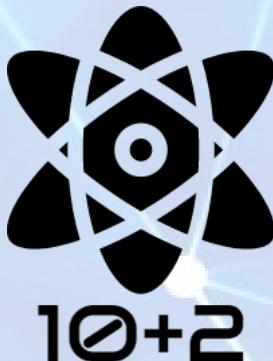


10+2 PCM NOTES

BY

JOYOSHISH SAHA

(PDF version handwritten notes of Maths, Physics and Chemistry
for 10+2 competitive exams like JEE Main, WBJEE, NEST, IISER
Entrance Exam, CUCET, AIPMT, JIPMER, EAMCET etc.)



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With best wishes from Joyoshish Saha

Group 1



Alkaline earth metals Group 2

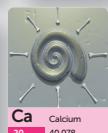


Beryllium (Be)



Magnesium (Mg)

12 24.305



Calcium (Ca)

20 40.078



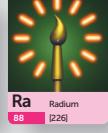
Strontium (Sr)

38 87.62



Barium (Ba)

56 137.327



Radium (Ra)

88 [226]

Alkali metals

Group 3



Scandium (Sc)

21 44.956



Titanium (Ti)

22 47.867



Vanadium (V)

23 50.942



Chromium (Cr)

24 51.996

Transition metals



Manganese (Mn)

25 54.938



Iron (Fe)

26 55.845



Cobalt (Co)

27 58.933

Group 4

Nickel (Ni)

28 58.693

Copper (Cu)

29 63.546

Group 5

Zinc (Zn)

30 65.38

Aluminum (Al)

13 26.982

Silicon (Si)

14 28.085

Phosphorus (P)

15 30.974

Sulfur (S)

16 32.06

Chlorine (Cl)

17 35.45

Argon (Ar)

18 35.948

Group 6

Boron (B)

5 10.81

Carbon (C)

6 12.011

Nitrogen (N)

7 14.007

Oxygen (O)

8 15.999

Fluorine (F)

9 18.998

Neon (Ne)

10 20.180

Group 7

Chromium (Cr)

25 51.996

Manganese (Mn)

26 54.938

Iron (Fe)

27 55.845

Cobalt (Co)

28 58.933

Nickel (Ni)

29 63.546

Copper (Cu)

30 65.38

Zinc (Zn)

31 69.723

Gallium (Ga)

32 72.630

Germanium (Ge)

33 74.922

Arsenic (As)

34 78.971

Selenium (Se)

35 78.971

Bromine (Br)

35 79.904

Krypton (Kr)

36 83.798

Group 8



Ruthenium (Ru)

44 101.07



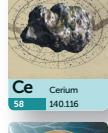
Rhodium (Rh)

45 102.906



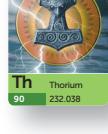
Technetium (Tc)

43 [98]



Osmium (Os)

76 190.23



Platinum (Pt)

78 195.084



Iridium (Ir)

77 192.217

Rhodium (Rh)

46 105.42

Palladium (Pd)

47 107.868

Silver (Ag)

48 112.414

Cadmium (Cd)

49 114.818

Indium (In)

50 118.710

Tin (Sn)

51 121.760

Antimony (Sb)

52 127.60

Tellurium (Te)

53 126.904

Iodine (I)

54 131.293

Astatine (At)

85 [210]

Radon (Rn)

86 [222]

Group 9

Osmium (Os)

76 190.23

Platinum (Pt)

78 192.217

Rhodium (Rh)

45 [278]

Technetium (Tc)

43 [281]

Darmstadtium (Ds)

110 [281]

Roentgenium (Rg)

111 [280]

Copernicium (Cn)

112 [285]

Nh (Nh)

113 [286]

Flerovium (Fl)

114 [289]

Moscovium (Mc)

115 [289]

Livermorium (Lv)

116 [293]

Tennessine (Ts)

117 [294]

Oganesson (Og)

118 [294]

Group 10

Terbium (Tb)

65 162.500

Dysprosium (Dy)

66 164.930

Holmium (Ho)

67 167.259

Erbium (Er)

68 168.934

Thulium (Tm)

69 173.045

Ytterbium (Yb)

