PERIODIC CLASSIFICATION OF ELEMENTS

Important terms & condition:

Classification of elements: the arrangement of elements in such a manner that elements with similar properties are grouped together while elements with dissimilar properties are separated.

EARLY ATTEMPTS OF CLASSIFICATION OF ELEMENTS

1. Lavoisier's classification of elements: In 1789, Lavoisier first attempted to classify the elements into two divisions namely Metals and Non-metals. However this classification was not satisfactory as there were many exceptions in each category.

2. Dobereiner's classification of elements: In 1817, Johann Wolfgang Dobereiner grouped three elements into what he termed triads.

In each case, the middle element has an atomic mass almost equal to the average atomic masses of the other two elements in the triad.

For example, elements like lithium, sodium and potassium have atomic masses 7, 23 and 39 respectively. They are grouped together into a triad as,

Li (7) Na (23) K (39)

Here the atomic mass of sodium is the average of atomic masses of lithium and potassium.

Limitation of Dobereiner's law

Only three triads were identified from the element known at that time. Hence, this classification was not useful.

Newland's law of octaves:

In 1863, John Newland suggested another classification of elements . He arranged the elements in the order of increasing atomic masses starting with hydrogen (least atomic mass) and ended with thorium having atomic mass 56. According to him, the properties of every eighth element are similar to the first element. It was compared to music notations Sa, Re, Ga, Ma, Pa, Da, Ni, Sa, and thus the name Newland's law of octaves (note of music). He then arranged the 49 elements known at that time into seven groups of seven each. Newland referred to his arrangement as the Law of octaves.

The Law of octaves: If elements be arranged in ascending order of their atomic masses then every eighth element was a kind of repetition of the first one either succeeding or preceding it like eighth note in octave of music.

Periodicity : Periodicity is the recurrence of similar physical and chemical properties of elements when arranged in a particular order.

For example, Sodium is similar to Lithium. Similarly Magnesium is similar to Beryllium

Note	1 (Sa)	2 (re)	3 (ga)	4 (ma)	5 (pa)	6 (dha)	7 (ni)
Element	Li	Be	B	C	N	O	F
	Na	Mg	Al	Si	P	S	Cl
	K	Ca	Cr	Ti	Mn	Fe	-

Limitations:

1. It was applicable only for lighter elements having atomic mass up to 40 amu, i.e.upto calcium.
2. He believed that only 56 elements existed in nature but later on more elements were discovered whose properties did not fit into Newland's law of octaves.
3. Some elements having different properties were grouped together like cobalt and nickel have been placed with halogens. Due to above limitations, Newlands law of octaves was rejected.

Lothar Meyer's classification of elements:

In 1864, Lothar Meyer plotted atomic weight against atomic volume of various elements. He found that elements with similar properties and valency fell under one another. However, this also could not give the better understanding.

Mendeleev's periodic table:

Mendeleev (1834-1907), a Russian chemist arranged the elements in order of increasing atomic masses, similarity in physical and chemical properties of elements. Properties of hydrides and oxides of different elements were studied and elements with similar properties were grouped together

He classified the elements in table Consisted of vertical columns called groups and horizontal rows called periods. There were 7 groups in table and group is subdivided into subgroups A and B except group 7 which has three sets of elements in 4th, 5th and 6th period. **("R" is used to represent any of the elements in a group)**

Groups	I	II	III	IV	V	VI	VII	VIII		
Oxide : Hydride:	R_2O RH	RO RH_2	R_2O_3 RH_3	RO_2 RH_4	R_2O_5 RH_3	RO_3 RH_2	R_2O_7 RH	RO_4		
Periods	A B	A B	A B	A B	A B	A B	A B	Transition		Series
1	H 1.008									
2	Li 6.941	Be 9.012	B 10.81	C 12.011	N 14.007	O 15.999	F 18.998			
3	Na 22.99	Mg 24.31	Al 26.98	Si 28.09	P 30.97	S 32.06	Cl 35.453			
4 First Series	K 39.10	Ca 40.08	--	Ti 47.90	V 50.94	Cr 52.20	Mn 54.94	Fe 55.85	Co 58.93	Ni 58.69
Second Series	Cu 63.55	Zn 65.39	--	--	As 74.92	Se 78.96	Br 79.90			
5 First Series	Rb 85.47	Sr 87.62	Y 88.91	Zr 91.22	Nb 92.91	Mo 95.94	Tc 98	Ru 101.07	Rh 102.9	Pd 106.4
Second series	Ag 107.87	Cd 112.41	In 114.82	Sn 118.71	Sb 121.76	Te 127.90	I 126.90			
6. First series	Cs 132.90	Ba 137.34	La 138.91	Hf 178.49	Ta 180.95	W 183.84	--	Os 190.2	Ir 192.2	Pt 195.2
Second series	Au 196.97	Hg 200.59	Tl 204.38	Pb 207.2	Bi 208.98					

Mendeleev's periodic table is mainly based on two facts-

(i)Atomic mass

(ii)Similarity of chemical properties

Mendeleev's periodic law : "The physical and chemical properties of elements are the periodic functions of their atomic masses".

Characteristics of Mendeleev's Periodic table:

1. Mendeleev felt that similar properties occurred after periods (horizontal rows) of varying length.
2. Mendeleev made an eight-column table of elements.
3. He had to leave some blank spaces in order to group all the elements with similar properties in the same column.
4. Mendeleev suggested that there must be other elements that had not been discovered.
5. He predicted the properties and atomic masses of several elements that were known at that time. Later on, when these elements were discovered their properties remarkably agreed with the predicted one.

