PERIODIC CLASSIFICATION OF ELEMENTS

There are 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 a few groups in such a way that elements in the same group have similar properties.

DOBEREINER'S TRIADS

According to Dobereiner's law of triads : When elements are arranged in the order of increasing atomic masses, 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 the atomic masses of the other two elements.

1. The Alkali Metal Group - (Lithium, Sodium and Potassium)

(i) All these elements are metals,
(ii) All of them react with water to form alkalis and hydrogen gas,
(iii) All of them have a valency of 1 (they are monovalent).

Elements	Symbols	Masses
1. Lithium	Li	7
2. Sodium	Na	23
3. Potassium	K	39

Average of atomic masses of lithium and potassium = 7 + 39 / 2
= 46 / 2
= 23 And, Actual atomic mass of sodium = 23

2. The Alkaline Earth Metal Group (Calcium, Strontium and Barium)

(i) All these elements are metals,
(ii) The oxides of all of them are alkaline in nature, and
(iii) All these elements have a valency of 2 (they are divalent).

Elements	Symbols	masses
1. Calcium	Ca	40
2. Strontium	Sr	88
3. Barium	Ba	137

40 + 137 / 2 = 88.5 And, Actual atomic mass of Strontium = 88

//story// Elements calcium, strontium and barium are called alkaline earth metals because their oxides are alkaline in nature which existed in the earth. These oxides were called "alkaline earths" and hence their metals as alkaline earth metals.

3. The Halogen Group (Chlorine, Bromine and Iodine)

(i) All these elements are non-metals,
(ii) All these elements react with water to form acids, and
(iii) All these elements have a valency of 1 (they are monovalent).

Elements	Symbols	Masses
1. Chlorine	Cl	35.5
2. Bromine	Br	80
3. Iodine	I	127

35.5 + 127 / 2 = 81.2 And, Actual atomic mass of Bromine = 80

The limitation of Dobereiner's classification was that it failed to arrange all the then known elements in the form of triads of elements having similar chemical properties. Dobereiner could identify only three triads from the elements known at that time.

NEWLANDS' LAW OF OCTAVES

According to the Newlands' law of octaves : When elements are arranged in the order of increasing atomic masses, the properties of the eighth element (starting from a given element) are a repetition of the properties of the first element.

Li	Be	B	C	N	O
Na	Mg	Al	Si	P	S
K	Ca	Cr	Ti	Mn	Fe
Cu	Zn	Y	In	As	Se
Rb	Sr	Ce and La	Zr	—	—

//story// if we start with lithium (Li) as the first element, we find that the eighth element from it is sodium (Na). And according to Newlands' law of octaves, the properties of eighth element sodium should be similar to those of the first element lithium. It has actually been found that lithium and sodium have similar chemical properties. Again, if we take sodium (Na) as the first element, then the eighth element from it will be potassium (K). So, according to Newlands' law of octaves, the properties of potassium should be similar to that of sodium. It has actually been found that sodium and potassium have similar chemical properties.

//story// If we take beryllium (Be) as the first element, then the eighth element from it will be magnesium (Mg). And according to Newlands' law of octaves, the properties of eighth element magnesium should be similar to those of the first element beryllium. It

has actually been found that beryllium and magnesium have similar chemical properties. Again, if we take magnesium (Mg) as the first element, then the eighth element from it will be calcium (Ca). So, according to Newlands' law of octaves, the properties of calcium should be similar to that of magnesium. It has actually been found that magnesium and calcium have similar chemical properties.

Newlands' law of octaves had the following limitations :

1. Newlands' law of octaves was applicable to the classification of elements up to calcium only. After calcium, every eighth element did not possess the properties similar to that of the first element. (lighter elements only.)

2. Newlands assumed that only 56 elements existed in nature and no more elements would be discovered in the future. But later on, several new elements were discovered whose properties did not fit into Newlands' law of octaves.

