PERIODIC CLASSIFICATION OF ELEMENTS.

There are around 118 elements known at present and it is very difficult to study the properties of all these elements separately. So all the elements have been divided into few groups in such a way that elements in the same group have similar properties. In this way, the study of large number of elements is reduced to the study of few groups of elements. This is the reason of classification of elements.

- All earlier attempts for classification of elements were based on atomic weight as according to Dalton atomic theory atoms of one element can be distinguished from other on the basis of their atomic weight. Some of the earlier attempts of classifying elements are as follows. —.

1. DOBEREINER'S TRIADS — given by J.W. Dobereiner in 1817.

According to him, when elements are arranged in the order of increasing atomic mass, groups of three elements (known as triads), having similar chemical properties are obtained. The atomic mass of the middle element of the triad being equal to the arithmetic mean of atomic masses of other two elements. For example —.

(i) Li 7
Na $(39+7)/2 = 23$.
K. 39

- all these elements are metals.
- have valency +1.
- react with water to form alkali, therefore, they are also known as ALKALI METALS.

(ii) Ca 40
Sr 88 $[(137+40)/2 = 88.5]$
Ba 137

- all are metals.
- have valency +2.
- their oxides are alkaline in nature.

These elements are known as ALKALINE EARTH METALS as their oxides are alkaline in nature and present in earth crust.

(iii) Cl 35.5
Br 80 $(162.5/2 = 81.25)$.
I 127

- are non metals.
- have valency −1.
- react with water to form acid.

These elements are known as halogens as these react with metal to form salt. (Halo – salt ; gens – producer).

Limitation — He could identify only three triads from the elements known at that time. Other known element can not be arranged in the form of triads having similar chemical properties.

2. NEWLANDS' LAW OF OCTAVES — given by J. Newland in 1866.

- According to him, when elements are arranged in the order of increasing atomic mass, the properties of the eighth element (starting from a given element) are a repitition of the properties of first element. This repitition in properties of elements is just like the repitition of eighth note in an octave of music, so it is known as Laws of octaves.

- Newland divided elements into horizontal rows of seven elements as shown below —.

sa	re	ga	ma	pa	da	ni
H	Li	Be	B	C	N	O
F	Na	Mg	Al	Si	P	S
Cl	K	Ca	Cr	Ti	Mn	Fe
Co & Ni	Cu	Zn	Y	In	As	Se
Br	Rb	Sr	Ce & La	Zr		

Limitations —. (i) Law of octave was applicable only upto calcium as after calcium every eighth element did not possess properties similar to that of the first.

(ii) It was assumed by him that only 56 elements existed in nature and no more elements would be discovered in the future. But later on several elements were discovered whose properties did not fit into the Law of octaves.

(iii) In order to fit elements in his table, he put even two elements together in one slot and that too in the column of unlike elements having very different properties e.g. Co and Ni were put together in the same slot and that too with F, Cl & Br which have different properties from these elements. Iron, which resembles Co and Ni in properties has been placed far away from these elements.

3. MENDELEEV'S PERIODIC TABLE —. When Mendeleev started his work, only 63 elements were known. He arranged the elements on the basis of their fundamental property, the atomic mass and also on the similarity of chemical properties. For finding out chemical properties, he selected hydrogen and oxygen as they are very reactive and formed compounds with most of the elements. The formulae of the hydrides and oxide formed by an element were treated as the basic properties of an element for its classification. He then arranged the elements in increasing order of atomic mass and found that elements with similar properties occur at regular intervals. On the basis of this, Mendeleev formulated a periodic law which states that —

"The properties of elements are the periodic function of their atomic masses."

On the basis of the periodic law, Mendeleev presented his classification in the form of a table, now known as Mendeleev's periodic table. This table consists of vertical columns called groups and horizontal rows called periods. There are eight groups and six periods in the table. While classifying elements, he laid special emphasis on two factors —

(i) increasing atomic mass.
(ii) grouping together of elements having similar properties.

ACHIEVEMENTS OF MENDELEEV'S PERIODIC TABLE —

- In order to make sure that elements having similar properties are placed in the same vertical column or group, he placed a few elements in the wrong order of their atomic masses by keeping the element with higher atomic mass first and the element with lower atomic mass later. e.g. Cobalt (at mass = 58.9) appeared before Nickel (at. mass = 58.7).
- He also left some gaps in his periodic table for some elements that had not been discovered at that time. He named them by prefixing Eka to the name of preceding element in the same group. for instance, scandium, gallium and germanium, discovered later, have properties similar to Eka-boron, Eka-aluminium and Eka-silicon respectively.
- Noble gases like Helium, Neon and Argon were discovered very late as they are very inert and present in extremely low concentrations in our atmosphere. When these gases were discovered, they are placed in a separate group without disturbing the original form of the periodic table.

LIMITATIONS — (i) The position of hydrogen is not justified. The electronic configuration of hydrogen resembles that of alkali metals. and it combines with halogens, oxygen and sulphur to form compounds having similar formula as that of alkali metals. Hence it is placed in Group I with alkali metals. But certain properties of hydrogen resembles those of halogens. e.g. it needs only one electron to complete valence shell, it exists as diatomic molecule like halogens and it combines with metals and non metals to form covalent compounds.

(ii) The positions of isotopes could not be explained. Isotopes of an element have similar chemical properties but different atomic masses. Therefore, istotopes should be placed at different positions in periodic table.

(iii) Wrong order of atomic masses of some elements could not be explained.

4. MODERN PERIODIC TABLE – In 1913, Henry Moseley showed that atomic number is more fundamental property than atomic mass. Thus atomic number was adopted as the basis of modern periodic table and the MODERN PERIODIC LAW can be stated as follows –.

