NECESSITY FOR CLASSIFICATIONOF ELEMENTS:-

As a large number of elements were discovered, it was realized that it is not very much possible to study all the elements by a chemist, unless they are classified. Following are the reasons for the classification of elements.

a) Classification may help to study elements better.
b) Classification may lead to correlate the properties of elements with some fundamental properties, characteristic to all elements.
c) Classification may further reveal relationship between one element and another element.

HISTORIC CLASSIFICATION OF ELEMENTS:-

With the developments in the field of Chemistry, various scientists attempted to classify the known elements of their times so that their study may become easier and more informative. Some of the attempts are mentioned as under:

i) **Division of elements into metals and non-metals:** Earlier chemists realized that there are two types of elements i.e. metals and non.metals, which can be distinguished from each other on the basis of set of physical and chemical properties. However, there are a large number of metals and non-metals whose properties are quite different from one another. So such classification is quite inadequate due to the following reasons:
   a) Such classification hardly serves any purpose as the elements are just divided into two major groups.
   b) There is no justification for more active metals and active non-metals.
   c) Certain elements exhibit both metallic and non-metallic properties (Metalliods).

ii) **Dobernier's Traids:** In 1829, an eminent scientist named Dobernier attempted to classify the various elements of his time on the basis of their atomic weights. He arranged many of them into a group of three elements referred to as traids. In each traid, the atomic weight of the middle element was nearly equal to the arithmetic mean of the atomic weights of the other two members of the traid. According to Dobernier's law of Traids, when elements are arranged in the order of increasing atomic masses, groups of three, having similar chemical, properties are obtained. The atomic mass of the middle element of the Traid being equal to the arithmetic mean of the atomic masses of the other two elements. Examples,

a)	Lithium (Li)	Sodium (Na)	Potassium (K).
	A = 7	$A = \frac{7+39}{2}$	A = 39
b)	Berillium (Be)	Magnesium (Mg)	Calcium (Ca)
	A = 8	$A = \frac{8+40}{2} = \frac{48}{2} = 24$	A = 40

However, Dobernier was not successful in his attempt after classifying a few elements.

Reasons for rejecting classification on the basis of traids:

a) The classification into traids left room for the chance. It is possible to group quite dissimilar elements in traids.
b) Quite a large number of elements cannot be grouped into traids.

iii) Newland's Octaves: In 1864, a scientist named J. A. Newland also attempted to arrange various elements of his time in accordance to increasing order of their atomic weights. He found that every 8^{th} member produced a replica of the first i.e. it showed properties near or less similar to that of the first element and hence he referred it as, "Laws of Octaves". According to Newland's law of Octaves; when elements are arranged in the order of increasing atomic masses, the properties of the 8^{th} element are a repetition of the properties of the first element into horizontal rows of seven elements.

Eg,	Li	Be	B	C	N	O	F
	Na	Mg	Al	Si	P	S	Cl

If we start with lithium as the first element, we find that the eighth element from it is sodium. And according to the law of Newlands, the property of sodium should be similar to that of the element Lithium.

Anamolies in Newland's law of Octaves:- Newland's classification suffered from certain defects or limitations.

a) This classification was successful only upto the element calcium. After that, every eighth element did not possess the same properties as by the element lying above it in the same period. For example, the elements cobalt and nickel placed below chlorine had different properties.

b) Newland placed two elements in the same slot in a particular group. He could not offer any explanation for such an arrangement.
c) Newland thought that only 50 elements existed in nature and no more elements were likely to be discovered. But he was proved wrong.
d) When noble gas elements were discovered at a later stage, their inclusion in the table disturbed the entire arrangement.

MENDELEEV'S PERIODIC LAW:

Dmitiri Mendeleev, a Russian scientist, noticed that the properties of elements varied regularly with atomic mass. He formulated a law, now known as Mendeleev's Periodic Law. According to it, the properties of an element are a periodic function of its atomic mass. This means that if the elements are arranged in order of increasing atomic mass then those with similar properties are repeated at regular intervals.

Mendeleev arranged the 63 elements then known into horizontal rows and vertical columns on the basis of similarities in properties. The horizontal rows of elements are known as periods and the vertical columns as groups. Elements with similar properties came within the same group. This arrangement of elements into groups and periods is called the periodic table.