70 174.967

Lutetium (Lu)

71 174.967

Lanthanides

Cerium (Ce)

58 140.116

Praseodymium (Pr)

59 140.908

Neodymium (Nd)

60 144.242

Promethium (Pm)

61 [145]

Samarium (Sm)

62 150.36

Europium (Eu)

63 151.964

Gadolinium (Gd)

64 157.25

Terbium (Tb)

65 158.925

Dysprosium (Dy)

66 162.500

Holmium (Ho)

67 164.930

Erbium (Er)

68 167.259

Thulium (Tm)

69 168.934

Ytterbium (Yb)

70 173.045

L

Periodic Table

Group 1

H	Hydrogen
1	1.008

Alkaline earth metals Group 2

Li	Lithium
3	6.94

Beryllium

4 9.012

Na	Sodium
11	22.990

Magnesium

12 24.305

These are the 118 currently known and officially named elements that make up the periodic table (IUPAC 2016).

The periodic table arranges the elements, with their diverse physical and chemical properties, in order of atomic number and fits them into a logical pattern. Eighteen columns divide the elements into groups with closely related physical properties. Rows list elements in order of mass and are called series or periods. Properties of elements change in a systematic way through a period.

Atomic number

The atomic number is equal to the number of protons in the nucleus.

Relative atomic mass

The ratio of the average mass of the various isotopic forms of an element to one-twelfth of the mass of a carbon-12 atom in its ground state. A number in brackets indicates that all isotopes of the element are unstable, ie radioactive.

Cu
Copper

29 63.546

Group 13	Group 14	Group 15	Group 16	Group 17
B Boron	C Carbon	N Nitrogen	O Oxygen	F Fluorine
5 10.81	6 12.011	7 14.007	8 15.999	9 18.998
Al Aluminium	Si Silicon	P Phosphorus	S Sulfur	Cl Chlorine
13 26.982	14 28.085	15 30.974	16 32.06	18 39.948
Ga Gallium	Ge Germanium	As Arsenic	Se Selenium	Br Bromine
31 69.723	32 72.630	33 74.922	34 78.971	36 83.798
Kr Krypton	I Iodine	Xe Xenon		
37 85.468	38 87.62	39 88.906	40 91.224	41 92.906
Rb Rubidium	Sr Strontium	Y Yttrium	Zr Zirconium	Nb Niobium
42 95.95	43 [98]	44 101.07	45 102.906	46 106.42
Mo Molybdenum	Tc Technetium	Ru Ruthenium	Rh Rhodium	Pd Palladium
47 112.414	48 114.818	49 118.710	50 121.760	51 127.60
Ag Silver	Cd Cadmium	In Indium	Sn Tin	Te Tellurium
52 127.60	53 126.904	54 131.293	55 126.904	56 131.293
Cs Caesium	Ba Barium	La Lanthanum	Hf Hafnium	Ta Tantalum
55 132.905	56 137.327	57 138.905	72 178.49	73 180.948
Fr Francium	Ra Radium	Ac Actinium	Rf Rutherfordium	Db Dubnium
87 [223]	88 [226]	89 [227]	104 [267]	105 [268]
Sg Seaborgium	Bh Bohrium	Hs Hassium	Mt Meitnerium	Ds Darmstadtium
106 [269]	107 [270]	108 [269]	109 [278]	110 [281]
Rg Roentgenium	Cn Copernicium	Nh Nihonium	Fl Flerovium	Mc Moscovium
111 [280]	112 [285]	113 [286]	114 [289]	115 [289]
Pt Platinum	Au Gold	Hg Mercury	Tl Thallium	Pb Lead
78 195.084	79 196.967	80 200.592	81 204.38	82 207.2
Os Osmium	Ir Iridium	Ho Holmium	Er Erbium	Tm Thulium
76 190.23	77 192.217	67 164.930	68 167.259	69 168.934
W Tungsten	Re Rhenium	Dy Dysprosium	Yb Ytterbium	Lu Lutetium
74 183.84	75 186.207	65 158.925	70 173.045	71 174.967
Ce Cerium	Pr Praseodymium	Nd Neodymium	Pm Promethium	Sm Samarium
58 140.116	59 140.908	60 144.242	61 [145]	62 150.36
Th Thorium	Pa Protactinium	U Uranium	Np Neptunium	Pu Plutonium
90 232.038	91 231.036	92 238.029	93 [237]	94 [244]
Am Americium	Cm Curium	Bk Berkelium	Cf Californium	Es Einsteinium
95 [243]	96 [247]	97 [247]	98 [251]	99 [252]
Fm Fermium	Md Mendelevium	No Nobelium	Lr Lawrencium	
100 [257]	101 [258]	102 [259]	103 [262]	