"Properties of elements are a periodic function of their atomic number."

The significance of atomic number in the classification of elements is that –.

(i) being equal to the number of electrons in an atom, it helps in arranging the elements according to their electronic configuration.

(ii) atomic number increases regularly by one from element to element. It is fixed and also no two elements can have same atomic number.

- atomic number of an element is a more fundamental property than atomic mass as it gives the number of electrons in an atom. The chemical properties of an element depends upon the number of electrons in an atom (particularly in valence shell), while atomic mass determines only physical properties of the element and not its reactivity.

- In modern periodic table, when elements are arranged in increasing order of their atomic numbers, there is a periodicity in the electronic configuration of elements which leads to periodicity in their chemical properties.

- There are 7 periods (horizontal rows) and 18 groups (vertical columns) in periodic table. The number of elements in a period is fixed and is given by the number of electrons which can be accomodated in various shell of an atom. The maximum number of electrons in a given shell is given by $2n^2$ where 'n' is the number of given shell from the nucleus. e.g. -

K shell ⇒ $2 \times 1^2 = 2$. ∴ first period has 2 elements.

L shell ⇒ $2 \times 2^2 = 8$ ∴ second period has 8 elements.

M shell ⇒ $2 \times 3^2 = 18$ but the outermost shell can have only 8 electrons, therefore, third period also has 8 ~~electrons~~ elements.

The atoms of different elements having the same outermost electronic configuration occupy the same group in the periodic table.

- The position of any element in periodic table can be fund out from its electronic configuration.
  - number of shells gives the period number.
  - from valence electron, we can find out its group number
    - if valence electron is 1 ⇒ Group 1
    - if valence electron is 2 ⇒ Group 2.
    - valence electron is 3-8 ⇒ then add 10 to valence electron and ∴ Group no. will be 13-18.

e.g. (1) Calcium (at no. 20); electronic configuration – 2,8,8,2
∴ It will belong to 2nd group and 4th period.
(2) Aluminium (at no. 13); 2,8,3.
⇒ thirteenth group and third period.

EXPLANATION OF LIMITATIONS OF MENDELEEV'S PERIODIC TABLE –

(i) Since all the isotopes of an element have same atomic number they can be placed at one place in periodic table.
(ii) Cobalt with at. no. 27 is placed before Nickel (at. no. 28) even if their atomic mass is in wrong order.
(iii) Hydrogen is placed at the top of group 1, above the alkali metals because it electronic configuration is similar to that of alkali metals (all have one valence electron). In some periodic table, hydrogen is not placed in any group. It is treated as a special element and placed separately in the middle just above the periodic table.

TRENDS IN MODERN PERIODIC TABLE –

1. VALENCY – The number of electrons lost or gained (or shared) by an atom of an element to achieve nearest inert gas configuration gives the valency of the element. The valency of an element is determined by its valence electrons –
if valence electron is 1–3 ⇒ valency will also be 1–3.
if valence electrons are 4–8 ⇒ valency will be (8 – valence electrons) i.e. from 4 to zero.

- All the elements in a particular group have same valency as they have same number of valence electrons.

Group →	1	2	13	14	15	16	17	18
Ist period:	Li (2,1)	Be (2,2)	B (2,3)	C (2,4)	N (2,5)	O (2,6)	F (2,7)	Ne (2,8)
IInd period	Na (2,8,1)	Mg	Al	Si	P	S	Cl (2,8,7)	Ar
IIIrd period	K (2,8,8,1)	Ca					Br (2,8,8,7)	
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- The number of valence electrons increases from 1 to 8 on moving from left to right across a period, therefore, valency increases from 1 to 4 and then decreases to zero.

2. ATOMIC SIZE – The term atomic size refers to the radius of an atom i.e. the distance between the centre of nucleus to the outermost shell of an isolated atom. It is given in picometre ($1\ pm = 10^{-12} m$) e.g. the size of hydrogen atom is 37 pm.

- Atomic size increases down the group as new shells are added as we move down the group. This increases the distance between the outermost shell and the nucleus so that atomic size increases in spite of the increase in nuclear charge.

- Atomic size decreases across a period. In moving from Left to right across the period, the electron is added in the same shell while nuclear charge increases progressively by one unit. This increased nuclear charge pulls the electrons closer to the nucleus and reduces the size of atom.

3. METALLIC AND NON METALLIC CHARACTER – Metals tend to lose electrons while forming bonds i.e. they are electropositive in nature. On the other hand, non metals tend to form bonds by gaining electrons i.e. they are electronegative.

- Metallic character (or reactivity) increases down the group. → down the group effective nuclear charge experienced by valence electron decreases because the outermost electrons are farther away from the nucleus. Thus these can be lost easily.

- Across a period effective nuclear charge acting on the valence shell electrons increases, therefore tendency to lose electrons will decrease or metallic character decreases across a period.

- Non metallic character decreases down the group as due to increase in size lesser will be force of attraction by nucleus for incoming electron.

- Across a period non metallic character increases due to decrease in size.

Thus metals are found on the left hand side of the periodic table and non metals are on right hand side. Metals and non metals are separated by a zig-zag line running diagonally across the periodic table. The elements (boron, silicon, germanium, arsenic, antimony, tellurium and polonium) bordering this line show properties that are characteristics of both metals and non metals. These elements are called SEMI METALS OR METALLOIDS.

4. NATURE OF OXIDES — The oxides of metals are basic and that of non metals are acidic. Therefore across a period the nature of oxide gradually changes from strongly basic to strongly acidic.