Merits of Mendeleef's Periodic Table:

1. Mendeleef's Periodic table grouped the elements on a more fundamental basis of atomic mass as compared to the earlier attempts at classification of elements.
2. Mendeleef's Periodic Law left proper gaps in the periodic table for the then undiscovered elements like Gallium, Scandium and Germanium. When these elements were discovered, they were placed in those gaps, without disturbing the existing elements.
3. Mendeleef's Periodic table could predict the properties of several elements on the basis of their position in the periodic table.
4. Mendeleef's Periodic table could predict the errors in the atomic weights of the some of the elements on the basis of their position in the periodic table.

Defects of Mendeleef's Periodic Table or Anomalies of Mendeleef's Periodic Table:

Mendeleef was successful in arranging the elements according to his law in the form of a table, but the table produced some defects which, he could not explain. These defects are:

a) **Position of Hydrogen atom:** The position of Hydrogen atom was not clear in the Mendeleef's Periodic table, because it behaves both as a member of first and seventh group of his periodic table.
b) **Position of Isotope:** Isotopes are the atoms of the same elements, which possess different atomic masses but same atomic numbers and properties. These are supposed to lie in the same group but Mendeleef arranged them wrongly in different group in accordance to his law.
c) **Position of Isobars:** Isobars are the atoms of different elements, which possess same atomic mass but different atomic numbers and properties. These are supposed to lie in different groups because of their diverse properties but Mendeleef arranged them wrongly in different group in accordance to his law.
d) **Position of argon and potassium:** The elements like Argon (atomic mass = 39.95) and potassium (atomic mass = 39.10) were placed in wrong group when placed in accordance with their accurate position which was against the basic law of the table.
e) **Wrong grouping of elements:** Some elements like copper (Cu), Silver (Ag), and gold (Au) were placed in the same group inspite of their dissimilar properties and some other elements like potassium, palladium and nickel were arranged in different groups without concerning their similar properties.
f) **Position of Lanthanides:** The Lanthanides are the 15 elements from atomic No. 57 to 71. When these elements were arranged as per the basic law of the table, the table produced an undue side-wards projection, which Mendeleef could not explain.
g) **Position of Actinides:** The Actinides are the 15 elements from atomic No. 89 to 103. The arrangement of these 15 elements as per the basic law of the table also exhibited an undue side wards projection of the table, which was not explainable to Mendeleef.

Modern Periodic Law: In 1911-12, Moseley, a British Physicist, changed the basis of classification of elements from atomic weight to atomic number and devised a law known as Moseley's Periodic Law or Modern Periodic Law. It states that, " The physical and chemical properties of an element are the periodic function of their atomic numbers". On the basis of this law, he constructed a table as Moseley's Periodic Table or Long Form of Periodic Table.

Modern Periodic Table: On the basis of Modern Periodic Law, Moseley constructed a periodic table in 1911-12, which is known as modern periodic table. The table contains 7 horizontal rows (periods) and 18 vertical columns (groups) as explained under:

Periods: The horizontal rows in the periodic table are called periods. There are seven periods in all such that each period has consecutive (or continuous) atomic numbers. The number of elements in a period correspond to maximum number of electrons which can be accommodated in its one shell, whereas the number of period to which an element belongs is given by the number of outermost shell (quantum number).

The number of elements in each period are given below, where n is the quantum number.

n = 1 (Maximum no. of electrons 2). Thus first period has 2 elements. It is called very short period.
n = 2 (Maximum no. of electrons 8). Thus 2nd period has 8 elements. It is called short period.
n = 3 (Maximum no. of electrons 8). Thus 3rd period has 8 elements. It is called short period.
n = 4 (Maximum no. of electrons 18). Thus 4th period has 18 elements. It is called long period.
n = 5 (Maximum no. of electrons 18). Thus 5th period has 18 elements. It is called long period.
n = 6 (Maximum no. of electrons 32). Thus 6th period has 32 elements. It is called very long period.
n = 7 (Maximum no. of electrons 32). Thus 7th period has 32 elements. It is called very long period.

