PERIODIC TABLE

INTRODUCTION

- You must have visited a library. There are thousands of books in a large library. In spite of this if you ask for a particular book, the library staff can locate it easily.
- In library, the books are classified into various categories and sub-categories. They are arranged on shelves accordingly. Therefore location of books becomes easy.
- Let us come back to chemistry. Most of the matter that we see, touch and feel is made up of compounds. There are millions of such compounds existing presently.
- This task was simplified by simple classification of elements into few groups. Instead of studying each and every element or compounds, we just learn the properties of groups.

DOBEREINER'S TRIADS AND NEWLAND'S LAW OF OCTAVES

DOBEREINER'S TRAIADS

In the year 1829, Johann Wolfgang Dobereiner, a German scientist, was the first to classify elements. He grouped the elements that showed similar chemical properties into groups of three called '**Triads**'. The distinctive feature of a triad was the atomic mass of the middle element.

When elements were arranged in order of their increasing atomic mass, the atomic mass of the middle element was approximately the arithmetic mean of the other two elements of the triad.

EXAMPLES OF DOBEREINER'S TRIADS

Element	Lithium	Sodium	Potassium	Arithmetic mean
Atomic mass	7.0	23.0	39.0	$\frac{7+39}{2} = 23.0$

Element	Calcium	Strontium	Barium	Arithmetic mean
Atomic mass	40.0	87.5	137	$\frac{40+137}{2} = 88.1$

Element	Chlorine	Bromine	Iodine	Arithmetic mean
Atomic mass	35.5	80	127	$\frac{35.5+127}{2} = 81.25$

NEWLAND'S LAW OF OCTAVES

John Alexander Reina Newland was a chemist as well as a lover of music.
He arranged many of the known elements in the increasing order of their atomic masses. It was noticed that the eighth element was similar in properties to the first element, just like the eighth note in music - Western as well as Indian.

Western	Indian		
Do	Sa	Lithium	Sodium
Re	Re	Beryllium	Magnesium
Me	Ga	Boron	Aluminium
Fa	Ma	Carbon	Silicon
So	Pa	Nitrogen	Phosphorus
La	Da	Oxygen	Sulphur
Ti	Ni	Fluorine	Chlorine
Do	Sa	–	–

The eighth element after lithium is sodium. It is similar to lithium in many of its chemical properties. Similarly, the eighth element after sodium is potassium, whose properties are similar to sodium. The eighth element from fluorine is chlorine both of which are similar in their properties. The eighth element from nitrogen is phosphorus and both these elements are similar in properties.

Based on this observation, Newland stated his law of octaves thus

When elements are arranged in increasing order of their atomic mass, the eighth element resembles the first in physical and chemical properties just like the eighth note on a musical scale resembles the first note.

However, a very important conclusion was made that there is some systematic relationship between the order of atomic masses and the repetition of properties of elements. This gave rise to a new term called **Periodicity**. It is the recurrence of characteristic properties of elements arranged in a table, at regular intervals of a period.

Illustrations –1: (i) The tenth element in the Newlands periodic classification resembles with

Solution: Third

(ii) Who give the Law of Octaves.

Solution: Newland

MENDELEEV'S PERIODIC LAW AND CHARACTERISTIC AND LIMITATIONS

He studied the chemical properties of all 63 elements known at that time. On the basis of their properties, he proposed that when elements are arranged in the increasing order of their atomic masses, the elements with similar properties appear at regular intervals or periods, i.e., chemical properties of the elements are a periodic function of their atomic masses (atomic weights).

Later on when Mendeleev came to know about the work of Lother Meyer, he integrated the two statements (Lother Meyer's and his own statement) in the form of a law called Mendeleev Lother Meyer periodic law or simply Mendeleev's periodic law.

This law states that:

The physical and chemical properties of the elements are a periodic function of their atomic weights, i.e., when the elements are arranged in the increasing order of their atomic weights, the elements with similar properties are repeated after certain regular intervals.

CHARACTERISTICS OF MENDELEEV'S PERIODIC TABLE

- In Mendeleev's table, the elements were arranged in **vertical columns, called groups.**
- There were in all eight groups: Group I to VIII. The group numbers were indicated by *Roman numerals*. i.e., I, II, III, IV, V, VI, VII & VIII.