Wall chart © Royal Society of Chemistry 2017

Noble gases Group 18

He Helium
2 4.003



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visit www.rsc.org/periodic-table, or scan the QR code.

www.rsc.org/periodic-table

* Dobereiner's Triads: According to Dobereiner, when elements of same properties are kept in the increasing order of their atomic weights, the atomic weight of the middle element is equal to the mean atomic weight of the remaining elements. Such a group elements is called Dobereiner's Triad.

eg.	Li	Na	K	$\left \frac{7+39}{2} = 23 \right.$
	7	23	39	

* Modern Periodic Table:

- i) Proposed by Bohr, prepared by Rang & Warner.
- ii) Has seven periods, 18 groups (according to CAS system, groups are 16). There are 2 elements in the 1st period, 8 elements each in the 2nd & 3rd period, 18 elements each in the 4th & 5th period, 32 elements in the 6th period, 19 elements till now in the 7th period.

* Division of elements (electron configuration):

- a) s-block elements: i) last electron enters s-orbital.
ii) general formulae ns^1 & $ns^2 (1-7)$

iii) IA group elements are known as alkali metals because they react with water to form alkali. II A group elements are known as alkaline-earth metals because their oxides react with water to form alkali & these are found in the soil.

iv) Fr⁸⁷, Ra⁸⁸ are radioactive, it is gaseous; Cs & Fr are liquid. v) These elements are soft, malleable and good conductors. vi) These metals

and their salts impart characteristic colour to the flame. vii) The elements of this group have larger size, strong reducing nature, high electropositive nature, very low electronegativity, ionization energy & electron affinity.

b) p-block elements: i) last electron enters p-orbital.
ii) p-block elements divided into 6 groups - IIIA, IVA, VA, VIA, VIIA & zero groups. iii) The general formulae for p-block elements ns^2np^{1-6} ($n=2$ to 6). iv) The zero group elements (ns^2np^6) are inert. v) They include both metals & non-metals but there is a regular gradation from metallic to non-metallic character as we move from left to right across the period. vi) They don't impart colour in flame test. vii) Except F & inert gases, they all show variable oxidation state.

c) d-block elements: i) last electron enters d-orbital.
ii) divided in groups - IIIB, IVB, VB, VIIB, VIIIB, VIB, IB, IIB. iii) In d-block elements, the electron gets filled up in the d orbital of the penultimate shell. That is why, these elements are known as transition elements. iv) general formulae $(n-1)s^2p^6d^{1-10}ns^{1-2}$ ($n=1$ to 7). v) all are metals. vi) mercury is only liquid element. vii) They show variable valency. viii) They are ductile & malleable. ix) These metals & their compounds are widely used as catalysts.

- d) f-block elements: i) last electron enters the f-orbital. ii) The f-block elements are from 58 to 71 & from 90 to 103.
- iii) All actinides are radioactive. iv) The general formulae $(n-2)s^2p^6d^{10}f^{(1-14)}(n-1)s^2p^6d^{0-1}ns^2$ [n=6,7].
- v) They form coloured ions & complexes.
- vi) Actinides are radioactive in nature.

* Trends in Periodic Properties of Elements:

- i) Atomic Radius: As the absolute value of atomic radius cannot be determined so it is expressed in terms of the operational definitions such as ionic radius, covalent radius, van der Waal's radius & metallic radius.
- ii) Covalent radius: It is half of the distance between two successive nuclei of two covalent bonded similar atoms in a molecule. If bond length is a , then $r_{\text{cor}} = \frac{1}{2}a$.
- iii) Van der Waal's Radius: It's one-half of the distance between the nuclei of two non bonded isolated adjacent atoms belonging to two neighbouring molecules of an element in the solid state.
- iv) Metallic radius: It's the half of the distance between any two successive nuclei of two adjacent metal atoms in a closely packed crystal lattice.

iv) Ionic radius: It is the effective distance from the centre of nuclei of an ion up to which it has an influence over electron cloud.

