UG 1st SEM (MAJOR)
SUBJECT: CHEMISTRY
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YEAR: 2023

Unit 1: Atomic Structure and Periodicity of Elements

Periodicity of elements: s, p, d, f block elements, the long form of periodic table.

Mendeleev's Periodic Law:
According to Mendeleev's periodic law, the physical and chemical properties of elements are periodic functions of their atomic weights.

Disadvantages of Mendeleev's Periodic Table:

1. Position of hydrogen: It has been confirmed that hydrogen has many characters which match with halogen elements too. But it is only placed in Group IA. Thus position of hydrogen is not clear.

2. Position of isotopes: Since in Mendeleev's periodic table elements have been arranged according to their atomic masses, isotopes (more than one element) are placed at a one place which is confusing.

3. Position of the isobar: Since in Mendeleev's periodic table elements have been arranged according to their atomic masses, different elements having different atomic numbers but same mass number (isobars) are placed at one place which is again confusing.

4. No attempts were made to separate metals from non-metals.

5. Dissimilar elements placed together in the same group: Elements showing different chemical properties have been placed together in the same group. For example Li, Na, k and Cu, Ag, Au have been placed in Group IA.

MODERN PERIODIC TABLE:

Moseley's experiment confirmed that atomic number of an element and square root of the frequency of X-ray of that element (which is obtained when various elements were bombarded with cathode rays) are directly proportional to each other. This triggered the chemist to modify the old periodic law.

- According to modern periodic law, "The properties of elements are the periodic function of their atomic numbers"
- In modern periodic table, the **horizontal lines are periods** and the **vertical lines are groups**.
- The periodic table has total **7 periods** and **18 groups**.
- If elements are arranged in increasing order of their atomic numbers, there is repetition of properties after 2, 8, 18, and 32 elements.
- There are two elements in the first period, eight elements in each of the second and third periods, eighteen elements in each of fourth and fifth period, thirty two elements in the sixth period and only nineteen elements till now in the seventh period.

Advantages of the Long Form of the Periodic Table:

(a) The table is based on a more fundamental property i.e. atomic number.

(b) It correlates the position of elements with their electronic configuration more clearly.

(c) The completion of each period is more logical. In a period, as the atomic number increases, the energy shells are gradually filled up until an inert gas configuration is reached.

(d) It eliminates the even and odd series of IV, V and VI periods of Mendeleev's periodic table.

(e) The position of VIII group is also justified in this table. All the transition elements have been brought to the middle as the properties of transition elements are intermediate between s-and p-block elements.

(f) Due to the separation of two sub-groups, dissimilar elements do not fall together. One vertical column accommodates elements with same electronic configuration thereby showing same properties.

(g) The table completely separates metals and non-metals. Non-metals are present in upper right corner of the periodic table.

(h) There is a gradual change in properties of the elements with increase in their atomic numbers i.e., periodicity of properties can be easily visualized. The same properties occur after the intervals of 2, 8, 8, 18, 18 and 32 elements which indicates the capacity of various periods of the table.

(i) The greatest advantage of this periodic table is that this can be divided into four blocks namely s-, p-, d- and f-block elements.

(j) This arrangement of elements is easy to remember and reproduce.

Defects of the Long Form of the Periodic Table:

(a) The position of hydrogen is still disputable as it was there in **MENDELEE**V periodic table in group IA as well as IVA & VIIA.

(b) Helium is an inert gas but its configuration is different from that of the other inert gas elements

(c) Lanthanide and actinide series could not be adjusted in the main periodic table and therefore they had to be provided with a place separately below the table.

Period-The details about the seven periods are as follows:-

Period	Atomic number		Number of elements
	From	To	
First	H (1)	He (2)	2
Second	Li (3)	Ne(10)	8

Third	Na (11)	Ar (18)	8
Fourth	K (19)	Kr(36)	18
Fifth	Rb (37)	Xe (54)	18
Sixth	Cs (55)	Rn (86)	32 (including lanthanides)
Seventh	Fr (87)	Ha (105)	19 (including actinides)

Group: The modern periodic table has 18 vertical columns and according to CAS system there are 16 groups having the following number of elements.

Group	Number of Elements
(a) I A group	**7 (H, Li, Na, K Rb, Cs, Fr) Alkali metals**
(b) II A group	**6 (Be, Mg, Ca, Sr, Ba, Ra) Alkaline earth metals**
(c) III A group	**5 (B, Al, Ga, In, Tl) Boron family**
(d) IV A group	**5 (C, Si, Ge, Sn, Pb) Carbon family**
(e) V A group	**5 (N, P, As, Sb, Bi) Nitrogen family**
(f) VI A group	**5 (O, S, Se, Te, Po) Oxygen family (Chalcogen)**
(g) VII A group	**5 (F, Cl, Br, I, At) Halogen family**
(h) Zero group	**6 (He, Ne, Ar, Kr, Xe, Rn) Inert elements**
	32 (Sc, Y, La, Ac & 14 lanthanide elements & 14 actinide elements.)
(i) III B group	**These are elements of IIIB group, which could not be accommodated in one column and therefore written separately outside the periodic table.**
(j) IV B group	**4 (Ti, Zr, Hf, Rf)**
(k) V B group	**4 (V, Nb, Ta, Db)**
(l) VI B group	**3 (Cr, Mo, W)**
(m) VII B group	**3 (Mn, Tc, Re)**
(n) VIII (3) group	**9 (Fe, Co, Ni, Ru, Rh, Pd, Os, Ir, Pt)**
(o) I B group	**3 (Cu, Ag, Au)**
(p) II B group	**3 (Zn, Cd, Hg)**

Periodicity of Elements (Cause of Periodicity):

The recurrence of elements with similar properties after certain regular intervals when these are arranged in the increasing order of their atomic numbers is called the periodicity.

