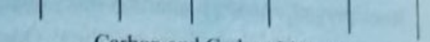
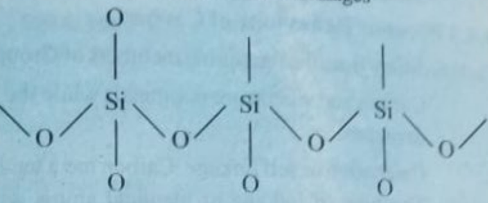
the peculiar pro[illegible] carbon chains, silicon forms long chains of alternating silicon and oxygen atoms.

1. Carbon and silicon both form acidic oxides, whereas the oxides of germanium, tin and lead are amphoteric in nature.

2. Both carbon and silicon form covalent bonds. Their oxides are acidic and both form hydrides and chlorides.



Carbon and Carbon Linkages



Silicon and Oxygen Linkages

The elements of group IVA are characterized by a set of four valence electrons, which form two pairs.

In the first three elements of IVA group, carbon, silicon and germanium, all the four outermost electrons are used as valency electrons, while in tin and lead either all four (stannic and plumbic compounds) or only one of the pairs of electrons (stannous and plumbous compound) is used for bonding.

The pair of valence electrons that do not readily take part in chemical combination is termed as inert pair. As in other groups, the inert pair effect is most marked in the element of highest atomic mass, namely lead. The increase in electropositive character from carbon through silicon, tin, and lead is pronounced. This trend is shown also by the increase in the metallic character of the elements with increased atomic mass.

The Following are the Common Properties of Group IVA Elements:

1. All the elements of this group show a valency of four.
2. All of them form hydrides, MH_4.
3. They form tetrachlorides, MCl_4.
4. They also form the dioxides, MO_2.

3.4.1 Occurrence of Carbon

Carbon occurs naturally in two states. One is crystallline (graphite, diamond) form and the other is amourphous (coal, charcoal) form.

3.4.2 Occurrence of Silicon

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

Silicon, unlike carbon, is not found in free state. Silicon is found as a major constituent

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

$XeOF_4$ is a ... vessel. It reacts with water to give XeO_3.

$$XeOF_4(l) + 2H_2O(l) \longrightarrow XeO_3(aq) + 4HF(g)$$

Xenon oxydifluoride, $XeOF_2$ is obtained when xenon reacts with oxygen difluoride in an electric discharge.

$$Xe(g) + F_2O \longrightarrow XeOF_2(s)$$

7.5 Oxides of Xenon

There are two oxides of xenon

1. Xenon trioxide
2. Xenon tetraoxide

Xenon Trioxide XeO_3

Xenon trioxide can be obtained when XeF_6 is hydrolysed slowly.

$$XeF_6 + 3H_2O \longrightarrow XeO_3 + 6HF$$

It is a crystalline solid. It explodes at very low temperature. It is weakly acidic and its aqueous solution is almost non-conductor.

Xenon Tetraoxide XeO_4

It is obtained by the addition of barium or sodium perxenate to conc. H_2SO_4

$$Ba_2XeO_6 + 2H_2SO_4 \longrightarrow XeO_4 + 2BaSO_4 + 2H_2O$$

$$Na_4XeO_6 + 2H_2SO_4 \longrightarrow XeO_4 + 2Na_2SO_4 + 2H_2O$$

7.6 Applications of the Noble Gases

- Helium is used in weather balloons, in welding and in traffic signal lights.
- A mixture of 80% helium and 20% oxygen is used for breathing by the sea divers.
- Helium is used as a cooling medium for nuclear reactors.
- Neon is largely used in making neon advertising signs, in high voltage indicators and TV tubes.
- Neon and helium arc is used in making glass lasers.
- Argon is used in electric light bulbs, in fluorescent tubes, in radio tubes, and in Geiger counters (used to detect radioactivity).
- Argon is also used for arc welding and cutting.
- Krypton is used to fill fluorescent tubes and in flash lamps for high speed photography.
- Xenon is used in bactericidal lamps.
- Radon being radioactive is used in radiotherapy for cancer and for earth quake prediction.

Vitreous silica possesses the following interesting and useful properties.

1. High transparency to light.
2. Very refractory, does not soften below 1500 to 1600°C.
3. Very low thermal expansion.
4. Excellent insulator.
5. Hard, brittle and elastic.
6. Insoluble in water and inerts towards many reagents.
7. It is resistant towards all acids except HF.

Quartz, the common crystalline form of silicon dioxide, is a hard, brittle, refractor, colourless solid which differs very markedly from carbon dioxide.

Both carbon and silicon have four electrons in their valence shells and both also form four covalent bonds. So, why should there be a big difference between CO_2 and SiO_2?

The answer lies in the fact that silicon atoms are much larger than carbon atoms and thus tend to surround themselves with more oxygen neighbours; silicon forms only single bonds with oxygen atoms whereas carbon may form double bonds. Carbon, in fact, forms double bonds with each of the two oxygen atoms to produce a small, symmetrical, linear molecule CO_2, which is volatile and reasonably reactive.

The silicon atom can be approached closely by four oxygen atoms and forms a single bond with each at tetrahedral angles. This structure can be continued in three dimensions to produce a continuous giant silicon oxygen network extending out to give the massive silicon dioxide crystal.

In the interior of the silica network every silicon atom is bonded tetrahedrally with four oxygen atoms and every oxygen atom is bonded to two silicon atoms. The overall ratio of silicon to oxygen atoms is 1 : 2 and the simplest formula for silica therefore is SiO_2. The silicon oxygen bonds are strong and keep the atoms firmly in place.

