5. Periodic Classification of Elements

Dobereiner's Triads :-

i) In the year 1817, John Wolfgang Dobereiner, a German chemist, tried to arrange the elements with similar properties into groups.

ii) Dobereiner suggested that properties of elements are related to their atomic masses.

iii) He classified existing elements in a tubular form by placing three elements having similar chemical properties in a group called triad.

iv) In each triad, the elements were placed according to increasing order of their atomic masses.

v) The atomic mass of the middle elements in each triad was approximately equal to the mean of the atomic masses of the other two elements.

Ex. Take the triad consisting of lithium (Li), Sodium (Na) and potassium (K) with respective atomic masses 6.9, 23.0 and 39.0.

Sr.No.	Triad	Actual atomic mass (a)			Element-2 (Mean) Mean=a+b /c
		Element-1	Element-2	Element-3	
1	Li, Na, K	Lithium Li=6.9	Sodium Na=23.0	Potassium K=39.1	Sodium 6.9+39.1 / 2=23.0
2	Ca, Sr, Ba	Calcium Ca=40.1	Strontium Sr=87.6	Barium Ba=137.3	Strontium 40.1+137.3 / 2=88.7
3	CI, Br, I	Chlorine CI=35.5	Bromine Br=79.9	Iodine I=126.9	Bromine 35.5+126.9 /2 =81.2

What is the average of the atomic masses of Li and K? Hoe does this compare with the atomic mass of Na?

Drawback of Dobereiner's triads:-

All the known elements could not be classified into the Dobereiner's triads.

Newlands Law of Octaves:-

i) The English scientist John Newlands correlated the atomic masses of elements to their properties in different way.

ii) In the year 1866 Newlands arranged the elements known at that time in an increasing order of their atomic masses.

Musical Note	Do (Sa)	Re (Re)	Mi (Ga)	Fa (Ma)	Sol (Pa)	La (Dha)	Ti (Ni)
Elements	H F Cl Co & Ni Br	Li Na K Cu Rb	Be Mg Ca Zn Sr	B Al Cr Y Ce & La	C Si Ti In Zr	N P Mn As	O S Fe Se

iii) This arrangement started with the lightest element hydrogen and ended up with thorium which was the 56^{th} elements.

iv) He found that every eight elements had properties similar to those of the first element as observed in octaves of music. Therefore, He called it the 'Law of Octaves'. It is known as 'Newlands Law of Octaves'.

Ex. Sodium is the eighth element from lithium and both have similar properties. Similarly, magnesium is the eighth element from beryllium and both have similar properties.

Limitation of Newland's Octaves:-

i) This law was found to be applicable up to calcium.

ii) After calcium every eighth element did not possess properties similar to that of first.

iii) In order to fit all the known elements, Newlands placed two elements in the same position. For example, Co and Ni, Ce and La.

iv) Newland's octaves did not have provision to accommodate the newly discovered elements. The properties of the new elements discovered later on did not fit in the Newland's octaves.

Mendeleev's Periodic table:-

i) The Russian scientist Dmitri Mendeleev developed the periodic table of elements during the period 1869 to 1872. Mendeleev's periodic table is the most important step in the classification of elements.

ii) Mendeleev considered the fundamental property of elements, namely, the atomic mass, as standard and arranged 63 elements known at that time in an increasing order of their atomic masses.

iii) Mendeleev organized the periodic table on the basis of the chemical and physical properties of the elements.

iv) Among chemical properties, Mendeleev concentrated on the compound formed by elements with oxygen and hydrogen. The formulae of the hydrides and oxides formed by an element were treated as one of the basic properties of an elements for it's classification.

v) Mendeleev found that the elements with similar physical and chemical properties repeat after a definite interval. **On the basis of this finding Mendeleev stated the following periodic law.**

"Properties of elements are periodic function of their atomic masses."

vi) "The vertical columns in the Mendeleev's periodic table are called groups while the horizontal rows are called periods."

Achievements of Mendeleev's Periodic Table:-

i) There were a few instances where Mendeleev had to place an element with a slightly atomic mass before an element with a slightly lower atomic mass. The sequence was inverted so that elements with similar properties could be grouped together.

Ex. Cobalt (Atomic mass 58.9) appeared before nickel (Atomic mass 58.7).

ii) Atomic masses of some elements were revised so as to give them proper place in the periodic table in accordance with their properties.

Ex. The previously determined atomic mass of beryllium, 14.09, was changed to the correct value 9.4, and beryllium was placed before boron.

iii) Mendeleev kept vacant places in the periodic table for elements not discovered till then.

Three of these unknown elements were given the names eka-boron, eka-aluminium and eka-silicon from the known neighbours and their atomic masses were indicated as 44, 68 and 72, respectively. Not only this but their properties were also predicted. Later on these elements were discovered and named as scandium (Sc), gallium (Ga) and germanium (Ge) respectively.

iv) When noble gases such as helium, neon and argon were discovered the end of nineteen century, Mendeleev created the 'zero' group without disturbing the original periodic table in which the noble gases were fitted very well.

