PART-A (PERIODIC TABLE)

INTRODUCTION :

The arrangement of all the known elements according to their properties in such a way that the elements of similar properties are grouped together in a tabular form is called periodic table.

Development of periodic table :

(A) LAVOISIER CLASSIFICATION OF ELEMENTS

At first Lavoisier classified the elements into two categories.

(i) Metal

(ii) Non-metal

Note : This classification cannot categories the metalloid variety.

(B) DOBEREINER'S TRIAD RULE [1817]

(i) He made groups of three elements having similar chemical properties called TRIAD.

(ii) In Dobereiner triad, atomic weight of middle element is nearly equal to the average atomic weight of first and third element.

e.g.

Cl	Br	I	
35.5	80.0	127	$\frac{35.5+127}{2}=81.25$
Ca	Sr	Ba	
40	87.5	137	$\frac{40+137}{2}=88.5$
Li	Na	K	
7	23	39	At. wt of $Na=\frac{7+39}{2}=23$

(iii) Other examples – (K, Rb, Cs), (P, As, Sb), (S, Se, Te), (H, F, Cl), (Sc, Y, La)

(C) NEWLAND'S OCTAVE RULE [1865]

(i) He arranged the elements in the increasing order of their atomic mass and observed that properties of every 8th element was similar to the 1stone, like in the case of musical vowels notation.

Sa	Re	Ga	Ma	Pa	Dha	Ni	Sa
1	2	3	4	5	6	7	8

(ii) At that time inert gases were not known.

						H
Li	Be	B	C	N	O	F
Na	Mg	Al	Si	P	S	Cl
K	Ca					

(iii) The properties of Li are similar to 8th element i.e. Na, Be are similar to Mg and so on.

Drawbacks or Limitations :

(a) This rule is valid only upto Ca. because after Ca due to filling of d-orbitals there is difference of 18 elements instead of 8 element.

(b) After the discovery of inert gas this law had to be dropped out.

(c) He failed in the case of heavier metals as Fe has been placed along with O and S.

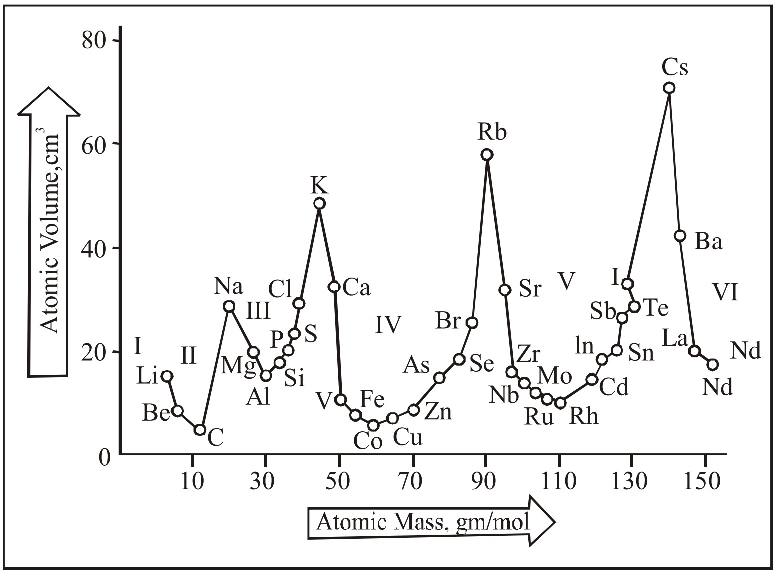
(D) LOTHER MEYER'S CURVE [1869]

(i) He plotted a curve between atomic weight and atomic volume of different elements.
(ii) The following observations can be made from the curve –
(a) Most electropositive elements i.e. alkali metals (Li, Na, K, Rb, Cs etc.) occupy the peak portions of the curve.
(b) Less electropositive i.e. alkaline earth metals (Be, Mg, Ca, Sr, Ba) occupy the descending portions of the curve.
(c) Metalloids (B, Si, As, Te, At etc.) and transition metals occupy bottom part of the curve.
(d) Most electronegative i.e. halogens (F, Cl, Br, I) occupy the ascending portion of the curve.

