of the ores of the elements of Gr III-A and IV-A.

Ans.

Tincal (borax)	$Na_2B_4O_7 . 10H_2O$
Colemanite	$Ca_2B_6O_{11} . 5H_2O$
Orthoboric acid	H_3BO_3
Feldspar	$K_2O . Al_2O_3 . 6SiO_2$
Mica (muscovite)	$KH_2Al_3(SiO_4)_3$
Kaolin (clay)	$Al_2O_3 . 2SiO_2 . 2H_2O$
Corrundum	Al_2O_3
Emerald	$Al_2F_2SiO_4$
Gibbsite	$Al_2O_3 . 3H_2O$
Bauxite	$Al_2O_3 . 2H_2O$
Diaspore	$Al_2O_3 . H_2O$
Cryolite	Na_3AlF_6
Limestone	$CaCO_3$
Dolomite	$CaCO_3 . MgCO_3$
Magnesite	$MgCO_3$
Analcite	$NaAl(SiO_3)_2 . H_2O$
Asbestos	$CaMg_3Si_4O_{12}$ / $CaMg_3(SiO_3)_4$
Talc / Soapstone	$H_2Mg_3Si_4O_{12}$ / $H_2Mg_3(SiO_3)_4$
Zircon	$ZrSiO_4$

Q.15 What is the effect of heat on the following?

Ans. (i) Lead oxalate:

$$2PbC_2O_4 \xrightarrow{\text{Heat}} Pb_2O + 3CO_2 + CO$$

(ii) Red lead:

$$2Pb_3O_4 \xrightarrow{470^\circ C} 6PbO + O_2$$

Q.16 What is sodium silicate? Give its uses.

Ans. It is sodium salt of metasilicic acid H_2SiO_3. It is also called "water glass". It is prepared by fusing sodium carbonate with pure sand. This process is carried in the reverberatory furnace.

$$Na_2CO_3 + SiO_2 \longrightarrow Na_2SiO_3 + CO_2$$

It is soluble in water and the solution is strongly alkline due to hydrolysis.

$$Na_2SiO_3 + 2H_2O \longrightarrow H_2SiO_3 + 2NaOH$$

Uses of Na_2SiO_3:

(i) It is used as filler in soap industry.

(ii) It is used in textile as fire proof.

(iii) It is used in furniture polish.

(iv) It is used in calico printing.

Q.17 What are the properties of vitreous silica (silica glass)?

Ans. Vitreous silica has the following properties:

(i) High transparency to light.

(ii) Very refactory (heat resistant).

(iii) It does not soften below 1500 – 1600°C.

(iv) It has very low thermal expansion.

(v) It is excellent insulator.

(vi) It is hard, brittle and elastic.

(vii) It is insoluble in water.

(viii) It is resistant towards all acids except HF.

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

Q.18 What are the uses of Borax?

Ans. (i) It is used to prepare borate glass which is heat resistant.

(ii) It is used in softening of water.

(iii) It is used in the borax bead test.

(iv) It is used in the metallurgical operations.

(v) It is used as flux in welding.

(vi) It is used in making washing powders.

(vii) It is used in the leather industry for tanning and dyeing.

(viii) It is used in cosmetics, medicine, paints, textile industry.

(ix) It is used in the match industry.

(x) It is used as preservative.

Q.19 What are semi-conductors?

Ans. A semi-conductor is a substance that has different resistance to the passage of electric current under different circumstances.

They include elements like Ge, Se, Si and compounds and like ZnS, SiC, CdS, AlP, GaP, GaAs, InAs InSb. Semi-conductors are also called half conductors. They are better conductor than insulators and less conductors than metals. Their conductivity increases with increase of temperature. They are used in making transistors which are used in television, computers, radios and calculators.