Inorganic Chemistry

Some basic concept of chemistry

Kinetics and thermodynamics
Feasibility of process.
Role of equilibrium
Types of inorganic reactions.

Kinetics and Thermodynamics :

Rate of Reaction — energy changes.

The catalyst has a kinetic effect on a reaction and alters rate of reaction without changing the ΔH of the reaction.

* Inert - low rate of reaction i.e. kinetics
* stable - less energy i.e. thermodynamics

Feasibility of Process :

> Related to thermodynamics.
> A process is feasible if ΔG for the given process is negative under specified conditions.
> spontaneous ($\Delta G = -ve$)
> Under coupled condition, the non spontaneous reaction ($\Delta G = +ve$) can also move in the forward direction eg: $Cu^{+2} + (I^-) \longrightarrow Cu^{+1} + I_2$
» strong Reducing agent

Role of equilibrium :

> ~~Rate~~ Related to thermodynamics.
> At equilibrium, rate of forward and backward reaction becomes equal and the concentration becomes constant (not equal)

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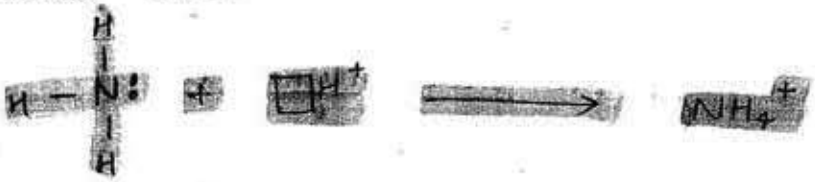
> high value of equilibrium constant (K_c) represent high stability of product and very low value represent high stability of reactant

$$\because K_c = \frac{[B]}{[A]} \qquad A \rightleftharpoons B$$

Types of inorganic Reactions :

- Acid - Base
- Redox
- Precipitation
- complex formation
- thermal decomposition

eg:) Acid - Base

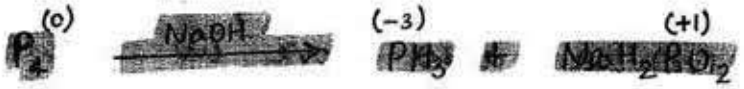


O.S = (-3) O.S = (-3)

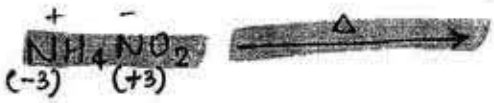
∵ no change in O.S ∴ no redox reaction

eg) Redox





(disproportion)



(com-proportion)

eg) Precipitations

* Nitrates are ALWAYS soluble



Ag, Hg, Pb compound of these metals are generally insoluable

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Precipitation are generally irreversible
Ag, Hg, Pb (आगा जाता श्रीधर)

$CuSO_4 + KI \longrightarrow Cu_2I_2\downarrow + I_2 + K_2SO_4$
(white) (violet)

eg of redox as well as precipitate.

eg) complex formation

$Fe^{+2} \xrightarrow{KCN\ (excess)} K_4[Fe(CN)_6]$

> generally d-block ion form complex because of their small size and high polarising power.
generally these compounds are water soluable

eg) Thermal decomposition

$CaCO_3(s) \xrightarrow{\Delta} CaO(s) + CO_2(g)$
limestone (calcite)

$\overset{+}{N}H_4\overset{-}{N}O_2(s) \xrightarrow{\Delta} 2H_2O(l) + N_2(g)$ com-proportion + thermal decompo

$\overset{-3}{N}H_4\overset{+5}{N}O_3(s) \xrightarrow{\Delta} N_2O(g) + H_2O(l)$ com-proportion + thermal decompo

$H_2O(ice) \xrightarrow{\Delta} H_2O(l)$ ✗ not a thermal decomposition.

* Heating in absence of air : Calcination.

Study ~~Structure~~ of Periodic Table

→ Structure of P.T

→ Periodicity ø in properties.

→ Development of P.T

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* Study of Periodic Table :

- formula for P.T. + arrangement of block
- e⁻ configuration
- To find gp no/Pd no
- Rel^{n} b/w no. of elements and Pd no.

