Chemistry - Class X

Chapter 5 - Periodic Classification of Elements.

Introduction

Matter around us is present in the form of elements, compounds and mixtures and the elements contain atoms of only one type. At present, 114 elements are known to us 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. Now study of a large number of elements is reduced to a few groups of elements.

Classification mean identifying similar species and grouping them together.

Doberiner'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.

(i) Alkali Metal Group

Lithium (Li) - 7
Sodium (Na) - 23
Potassium (K) - 39

Arithmetic mean $= \frac{7+39}{2} = 23$

(ii) The Alkaline Earth Metal Group:

Calcium (Ca) - 40
Strontium (Sr) - 88
Barium (Ba) - 137

$\text{mean} = \frac{40+137}{2}$

$= 88.5$

(iii) The Halogen Group:

Chlorine (Cl) - 35.5
Bromine (Br) - 80
Iodine (I) - 127

$\text{mean} = \frac{35.5+127}{2} = 81.2$

The Limitations of Dobereiner's Classification

Only three triads were recognized from the elements known at that time.

Li	Ca	Cl
Na	Sr	Br
K	Ba	I

Dobereiner could identify only three triads. He was not able to prepare triads of all the known elements.

Newlands' Law of Octaves.

"When elements are arranged in the order of increasing atomic masses, the properties of the eighth (8^{th}) element (starting from a given element) are a repetition of the properties of the first element."

This repetition in the properties of elements is just like the repetition of eight note in an octave of music, so it is known as the law of octaves.

Sa (do)	Re (re)	Ga (mi)	Ma (fa)	Pa (so)	Dha (la)	Ni (ti)
H	Li	Be	B	C	N	O
F	Na	Mg	Al	Si	P	S
Cl	K	Ca	Cr	Ti	Mn	Fe
Co & Ni	Rb	Sr	Ce, La	Zn		

Limitations of Newlands law of octaves.

(i) The law was applicable to elements up to Calcium (Ca) only.

(ii) It contained only 56 elements. Further it was assumed by Newlands that only 56 elements existed in Nature and more elements would be discovered.

(iii) In order to fit elements into the table, Newlands adjusted two elements in the same column as fluorine, chlorine and bromine which have very different properties than these elements.

Iron, which resemble cobalt and nickel in properties, has been placed differently away from these elements.

Mendeleev's Periodic Table

Dmitri Ivanovich Mendeleev, a Russian chemist, was the most important contributor to the early development of a periodic table of elements where in the elements were arranged on the basis of their atomic mass and chemical properties.

Characteristics of Mendeleev's Periodic Table:

(i) Mendeleev arranged all the 63 known elements in increasing order of their atomic masses.

(ii) The table consists of vertical columns called 'group' and horizontal rows called 'period's

(iii) The elements with similar physical and chemical properties came under same groups.

Mendeleev's Periodic law: The properties of elements are the periodic function of their atomic masses.

Merits of Mendeleev's Periodic Table:

(i) Mendeleev's left some blank spaces for undiscovered elements.
(ii) Mendeleev's predicted the discovery of some elements and name them as eka-boron, eka aluminium and eka-silicon
(iii) Noble gases discovered later could be placed without disturbing the existing order. (4)

Mendeleev's Periodic Table

Group	I	II	III	IV	V	VI	VII	VIII
Oxide : Hydride:	R_2O RH	RO RH_4	R_2O_3 RH_4	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 6.939	Be 9.012	B 10.81	C 12.011	N 14.007	O 15.999	F 18.998	
3	Na 22.99	Mg 22.99	Al 24.31	Si 28.09	P 30.974	S 32.06	Cl 35.453	
4 First series Second series	K 39.102 Cu 63.54	Ca 40.08 Zn 65.54	Sc 44.96 Ga 69.72	Ti 47.90 Ge 72.59	V 50.94 As 74.92	Cr 50.20 Se 78.96	Mn 54.94 Br 79.909	Fe Co Ni 55.85 58.93 58.71
5 First series Second series	Rb 85.47 Ag 107.87	Sr 87.62 Cd 112.40	Y 88.91 In 114.82	Zr 91.22 Sn 118.69	Nb 92.91 Sb 121.60	Mo 95.94 Te 127.60	Tc 99 I 126.90	Ru Rh Pd 101.07 102.91 106.4
6 First series Second series	Cs 132.90 Au 196.97	Ba 137.34 Hg 200.59	La 138.91 Tl 204.37	Hf 178.40 Pb 207.19	Ta 180.95 Bi 208.98	W 183.85		Ru Rh Pd 190.2 192.2 195.09