Note : Elements having similar properties occupy similar portions of the curve.

Conclusion :

On the basis of this curve, Lother Meyer proposed that the physical properties of the elements are periodic function of their atomic weight and this became the basis of Mendeleev's periodic table.



(E) MENDELEEV'S PERIODIC TABLE [1869]

(i) ***Mendeleev's periodic law –*** The physical and chemical properties of elements are the periodic function of their atomic weight

(ii) ***Characteristic of Mendeleev's periodic table –***

(a) It is based on atomic weight
(b) 63 elements were known, noble gases were not discovered.
(c) He was the first scientist to classify the elements in a systamatic manner i.e. in horizontal rows and in vertical columns.
(d) Horizontal rows are called periods and there were 7 periods in Mendeleev's Periodic table.
(e) Vertical columns are called groups and there were 8 groups in Mendeleev's Periodic table.
(f) Each group upto VIIth is divided into A & B subgroups.'A' sub group elements are called normal elements and 'B' sub group elements are called transition elements.
(g) The VIIIth group consists of 9 elements in three rows.
(h) The elements belonging to same group exhibit similar properties.

(iii) Merits or advantages of Mendeleev's periodic table –

(a) Study of elements – For the first time, all known elements were classified in groups according to their similar properties. So study of the properties of elements became easier.

(b) Prediction of new elements – It gave encouragement to the discovery of new elements as some gaps were left in it.

Sc (Scandium), Ga (Gallium), Ge (Germanium), Tc (Technetium)

were the elements whose position and properties were well defined by Mendeleev even before their discoveries and he left the blank spaces for them in his table.

e.g. - Blank space at atomic weight 72 in silicon group was called Eka silicon (means properties like silicon) and element *(discovered later)* was named Germanium .

Similarly other elements discovered after mendeleev periodic table were :

Eka aluminium – Gallium(Ga)

Eka Boron – Scandium (Sc)

Eka Silicon – Germanium (Ge)

Eka Manganese – Technetium (Tc)

(c) Correction of doubtful atomic weights–Corrections were done in atomic weight of some elements.

$$\boxed{\text{Atomic Weight} = \text{Valency} \times \text{Equivalent weight.}}$$

Initially, it was found that equivalent weight of Be is 4.5 and it is trivalent (V = 3), so the weight of Be was 13.5 and there is no space in Mendeleev's table for this element. So, after correction, it was found that Be is actually divalent (V = 2). So, the weight of Be became 2 × 4.5 = 9 and there was a space between Li and B for this element in Mendeleev's table.

Corrections were done in atomic weight of elements are – U, Be, In, Au, Pt.

(iv) Demerits of Mendeleev's periodic table –

(a) Position of hydrogen – Hydrogen resembles both, the alkali metals (IA) and the halogens (VIIA) in properties so Mendeleev could not decide where to place it.

(b) Position of isotopes – As atomic weight of isotopes differs, they should have been placed in different position in Mendeleev's periodic table. But there was no such place for isotopes in Mendeleev's table.

(c) Anomalous pairs of elements – There were some pair of elements which did not follow the increasing order of atomic wts.

eg : Ar and Co were placed before K and Ni respectively in the periodic table, but having higher atomic weights.

$$\underset{\text{in modified mendeleev P.T.}}{\begin{pmatrix} \text{Ar} & \text{K} \\ 39.9 & 39.1 \end{pmatrix}} \qquad \begin{pmatrix} \text{Te} & \text{I} \\ 127.5 & 127 \end{pmatrix}$$

$$\begin{pmatrix} \text{Co} & \text{Ni} \\ 58.9 & 58.6 \end{pmatrix} \qquad \begin{pmatrix} \text{Th} & \text{Pa} \\ 232 & 231 \end{pmatrix}$$

(d) Like elements were placed in different groups.

There were some elements like Platinum (Pt) and Gold (Au) which have similar properties but were placed in different groups in Mendeleev's table.

Pt	Au
VIII	IB

(e) Unlike elements were placed in same group.