- Except VIII, every group is further divided into subgroups i.e., A and B. Groups VIII occupy three triads of three elements each, *i.e.*, in all nine elements
- The properties of the elements in same group or subgroup are similar.
- There is no resemblance in the elements of subgroups A and B of same group except valency.
- The **horizontal rows** of the periodic table are known as **periods.**
- There were seven **periods**, represented by Arabic numerals 1 to 7. To accommodate more elements, the periods 4, 5, 6 and 7 were divided into two halves. The first half of the elements are placed in the upper left corner and second half in the lower right corner.

For example, the elements occupying the box corresponding to group I and period 4 are potassium (K) and copper (Cu), K is written in the top left corner, while Cu is written in the lower right corner.

- (viii)A period comprises the entire range of elements after which the properties repeat themselves.
- (ix)In a period, the properties of the elements gradually change from metallic to nonmetallic while moving from left to right.
- (x) There were gaps left in the periodic table. Mendeleev left these gaps knowingly, as these elements were not discovered at that time.

LIMITATIONS OF MENDELEEV'S PERIODIC TABLE

(i) POSITION OF HYDROGEN

The position of hydrogen is not correctly defined. It is still not certain whether to place hydrogen in group I A or VII A.

(ii) ANOMALOUS PAIRS OF ELEMENTS

In certain pairs of elements like, Ar (40) and K (39); Co (58.9) and Ni (58.6); Te (127.6) and I (126.9) the arrangement was not justified. For e.g., argon was placed before potassium whereas its atomic mass is more than potassium. In this case, the periodic law is violated.

(iii) POSITION OF ISOTOPES

Isotopes are atoms of the same element having different atomic mass but same atomic number. For e.g., there are three isotopes of hydrogen with atomic mass 1, 2, and 3. According to Mendeleev's periodic table these should be placed at three separate places. However isotopes have not been given separate places in the periodic table.

(iv) GROUPING OF ELEMENTS

Certain chemically dissimilar elements have been grouped together. Elements of group IA such as lithium, sodium and potassium were grouped with dissimilar elements such as copper, silver and gold.

(v) CAUSE OF PERIODICITY

Mendeleev's table was unable to explain the cause of periodicity among elements. That is by the elements with similar properties fall one below the other, if they are arranged in the increasing order of their atomic weights.

(vi) POSITION OF LANTHANIDES AND ACTINIDES

Fourteen elements that follow lanthanum called lanthanides and fourteen elements following actinium called actinides were not given proper places in Mendeleev's periodic table.

Illustrations –2: (i) What was the basis of Mendeleev's periodic Law?

Solution: Atomic Weight.

(ii) How many periods in Mendeleev's periodic table?

Solution: Seven.

MODERN PERIODIC LAW

The discovery of atomic number in 1913-14 by Mosley indicated that the properties of the elements are largely defined by their atomic numbers rather than their atomic weights. Atomic number was, therefore, adopted as the basis of classification of elements in place of atomic weights. Thus, the periodic Law may, now, be restated in a more precise form. **The physical and chemical properties of elements are a periodic function of their atomic number.** In other words, when the elements are arranged in order of their increasing atomic number, the elements with similar properties are repeated after certain regular intervals. The periodic table that is obtained by arranging the elements in order of increasing atomic number is the same as Mendeleev's Periodic Table.

LONG FORM OF THE PERIODIC TABLE

The Long Form of Periodic Table is based upon the Modern Periodic Law. Many efforts have been made to improve the Periodic Table. Perhaps the most useful modification of the Periodic Table is Long Form of the Periodic Table. This Periodic Table is sometime referred to as Bohr's table, because it apparently

follows Bohr's theory of electronic arrangement in the various type of elements. The Long Form of the Periodic Table is the most frequently used Periodic Table.

LONG FORM OF PERIODIC TABLE

	Light Metals IA	IIA	Heavy Metals (Transition Metals) IIIB	IVB	VB	VIB	VIIB	VIIB	VIIB	IB	IIB	Non-Metals IIIA	IVA	VA	VIA	VIIA	VIIA or 0
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 Ti	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									

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 modern periodic table is divided into two main categories:
  - Vertical columns called Groups and
  - Horizontal columns called Periods.
- There are 18 vertical columns or groups. These are further sub-divided into A and B (groups I to VII), VIII group and zero group.
- Member of the same group have similar electronic configuration of the valence shell and thus show same valency.
- Elements of groups IA to VIIA are called groups of typical elements, representative elements or normal elements.
- Groups IA and IIA are strongly metallic and are called group of 'alkali metals and alkaline earth metals'.
- Groups IB to VII B and VIII lie in the middle of the table between IIA and IIIA groups and are called groups of transition elements. They consist of metals.
- The Zero group consists of 'Noble gases'.
- There are 7 horizontal rows in the periodic table. These are called the periods.

