

General Characteristics of Main Group Elements (*s*- and *p*- Block Elements)

Introduction

The elements of groups IA(1), IIA (2), IIIA (13), IVA (14), VA (15), VIA (16), VIIA (17) and zero (18) are called *main group elements*. Out of these the elements of groups IA, IIA, IIIA, IVA, VA, VIA and VIIA are called *normal or representative elements* and those of zero group are called *noble gases* or *inert gases*. Thus we see that the representative elements and noble gases are main group elements. On the basis of the orbital into which the last electron goes, main group elements have been grouped into the following categories : (a) *s*-block elements. In the atoms of these elements the last electron goes to *ns* orbital. Thus the elements of groups IA and IIA are *s*-block elements. (b) *p*-block elements. In the atoms of these elements the last electron enters *np* orbital. Thus the elements of groups IIIA, IVA, VA, VIA and VIIA are *p*-block elements. *s*- and *p*-block elements are collectively called main group elements.

General characteristics of main group elements

1. Electronic configuration. Electronic configuration of the atoms of main group elements according to their position in different periods and in different groups of the periodic table, has already been discussed in chapter 4.

2. Atomic and ionic radii. The atomic and ionic radii of main group elements generally decrease in moving from left to right in a given period and increase in moving down the group. Some irregular trends in these have also been observed. An explanation of irregular trends of atomic and ionic radii has already been given in chapter 5.

3. Ionisation energy (IE). Generally the values of first IE increase on crossing a period from left to right and decrease on moving down a group. A detailed explanation of these trends has already been given in chapter 5.

From these values as given in chapter 5, it may be seen that the ionisation energies decrease regularly as we move down the groups (groups IA and IIA) and increase across a period of *s*-block elements, but some *p*-block elements show irregular trends in these values. For example in the elements of 2nd and 3rd periods, the ionisation energy values do not increase regularly as we move from left to right in the given period. This irregular variation of ionisation energy has already been explained in chapter 5.

4. Electron affinity (EA). Generally electron affinity values increase as we move from left to right in a given period (*i.e.*, from alkali metals to halogens) and decrease in going down a group. The reason for this variation has already been given in chapter 5. The elements of group IIA have either zero or negative values for their electron affinity. EA values of N and P are very low. Noble gases have either zero or negative EA values. The reasons for these abnormal values have already been discussed at the appropriate pages of chapter 5.

5. Electronegativity. According to Pauling, electronegativity of an atom of an element in a molecule is its relative tendency (or power or ability) to attract the shared electron pair towards itself. Electronegativity values of main group elements are given in chapter 5. These values increase on moving from left to right in a period and decrease in moving down a group of *s*-block elements, but these values do not follow this trend in the elements of groups IIIA and IVA which belong to *p*-block (See chapter 5).

6. Metallic (electropositive) and non-metallic (electronegative) character. The variation of these properties on moving from left to right and down a given group of main group elements has already been discussed in chapter 5.

7. Density of elements in the solid state (Also see chapter 5). Densities (g cm^{-3}) of main group elements in the solid state are given in Table 5.8 of chapter 5. It may be seen from the table that the densities do not show any regular trend as we move from left to right in a given period. These values generally increase as we move down a given group.

8. Atomic volumes of elements (Also see chapter 5). The atomic volumes (cm^3) of main group elements are given in Table 5.9 of chapter 5. Atomic volumes increase in moving down the group. This increase is due to the increase in atomic radii. Atomic volumes show no regular trend in a period.

9. Melting and boiling points (Also see chapter 5). The values of melting and boiling points ($^{\circ}\text{C}$) of the main group elements are given in Table 5.10 of chapter 5. These values generally decrease on moving down the group. The melting and boiling points generally increase across a period and attain a maximum value in the middle and, thereafter, decrease until we reach noble gas element.

Explanation. The explanation of the variation of melting and boiling points along a group and a period has already been given in chapter 5.

10. Electrode potential of elements (Also see chapter 5). The values of standard reduction electrode potential (in volts) of some main group elements are given in Table 5.11 of chapter 5. From these values a number of important points may be noted. These points have been discussed in chapter 5.

11. Oxidising and reducing properties of the elements in aqueous solution. See chapter 5.

12. Oxidation states (Also see chapter 5). Oxidation states shown by main group elements are given in Table 5.12 of chapter 5. It may be noted that *s*-block elements show only one positive oxidation state which is equal to their group number. On the other hand most of the *p*-block elements show more than one positive as well as negative oxidation states.

13. Diagonal relationship or diagonal similarity. See chapter 10.

14. Reluctance of the heavier elements to form (*p* – *p*) π -bonds. The lighter non-metals of *p*-block elements (e.g., C, N, O etc.) frequently give structures which contain one or more (*p* – *p*) π -bonds. On the other hand, the heavier *p*-block elements like Si, P, S etc., give structures which contain only single σ -bonds. For example :

(i) While carbon forms double bond between carbon and oxygen atoms in CO_2 molecule, Si – atom forms four single Si – O σ -bonds in SiO_2 molecule. CO_2 molecule has a linear monomeric structure ($\text{O} = \text{C} = \text{O}$) in which C–O π -bonds are obtained by the *p* – *p* overlap. On the other hand SiO_2 does not have the structure viz., $\text{O} = \text{Si} = \text{O}$; rather it has an infinite three dimensional polymeric structure in which a large number of SiO_4 tetrahedrons are linked together. The linking of many SiO_4 tetrahedrons gives giant molecular (i.e., polymeric) structure to SiO_2 molecule. In each SiO_4 tetrahedron Si-atom is covalently linked with four O-atoms. Thus we see Si-atom does not form (*p* – *p*) π -bonds with O-atoms in SiO_2 molecule as carbon atom does in CO_2 molecule.

Reason. Since the size and energy of *2p* orbitals of carbon and oxygen atoms are nearly the same, they overlap effectively and form C–O π -bond in CO_2 molecule. In case of SiO_2 molecule, since the *3p* orbitals of Si-atom and *2p* orbitals of O-atoms have appreciable difference in their size and energy, they cannot overlap effectively to form Si–O π -bond. The tetravalency of Si-atom is satisfied by forming four single Si–O σ -bonds.