		Ist group		
	IA		IB	
	Li			
	Na			
More reactive	K		Cu	Less reactive
Alkali metal	Rb		Ag	Coinage metal
Normal elements	Cs		Au	Transition element
	Fr			

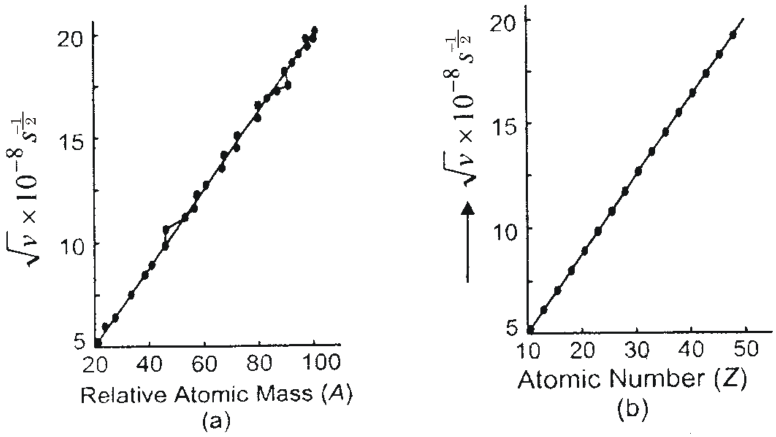
Cu, Ag and Au placed in Ist group along with Na, K etc. While they differ in their properties (Only similar in having ns^1 electronic configuration)

(F) MODERN PERIODIC TABLE (MODIFIED MENDELEEV PERIODIC TABLE)

(i) It was proposed by **Moseley (1913)**.

(ii) Modern periodic table is based on atomic number.

(iii) Moseley did an experiment in which he bombarded high speed electron on different metal surfaces and obtained X-rays.



Moseley's Experiment

He found out that $\sqrt{\nu} \propto Z$ (where ν = frequency) of X-rays from this experiment, Moseley concluded that the physical and chemical properties of the elements are periodic function of their atomic number. It means that when the elements are arranged in the increasing order of their atomic number, elements having similar properties gets repeated after a regular interval. This is also known as **'Modern Periodic Law'**.

(iv) Modern periodic law – The physical & chemical properties of elements are a periodic function of their atomic number.

(v) Characteristics of modern periodic table –

(a) 9 vertical columns called groups.

(b) IA to VIIA, IB to VIIB, VIII and 0

(c) Inert gases were introduced in periodic table by Ramsay.

(d) 7 horizontal series called periods.

(G) LONG FORM / PRESENT FORM OF MODERN PERIODIC TABLE

(It is also called as 'Bohr-Burry & **Rang**, Werner Periodic Table.)

(i) It is based on the Bohr-Burry electronic configuration concept and atomic number.

(ii) This model was proposed by Rang & Werner

(iii) It consists of 7 horizontal periods and 18 vertical columns (groups)

(iv) According to I. U. P. A. C. 18 vertical columns are named as 1^{st} to 18^{th} group.

(v) The co-relation between the groups in long form of periodic table and in modern form of periodic table are given below.

IA,	IIA,	IIIB,	IVB,	VB,	VIB,	VIIB,	VIII,	IB,	IIB,	IIIA,	IVA,	VA,	VIA,	VIIA,	0
1	2	3	4	5	6	7	8, 9, 10	11	12	13	14	15	16	17	18

(vi) Elements belonging to same group have same no. of electrons in the outermost shell so their properties are similar.

Description of periods :

Period	n	Sub shell	No. of elements	Element	Name of Period
1.	1	1s	2	$_{1}H$ – $_{2}He$	Shortest
2.	2	2s, 2p	8	$_{3}Li$ – $_{10}Ne$	Short
3.	3	3s, 3p	8	$_{11}Na$ – $_{18}Ar$	Short
4.	4	4s, 3d, 4p	18	$_{19}K$ – $_{36}Kr$	Long
5.	5	5s, 4d, 5p	18	$_{37}Rb$ – $_{58}Xe$	Long
6.	6	6s, 4f, 5d, 6p	32	$_{55}Cs$ – $_{86}Rn$	Longest
7.	7	7s, 5f, 6d, 7p	32	$_{87}Fr$ – $_{118}Og$	Longest