Formula for P.T.

$$\boxed{n\,s\;(n-2)\,f\;(n-1)\,d\;np}$$

1s ~~1p~~ 2p ~~2d~~ ~~2d~~ 3d ~~4f~~ ~~3f~~ ~~3f~~ 4f

when $n=1$	1S (1-2)			
$n=2$	2S (3-4)			2p (5-10)
$n=3$	3S (11-12)			3p (13-18)
$n=4$	4S (19-20)		3d (21-30)	4p (31-36)
$n=5$	5S (37-38)		4d (39-48)	5p (49-54)
$n=6$	6S (55-56)	4f (58-71)	5d 57 (72-80)	6p (81-86)
$n=7$	7S (87-88)	5f (90-103)	6d 89 (104-112)	7p (113-118)

Arrangement of blocks :

- s block : gp no → 1, 2
- d ~~f~~ block : gp no → 3, 4 12
- p ~~d~~ block : gp no → 13 18
- f ~~f~~ block : gp no → III

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electronic configuration :

S - block

'S' = $(In)_{pre}\ ns^{1-2}$

Note : S - block configuration must not contain any e^- in $(n-2)f$, $(n-1)d$ or np subshell.

Q) A : The configuration ~~4~~ $(Xe)\,4f^0\,5d^1\,6s^2$ is a valid configuration for ground state of an element

R : This configuration belongs to s - block

[c]

∵ This is the ~~six~~ element with atomic no (57)

exception

P - block

'P' = $(In)_{pre}\ (n-2)f^{14}\ (n-1)d^{10}\ ns^2\ np^{1-6}$

examples :

II pd ⇒ $(He)\ 2s^2\ 2p^{1-6}$

III pd ⇒ $(Ne)\ 3s^2\ 3p^{1-6}$

IV pd ⇒ $(Ar)\ 4s^2\ 3d^{10}\ 4p^{1-6}$

V pd ⇒ $(Kr)\ 5s^2\ 4d^{10}\ 5p^{1-6}$

VI pd ⇒ $(Xe)\ 6s^2\ 4f^{14}\ 5d^{10}\ 6p^{1-6}$

& No exception

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d-block

(3d, 4d) W
(57, 89)
(4c) Pd

'd' = (In) pre $(n-2)f^{0/14}$ $(n-1)d^{1-10}$ ns^{0-2}

$21-30$ 3d Sc – Zn ⟶ d^4, d^9 X d^5, d^{10} (repeat) ∵ more stable

$39-48$ 4d Y – Cd ⟶ d^3, d^6, d^9 X d^5, d^{10} (repeat)

$57, 72-80$ 5d La – Hg ⟶ d^8 X d^{10} (repeat)

6d ⟶ d^9 X d^{10} (repeat)

eg: (4d) ⇒

39 →	$[Kr]_{36}$	$4d^1$	$5s^2$	
40 →	$[Kr]_{36}$	$4d^2$	$5s^2$	
41 →	$[Kr]_{36}$	$4d^4$	$5s^1$	
42 →	$[Kr]_{36}$	$4d^5$	$5s^1$	d^3, d^6, d^9 X
43 →	$[Kr]_{36}$	$4d^5$	$5s^2$	d^5, d^{10} ✓
44 →	$[Kr]_{36}$	$4d^7$	$5s^1$	
45 →	$[Kr]_{36}$	$4d^8$	$5s^1$	
* 46 →	$[Kr]_{36}$	$4d^{10}$	$5s^0$	
47 →	$[Kr]_{36}$	$4d^{10}$	$5s^1$	
48 →	$[Kr]_{36}$	$4d^{10}$	$5s^2$	

∵ $[Kr]_{36}$ ⇒ $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ d^{10} $4p^6$

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Q) Write the electronic configuration of 3d & 5d series.