- $r_{\text{ion}} > r_{\text{met}} > r_{\text{anionic}} > r_{\text{cov}} > r_{\text{cationic}}$

- Factors affecting size:

- Effective nuclear charge ($Z_{\text{eff}} =$

$$Z - \{ 0.35(N_n) + 0.86(N_{n-1}) + (N_{n-2}) \}.$$

$Z \rightarrow$ atomic no.; $N_n, N_{n-1}, N_{n-2} \rightarrow$ no. of electrons in $n^{\text{th}}, n-1, n-2$ orbit.

- size \propto 1/effective nuclear charge.

- size \propto number of orbits

- \propto number of inner shell electrons

- \propto electronic repulsion

- size \propto 1/bond order or multiplicity.

- Variation in the value of radii:

Period - Moving left to right, atomic size decreases.

$$\text{IA} > \text{IIA} > \text{IIIA} > \text{IVA} > \text{VA} \approx \text{VI} > \text{VII} < \text{Zero group.}$$

Group - Increases from top to bottom, as Z_{eff} decreases.

- Size of cation is always smaller than its atom & size of anion is always greater than its atom.

- If the covalent bond present have different electronegativities, then atomic radius is determined by formula given

by Shoemaker & Stevenson rule.

$$d_{A-B} = r_A + r_B - 0.09 (x_A - x_B).$$

d_{A-B} = bond length ; $x_A, x_B \rightarrow$ electronegativities of A & B.

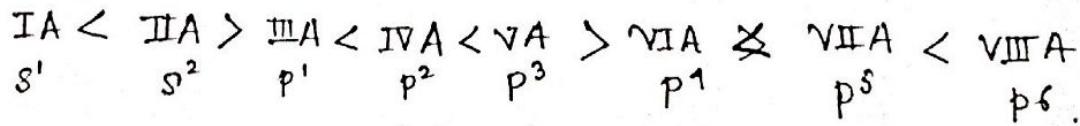
• Ionization Enthalpy: Energy required to remove the most loosely bound electron from an isolated atom in the gaseous state. $I_1 < I_2 < I_3 \dots$

■ Factors affecting Ionisation Energy:

- i) $I \propto Z_{\text{eff}}$
- ii) $I \propto 1/\text{atomic size}$.
- iii) $I \propto 1/\text{screening effect of inner electrons}$.
- iv) $I \propto \text{stable electronic config.}$
- v) $I \propto \text{penetration effect of electrons. } (s > p > d > f)$.

■ Variation in value of Ionisation Energy:

period - moving left to right, I increases.



group - moving top to bottom in a group ionisation energy decreases as Z_{eff}

decreases.

■ In periodic table, He has max I_1 (1800eV) & Cesium (Cs) has lowest value.

■ The largest jump, between I_2 & I_3 is for alkaline earth metals as config. changes from ns^1 to ns^2np^6 . $\text{Be} \xrightarrow[1s^2 2s^2 \quad I_1]{-e} \text{Be}^+ \xrightarrow[2s^1 \quad I_2]{-e} \text{Be}^{2+} \xrightarrow[1s^2 \quad I_3]{-e} \text{Be}^{3+} \xrightarrow[1s^1]$

■ Importance of Ionisation Energy:

Elements having low IE are reducing agents, basic in nature, form cations, ionic compounds & shows max. photoelectric effect. Cf & K show max. photoelectric effect.

• Electron Gain Enthalpy / Electron affinity:

Energy released when neutral isolated gaseous atom accepts an extra electron to form a gaseous anion. $E_1 > E_2 > E_3$

■ Factors affecting E :

i) $E \propto 1/\text{atomic size}$. iii) $E \propto 1/\text{screening effect}$

ii) $E \propto Z_{\text{eff}}$ iv) $E \propto 1/\text{stable electronic config.}$

■ Variation in Value of E :

Period - Moving left to right E increases.