Extended or Long Form of the Periodic Table

s-Block Elements | d-Block Elements | p-Block Elements

Metals (white) | Non metals (green) | Metalloids (black)

Group →

Period ↓	IA (1)	IIA (2)	IIIB (3)	IVB (4)	VB (5)	VIB (6)	VIIB (7)	(8)	VIII (9)	(10)	IB (11)	IIB (12)	IIIA (13)	IVA (14)	VA (15)	VIA (16)	VIIA (17)	0 (18)
1	1 H 1.0079 Hydrogen																	2 He 4.0026 Helium
2	3 Li 6.940 Lithium	4 Be 9.0122 Beryllium											5 B 10.811 Boron	6 C 12.011 Carbon	7 N 14.007 Nitrogen	8 O 15.999 Oxygen	9 F 18.998 Fluonne	10 Ne 20.180 Neon
3	11 Na 22.990 Sodium	12 Mg 24.305 Magnesium											13 Al 26.982 Aluminium	14 Si 28.086 Silicon	15 P 30.974 Phosporus	16 S 32.066 Sulphur	17 Cl 35.453 Chlorine	18 Ar 39.948 Argon
4	19 K 39.098 Potassium	20 Ca 40.078 Calcium	21 Sc 44.956 Scandium	22 Ti 47.867 Titanium	23 V 50.941 Vanadium	24 Cr 51.996 Chrominum	25 Mn 54.938 Manganese	26 Fe 55.847 Iron	27 Co 58.933 Cobolt	28 Ni 58.693 Nickel	29 Cu 63.546 Copper	30 Zn 65.39 Zinc	31 Ga 69.723 Gallium	32 Ge 72.61 Germanium	33 As 74.922 Arsenic	34 Se 78.96 Selenium	35 Br 79.904 Bromine	36 Kr 83.80 Krypton
5	37 Rb 85.468 Rubidium	38 Sr 87.62 Strontium	39 Y 88.906 Yttrium	40 Zr 91.224 Zirconium	41 Nb 92.906 Niobium	42 Mo 95.94 Molybdenum	43 Tc 98 Technetium	44 Ru 101.07 Ruthenium	45 Rh 102.91 Rhodium	46 Pd 106.42 Palladium	47 Ag 107.87 Silver	48 Cd 112.41 Cadmium	49 In 114.82 Indium	50 Sn 118.71 Tin	51 Sb 121.76 Antimony	52 Te 127.60 Tellurium	53 I 126.90 Iodine	54 Xe 131.29 Xenon
6	55 Cs 132.91 Cesium	56 Ba 137.33 Barium	57 La* 138.91 Lanthanum	72 Hf 178.49 Hafnium	73 Ta 180.95 Tantalum	74 W 183.84 Tungsten	75 Re 186.21 Rhenium	76 Os 190.23 Osmium	77 Ir 192.22 Iridium	78 Pt 195.08 Platinum	79 Au 196.97 Gold	80 Hg 200.59 Mercury	81 Tl 204.38 Thallium	82 Pb 207.2 Lead	83 Bi 208.98 Bismuth	84 Po 210 Polonium	85 At 210 Astatine	86 Rn 222 Radon
7	87 Fr 223 Francium	88 Ra 226 Radium	89 Ac** 227 Actinium	104 Rf 267 Rutherfordium	105 Db 270 Dubnium	106 Sg 271 Seaborgium	107 Bh 270 Bohrium	108 Hs 277 Hassium	109 Mt 276 Meitnerium	110 Ds 281 Darmstadtium	111 Rg 282 Roentgenium	112 Cn 285 Copernicium	113 Nh 285 Nihonium	114 Fl 289 Flerovium	115 Mc 288 Moscovium	116 Lv 293 Livermorium	117 Ts 294 Tennessine	118 Og 294 Oganesson