3d Series (21-30)

21 → [Ar] 3d¹ 4s²
22 → [Ar] 3d² 4s²
23 → [Ar] 3d³ 4s²
24 → [Ar] 3d⑤ 4s¹
25 → [Ar] 3d⑤ 4s²
26 → [Ar] 3d⁶ 4s²
27 → [Ar] 3d⁷ 4s²
28 → [Ar] 3d⁸ 4s²
29 → [Ar] 3d⑩ 4s¹
30 → [Ar] 3d⑩ 4s²

d^4, d^9 ✗
d^5, d^{10} ✓

∵ $[Ar]_{18}$ ⇒ $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

5d Series 57, (72-80)

57 → [Xe] $4f^0$ $5d^1$ $6s^2$
72 → [Xe] $4f^{14}$ $5d^2$ $6s^2$
73 → [Xe] $4f^{14}$ $5d^3$ $6s^2$
74 → [Xe] $4f^{14}$ $5d^4$ $6s^2$
75 → [Xe] $4f^{14}$ $5d^5$ $6s^2$
76 → [Xe] $4f^{14}$ $5d^6$ $6s^2$
77 → [Xe] $4f^{14}$ $5d^7$ $6s^2$
78 → [Xe] $4f^{14}$ $5d^9$ $6s^1$
79 → [Xe] $4f^{14}$ $5d^{10}$ $6s^1$
80 → [Xe] $4f^{14}$ $5d^{10}$ $6s^2$

d^8 ✗
d^{10} ✓

∵ $[Xe]_{54}$ ⇒ $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}$

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f block

'f' = $(In)_{pre}$ $(n-2)f^{1-14}$ $(n-1)d^{0-1}$ ns^2

* Ln (58 – 71) : $[Xe]$ $4f^{1-14}$ $5d^{0-1}$ $6s^2$ $f^0, f^2, f^8 \times f^{14}, f^7$ ✓

* Ac (90 – 103) : $[Rn]$ $5f^{1-14}$ $6d^{0-1}$ $7s^2$ $f^1, f^5, f^8 \times f^7, f^{14}$ ✓

(La) ⇒

58 →	$[Xe]_{54}$	$4f^1$	$5d^1$	$6s^2$
59 →	$[Xe]_{54}$	$4f^3$	$5d^0$	$6s^2$
60 →	$[Xe]_{54}$	$4f^4$	$5d^0$	$6s^2$
61 →	$[Xe]_{54}$	$4f^5$	$5d^0$	$6s^2$
62 →	$[Xe]_{54}$	$4f^6$	$5d^0$	$6s^2$
63 →	$[Xe]_{54}$	$4f^{(7)}$	$5d^0$	$6s^2$
64 →	$[Xe]_{54}$	$4f^{(7)}$	$5d^1$	$6s^2$
65 →	$[Xe]_{54}$	$4f^9$	$5d^0$	$6s^2$
66 →	$[Xe]_{54}$	$4f^{10}$	$5d^0$	$6s^2$
67 →	$[Xe]_{54}$	$4f^{11}$	$5d^0$	$6s^2$
68 →	$[Xe]_{54}$	$4f^{12}$	$5d^0$	$6s^2$
69 →	$[Xe]_{54}$	$4f^{13}$	$5d^0$	$6s^2$
70 →	$[Xe]_{54}$	$4f^{(14)}$	$5d^0$	$6s^2$
71 →	$[Xe]_{54}$	$4f^{(14)}$	$5d^1$	$6s^2$

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(Ac) ⇒

90 →	$[Rn]_{86}$	$5f^0$	$6d^2$	$7s^2$
91 →	$[Rn]_{86}$	$5f^2$	$6d^1$	$7s^2$
92 →	$[Rn]_{86}$	$5f^3$	$6d^1$	$7s^2$
93 →	$[Rn]_{86}$	$5f^4$	$6d^1$	$7s^2$
94 →	$[Rn]_{86}$	$5f^6$	$6d^0$	$7s^2$
95 →	$[Rn]_{86}$	$5f^{(7)}$	$6d^0$	$7s^2$
96 →	$[Rn]_{86}$	$5f^{(7)}$	$6d^1$	$7s^2$
97 →	$[Rn]_{86}$	$5f^9$	$6d^0$	$7s^2$
98 →	$[Rn]_{86}$	$5f^{10}$	$6d^0$	$7s^2$
99 →	$[Rn]_{86}$	$5f^{11}$	$6d^0$	$7s^2$
100 →	$[Rn]_{86}$	$5f^{12}$	$6d^0$	$7s^2$
101 →	$[Rn]_{86}$	$5f^{13}$	$6d^0$	$7s^2$
102 →	$[Rn]_{86}$	$5f^{(14)}$	$6d^0$	$7s^2$
103 →	$[Rn]_{86}$	$5f^{(14)}$	$6d^1$	$7s^2$