Characteristics :

(i) In the periodic table, the elements are arranged in vertical rows called groups and horizontal rows called periods.

(ii) There are eight groups indicated by Roman Numerals I, II, III, IV, V, VI, VII, VIII. The elements belonging to first seven groups have been divided into sub-groups designated as A and B on the basis of similarities. The elements are present on the left hand side in each group constitute sub-group A while those on the right hand side form sub-group B. Group VIII consists of nine elements in three triads.

(iii) There are six periods (numbered 1, 2, 3, 4, 5 and 6). In order to accomodate more elements, the periods 4, 5, 6 are divided into two halves. The first half of the elements are placed in the upper left corners and the second half occupy lower right corners in each box.

Achievements of Mendeleev's periodic Table

(i) The arrangements of elements in groups and periods made the study of elements quite systematic in the sense that if properties of one elements in a group are known, those of the others can be easily predicted.

(ii) Prediction of new elements and their properties:

Many gaps were left in this table for undiscovered elements. However, properties of these elements could be predicted in advance from their expected position. This helped in the discovery of these elements. The elements silicon, gallium and germanium were discovered in this manner.

(iii) Correction of doubtful atomic masses:

Mendeleev corrected the atomic masses of certain elements with the help of their expected position and properties.

Limitations of Mendeleev's classification:

(i) He could not assign a correct position of hydrogen in his periodic table, as the properties of hydrogen resembles both with alkali metals as well as with halogens.

(ii) The isotopes of the same elements will be given different position if atomic number is taken as basis, which will disturb the symmetry of the periodic table.

(iii) The atomic masses do not increases in a regular manner in going from one elements to the next.

So it was not possible to predict how many elements could be discovered between two elements.

Position of elements in the modern periodic table

1) The Modern Periodic Table consists of 18 vertical columns termed as 'groups'.
2) It also consists of 7 horizontal rows termed as 'periods'.
3) The elements present in any one group have the same number of valence electrons. For instance, elements like fluorine (F) and chlorine (Cl), belong to group 17.
4) There is an irregularity with the position of hydrogen as it can be placed either in group 1 or group 17 in the first period.
5) The maximum number of electrons that can be filled in a shell can be calculated by the formula $2n^2$ where 'n' is the number of the given shell from the nucleus.

K Shell – $2 * (1)^2 = 2$,
So the first period has 2 elements.

L Shell – $2 * (2)^2 = 8$,
So the second period has 8 elements.

M Shell – $2 * (3)^2 = 18$,
As outermost shell can have only 8 electrons, so the third period also has only 8 elements.

Metals like Na and Mg occupy the left-hand side whereas the non-metals like sulphur and chlorine occupy the right-hand side of the Periodic Table. Silicon or some other metals exhibiting the properties of both metals and non-metals termed as semi-metal or metalloid are positioned in the middle of periodic table.

Trends in the modern periodic table

- The number of shells increases on going down the group.
- The number of valence shell electrons increases with the increase in atomic number on moving from left to right in a period with each period marking the filling of a new electronic shell.
- Atomic size decreases in moving from left to right along a period due to an increase in nuclear charge pulling the electrons closer to the nucleus.
- Addition of new shells down the group increases the distance between the outermost electrons and the nucleus thereby increasing the atomic size down the group.
- Across a period effective nuclear charge acting on the valence shell electrons increases which decreases the tendency to lose electrons. Hence metallic character decreases and non-metallic character increases across a period.
- Down the group, the effective nuclear charge decreases which increases the tendency to lose electrons. Hence metallic character increases and non-metallic character decreases down a group.