Characteristics of Periods:

1. <u>Valence electrons:-</u> In moving from left to right in a period, the number of valence electrons increases

Change in number of valence electrons in a period

Third period	Na	Mg	Al	Si	P	S	Cl	Ar
Electronic configuration	2, 8, 1	2, 8, 2	2, 8, 3	2, 8, 4	2, 8, 5	2, 8, 6	2, 8, 7	2, 8, 8
Number of valence electrons	1	2	3	4	5	6	7	8

2. <u>Valency:-</u> In the 2nd and 3rd periods, valency with respect to hydrogen increases from 1 to 4 and then decreases from 4 to 1 on moving from left to right.

Third period	Na	Mg	Al	Si	P	S	Cl
Valency	1	2	3	4	3	2	1

Thus, elements in the same period have different valencies.

3. <u>Atomic size:-</u> The atomic size of elements decreases from left to right in a period.

Third period	Na	Mg	Al	Si	P	S	Cl
Atomic size (A)	1.54	1.30	1.18	1.11	1.06	1.02	0.99

4. <u>Metallic character:-</u> In a period, the metallic character of elements gradually decreases from left to right. Therefore, the typical metals are on the extreme left whereas typical nonmetals are on the extreme right of the periodic table.

Na	Mg	Al	Si	P	S	Cl

5. **Ionization energy:-** On moving from left to right in a period, the ionization energy gradually increases, i.e., the electropositive character of the element decreases.
6. **Electro affinity:-** The electro affinity increases from left to right in a period.
7. **Electronegativity:-** In a period, the electronegativity of an element increases from left to right. This is due to the fact that atomic size decreases from left to right, hence it is easier for the extra electron to be pulled towards the nucleus.
8. **Nature of oxides:-** In a period, the nature of the oxide gradually changes from strongly basic to strongly acidic from left to right.

Na	**Mg**	**Al**	**Si**	**P**	**S**	**Cl**

9. **Diagonal relationship:-** There is a marked similarity in the properties of elements when they are placed diagonally across in the periodic table.

Second period: Lithium Beryllium Boron Carbon

Third period: Sodium Magnesium Aluminium Silicon

Groups: The vertical columns in the periodic table are called groups. There are 18 groups in the long form of periodic table. Groups I A (1) and II A (2) constitute alkali metals and alkaline earth metals whereas group VII A constitutes halogens. The elements in a group do not have consecutive atomic numbers. However, each element in a group has some number of valence electrons and hence, same chemical properties. The elements in zero groups are called rare gases or noble gases. The elements in group I B to group VIII are called transition elements or d-block elements. The elements with atomic number 57 to 71 are called lanthanides series and with atomic number 89 to 103 are called actinides series. These elements are placed separately outside the periodic table.

Characteristics of Groups:

1. **Electronic Configuration:-** All the elements in a group have a similar electronic configuration of the outermost shell, i.e., the number of valence electrons in atoms of all the elements in the same. Since the chemical properties of an element are determined by its valence electrons, the elements within a group have similar properties.

Group 1	
Lithium (Li)	1 2
Sodium (Na)	2 8 1
Potassium (K)	2 8 8 1
Rubidium (Rb)	2 8 18 8 1

2. **Valency:-** In a group, all the elements have the same valency. Therefore, the elements of groups 1 and 2 have valencies 1 and 2 respectively.

Group 1	Valency	Group 2	Valency	Group 17	Valency
Li	1	Be	2	F	1
Na	1	Mg	2	Cl	1
K	1	Ca	2	Br	1

3. **Atomic size or atomic radius:-** On moving down a group the size of the atom increases. This is because one more shell of electrons is added at each step.

Group 1	Radii
Li	152
Na	186
K	231
Rb	244
Cs	262
Fr	270

4. **Ionization energy:-** On moving down a group, atomic size increase. This means that the ionization energy goes on decreasing on moving down a group, i.e., the electropositive character keeps increasing on moving down a group.
5. **Metallic character:-** On moving down a group, the metallic character of the element increases. The most pronounced metallic character is seen in the elements at the end of the group.
6. **Electron affinity:-** In a group of the periodic table, electron affinity decreases on moving form top to bottom. This is due to the fact that atomic size increases from top to bottom in a group. Hence, the valence shell electrons are less tightly bound.
7. **Electronegativity:-** In a group of the periodic table, the electronegativity of the element s decreases from top to bottom.
8. **Chemical reactivity:-** All the elements of a group have similar electronic configurations. Hence, their chemical properties are similar. However, chemical reactivity shows a regular gradation on moving down a group.
   a) The chemical reactivity of metals increases on moving down a group.
   b) The chemical reactivity of nonmetals decreases on moving down a group.
9. **Physical properties:-** On moving down a group there is a gradual change in physical properties (like melting points and boiling points) of the elements.
   a) The melting and the boiling points of metals show a gradual decrease on moving down a group. Densities show an increasing trend.
   b) The melting points, the boiling points and densities of nonmetals increase on moving down a group.

