CLASSIFICATION OF ELEMENTS

Long Answer Questions:

1) Define first and second ionization potentials. Why is the second ionization potential greater than the first ionization potential? Discuss three factors affecting IP values of elements?

Ans. The minimum energy required to remove the most loosely bound electron from an isolated gaseous atom to convert it into a gaseous ion is called first ionization potential. It is expressed in e.v/atom or k.j/mole or k.cal/mole.

$$M_{(g)} + I_1 \rightarrow M^{+}_{(g)} + e^{-}$$

unipositive ion

Second ionization Potential:

The energy required to remove an electron from unipositive gaseous ion is called second ionization potential.

$$M^{+}_{(g)} + I_2 \rightarrow M^{2+}_{(g)} + e^{-}$$

Dipositive ion

IP_2 is greater than IP_1:

In neutral atom, the number of electrons is equal to the number of protons. In unipositive, ion the number of electrons is less than the number of protons. So in unipositive ion, the attraction of the nucleus over the outermost electrons is high. Hence the energy required to remove the electron from unipositive ion is higher than that from neutral atom. So, $I.P_2$ is greater than the $I.P_1$

$$I.P_1 < I.P_2 < I.P_3 \ldots\ldots\ldots\ldots I.P_n$$

: n = number of electrons

Factors influencing I.P

1) Atomic Radius: As the atomic radius increases, the nuclear force of attraction over the valence electrons decreases. So I.P value decreases.

$$I.P \alpha \frac{1}{Atomic\ radius}$$

2) Nuclear Charge: As the nuclear charge increases, the force of attraction on the valence electrons increases. Hence I.P value increases.

$$I.P \propto Nuclear\ charge$$

3) Screenig Effect: (or) Sheilding Effect: The electrons present in inner orbitals reduce the nuclear attraction on the valency electrons. This is called Screening or Sheilding effect. As the number of electrons in the inner shells increases, sheilding effect increases. So I.P value decreases. In a given orbit the Sheilding effect caused various sublevels is in the order $s > p > d > f$

$$\text{Ionization energy } \alpha \ \frac{1}{\text{Screening effect}}$$

4) Extent of penetration of Orbitals of Valence Electrons: Penetration power of orbitals depends on the shapes of orbitals. Penetration power of orbitals is in the order $s > p > d > f$ .Greater the penetrating power higher is the ionisation potential.

∴I.P values of electrons in different orbitals of same energy level is in the order $s > p > d > f$

5) Half filled or completely filled Subshells: Atoms with half filled (or) completely filled subshells are more stable. So I.P values of these atoms are high.

Example: $I.P_1$ of N> $I.P_1$ of oxygen, because N atom has stable half filled P-sub-shell

i.e. $2P^3$

2) State Modern periodic law. Justify the classification of elements into 4 blocks?

Ans. Modern periodic law states that "The physical and chemical properties of the elements and their compounds are the periodic functions of their electronic configurations".

Basing on the electronic configuration, elements are classified in to four blocks. They are

1. S-Block Elements:-

i) The position of s-block elements is on the left hand side of the periodic table

ii) In these elements the differentiating electron enters into the S-subshell of outer most orbit.

iii) s-block contains two groups IA and IIA (Groups1 & 2). These elements are called alkali metals and alkaline earth metals.

iv) The general electronic configuration of IA group elements is nS^1 and IIA group elements is nS^2.

General Properties:-

a) Highly electropositive and reactive metals.

b) Do not occur in free state in nature, but only occur as their compounds.

c) They form M^{+} (IA), and M^{+2} ions (IIA). Their ions are colourless and diamagnetic.

2. P-Block Elements:-

i) The position of p-block elements is on the right hand side of the periodic table.

ii) In these elements the differentiating electron enters into the p-subshell of outermost orbit.

iii) p-block elements contain '6' groups IIIA, IVA, VA, VIA, VIIA and '0' groups (From group 13 to 18). The general electronic configuration is nS^2np^{1-6}

FAMILY	GROUP	OUTER ELECTRONIC CONFIGURATION
Boron Family	IIIA OR 13	ns^2np^1
Carbon Family	IVA OR 14	ns^2np^2
Nitrogen Family	VA OR 15	ns^2np^3
Oxygen Family	VIA OR 16	ns^2np^4
Halogen Family	VIIA OR 17	ns^2np^5
Noble Family	0 OR 18	ns^2np^6

General Properties

a) p-block contains all non-metals, metalloids and few metals.

b) Electronegative in nature due to high electron gain enthalpies

c) They also share electrons to form covalent compounds

Ex:- Cl_2 ,HCl

3. d-Block Elements:-

i) The position of d-block elements is in between s- and p-block elements in the long form periodic table.

ii) In these elements, the differentiating electron enters into d-subshell of penultimate orbit.