Halogens > Oxygen Family > Carbon Family > Nitrogen Family > metals of grp I & III > metals of grp II > zero group.

Group - moving down the group electron affinity decreases as Z_{eff} decreases.

■ For VII grp, sequence is I < Br < F < Cl

■ Oxidising power $\propto E_a$

reactivity of non metal $\propto E_a$.

- Electronegativity: Power or tendency of an atom in a molecule to attract the shared pair of electrons towards itself.

Electronegativity Scale:

i) Pauling's Scale: $\frac{1}{2}(E_A - E_A) + \frac{1}{2}(E_B - E_B) \rightarrow A - B$.

Pauling related the resonance energy of a molecule AB with the electronegativities of the atoms A & B.

$$\Delta_{AB} = E_{A-B}(\text{experimental}) - E_{A-B}(\text{theoretical})$$

$$= E_{A-B} - (E_{A-A} \times E_{B-B})^{1/2}$$

$$\Delta_{AB} = 30(x_A - x_B) \Rightarrow [0.182\sqrt{\Delta_{AB}} = x_A - x_B] \text{ in eV}$$

$$[0.088\sqrt{\Delta_{AB}} = x_A - x_B] \text{ in kJ}$$

So, to calculate x_A , when x_B , E_{A-B} , E_{A-A} & E_{B-B} are given, $x_A = x_B + 0.088\sqrt{E_{A-B} - \sqrt{E_{A-A} \cdot E_{B-B}}}$

ii) Mulliken's Scale: $x = \frac{I + E}{2}$, average of ionisation energy & electron affinity (in eV).

$$x = \frac{I + E}{540} \quad (\text{in kJ/mol})$$

iii) Alfred & Rochow's Method: $x = -0.359 \times \frac{Z_{\text{eff}}}{r^2} + 0.744$
r → covalent rad.

■ Factors affecting EN:

- i) $EN \propto z_{\text{eff}}$
- ii) $EN \propto 1/\text{size}$
- iii) $EN \propto IE$
- iv) $EN \propto EA$.

v) Higher the +ve charge greater EN.

vi) EN depends upon the nature of substituent attached to atom.

vii) $EN \propto s\text{-percentage}$. $sp > sp^2 > sp^3$.

■ Variations in EN value:

period - moving left to right EN

increases. IA < IIA > IIIA < IV A < VA > VIA < VIIA

group - moving top to bottom EN decreases.

■ Decreasing order of EN: F > O > N > Cl > C > B.

 1 3.5 3 2.97 2.5 2.

■ Application:

i) Calculation of partial ionic character on a covalent bond:

Hannay & Smyth Eqn:

$$\text{Ionic Character \%} = 16(x_A - x_B) + 3.5(x_A - x_B)^2$$

$$\text{Ionic Character \%} = 1 - e^{-1/4}(x_A - x_B)^2$$

When EN difference is greater than 1.7
the compound will be ionic in nature.

ii) Bond strength: Directly proportional to the EN difference of bonded atoms. HF > HCl > HBr > HI.

iii) Bond angle: Bond angle & EN of central atom.

iv) Acidic & Basic Nature of Oxides of Normal elements in period:

If $(x_{\text{oxygen}} - x_{\text{element}})$ value is about 2.3 or more then oxide will be basic. If $(x_{\text{o}} - x_{\text{E}})$ is less than 2.3 the oxide will be acidic.

• Nature of Oxy-acids: In a period the strength of oxy acids formed by non metals increase from left to right. In a group, the strength of oxy-acid of non metal decreases.

* Principal quantum number of an element (n) denotes the period of the element & number of elements in a period is equal to the number of electrons required to fill an orbit to the next level. e.g.