Limitation of Mendeleev's Classification:-

i) No fix position can be given to hydrogen in the periodic table. This was the first limitation of Mendeleev's periodic table.

ii) Isotopes were discovered long time after Mendellev put forth the periodic table. As isotopes have the same chemical properties but different atomic masses, a challenge was posed in placing them in Mendeleev's periodic table.

iii) Another problem was that the atomic masses do not increase in a regular manner in going from one element to the next. So it was not possible to predict how many elements could be discovered between two elements- especially when we considered the heavier elements.

Hydrogen shows similarity with halogens. Electronic configuration of hydrogen resembles that of alkali metals. Like alkali metals, hydrogen combines with halogens, oxygen and sulphur to form compound having similar formulae, as shown in the examples here.

On the other hand, just like halogens, hydrogen also exists as diatomic molecules and it combines with metals and non-metals to form covalent compounds.

Compounds of H	Compounds of Na
HCI (Hydrogen chloride)	NaCI (Sodium chloride)
H_2O (Water)	Na_2O (Sodium oxide)
H_2S (Hydrogen sulphide)	Na_2S (Sodium sulphide)

Modern Periodic Table:-

i) In 1913, Henry Moseley showed that atomic number of an element is a more fundamental property than it's atomic mass.

ii) Mendeleev's Periodic Law modified and atomic number was adopted as the basic 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."

iii) The atomic number gives us the number of protons in the nucleus of an atom and this number is increases by one in going from one element to the next. Elements, when arranged in order of increasing atomic number (Z).

iv) The modern periodic table is also called the long form of the periodic table.

v) In the modern periodic table the elements are arranged in accordance with their atomic number.

vi) The relation between atomic number and of an element and it's electronic configuration is clearly seen in the modern periodic table.

Position of Elements in the Modern Periodic Table:-

i) The Modern Periodic Table has 18 verticle columns known as 'groups' and 7 horizonatal rows known as 'periods'.

ii) In a perticular group that all these elements contain the same number of valence electrons.

iii) The elements present in one group have the same number of valence electrons. For example, Elements fluorine (F) and chlorine (CI), belong to group 17, which contain five electron in their outermost shells.

Hence, we can say that groups in the periodic table signify an identical outer shell electronic configuration.

iv) When we move top to bottom in a group the number of shells increases.

v) In a period, the elements do not have same number of valence electrons, but they contain the same number of shells and the number of valence electron is increases by one unit , as the atomic number increases by one unit on moving from left to right in a period.

vi) The atoms of different elements with the same number of occupied shells are placed in the same period.

Ex. Na, Mg, Al, Si, P, S, CI and Ar belong to the third period ot the modern periodic table, since the electrons in the atoms of these elements are filled in K, L and M shells.

vii) Capacity of shells can be discussed bellow:-

The maximum number of electrons that can be accommodated in a shell depends on the formula $2n^2$ where 'n' is the number of the given shell from the nucleus.

K Shell- 2 X $(1)^2$ = 2, Hence the first period has 2 elements.

L Shell- 2 X $(2)^2$ = 8, Hence the second period has 8 elements.

M Shell- 2 X $(3)^2$ = 18, But the outermost shell can have only 8 electrons, so the third period also have only 8 elements.

viii) The position of elements in the periodic table tells us about it's chemical reactivity.

Trends in the Modern Periodic Table:-

1] Valency:-

"The valency of an element is determined by the number of valence electrons present in the outermost shell of it's atom".

2] Atomic size:-

i) "The distance between the nucleus of an atom and outermost shell is called atomic radius".

ii) Atomic radius is expressed in the unit picometer (pm) which is the smallest than nanometer. (1 pm = 10^{-12m})

iii) The atomic radius of hydrogen is 37 pm.

iv) The atomic radius decreases in moving from left to right along a period. This is due to an increase in nuclear charge which tends to pull the electrons closer to the nucleus and reduces the size of the atoms.

v) The atomic size increases down the group. This is because new shells are being added as we go down the group. This increases the distance between the outermost electrons and the nucleus so that the atomic size increases in spite of the increase in nuclear charge.

3] Metallic and Non-metallic properties:-

i) The metals like sodium and magnesium are towards the left-hand side of the periodic table while the non-metals like sulphur and chlorine are found on the right hand side.

ii) In the middle, we have silicon, which classified as a semi-metals or metalloid because it exhibits some properties of both metals and non-metals.

iii) In the Modern Periodic Table, a zig-zag line separates metals from non-metals. The borderline elements- boron, silicon, germanium, arsenic, antimony, tellurium and polonium-are intermediate in properties and are called metalloids or semi-metals.

iv) In case of period, as the effective nuclear charge acting on the valence shell electrons increases across a period, the tendency to lose electrons will decreases. Hence the metallic character decreases across a period.

v) In case of group, the effective nuclear charge experienced by valence electrons decreases because the outermost electrons are farther away from the nucleus. Therefore they can lost easily. Hence metallic character increases down a group.