3. In order to fit elements into his table, Newlands put even two elements together in one slot and that too in the column of unlike elements having very different properties. For example, the two elements cobalt (Co) and nickel (Ni) were put together in just one slot, and that too in the column of elements like fluorine, chlorine and bromine which have very different properties from these elements.

4. Iron element (Fe) which resembles cobalt and nickel elements in properties, was placed far away from these elements.

//New Story//

Oxygen and hydrogen are chemically very reactive. So, most of the elements combine with oxygen to form oxides, and react with hydrogen to form hydrides. The elements having similar chemical properties form oxides having similar formulae. They also form hydrides having similar formulae.

(i) If some elements form oxides having the same general formula, then they will have similar chemical properties. For example, the elements Li, Na, and K form the oxides Li_2O, Na_2O and K_2O, having the same general formula R_2O, so they have similar chemical properties. Similarly, other elements form oxides having general formulae such as RO (MgO), R_2O_3 (Al_2O_3); RO_2 (CO_2); R_2O_5 (N_2O_5); RO_3 (SO_3); R_2O_7 (Cl_2O_7), etc.

(ii) If some elements form hydrides having the same general formula, then they will also have similar chemical properties. For example, the elements Li, Na, and K form the hydrides LiH, NaH and KH, having the same general formula RH, so they have similar chemical properties. Similarly, other elements form hydrides having general formulae such as RH_2 (MgH_2); RH_3 (NH_3); RH_4 (CH_4), etc.

MENDELEEV'S PERIODIC TABLE

According to Mendeleev's periodic law : The properties of elements are a periodic function of their atomic masses.

	GROUP I	GROUP II	GROUP III	GROUP IV	GROUP V	GROUP VI	GROUP VII	GROUP VIII
Oxides →	R_2O	RO	R_2O_3	RO_2	R_2O_5	RO_3	R_2O_7	RO_4
Hydrides →	RH	RH_2	RH_3	RH_4	RH_3	RH_2	RH	—

The undiscovered elements (or unknown elements) at that time for which gaps were left in the periodic table were named by Mendeleev as **eka-boron, eka-aluminium and eka-silicon** by prefixing the term 'eka' to the name of the preceding element in the same group. The term 'eka' is derived from Sanskrit and means 'first'. So, eka-boron means, first comes boron and then the unknown element. When these elements were discovered later on, then eka-boron was named as scandium (symbol Sc), eka-aluminium was named as gallium (symbol Ga), and eka-silicon was named as germanium (symbol Ge).

Merits of Mendeleev's Classification of Elements

1. Mendeleev's periodic law predicted the existence of some elements that had not been discovered at that time. In fact, Mendeleev's periodic table left proper gaps for the then undiscovered elements like gallium (Ga), scandium (Sc) and germanium (Ge). When these elements were discovered later on, they were placed in those gaps, without disturbing the existing elements.

2. Mendeleev's periodic table could predict the properties of several elements on the basis of their positions in the periodic table.

3. Mendeleev's periodic table could accommodate noble gases when they were discovered.

Limitations of Mendeleev's Classification of Elements

1. The position of isotopes could not be explained. Isotopes are the atoms of the same element having similar chemical properties but different atomic masses.
The isotopes are placed at the same place in the Mendeleev's periodic table.
For example, the element chlorine has two isotopes, Cl-35 and Cl-37, having atomic masses of 35 and 37 respectively. The placing of these two isotopes of chlorine (having different atomic masses) in the same group of the periodic table could not be explained by Mendeleev's periodic law.

2. Wrong order of atomic masses of some elements could not be explained.

when put in the correct group on the basis of its chemical properties, the element cobalt having higher atomic mass of 58.9 comes first and nickel element with slightly lower atomic mass of 58.7 comes later. Mendeleev's periodic law could not explain this abnormal situation of wrong order of atomic masses.