<u>Period</u>	<u>Filling of electron (Aufbau)</u>	<u>no. of electrons</u>
1	1s	2 (2x1)
2	2s 2p	8 (2x1 + 6x1)
3	3s 3p	8 (2x1 + 6x1)
4	4s 3d 4p	18 (2+10+6)
5	5s 4d 5p	18 (2+10+6)
6	6s 4f 5d 6p	32 (2+14+10+6)
7.	7s 5f 6d 7p.	32 (yet to be filled)

* Group-wise	special names of elements:	
Group 1	- Alkali Metal	- Li, Na, K, ...
Group 2	- Alkaline-earth Metal	- Be, Mg, Ca, ...
Group 11	- Coinage Metal	- Cu, Ag, Au
Group 15	- Pnictogens	- N, P, As, Sb, ..
Group 16	- Chalcogens	- O, S, Se, ...

* IUPAC Nomenclature for elements with $Z > 100$:

It was decided by IUPAC that the names of elements beyond atomic number 100 should use latin words for their numbers.

The names of these elements are derived from their numerical roots.

Numerical roots. —

0	1	2	3	4	5	6	7	8	9
nil	un	bi	tri	quad	pent	hex	sept	oct	en

e.g. $Z=101$ name - Unnilium

$Z=117$ name - Ununseptium

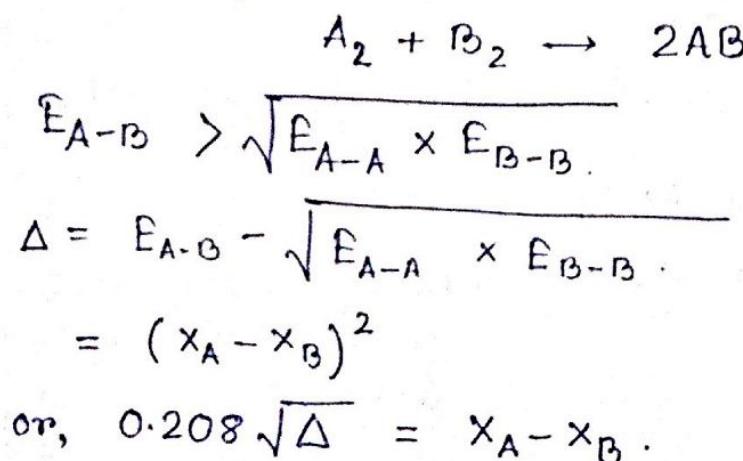
$Z=120$ name - Unbinilium

* A difference of 1.7 in electronegativities, the bond has 50% ionic character. If the difference is less than 1.7, the bond is considered covalent, and greater than 1.7 it is considered ionic.

* LiCl has lower M.Pt. than NaCl due to covalent nature.

Periodic Table.

- * Percentage of ionic character in a polar covalent bond: i) When change in electronegativities $X_A - X_B = 1.7$ the amount of ionic character in $A^{8-} - B^{8+}$ bond is 50% & that of covalent character is 50%. ii) When $(X_A - X_B) < 1.7$ the bond is more than 50% covalent & less than 50% ionic. iii) When $X_A - X_B > 1.7$ the bond is more than 50% ionic & less than 50% covalent.
 - * Fajan's Rules: 1. A small positive ion favours covalency. 2. A large negative ion favours covalency. 3. Large charges on either ion, or on both ions, favour covalency. 4. Polarisation, & hence covalency, is favoured if the positive ion does not have a noble gas configuration.
 - * Electronegativity in Pauling's Scale:



EN of H_2 is taken to be 2.1.

[0.208 arises from conversion of Kcals to eV]

* Electronegativity in Mulliken's Scale:

$$EN = \frac{I.E. + E.A.}{2}$$

1 eV = 96.48 kJ/mol

$$(EN)_{\text{Mulliken}} = 2.8 \times (EN)_{\text{Pauling}}$$

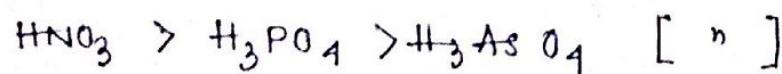
$$\Rightarrow (EN)_{\text{Pauling}} = \frac{IE + EA}{2 \times 2.8 \times 96.48} = \frac{IE + EA}{540}$$

* Nature of Oxides & Hydroxides:

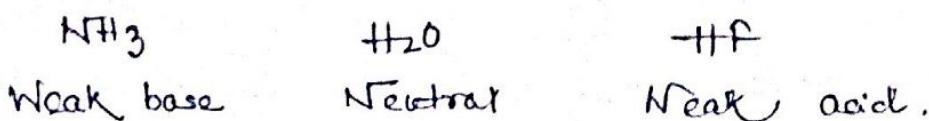
On moving left to right in a period basic nature decreases while acidic nature increases & moving down the group opposite happens. e.g. $\text{Na}_2\text{O} > \text{MgO} > \text{Al}_2\text{O}_3 > \text{SiO}_2 > \text{P}_2\text{O}_5 > \text{SO}_2 > \text{Cl}_2\text{O}_7$

$\text{NaOH} > \text{Mg(OH)}_2 > \text{Al(OH)}_3 > \text{Si(OH)}_4$ [Basicity].
most basic. most acidic.

* Nature of Oxy-acids: In a period, the strength of the oxy acids formed by non-metals increases from left to right & moving down group opposite happens.



* Nature of Hydrides: Nature changes from basic to acidic on moving left to right in a period.



Periodic Table.

- * Atomic volume: Volume occupied by one mole atoms of the elements in solid state at its melting point.

$$V_{\text{atomic}} = \frac{\text{gram atomic mass}}{\text{density}}$$

In a period, on moving left to right first it decreases to a minimum value & then start increasing. In a group, it increases down group.

- * B.Pt., M.Pt., Density: B.Pt., M.Pt., density increase to a maximum value then decrease along the period.

In a group, they increase down the group.

- * Hydration energy, Lattice Energy:

$$\begin{aligned} E_{\text{Hydration}} / E_{\text{lattice}} &\propto \text{charge on ion} \\ &\propto \frac{1}{\text{size of ion}} \end{aligned}$$

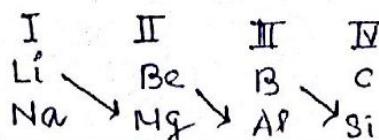
These increase left to right & decrease down the group. $\text{Li}^+ < \text{Be}^{2+} < \text{B}^{3+}$

- * Ionic Mobility: Ionic mobility $\propto \frac{1}{\text{charge on ion}} \propto \frac{1}{\text{size of ion}}$

It decreases left to right in a period.

- * Diagonal Relationship: Certain II period elements show some similarities

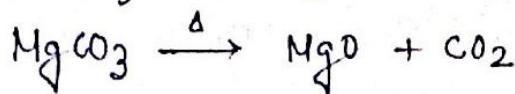
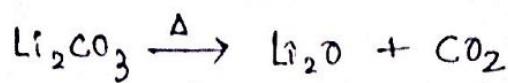
with the 3rd Period elements which are diagonal to them. It's due to the similar Ionic sizes, electronegativities & polarising power.



$$\text{Polarising power} = \frac{\text{Ionic charge}}{(\text{Ionic Gaydoshash}^2 \text{ Saha})}$$

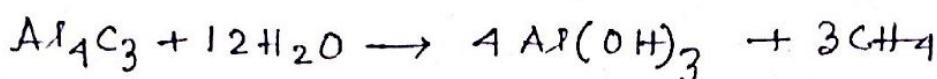
Diagonal relationship does not occur after IV group.

e.g. Both Li_2CO_3 & MgCO_3 on heating form their oxides & CO_2 .



BeO & Al_2O_3 are amphoteric oxides.

Carbides of Be & Al on hydrolysis give CH_4 .



* $\text{Fe}, \text{Co}, \text{Ni}$ have nearly same Z_{eff} value, so have almost same size & IE etc.

* Properties increasing along period, decreasing along group.

Properties decreasing along period, increasing along group.

1. Non-metallic nature
2. Electronegative nature
3. Oxidising nature
4. Electronegativity
5. ~~Oxidising~~ IE
6. Electron affinity
7. Lattice energy
8. Hydration Energy.
9. Aeric nature

1. Metallic nature
2. Electropositive nature
3. Reducing nature
4. Basic nature
5. Radius or size of atom
6. Ionic mobility.

* The bond-dissociation energy of F-F bond is very low. The weak F-F bond makes F the strongest oxidising halogen.