- In a period, the number of valence shell remains the same for all elements. However, the number of electrons in the valence shell increases from left to right .
- The 6 th period consists of elements that have atomic numbers 58 to 71. They are called Lanthanides. The 7th period consists of elements that have atomic numbers 90 to 105. They are called Actinides. Both of them are called inner transition elements.
- The 7 th period is an incomplete period as it has only 23 elements.
- Lanthanides and actinides are not accommodated in the main body of the periodic table but are placed separately at the bottom of the table.
- The position of hydrogen is not certain. Thus it can be placed in both group IA and group VIIA.
- Group VIIA elements are called halogens or salt producers. Representative periodic table for eight groups up to calcium (atomic number 20) with their electronic configuration is given in the table.

Illustrations –3: (i) How many groups and periods in the Modern Periodic Table?

Solution: Eighteen , Seven.

(ii) Modern Periodic Law based on

Solution: Atomic Number

(iii) Elements of Group 17 are called

Solution: Halogens

CLASSIFICATION OF ELEMENTS

The long form of the period table has also been divided into four blocks known as s, p, d and f-blocks.

S-BLOCK ELEMENTS

s-Block of the periodic table includes those elements in which the last electron is filled in the valence s-sub-shell of the outermost energy shell. Since the s-sub-shell can have a maximum of two electrons only, therefore only two groups (1, 2) constitute this block. The elements included in group 1 have ns^1 electronic configuration and are called alkali metals. Similarly, group 2 contains alkaline earth metals with ns^2 electronic configuration. General electronic configuration : ns^{1-2}

P-BLOCK ELEMENTS

The elements in which the last electron is filled in the valence p-sub-shell are included in the p-block of the periodic table.

As the p-sub-shell can have a maximum of six electrons, there are six groups in the block (13 to 18)
General electronic configuration : ns^2np^{1-6}.

D-BLOCK ELEMENTS

This block of the period table includes those elements in which the last electron enters the d-sub-shell of the last but one (penultimate) energy level. Since the d-sub-shell can have a maximum of five orbitals and then electrons, therefore, there are ten vertical columns or groups in the d-block which have been numbered from 3 to 12. In the atoms of these elements, the outermost s-sub-shell (ns) can have 1 or 2 electrons (even zero in some cases) while the filling takes place in the penultimate d-sub-shell i.e. (n – 1)d.
General electronic configuration : $(n-1)d^{1-10}ns^{1-2}$.

F-BLOCK ELEMENTS

In this block of periodic table, the filling of the last electron takes place in the (n- 2) f-sub-shell (also called antepenultimate sub-shell). At the same time, (n – 1)d sub-shell may contain zero or one electron while ns sub-shell is having two electrons.
General electronic configuration : $(n-2)f^{1-14}(n-1)d^{0-1}ns^2$.

Illustrations –4: (i) The electronic configuration of element is $1s^22s^22p^63s^2$. The element belongs to which block.

Solution: s-block.

(ii) The electronic configuration of element is $1s^22s^22p^63s^23p^2$. The element belongs to which block.

Solution: p-Block.

KEY POINTS

- When elements were arranged in order of their increasing atomic mass, the atomic mass of the middle element was approximately the arithmetic mean of the other two elements of the triad.
- Newland (1863-65) arranged the elements in increasing atomic weight and observed that the eight element starting from a given element was the repetition of the first element, like an eight note in an octave of music.
- Mandeleev's Periodic Law (1869) states that the physical and chemical properties of elements are the periodic function of their atomic weights.

- According to Modern Periodic Law, the physical and chemical properties of elements are periodic function of their atomic number.
- Modern periodic table consists of 18 vertical columns called groups from 1 to 18 and seven horizontal columns called periods.
- The cause of periodicity of properties of elements is the recurrence of similar outer electronic configuration at regular intervals.