[(n-1)d]. The elements of III B, IV B, V B, VI B, VII B, VIII (these rows), I B and II B (Groups 3 to 12) are d-block elements.

iii) The general electronic configuration of these elements is $(n-1)d^{1-10}ns^{1or2}$

IV) Based on filling of differentiating electron d-block is divided into 4 series.

3d series- Sc (Z = 21) - Zn (Z = 30)

4d series- Y (Z = 39) - Cd (Z = 48)

5d series- La (Z = 57) - Hg (Z = 80)

6d series- Ac (Z = 89) - In complete

General Properties:-

a) Hard and heavy metals with high M.P. and B.P.

b) They form mostly coloured ions

c) They show variable valency

d) They show para magnetic nature.

(Due to the presence of unpaired electrons in d-orbitals)

4. f-Block Elements:-

i). The f-block elements are placed at bottom of the periodic table

ii). In these elements, differentiating electron enters into f-subshell of anti penultimate Shell i.e. (n-2)f

iii). f-block contains two series-lanthanides and actinides. Each series contains 14 elements. Lanthanides are $_{58}Ce-_{71}Lu$ and actinides are $_{90}Th-_{103}Lr$

iv). The general electronic configuration is $(n-2)f^{1-14}(n-1)d^{0-1}ns^2$

v). These are also known as inner transition elements.

General Properties:-

a)Most of these elements are Radio Active

b) They show +2 and +3 common oxidation states.

3) What is a periodic property? How the following properties vary in a group and in a period?

a) Atomic radius b) Ionisation enthalpy

c) Electro negativity d)Electron gain enthalpy.

Ans. Periodicity:

The repetition of properties of elements at regular intervals in the periodic table is called as periodic properties and the phenomenon is known as periodicity.

a) Atomic radius: The distance between the centre of the nucleus and the outer most shell of an atom is called as atomic radius.

In a period: Atomic size decreases from left to right in a period, because the effective nuclear charge increases as the differentiating electron enters into the same shell.

In a group: in a group Atomic radius increases from top to bottom as differentiating electron enters into different new shells.

b) Variation of ionisation energy in a group:

In a group from top to bottom I.P. decreases as atomic size and the screening effect increases.

Variation of ionisation enthalpy in a period:

In a period, the ionisation enthalpy increases with the increase in atomic number from left to right as atomic size decreases and the effective nuclear charge increases .

i) Be has high ionisation energy than that of Boron as Be has stable complete filled 2s – sublevel

ii) Similarly 'N' has high I.E. than 'O'; due to the stable half filled 2p- sublevel in 'N'

C) Electro Negativity:

The tendency of an atom to attract the bonded pair of electrons towards itself is called electro negativity.

In a period:

From left to right in a period, electro negativity increases due to the decrease in atomic size.

In a group:

From top to bottom in a group, electro negativity decreases due to increase in atomic size.

* F is the most electronegative element.

d) Electron Gain Enthalpy:

The amount of energy released when an electron is added to the valence shell of neutral gaseous atom is called as electron gain enthalpy or electron affinity.

In a period: Left to right in a period, electron affinity increases due to decrease in atomic size.

In a group: From top to bottom in a group, electron affinity decrease due to increase in atomic size.

Short Answer Questions

1. Which element of 3rd period has the highest? Explain the variation of in this period?

Ans.

i) Argon (Ar) of 3^{rd} period has the highest ionization energy

ii) The I.E increases across the period due to increase in nuclear charge. Therefore the increasing order of I.E should be $Na < Mg < Al < Si < S < Cl < Ar$ but the correct order is $Na < Mg > Al < Si < P > S < Cl < Ar$

I.E of Mg is more than Al due to completely filled 3s-subshell and more penetrating power of 's' orbital than the 'p' orbital in case of Al.

I.E of 'P' is more than 'S' because 'P' has stable half filled p-orbitals i.e. $3p^3$.