3. A correct position could not be assigned to hydrogen in the periodic table.
In Mendeleev's periodic table, hydrogen (H) has been placed in group I with alkali metals. This is because like alkali metals, (say, sodium), hydrogen also combines with halogens (chlorine, etc.), oxygen and sulphur to form compounds having similar formulae.

PRESENT BASIS FOR THE CLASSIFICATION OF ELEMENTS

//story// In 1913, Moseley showed that the atomic number of an element is a more fundamental property than atomic mass and hence atomic number is a better basis for the classification of elements. The atomic number increases regularly by 1 from element to element but atomic mass does not vary regularly from one element to the next. The atomic number of every element is fixed. No two elements can have the same atomic number. So, it was the discovery of atomic number which led to a change in Mendeleev's periodic law which was based on atomic mass.
The present basis for the classification of elements is the atomic number of elements.

Explanation of the Anomalies of Mendeleev's Classification of Elements

1. Explanation for the Position of Isotopes - All the isotopes of an element have the same number of protons, so their atomic number is also the same. Since all the isotopes of an element have the same atomic number, they can be put at one place in the same group of the periodic table.

2. Explanation for the Position of Cobalt and Nickel. The atomic number of cobalt is 27 and that of nickel is 28. cobalt with lower atomic number (27) should come first and nickel with higher atomic number (28) should come later, even if their atomic masses are in the wrong order.

Modern Periodic Law

The properties of elements are a periodic function of their atomic numbers.
(when elements are arranged according to increasing atomic numbers, there is a periodicity in the electronic configurations of elements.)

Explanation of Modern Periodic Law

When the elements are arranged according to increasing atomic numbers, then the elements having same number of valence electrons occur at regular intervals (or periods).

Atomic No. :	3	4	5	6	7	8	9	10
Elements :	Li	Be	B	C	N	O	F	Ne
Electronic configurations :	2, 1	2, 2	2, 3	2, 4	2, 5	2, 6	2, 7	2, 8
Atomic No. :	11	12	13	14	15	16	17	18
Elements :	Na	Mg	Al	Si	P	S	Cl	Ar
Electronic configurations :	2, 8, 1	2, 8, 2	2, 8, 3	2, 8, 4	2, 8, 5	2, 8, 6	2, 8, 7	2, 8, 8

MODERN PERIODIC TABLE (OR LONG FORM OF PERIODIC TABLE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Period 1	1 H																	2 He
Period 2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
Period 3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
Period 4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
Period 5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
Period 6	55 Cs	56 Ba	57 to 71	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
Period 7	87 Fr	88 Ra	89 to 103	104 Rf	105 Ha	106 Sg	107 Ns	108 Hs	109 Mt	110 Uun	111 Uuu	112 Uub		114 Uuq		116 Uuh		118 Uuo
Lanthanide series →			57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	
Actinide series →			89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	

The horizontal rows of elements in a periodic table are called periods. There are seven periods in the long form of periodic table. The elements in a period have consecutive (continuous) atomic numbers. The number of elements in each period is given below :

1st period contains 2 elements. It is called very short period.

2nd period contains 8 elements. It is called short period.

3rd period contains 8 elements. It is also a short period.

4th period contains 18 elements. It is called long period.

5th period contains 18 elements. It is also a long period.

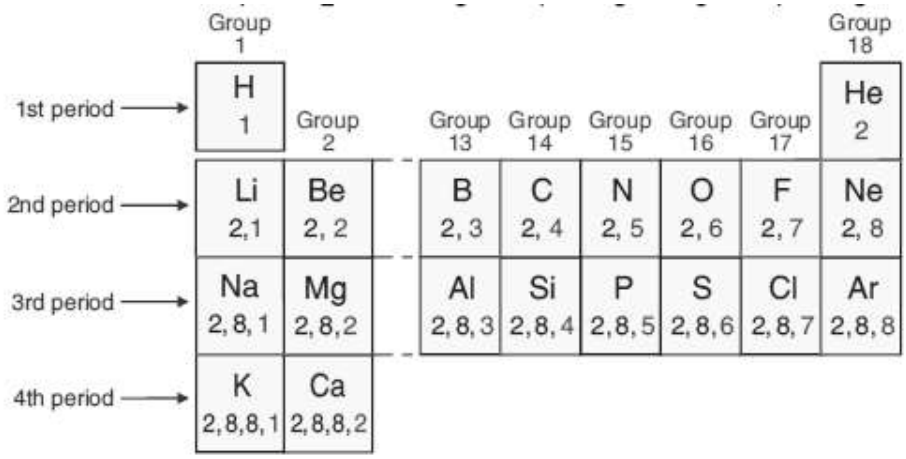
6th period contains 32 elements. It is called very long period.