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To find gp no / Pd no :

Case I: when atomic no (Z) is given

Pd: Interval of inert gas

gp: f block: III $\begin{bmatrix} 58-71 \\ 90-103 \end{bmatrix}$

gp no: $Z + 18 - (In)_{next}$

if the gp no from this formula comes to be (-ve), then apply

$Z + 32 - (In)_{next}$

Q. Find gp no | pd no | and block

i) 23	5	4	d
ii) 49	13	5	p
iii) 63	III	6	f
iv) 96	III	7	f
v) 87	1	7	s

i) $23 + 18 - 36$
$41 - 36 = 5$

ii) $49 + 18 - 54$
$67 - 54 = 13$

iii) $63 + 18 - 86$
$81 - 86 = -5$
$\therefore 63 + 32 - 86$
$95 - 86 =$
∵ lanthanoid

iv) 96
Actinoids

v) $87 + 32 - 118$
$119 - 118 = 1$

2	2
10	3
18	4
36	5
54	6
86	7
118	

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Case II : When electronic configuration is given:

1. $(In)_{pre}\ ns^x$ $(x = 1-2)$ [s-block]

   pd no → n

   gp no → x

2. $(In)_{pre}\ ns^2\ np^x$ $(x = 1-6)$ [p-block]

   pd no → n

   gp no → x + 12

3. $(In)_{pre}\ (n-2)f^{0/14}\ (n-1)d^x\ ns^y$ [d-block]

   pd no → n

   gp no → x + y

* In any configuration, the max no of ~~pd~~ quantum no (n) is the period no.

To find the relation b/w pd no and no of element

Period		no of element
1	1s	2
2	2s , 2p	8
3	3s , 3p	8
4	4s , 3d , 4p	18
5	5s , 4d , 5p	18
6	6s , 4f , 5d , 6p	32
7	7s , 5f , 6d , 7p	32

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$$n_e = \frac{(P+1)^2}{2} \quad \text{(when P is odd)}$$

$$n_e = \frac{(P+2)^2}{2} \quad \text{(when P is even} \Bigg] \text{ no of elements}$$

$$n_s = \sqrt{\frac{n_e}{2}} \quad \text{(no. of subshell)}$$

* The quantum no used by different subshell in a period.

$s \longrightarrow n$

$p \longrightarrow n$

$d \longrightarrow (n-1)$

$f \longrightarrow (n-2)$

$g \longrightarrow (n-3)$

$h \longrightarrow (n-4)$

Q. Find the no of element, no of subshell involved and the name of the subshell used in the imaginary 10th period of Periodic Table

$$n_e = \frac{(P+2)^2}{2} = \left(\frac{(10+2)}{2}\right)^2 = \frac{12^2}{2} = \frac{144}{2} = 72$$

$$n_s = \sqrt{\frac{72}{2}} = 6$$

i.e s p d f g h

∴ 10s 10p 9d 8f 7g 6h

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Periodicity

i) Shielding Effect : The inner e⁻s in an atom have a tendency to shield (repel) outer e⁻ from the nuclear charge. This tendency of inner e⁻ is called shielding effect.

> The order of shielding done by various sub-shells on others is $s > p > d > f$

> The inner shell e⁻s shield the outer shell e⁻ and not the vice versa.

k eg: 1s 2s 2p 3s 3p (4)s (3)d.

In this configuration 3d will shield 4s because 4s is outer

Slater Rule (Calculation of σ)

Same shell (n) → (0.35)

(n-1) → (0.85)

(n-2) → (1)

(n-3) and Inner → (1)

Q) Find the effective nuclear charge on the outermost e⁻ of Sc

$Sc_{21} \Rightarrow \underbrace{1s^2\ 2s^2\ 2p^6}_{(10\times1)}\ \underbrace{3s^2\ 3p^6\ 3d^1}_{(0.85\times9)}\ \underbrace{4s^{1+(1)}}_{(0.35\times1)}$

$\therefore \sigma_{net} = 18$

$ENC = Z - \sigma$ (Z: attractive, σ: repulsive)

$= 21 - 18 = 3$

∵ last e⁻ do not shield any e⁻

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Q. Which of the following is correct.