2. What is valency of an element? How does it vary with respect to hydrogen in the third period?

Ans. i). Valency is the combining capacity of an element.

ii). Valency with respect to hydrogen is number of hydrogen atoms with which one atom of an element combine.

iii). Across a period from left to right, valency increases up to IVA group from 1 to 4 and decreases to one in VIIA with respect to hydrogen.

iv). Each period starts with valency I and ends with zero. Valency = group number up to 4th group and valency = (8) - (group number) from 5th group onwards

v). The valence of the element is useful in writing the formulae of compounds.

3. What is diagonal relationship? Give a pair of elements having diagonal relationship. Why do they show this relation?

Ans. In the periodic table, an element of a group in the second period is similar in properties with second element of next group in the third period. This type of relationship is known as diagonal relationship.

Example: Li – Mg , Be – Al and B – Si

4. What is lanthanide contraction? What are its Consequences?

Ans. i). In lanthanides differentiating electron enters into 4f sub level. Due to peculiar shape and poor shielding effect of f-orbitals, the increased nuclear charge (due to increase the atomic number) attracts valence electrons firmly causing a steady decrease in the size of atom or ion.

ii). The contraction of size from one element to the other next in the lanthanide series is very small. But cumulative effect over 14 lanthanide elements from Ce to Lu is about. This decrease in size is significant and is known as lanthanide contraction

iii). This is more pronounced in +3 lanthanide ions.

iv). Consequences of lanthanide contraction

a) The melting points, boiling points and hardness of all the elements increases from Ce to Lu

b) The crystal structures and other properties of lanthanides are almost similar. Therefore it is not easy to seperate them from the mixture.

c) Inert pair effect is also a consequence of lanthanide contraction.

d) Due to this, pairs of elements such as Zr & Hf , Nb & Ta, Mo & W belonging to 4d and 5d series of elements have almost similar radii.

5. Give any four characteristic properties of transition elements?

Ans. Elements in which the ultimate and penultimate shells (n and (n–1) shells) are partially filled are called transition elements. Characteristic properties of transition elements are

(i). They are hard and heavy metals.

(ii). Their M.P, B.P and densities are very high.

(iii). They are good conductors of heat & electricity.

(iv). They show variable oxidation states.

(v). They form alloys.

VI) They show paramagnetism and Catalytic activity.

Very Short Answer Questions

1. An element 'X' has atomic number 34. Give its position in the periodic table.

Ans. Electronic configuration of X is $[Ar]3d^{10}4s^2 4p^2$ .As the valence shell is 4 ,X-belongs to 4th period and as the valence shell contains 4 electrons it belongs to VIA group .

2. **Among $N^{-3}, O^{-2}, F^{-}, Na^{+}, Mg^{+2}$ and Al^{+3}**

a. What is common in them?

b. Arrange them in the increasing ionic radii.

Ans. a. Number of electrons is common in all the above species. Each is having 10 electrons.

b. $Al^{3+} < Mg^{2+} < Na^{+} < F^{-} < O^{2-} < N^{3-}$

3. What is screening effect? How is it related to IE?

Ans. In multy electron atoms t he electrons present in inner orbitals decrese the nuclear attraction on the valence electrons. This is called Screening or Sheilding effect.

As the number of electrons in the inner shells increases, sheilding effect increases. So I.P value decreases. In a given orbit the Sheilding effect caused various sublevels is in the order $s > p > d > f$

Ionization energy $\alpha \frac{1}{\text{Screening effect}}$

4. Electron affinity of chlorine is more than that of fluorine - explain

Ans. The electron gain enthalpy of F is less negative than that of the succeeding element (chlorine).

This is because when an electron is added to F, the added electron goes to the smaller n=2 quantum level and suffers significant repulsion from the other electrons present in this level. For the n=3 quantum level (Cl) the added electron occupies a larger region of space and electron-electron repulsion is much less.

5. Among the elements B, Al, C and Si.

a. Which has the highest first ionization enthalpy?

b. Which has the most negative electron gain enthalpy?

c. Which has the largest atomic radius?

d. Which has the most metallic character?

Ans: a. Carbon(C)

b. Silicon(Si)

c. Aluminium(Al)

d. Aluminium(Al)

6. Consider the elements N, P, O and S and arrange them in order of:

a. Increasing first inonization enthalpy?

b. Increasing negative electron gain enthalpy?

c. Increasing non-metallic character?

Ans. a. S<P<O<N b. N<P<O<S c. P<S<N<O