7th period contains rest of the elements. It is incomplete.

The vertical columns in a periodic table are called groups. There are 18 groups in the long form of periodic table. These groups are numbered as 1 to 18. Group 1 is on the left side of the periodic table whereas group 18 is on the extreme right side of the periodic table.
The elements in a group do not have consecutive atomic numbers.
The groups 1 and 2, and 13 to 17 contain the normal elements
The group 3 to group 12 elements are called transition elements.
The elements with atomic numbers 57 to 71 are called lanthanide series (because their first element is lanthanum). And the elements with atomic numbers 89 to 103 are called actinide series (because their first member is actinium).

Position of Hydrogen

Hydrogen is treated as a very special element and placed alone at the head of the periodic table.



CHARACTERISTICS OF PERIODS

1. Valence Electrons (or Outermost Electrons) - no. of electron in outermost shell

number of valence electrons in elements increases from 1 to 8

Elements of third period :	11 Na	12 Mg	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
Electronic configurations :	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

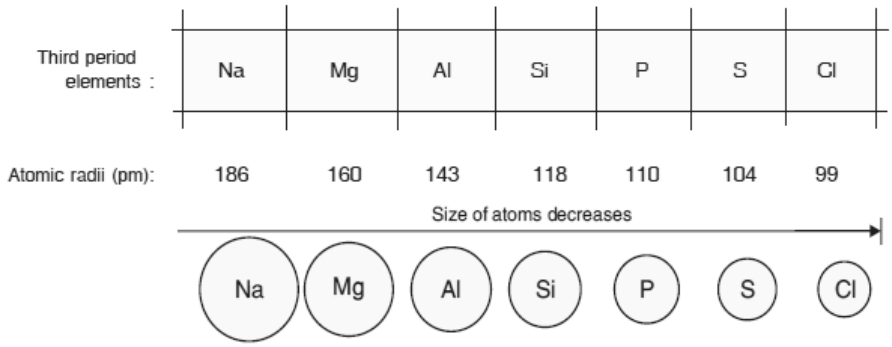
2. Valency - no. of electron transfer to complete their octane

:e clear : hird period elements :	Na	Mg	Al	Si	P	S	Cl	Ar
Valency :	1	2	3	4	3	2	1	0

On moving from left to right in each period, the valency of elements increases from 1 to 4 and then decreases to 0 (zero).

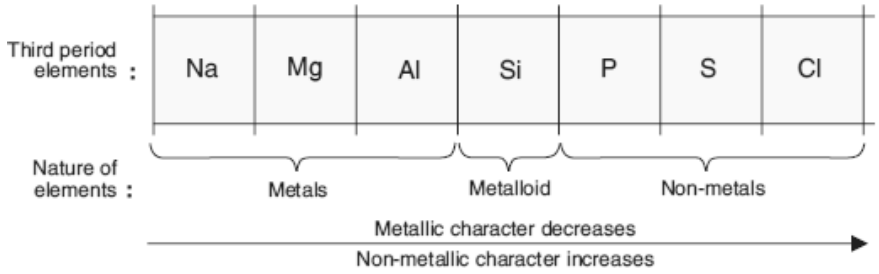
3. Size of Atoms (or Atomic size)

On moving from left to right in a period, the size of atoms decreases (or atomic size decreases).