f-Block Elements

6	*Lanthanide Series	58 Ce 140.12 Cerium	59 Pr 140.91 Praseodymium	60 Nd 144.24 Neodymium	61 Pm 145 Promethium	62 Sm 150.36 Samarium	63 Eu 151.96 Europium	64 Gd 157.25 Gadolinium	65 Tb 158.93 Terbium	66 Dy 162.50 Dyspro-	67 Ho 164.93 Holmium	68 Er 167.26 Erbium	69 Tm 168.93 Thulium	70 Yb 173.07 Ytterbium	71 Lu 174.97 Lutetium
7	**Actinide Series	90 Th 232.04 Thorium	91 Pa 231.04 Protactinium	92 U 238.03 Uranium	93 Np 237 Neptunium	94 Pu 244 Plutonium	95 Am 243 Americium	96 Cm 247 Curium	97 Bk 247 Berkelium	98 Cf 251 Californium	99 Es 252 Einsteinium	100 Fm 257 Fermium	101 Md 258 Mendelevium	102 No 259 Nobelium	103 Lr 262 Lawrencium

IUPAC designations of groups of elements are given in brackets

CLASSIFICATION OF ELEMENTS INTO s , p , d & f BLOCK ELEMENTS:

s – block :

(i) configuration ns^{1-2} **(ii)** last e^- enters in s orbital

(iii) two groups I A or 1 ; II A or 2

p – block :

(i) configuration $ns^2\ np^{1-6}$ **(ii)** last e^- enters in p orbital

(iii) six groups III A , IV A , V A , VI A , VII A , zero or 13 , 14 , 15 , 16 , 17 , 18

d – block : [Transition Elements]

(i) configuration $(n-1)\ d^{1-10}\ ns^{0-2}$ **(ii)** last e^- enters in d orbital

(iii) their two outermost shell are incomplete

(iv) 10 groups III B , IV B , V B , VI B , VII B , VIII (Triad) , I B , II B or 3 , 4 , 5 , 6 , 7 , (8 , 9 , 10) , 11 , 12 .

(v) four series 3 d , 4 d , 5 d , 6 d belong to 4^{th}, 5^{th}, 6^{th} & 7^{th} period respectively in long form of Periodic table.

f – block : [Inner Transition]

(i) configuration $(n-2)\ f^{0-14}\ (n-1)\ d^{0-2}\ ns^2$

(ii) last e^- enters in f orbital

(iii) two series 4 f Lanthanides & 5 f Actinides belong to 6^{th} & 7^{th} period respectively in long form of Periodic table.

Neil Bohr's classification of elements :

Using electronic configuration as the criteria, elements are of four types. The classification of the elements into these groups is dependent on the extent to which the s, p, d and f orbitals are filled.

Inert Gases :

(a) s – and p-orbitals of the outer most shell of these elements are completely filled. The outermost electronic configuration is ns^2np^6.

(b) Helium is also inert gas but its electronic configuration is $1s^2$

Representative or Normal Elements :

(a) Outermost shell of these elements is incomplete. The number of electrons in the outermost shell is less than eight.

(b) s-and p-block elements except inert gases are called normal or representative elements.

Transition Elements :

(a) These metals were placed between s-block metals and p-block elements so, are named transition metals.

(b) Their outermost electronic configuration is similar to d-block elements i.e. $(n-1)\ d^{1\text{-}10}\ ns^{1\text{-}2}$.

(c) Last two shells of these elements namely outermost and penultimate shells are incomplete.

(d) The last shell contains one or two electrons and the penultimate shell may contain more than eight and up to eighteen electrons.

(e) According to definition of transition elements, those elements which have partly filled d-orbitals in neutral state or in any stable oxidation state are called transition elements. According to this definition Zn, Cd and Hg (IIB group) are d-block elements but not transition elements because these elements have d^{10} configuration in neutral as well as in stable +2 oxidation state.

Inner Transition Elements :

(a) In these elements last three shells i.e. last, penultimate and prepenultimate shells are incomplete.

(b) These are related to IIIB i.e. group 3.

(c) The last shell contains two electrons. Penultimate shell may contain eight or nine electrons and pre-penultimate shell contains more than 18, up to 32 electrons.