Advantages of Modern Periodic Table: The Modern Periodic Table is highly useful and advantageous for a number of purposes. Some of its chief advantages are listed below:

1. It gives a clear distinction between the metallic, non-metallic and other elements, which makes study and identification of the various elements easy and informative.
2. It gives a clear idea about the number of shells, valence electrons and the valency of different elements and makes it easier to deal with them.
3. It gives a clear idea about the chemical reactivity of the elements and also indicates the type of bonding exhibited by them in their molecules.
4. It follows a simple pattern in the classification and arrangement of the various elements, which makes it very easier to attribute the right position of any element.
5. It follows easy method of grouping and arrangement of the various elements, which makes it easier to describe the properties of the elements.
6. It has arranged the various isobars and isotopes of the various elements correctly without any deviation of the basic laws of the table, which makes it easier to understand and describe their properties.
7. It has arranged the Lanthanides and Actinides rightly in an independent block (f-block) at the bottom, which helps to describe their features more easily.

Defects of the Long Form of the Periodic Table:- Through many of the defects of Mendeleevs's periodic table have been removed in the long form of the periodic table, the latter suffers from the following defects.

1. Position of hydrogen:- As in Mendeleev's periodic table, the position of hydrogen is a point of controversy in this table also.
2. Position of Helium:- On the basis of electronic configuration, helium should have been placed in group 2 along with the alkaline earth metals. But this element has been placed in group 18 with the noble gases.

How to predict the properties of an Atom:- The periodic table helps us predict some properties of an atom of an element. The position of an element in the periodic table gives the atomic numkber of the element. From the atomic number we can deduct the electronic configuration of the atom of the element. The electronic configuration of the atom gives us the following information.

1. Number of electron shells in the atom:- This number gives the period number of the element in the periodic table.
2. Number of valence electrons:- The number of electrons in the outermost shell, i.e., the valence electrons, gives the group number of the element in the periodic table.
3. Valency of the element:- The valency of the element is determined by the number of valence electrons in an atom of the element.
4. Metallic and nonmetallic character:- The numbert of valence electrons in an atom of the element also tells us whether the element is a metal or a nonmetal. If an atom of the element contains 1, 2 or 3 valence electrons, the element is a metal. Onm the other hand, if the atom contains 4 or more valence electrons, the element is a nonmetal.
5. Size of the atom:- The number of electron shells gives us an idea about the size of an atom of the element.

Reactivity of the element:- The position of the lement in the periodic table gives us an idea about the reactivity of the element.

Ionisation Energy: The energy required to remove an electron form an isolated atom, thus converting it into a positively charged ion is called ionization energy. Ionization energy decreases as one moves form the top to bottom in a group. It increases as one moves from left to right in a period.

Electron Affinity: Electron affinity of an element is defined as the amount of energy released by adding an extra electron in an isolated neutral gaseous atom, in its lowest state of energy, so as to convert it into a gaseous ion.

Electron affinity is measured in electron volts or mole^{-1}.

It generally increases as one moves down in a group.

It generally increases as one moves form left to right in a period.

Electro negativity:- It is defined as the ability of an atom to attract shared pair of electrons towards itself.

Valency: The valency of an element is determined by the member of electrons in the outermost shell, or the valence shell, of an atom of the element. The valency of an element is also determined by the number of electrons an atom of the element loses or gains while combining with other atoms.

Why do you think that the noble gases should be placed in a separate group?

In the Mendeleev's periodic table, the elements have been arranged in the different groups on the basis of valency. For example, the elements place in group I have valency equal to one. Since the noble gas elements valency equal to one. Since the noble gas elements He, Ne, Ar, Kr, Xe and Rn have zero valency, they could not find a place in Mendeleev's periodic table. These have been placed in a separate group called zero group in the periodic table.