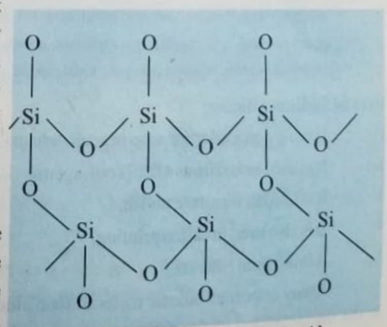


Fig. 3.1 Structure of Silicon dioxide

Note, however, that it is not the molecular formula for silica but the whole chunk of silica must be considered to be essentially one molecule. The atoms of silicon and oxygen at the surface of the chunk do not

$$2KClO_3 + H_2C_2O_4 + H_2SO_4 \longrightarrow \text{[illegible]}$$

ClO_2 explodes into Cl_2 and O_2 on warming. It is soluble in water and decomposes slowly in H_2O to HCl and $HClO_3$. It is a paramagnetic [illegible] antiseptic, for purification of water and to bleach cellulose material.

2. **Chlorine Heptaoxide, Cl_2O_7**

Cl_2O_7 is an anhydride of perchloric acid ($HClO_4$). It can be obtained [illegible] dehydration of $HClO_4$ with P_2O_5.

$$2HClO_4 + P_2O_5 \xrightarrow{10^\circ C} Cl_2O_7 + 2HPO_3$$

OXIDES OF BROMINE

Oxides of bromine are dark volatile liquids with low thermal stability.

Bromine Monoxide Br_2O

It can be prepared by the reaction of bromine vapours with mercuric oxide.

$$HgO + 2Br_2 \xrightarrow{50^\circ C} HgBr_2 + Br_2O$$

Br_2O can also be prepared by treating the suspension of mercuric oxide in CCl_4 with bromine. It is stable in dark in CCl_4 at $-20^\circ C$. It has oxidizing properties.

OXIDES OF IODINE

Out of all the oxides of iodine only iodine pentaoxide (I_2O_5) is important. The other compounds, I_2O_4 and I_4O_9 are salt like and are considered as iodine-iodates.

Iodine Pentoxide I_2O_5

It can be prepared by heating iodic acid at 240°C.

$$2HIO_3 \xrightarrow{240^\circ C} I_2O_5 + H_2O$$

It is a white crystalline solid, stable up to 300°C. It has a polymeric structure. It is insoluble in organic solvents. It forms iodic acid with water.

$$I_2O_5(s) + H_2O(\ell) \longrightarrow 2HIO_{3(aq)}$$

It reacts with H_2S, HCl and CO as an oxidizing agent. It is used for the quantitative analysis of CO.

$$5CO(g) + I_2O_5(s) \longrightarrow I_2(s) + 5CO_2(g)$$

5.5.3 Reactions of Chlorine with Cold and Hot NaOH

The reactions of chlorine with cold and hot NaOH are examples of "Disproportionation reactions".

A reaction in which a species (molecule, atom or ion) is simultaneously oxidized and redatmospheric oxygen and water under normal conditions. Because of this aluminium sheets are said to be corrosion free. However, if the aluminium powder is heated to 800°C and above, the metal will react with air to form aluminium oxide, Al_2O_3, and aluminium nitride, AlN. The reaction is accompanied by the evolution of heat and intense white light. This property of aluminium is made use of in flash light photography.

$$4Al_{(s)} + 3O_{2(g)} \longrightarrow 2Al_2O_{3(s)}$$

$$2Al_{(s)} + N_{2(g)} \longrightarrow 2AlN_{(s)}$$

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.

2. Reaction with Non-Metals

Heated aluminium combines with the halogens, sulphur, nitrogen, phosphorus and carbon, accompanied by the evolution of heat.

$$2Al_{(s)} + 3Cl_{2(g)} \longrightarrow 2AlCl_{3(s)}$$

Aluminium on heating with hydrogen forms aluminium hydride.

$$2Al_{(s)} + 3H_{2(g)} \longrightarrow 2AlH_{3(s)}$$

3. Reaction with Acids and Alkalies

Aluminium is amphoteric. It dissolves in both acids and bases with the liberation of hydrogen gas.

Aluminium reacts slowly with dilute acid and more rapidly with concentrated hydrochloric acid to displace hydrogen

$$2Al_{(s)} + 6HCl_{(aq)} \longrightarrow 2AlCl_{3(aq)} + 3H_{2(g)}$$

Aluminium does not react with dilute sulphuric acid. However, it is oxidized by hot concentrated sulphuric acid to liberate sulphur dioxide gas.

$$2Al_{(s)} + 6H_2SO_{4(conc)} \longrightarrow Al_2(SO_4)_{3(aq)} + 6H_2O_{(\ell)} + 3SO_{2(g)}$$

Aluminium does not react with nitric acid at any concentration, probably because of the formation of protective layer of aluminium oxide. The acid is said to render the aluminium passive. Nitric acid is, therefore, frequently transported in aluminium containers.

Aluminium dissolves in both sodium and potassium hydroxides to form a soluble aluminate, with the evolution of hydrogen.

$$2Al_{(s)} + 2NaOH_{(aq)} + 6H_2O_{(\ell)} \longrightarrow 2NaAl(OH)_{4(aq)} + 3H_{2(g)}$$

USES

1. Aluminium is very light (nearly three times less dense than iron) but posseses high tensile strength. These properties account for its extensive use in the transport industries, in the construction of aircrafts, ships and cars.