CHAPTER NAME : CLASSIFICATION OF ELEMENTS AND  
 PERIODICITY IN PROPERTIES

MODULE NO : 02/03(PERIODICITY IN PROPERTIES)

SUBJECT : CHEMISTRY CLASS : XI  
Periodicity-periodic properties

When elements are arranged in increasing order of atomic number, elements with similar properties reoccur (due to similar outer electronic configuration) at regular intervals of atomic numbers in the periodic table. This repetition of properties is called periodicity and such properties are called periodic properties.

Ex. Elements coming at intervals of 1,3,11,19,37,55 & 87 will have similar properties and thus grouped in one particular group(i.e Group 1)

Periodic trends in physical properties

1) Atomic size  
 (a) Atomic radii((i)covalent radius, (ii)metallic   
 radius(or crystal radius))

1. Inert gas radius(Van der waals’ radius)

(c) Ionic radii

2) Ionization energy /Ionization potential/Ionization enthalpy

3) Electron Gain Enthalpy

4) Electronegativity

1)Atomic size

Atomic radius is the distance between the centre of the nucleus and the electron cloud of outer most energy level is called atomic radius  
To avoid practical difficulties, Atomic radius cannot be determined directly, but measured from the inter nuclear distance of combined atoms, using X-ray diffraction techniques.  
 (a) Atomic radii((i)covalent radius, (ii)metallic   
 radius(or crystal radius))

1. Inert gas radius(Van der waals’ radius)
2. Ionic radii

(a) Atomic radii((i)covalent radius, (ii)metallic radius(or crystal   
 radius))  
 Atomic radius refer to both covalent or metallic radius depending on whether   
 the element is a non-metal or a metal.

(i)Covalent radius:

Half of the internuclear distance of the two atoms held together by a covalent bond is called covalent radius  
This radius is generally used in reference to non-metals held by covalent bond  
Ex. In the chlorine molecule (Cl2) internuclear distance is 198 pm and half of this distance (99 pm), is taken as the atomic radius of chlorine.

(ii)Metallic radius(or crystal radius):  
Half of the internuclear distance between the adjacent atoms of a solid metallic crystal is called crystal radius or metallic radius  
Ex. The distance between two adjacent copper atoms in solid copper is 256 pm; hence the metallic radius of copper is assigned a value of 128 pm.

1. Inert gas radius(Van der waals’ radius)

Half of the internuclear distance between two atoms of different molecules which are very close to each other in solid state due to Van der waals’ forces is called Van der waals’ radius.

This radius is used for molecular substances and inert gases in the solid state only.

Ex. The distance between two adjacent chlorine atoms of different Cl2 molecules is 360pm, Van der waals’ radius of Cl is 180pm

Order of radii: (Decreasing order)

Inert gas radius(Van der waals’ radius), Metallic radius(or crystal   
 radius),Covalent radius

(c) Ionic radii:

It is defined as the distance between the nucleus and the electron in the outer most shell of an ion.

The ionic radius of cation is less than that of neutral atom. It is because the cation has higher effective nuclear charge.  
Ex. Size of Na is bigger that Na+

Among the cations as the positive charge increases, the ionic radius decreases.

Ex. Ionic radius of Na+ is higher than Mg2+

The ionic radius of anion is more than that of its atom, due to decrease in effective nuclear charge.  
Ex. Ionic radius of Cl- is greater than Cl

Among the anions as the negative charge increases the ionic radius increases

Ex. O2- is bigger than F-

The decreasing order of the radii is   
Anion, Atom, Cation  
Ex. I-,I,I+

ISO-ELECTRONIC SPECIES   
The species(atoms or molecules or ions) having the same number of electrons are known as iso-electronic species

In iso-electronic species, the size increases with increase of negative charge and decreases with increase of positive charge.

Q. Arrange the following iso-electronic species in the decreasing order of size  
C4-, O2-,Ne,F-,N3-,Mg2+,Al3+,Si4+,Na+(iso electronic species with 10 electrons)

Ans: C4-, N3-, O2-, F-, Ne, Na+, Mg2+, Al3+, Si4+  
(Hint size α 1 )  
 effective nuclear charge

2) Ionization energy /Ionization potential/Ionization enthalpy:

The minimum amount of energy required to remove the most loosly bount electron(i.e outer- most shell e-)from an isolated neutral gaseous atom is known as Ionization energy/Ionization potential/Ionization enthalpy(IE/ΔiH)  
(Isolated -> without any bonding with other atom)

M(g) + IE1🡪 M+ (g) + 1e-

It is an endothermic process

It is measured in eV/atom or KJ/mol or Kcal/mol  
1eV/atom=23.06K.cal/mol=96.45KJ/mol=1.6.02x10-19J/atom

II Ionization Enthalpy is the energy required to remove an electron from unipositive ion to convert it into dipositive ion(IE2)  
  
M+(g) + IE2🡪 M++ (g) + 1e-

Here IE2 is greater than from IE1, as one electron is removed from neutral isolated gaseous atom effective nuclear charge increases in unipositive ion, hence to remove one more electron from unipositive ion more amount of energy is required

As the positive charge on cation increases, IE increases

As the negative charge on anion increases,IE decreases

Element with lowest IE-Cs and element with Highest IE-He

Ionization enthalpy decreases in groups due to increasing atomic size and increases in period due to increasing effective nuclear charge

Q. Why IE2 shows sudden jump for alkali metals whereas IE3 for alkaline earth metals?

Ans. As they get stable noble gas electronic configurations (i.e Ne)

* Alkali metals   
  ex Na-1s1,2s22p63s1
* Alkaline earth metals.  
   Ex Mg-1s22s22p63s2

Factors affecting ionisation potential:

1. Atomic size: Larger the atomic size, smaller in the lonisation potential It is due to that the size of atom increases the outermost electrons e- farther away from the nucleus and nucleus loses the attraction on that electrons and hence that can be easily removed   
    lonisation potential α 1\_\_\_\_\_\_  
    Atomic size

(b)Effective nuclear charge (Zeff ) : lonisation potential increases with the   
 increase in clear charge between outermost electrons and nucleus.  
 lonisation potential α effective nuclear charge

(c) Screening effect :Higher is the screening effort on the outer most electrons   
 causes less attraction from the nucleus and can be easily removed , which is   
 leading to the lower value of lonisation potential .   
 lonisation potential α 1\_\_\_\_\_\_  
 Screening effect

(d) Penetration power of sub shells:  
 (i) Order of attraction of subshells towards nucleus (Penetration power ) is  
 s>p>d>f

(ii) As subshell is more closer to nucleus so more energy will be required to   
 remove e- in comparision to p,d,&f.

Be B

1s2, 2s2  1s2 2s2 2p1

Ionisation potential(IE1) Be > B

After loosing one e- B attains electronic configuration of Be , so IInd  ionization  
 potential of B is more than Be   
 IInd lonisation potential of B > Be  
 lonisation potential α Penetration power of sub shells  
(e)Stability of half filled and fully filled orbitals :   
(I) Half filled p3 ,d5 ,f 7  or fully filled s2 , p6 ,  d10 , f 14 are most stable than others so it requires more energy .  
Ex : N O  
 1s2  2s2 2p3 1s2 2s2  2p4    
1st lonisation potential order is O < N because of half filled p- orbitals in N , its ionisation energy ( due to stability ) is higher than O.

lonisation potential α atoms with half filled and fully filled orbitals :

Other periodic trends in physical properties will continue in next module…

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