Looking at the elements of alkali metals in the modern periodic table, it's not difficult to realize that every element here has a similar outer electronic configuration. This repetition in similar outer electronic configurations after certain regular interval (as the atomic number increases while arranging the elements in the periodic table) is the cause of periodicity in properties of elements. This is because the chemical behavior of elements is due to the electrons in the outer most shells. Since all the elements in a particular group have similar outer electronic configuration their chemical behavior are almost same.

CLASSIFICATION OF PERIODIC TABLE BASED ON BLOCKS

1. **s-block Elements:**
   - ✓ Elements of groups 1 and 2 including He in which the last electron enters the s-orbitals of the valence shell are called s-block elements.
   - ✓ There are only **14 s-block elements** in the periodic table.

Characteristics:

(a) The electronic configuration of outermost shell of s-block elements is $\mathbf{ns^1}$ (alkali metals; group 1) or $\mathbf{ns^2}$ (alkaline earth metals; group 2)

(b) The valence of group I elements is +1 and those of group II elements is +2.

(c) These are soft metals having low melting points and boiling points.

(d) Most of these form ionic compounds on account of their lower ionization energy.

(e) Most of these metals (except Be & Mg) and their salts imparts characteristic colour to the flame e.g., sodium imparts a golden yellow colour; potassium imparts violet colour to the flame.

(f) These are highly reactive elements and are strong reducing agents.

(g) All are good conductors of heat and electricity.

2. **p-block Elements:** Elements of groups 13-18 in which the last electron enters the p orbitals of the valence shell are called p-block elements.

   Characteristics:

   (a) The electronic configuration of the outermost shell of p-block elements (group 13, 14, 15, 16, 17 and 18) is $\mathbf{ns^2\ np^{1-6}}$**.**

   (b) These elements include metals and non-metals with a few metalloids. The metallic character, however, decreases along the period but increases down the group.

(c) These possess relatively higher ionization energy which tends to increase along the period but decreases down the group.

(d) Most of them form covalent compounds.

(e) Most of these elements show negative (except some metals) as well as positive oxidation states (except F).

(f) The oxidizing power of these elements increases along the period but decreases down the group.

3. **d-Block Elements:** There are three complete series and one incomplete series of d-block elements.
   These are:
   - 1st or 3d-transition series which contains ten elements with atomic number 21-30 ($_{21}$Sc-$_{30}$ Zn).
   - 2nd or 4d-transition series which contains ten elements with atomic numbers 39-48 ($_{39}$ Y-$_{48}$ Cd).
   - 3rd or 5d transition series which contains ten elements with atomic numbers 57 and 72-80 ($_{57}$La, $_{72}$Hf-$_{80}$Hg).
   - 4th or 6d transition series which is incomplete at present and contains only nine elements. These are $_{89}$Ac, $_{104}$Rf, $_{105}$Ha, Unh (Seaborgium, Z = 106), $_{107}$Bh (Bohrium), $_{108}$ Hs (Hassium), $_{109}$Mt (Meitnerium), Ds (Darmstadtium, Z= 110) and Cn (Copernicium, Z = 112) or Ekamercury. The element, Z = 111 has not been discovered yet. Thus, in all, there are 39 d-block elements.

Characteristics:

(a) The electronic configuration of outermost shell of d-block elements is $\mathbf{ns^{0-2}}$ followed with $\mathbf{(n-1)\,s^2p^6d^{1-10}}$.

(b) All (except Hg) are hard, ductile metals with high melting and boiling points.

(c) All of these are good conductors of heat and electricity.

(d) Their ionization energies are higher than s-block elements but lesser than p-block elements.

(e) Most of the transition metals form coloured ions (Zn^{2+}, Hg^{2+}, Cd^{2+} are colourless.)

(f) These elements show variable oxidation states.

(g) Most of these elements possess catalytic activity.

(h) Metals and their ions are generally paramagnetic due to the presence of unpaired electrons.

(i) Most of the transition metal ions possess the tendency to form complex ions.

(j) Most transition metals form alloys.

4. f -block Elements:

f-Block elements are also called inner-transition elements. In these elements, the f-subshell of the inner-penultimate is progressively filled up. There are two series of f-block elements each containing 14 elements.

The fourteen elements from $_{58}$Ce - $_{71}$Lu in which, 4f-subshell is progressively filled up are called **lanthanides or rare elements**.

Similarly, the fourteen elements from $_{90}$Th – $_{103}$Lr in which, 5f-subshell is progressively filled up are called actinides.

Characteristics:

(a) The electronic configuration of outermost shell of f-block elements is $\mathbf{ns^2}$, followed with $\mathbf{(n–2)f^{1–14}, (n–1)\ d^{0–2}.}$ **{i.e. $\mathbf{(n\text{-}2)f^{1\text{-}14}(n\text{-}1)d^{0\text{-}1}, ns^2}$}**

(b) All are metals.

(c) **Lanthanoids are also known as rare earth elements whereas most of the members of actinoid series are known as transuranic elements (made artificially).**

(d) These show variable valency.

(e) These form coloured ions.

(f) Actinoids are radioactive.

(g) These also form complexes.