For example, He left a gap below silicon in group IV A, and called the yet undiscovered element as 'Eka silicon'. Discovery of 'Germanium' during his life time proved him correct.

6. Similarly Scandium for 'eka-boron' and Gallium for 'eka-aluminium' vacancies were later discovered during his life time.
7. Eight out of ten vacant spaces left by Mendeleev were filled by the discovery of new elements.
8. Incorrect atomic masses of some arranged elements were corrected. For example, atomic mass of Beryllium as corrected from 13 to 9.

Limitations of Mendeleev, periodic table:

1. Few elements having a higher atomic mass were placed before elements having a lower atomic mass. Example: Argon (39.9) was placed before Potassium (39.1) Cobalt (58.9) was placed before Nickel (58.6) Tellurium (127.9) was placed before Iodine (126.9)
2. No separate position has been given to isotopes of an element.
3. Position of hydrogen in the periodic table was not certain about keeping it with either in group IA or in group VII A.
4. Chemically dissimilar elements were placed in the same group.

The difficulty in the Mendeleev's periodic table is overcome by introduction of Modern periodic table. It is also known as Long form of periodic table. In this table, properties of elements are dependent on their electronic configurations (distributions). Hence, modern periodic law is defined as the properties of elements are the periodic function of their atomic numbers.

Modern periodic table:

In 1913 Moseley found that frequency of X-ray emitted by different elements is directly proportional to atomic number. These studies show that properties of elements depend upon atomic number but not atomic mass.

So atomic number is the basis of classification of element. Moseley gave modern periodic law which stated as

"The physical and chemical properties of the elements are periodic function of their atomic number"

In this table, elements have been arranged in order of increasing atomic number. **This table also consists of vertical rows called groups and horizontal rows called periods which are discussed as**:

(i) There are 18 groups designated as 1 to 18.

(ii)All the elements in a group have same no. of electrons in outermost shell.

(iii)The elements of each group have similar chemical properties due to same valence electrons .

(iv)There are in all seven periods.

(v)First three periods with 2,8,8 element called short periods. The next three periods with 18,18,32 element called long period while seventh period is an incomplete period. (vi)The number of elements in these periods are based on filling of electron into various shell on the formula $2n^2$ (n-number of shell)

For Ex:-K-shell (n=1)-(2.1)2=2 so first period has two elements

L-shell (n=2)-(2.2)2=8. So 2nd period has eight elements.

M-shell (n=3)-(2.3)2=18, but the outer most shell can have only 8-electron so third period also has eight elements.

Advantages of long form of periodic table:-

1. The position of the elements are linked with their electronic configuration.
2. Position of isotopes of an element is justified since they have same atomic number.
3. Similar properties of element in a group is also justified due to same valence electrons.
4. Each group is an independent group and idea of sub-group discarded.

Groups:

Elements in group 1 are called alkali metals.

Elements in group 2 are called alkaline earth metals.

Elements in group 17 are called halogens.

Elements in group 18 elements are called inert gases or noble gases.

Significance of group in the periodic table is that an element in a group has same no. of valence electrons, valence and thus identical chemical properties.

Periods :

1st period – 2 elements and is called very short period.

2nd period – 8 elements and is called short period.

3rd period - 8 elements and is called short period.

4th period – 18 elements and is called long period.

5th period – 18 elements and is called long period.

6th period – 32 elements and is called very long period.

7th period – incomplete period.

The number of shells present in the element indicates the period to which it belongs.

Valency: it is defined as the combing capacity of an atom of an element to acquire noble gas configuration. It is equal to the number of electrons lost, gained or shared during the formation of a chemical compound.

(i) In groups the elements present have same valence.

(ii) In periods: valence increases 1 to 4 and then decreases to zero.

Atomic size / Atomic radii: It is defined as the distance from the Centre of nucleus to the outermost shell of the atom. It is generally expressed in Pico meter (Pm).

On moving down the group the group the atomic radii increases.

Because on moving down the group a new energy shell is added which increases the distance between the outermost electrons and the nucleus. Although the nuclear charge also increases, but it is compensated by the additional shell being added thus, increasing the size of the atom.

Hence, In periods atomic radius decreases in moving from left to right due to increase in nuclear charge which have tendency to attract electron closer to the nucleus and reduces the size of atom.

Across the period the atomic radii decrease.

Due to the increased nuclear charge, the pull on the electrons increases and hence, they are pulled Closer to the nucleus thus, decreasing the atomic size.

Hence, in groups: Atomic size increases down the group because new shells are added down the group which increases distance between nucleus and outer most electrons.

Oxides and its nature: Metals react with oxygen to form oxides by loss of electrons. These oxides on dissolution in water form bases.

Reactivity of elements:

Down the group reactivity of metals increases as the tendency to lose electrons increases due to increased atomic size.

Reactivity of non- metals decreases down the group

Because of the increased atomic size and the tendency to gain electrons decreases.

On moving across the period, the reactivity first increases due to the decrease in the metallic character and increase in non metallic character.

Metallic and Non-metallic Properties

The metallic character of an element is expressed in terms of its electron releasing tendency while non-metallic character in term of electron accepting tendency.

In group: Metallic character of the element increases down the group due to increasing atomic size or because outermost electrons are farther away from the nucleus .So they can be easily lost.

In periods:- Metallic character of the element decreases along a period due to decrease in atomic size along a period or outermost electrons are closer to nucleus. So they can not be easily lost.

NOTE:- Non-metallic elements follow the same reverse trend. In modern periodic table a zig - zag line separates metals from Non-metals. The border line elements, B, Si, Ge, As, Sb, Te and Po are called metalloids or semi-metal.