(d) Their outemost electronic configuration is similar to f-block element i.e. $(n-2)\,f^{\,0-14}\ (n-1)\,d^{\,0-2}\ ns^2$

METALS, NON-METALS & METALLOIDS

Apart from classifying elements into s, p, d and *f*-blocks, there is yet another broad classification of elements based on their properties. The elements can be broadly classified into

(a) Metals:

Majority of the elements in periodic table are metals and appears on the left side of the periodic table.

Properties:

(i) These are usually solid at room temperature [exception - mercury]

(ii) They have high melting and boiling point [exception Gallium & Cesium have very low melting point (303 K and 302 K respectively)]

(iii) They are good conductor of heat and electricity.

(iv) They are malleable (can be flattened into thin sheets by hammering) and ductile (can be drawn into wires)

(b) Non-Metals:

These are placed at the top right hand side of periodic table. As we move horizontally along a period, the property of elements changes from metallic (on left) to non-metallic (on the right).

Properties :

(i) These are usually solids or gases at room temperature.

(ii) They have low melting point and boiling point (exception : Boron, Carbon).

(iii) Most Non-metallic solids are brittle and are neither malleable nor ductile.

(c) Metalloids (Semi-metals):

Properties of these elements show the characteristics of both metals and non-metals. Silicon (Si), Germanium(Ge), Arsenic(As), Antimony(Sb) and Tellurium(Te) are metalloids.

ESTIMATING POSITION OF AN ELEMENT FROM ITS ELECTRONIC CONFIGURATION

The last electron enters in which subshell gives idea of its block.

[☺ ***Think*** :$1s^1$ and $1s^2$ belongs to which block]

Period number = Principal quantum number of valence shell electron in ground state electronic configuration.

Group number for s block = number of valence shell electrons

Group number for p block = 10 + number of valence shell electrons

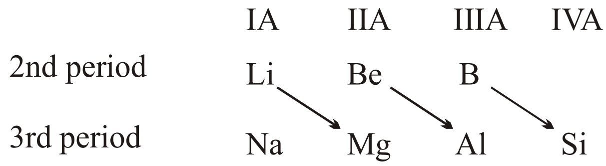
Group number for d block = number of [ns + (n–1) d] electrons

Group number for f-block = 3

[☺ **Use these carefully while locating the position.]**

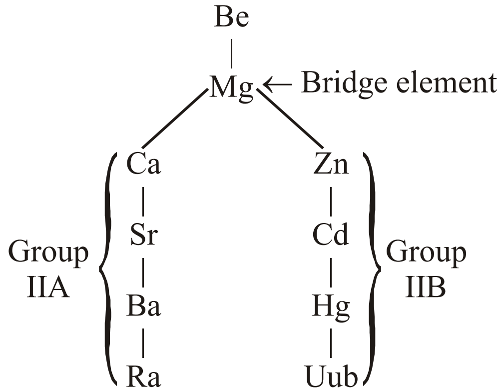
SOME COMMONLY USED TERMS

1. ***Noble Gases :*** Element of group 18 are called noble gases. These are also called as inert gases because their outermost ns and np orbitals are completely filled (except He and $1s^2$) and these gases are non-reactive in nature under ordinary conditions.
2. ***Typical elements :*** Elements of second and third period are known as typical elements.
3. ***Diagonal relationship :*** Properties of elements of second period resemble with the element of third period. This resemblance between properties of 2^{nd} & 3^{rd} period is called diagonal relationship.



4. ***Bridge elements :***

The typical elements of third period are also called bridge elements as the division between two subgroups A and B starts from these elements. In second group Mg acts as a bridge element. The properties of bridge element are some what mixed of the elements of two subgroups as magnesium shows similarities with alkaline earth metals (IIA) on one hand and with zinc metals (IIB) on the other.



IUPAC NOMENCLATURE OF THE ELEMENT :

The names are derived by using roots for the three digits in the atomic number of the element and adding the ending –ium. The roots for the number are

Digit	Name	Abbreviation
0	nil	n
1	un	u
2	bi	b
3	tri	t
4	quad	q
5	pent	p
6	hex	h
7	sept	s
8	oct	o
9	enn	e

Thus element with atomic number 109 will be named as **une** (**u** for 1, **n** for 0 and **e** for 9). Table summarises the names of the elements with atomic number above 100.