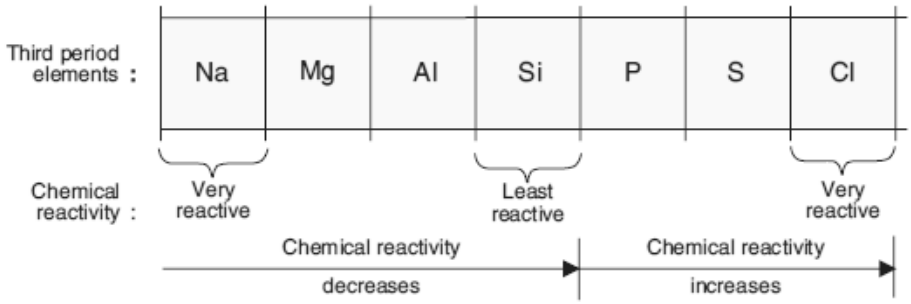
4. Metallic Character

On moving from left to right in a period, the metallic character of elements decreases (but the non-metallic character increases).



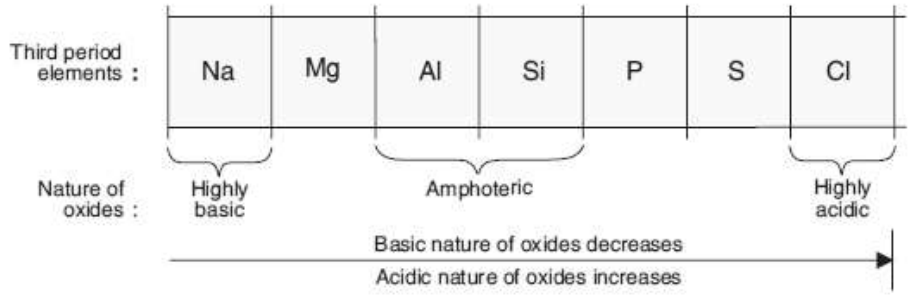
5. Chemical Reactivity

On moving from left to right in a period, the chemical reactivity of elements first decreases and then increases.



6. Nature of Oxides

On moving from left to right in a period, the basic nature of oxides decreases and the acidic nature of oxides increases.



CHARACTERISTICS OF GROUPS

1. Valence Electrons (or Outermost Electrons)

All the elements of a group have the same number of valence electrons.

Group 1		Electronic configurations	No. of valence electrons
Lithium	Li	2, 1	1
Sodium	Na	2, 8, 1	1
Potassium	K	2, 8, 8, 1	1

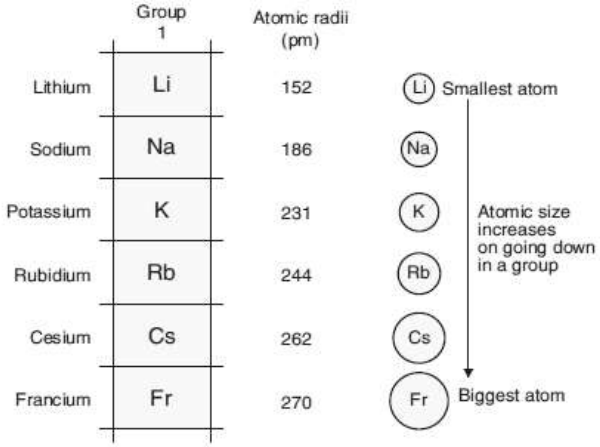
Group 17		Electronic configurations	No. of valence electrons
Fluorine	F	2, 7	7
Chlorine	Cl	2, 8, 7	7
Bromine	Br	2, 8, 18, 7	7
Iodine	I	2, 8, 18, 18, 7	7

2. Valency

all the elements in a group have the same valency.