i) As we move from left to right in a period, the total shield increase

ii) As we move from top to bottom in a group the total shield increase

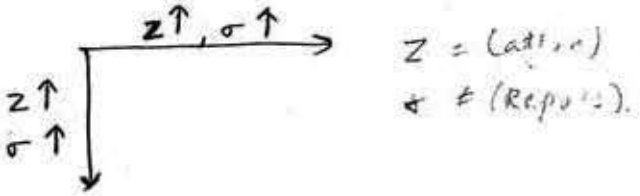
* iii) As we move from left to right in P-block, the increase in Zeff is more compared with the d-block

iv) All are correct.

iii) While moving in p-block from left to right, the last e^- enters in nth shell so increase in Zeff is approx 0.65 units.

In d-block, the last e^- enters in (n-1)d and the approx increase in Zeff is only 0.15

→ This also explain that the size of d-block element do not change too much from left to right

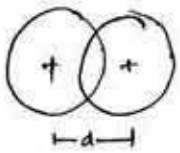


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Atomic Size :

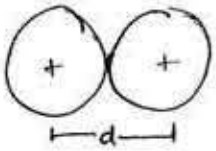
It is generally measured in 3 ways

i) Covalent Radius



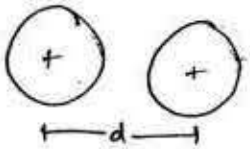
$$r_{covalent} = \frac{d}{2}$$

ii) Crystal / Metallic Radius



$$r_{crystal} = \frac{d}{2}$$

iii) Vanderwall Radius



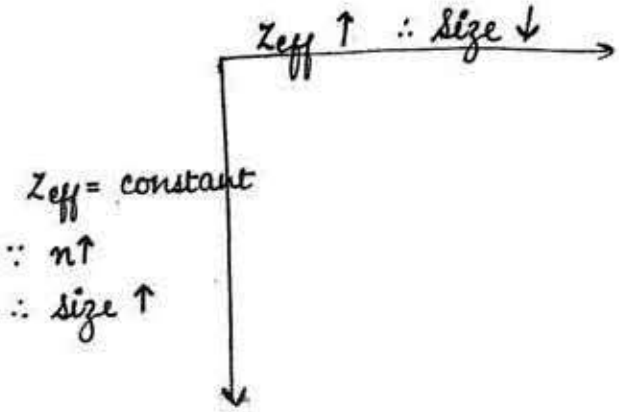
$$r_v = \frac{d}{2}$$

* When measured for the same ~~met~~ atom,

$$r_{vanderwall} > r_{crystal} > r_{covalent}$$

> The size of inert gases is abnormally high in a period because for them vanderwall radii is measured.

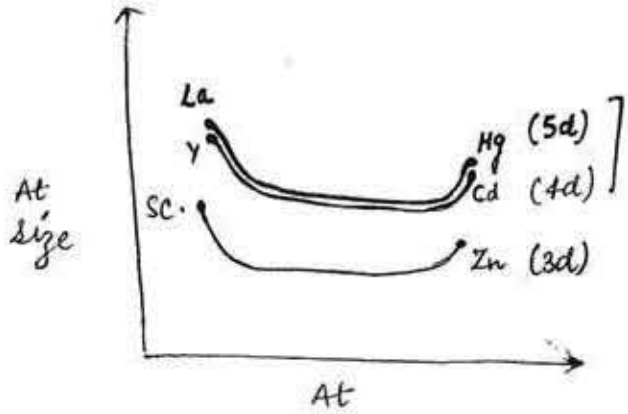
Variation of size in periodic Table :



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Exceptions :

i) (d-block) (L-R)



due to lanthanoid contraction

(T-B)

$Al \simeq Ga$

› B/w Al and Ga, 18 e^- are filled out of which 10 e^- belongs to 3d subshell. The d-orbitals has poor shielding due to ∯ diffused shape. ∴ The Shell effect is compensated by increase in Z_{eff}.

In brief, it can be explained by poor shielding of 3d e^- or Transition contraction.

* $4d \simeq 5d$

Size of 4d and 5d elements is observed to be quiet similar which can be explained by lanthanoid contraction.

