Chapter-2 Physical Properties of Group-14 Elements

Tin belongs to group 14 of the periodic table. It has $4d^{10}5s^25p^2$ electronic configuration. The oxidation state of tin in most compounds is +4, however, organotin compounds having divalent state of tin, have been reported. In its usual tetravalent state, tin assumes typical sp^3 hybridization and configuration of its covalent bonds is tetrahedral. In the tin atom, d orbitals are available and are utilized in the formation of penta- and hexacoordinated complexes by Lewis bases with organotinhalides. These complexes are either trigonalbipyramidal, octahedral or polymeric. Some basic physical properties of group 14 elements are given in table-1. The variations of the physical properties [1-5] among the members of the group are as follows:-

Electronic Configuration and Oxidation States:

The elements of this group have four electrons in their valence shells and their electronic configuration is ns^2, np^2. The electronic configuration reveals the presence of four valence electrons. The elements of this group form covalent bonds in their compounds with the highest oxidation state of +4. The elements also exhibit an oxidation state of +2 due to inert pair effect [6].

Density:

The density of members belonging to this group is found to increase down the group because of increase in mass per unit volume.

Atomic Radii:

The atomic radii of this group element are smaller than the corresponding elements of group 13 because from left to right in a period the nuclear charge increases with decrease in size.

Metallic character:

The elements of this group are less metallic due to large value of ionization energies as compared to group 13 elements and the metallic character increases as move down the group.

Electronegativity:

The elements belonging to this group are more electronegative as compared to elements of group 13 because of their small size and the value of electronegavity decreases from top to bottom in the group.

Ionization Energy:

The ionization energy decreases down the group due to increase in size and screening effect of inner electrons. The decrease is very sharp from carbon to silicon while there is a slight increase in the first ionization potential of lead as compared to that of tin.

Melting points and boiling points:

The melting and boiling points of group 14 elements are much higher as compared to those of group 13 elements because the atoms of group 14 can form four covalent bonds with each other and therefore there are strong binding forces between their atoms in both solids as well as in liquid states. However the value of melting and boiling points decreases down the group.

Table -1: Physical Properties of group – 14 elements

S. No.	Property	C	Si	Ge	Sn	Pb
1	Atomic No.	6	14	32	50	82
2	Electronic Configuration	$-2s^2 2p^2$	$-3s^2 3p^2$	$-3d^{10} 4s^2 4p^2$	$-4d^{10} 5s^2 5p^2$	$-4f^{14} 5d^{10} 6s^2 6p^2$
3	Atomic Radius (Covalent Radius) (A°)	0.77	1.17	1.22	1.40	1.44
4	Ionic Radius (A°)	0.15	0.41	0.53	0.71	0.84
5	Metallic Radius (A°)	-	-	1.37	1.62	1.75
6	Ionization Energy (eV)	11.3	8.2	7.8	7.3	7.4
		24.4	16.3	15.9	14.6	15.0
7	Electronegativity	2.5	1.9	1.8	1.7	1.7
8	Melting Point (°C)	>3550	1410	937	232	327
9	Boiling Point (°C)	4827	2355	2830	2260	1744
10	Density (g/ml)	3.51 (diamond) 2.0 (graphite)	2.34	5.32	7.26	11.34

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