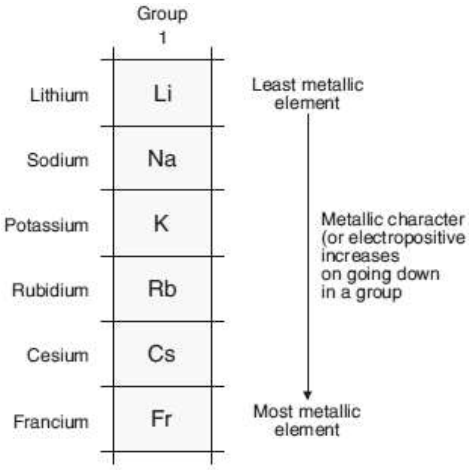
3. Size of Atoms (or Atomic size)

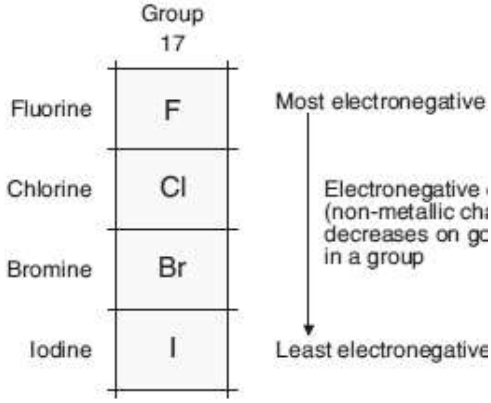
On going down in a group, the size of atoms increases (or atomic size increases).



4. Metallic Character

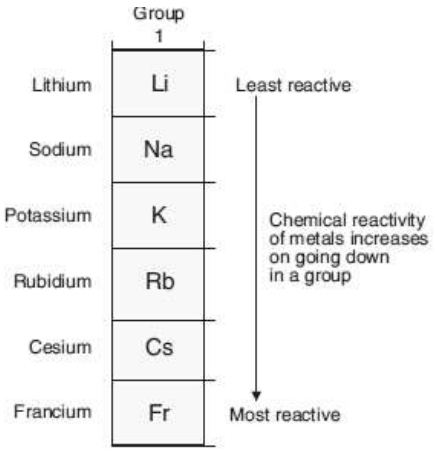
On going down in a group, the metallic character of elements increases.

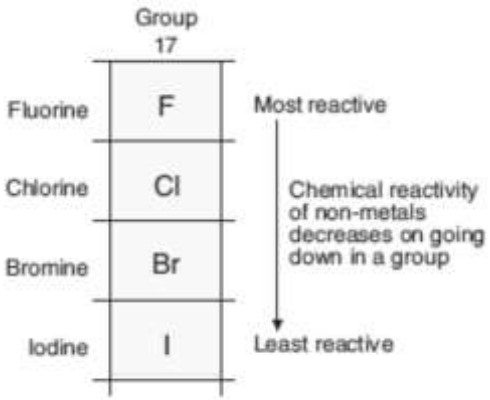




5. Chemical Reactivity

(i) The chemical reactivity of metals increases on going down in a group





(ii) The chemical reactivity of non-metals decreases on going down in a group.

6. Nature of Oxides

On going down in a group of the periodic table, there is no change in the nature of oxides of elements.

Merits of the Modern Periodic Table

1. based on the atomic numbers of elements which is the most fundamental property of elements.

2. helps us understand why elements in a group show similar properties but elements in different groups show different properties.

3. explains the reasons for the periodicity in properties of elements.

4. tells us why the properties of elements are repeated after 2, 8, 18 and 32 elements.

Advantages of the Periodic Table

1. The periodic table has **made the study of chemistry systematic and easy**. It acts as an aid to memory.

2. It is **easier to remember the properties of an element** if its position in the periodic table is known.

3. The **type of compounds formed by an element can be predicted** by knowing its position in the periodic table.

4. A periodic table chart is **used as a teaching-aid in chemistry in schools** and colleges.

-------End of Chapter----------