Table 5.6 Modern Periodic Table

Metals | Metalloids | Non-metals

The zigzag line separates the metals from the non-metals.

PERIODS	GROUP NUMBER 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H Hydrogen 1.0																	2 He Helium 4.0
2	3 Li Lithium 6.9	4 Be Beryllium 9.0											5 B Boron 10.8	6 C Carbon 12.0	7 N Nitrogen 14.0	8 O Oxygen 16.0	9 F Fluorine 19.0	10 Ne Neon 20.2
3	11 Na Sodium 23.0	12 Mg Magnesium 24.3											13 Al Aluminium 27.0	14 Si Silicon 28.1	15 P Phosphorus 31.0	16 S Sulphur 32.1	17 Cl Chlorine 35.5	18 Ar Argon 39.9
4	19 K Potassium 39.1	20 Ca Calcium 40.1	21 Sc Scandium 45.0	22 Ti Titanium 47.8	23 V Vanadium 50.9	24 Cr Chromium 52.0	25 Mn Manganese 54.9	26 Fe Iron 55.9	27 Co Cobalt 58.9	28 Ni Nickel 58.7	29 Cu Copper 63.5	30 Zn Zinc 65.4	31 Ga Gallium 69.7	32 Ge Germanium 72.6	33 As Arsenic 74.9	34 Se Selenium 79.0	35 Br Bromine 79.9	36 Kr Krypton 83.8
5	37 Rb Rubidium 85.5	38 Sr Strontium 87.6	39 Y Yttrium 88.9	40 Zr Zirconium 91.2	41 Nb Niobium 92.9	42 Mo Molybdenum 95.9	43 Tc Technetium (99)	44 Ru Ruthenium 101.1	45 Rh Rhodium 102.3	46 Pd Palladium 106.4	47 Ag Silver 107.9	48 Cd Cadmium 112.4	49 In Indium 114.8	50 Sn Tin 118.7	51 Sb Antimony 121.8	52 Te Tellurium 127.6	53 I Iodine 126.9	54 Xe Xenon 131.3
6	55 Cs Caesium 132.9	56 Ba Barium 137.3	57 La* Lanthanum 138.9	72 Hf Hafnium 178.5	73 Ta Tantalum 181.0	74 W Tungsten 183.9	75 Re Rhenium 186.2	76 Os Osmium 190.2	77 Ir Iridium 192.2	78 Pt Platinum 195.1	79 Au Gold 197.0	80 Hg Mercury 200.6	81 Ti Thallium 204.4	82 Pb Lead 207.2	83 Bi Bismuth 209.0	84 Po Polonium (210)	85 At Astatine (210)	86 Rn Radon (222)
7	87 Fr Francium (223)	88 Ra Radium (226)	89 Ac** Actinium (227)	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Uub	–	114 Uuq	–	Uuh	–	–

* Lanthanoides	58 Ce Cerium 140.1	59 Pr Praseodymium 140.9	60 Nd Neodymium 144.2	61 Pm Promethium (145)	62 Sm Samarium 150.4	63 Eu Europium 152.0	64 Gd Gadolinium 157.3	65 Tb Terbium 158.9	66 Dy Dysprosium 162.5	67 Ho Holmium 164.9	68 Er Erbium 167.3	69 Tm Thulium 168.9	70 Yb Ytterbium 173.0	71 Lu Lutetium 175.5
** Actinoides	90 Th Thorium 232.0	91 Pa Protactinium (231)	92 U Uranium 238.1	93 Np Neptunium (237)	94 Pu Plutonium (242)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (245)	98 Cf Californium (251)	99 Es Einsteinium (254)	100 Fm Fermium (253)	101 Md Mendelevium (256)	102 No Nobelium (254)	103 Lr Lawrencium (257)

(9)