∴ lanthanoid contraction : In lanthanoids i.e 58-71 the last e^- enter into 4f subshell which have poor shielding due to the diffused shell. ∴ Z_{eff} increases from left to right, resulting into contraction in size

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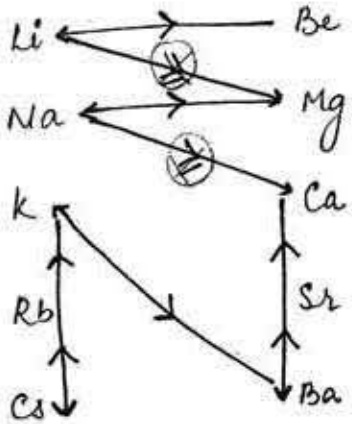
eg: $Ti < Zr \simeq Hf$

$Sc < Y < La$

Variation in size in s and p block :

s-block

(Atomic size)



(Ionic size)

2 exceptions

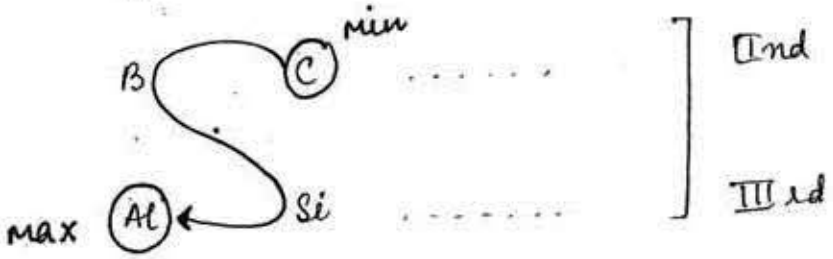
$Li^+ \geq Mg^{2+}$ $Na^+ < Mg^{2+}$

$Na^+ \geq Ca^{+2}$

∵ others are same as atomic size only.

P-block

The size of II and III rd period can be relat by s- symmetry which indicates dominance of the shell effects



$\therefore C < B < Si < Al$

Ionic size, Iso electronic ions :

i) $X \xrightarrow{-e} X^+$ $(X^+ < X)$

ii) $X \xrightarrow{+e} X^-$ $(X^- > X)$

iii) For Iso electronic series : $\boxed{\text{Size} \propto \frac{1}{Z}}$ ★★

eg: $Cu^+ > Ni^{+2}$

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Q) Give the correct order of size of atoms / ions.

i) Li Na | K Rb | Cs Fr
Δx Δy Δz

compare Δx, Δy and Δz (size different)

$\Delta x > \Delta y > \Delta z$ (∵ increase in size decreases down the group)

ii) Li^+, Na^+, Mg^{+2}, K^+, Sr^{+2}

$Mg^{+2} < Li^+ < Na^+ < Sr^{+2} < K^+$

iii) Li, Ca, Sr, K

$Li < Ca < Sr < K$ (∵ MN funda)

iv) C, N, P, Si

$N < C < P < Si$ (∵ s symmetry)

*v) Sc, Y, La

$Sc < Y < La$

*vi) Ti, Zr, Hf

$Ti < Zr \simeq Hf$

vii) Cu, Ag, Au

$Cu < Ag \simeq Au$

viii) Sc, Ni, Zn

$Ni < Zn < Sc$

*ix) Na^+, Mg^+, Mg^{+2} $Mg^+ > Na^+ > Mg^{+2}$

x) I^-, I^+, I

$I^+ < I < I^-$

xi) Ce^{+3}, Pr^{+3}, Pm^{+3}, Sm^{+3}, Nd^{+3}

$Sm^{+3} < Pm^{+3} < Nd^{+3} < Pr^{+3} < Ce^{+3}$ (Lan. contraction)

xii) $Cu^+ > Zn^{+2} > Ga^{+3} > Ge^{+4}$ $\left(\text{size} \propto \frac{1}{z}\right)$

xiii) Na^+, Mg^{+2}, F^-, O^{-2}, N^{-3}

$Mg^{+2} < Na^+ <$

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xiv) B < Al ≈ Ga < In < Tl

xv) H, H^-, F^-

$H^- > F^- > H$

In conversion of $H \longrightarrow H^{\ominus}$, there is 100% increase in the no of e⁻ which results into abnormal growth of Atomic size.

Ionisation Energy: [IE_1 / IP / ΔH_e]

The energy required to remove, the most loosly held e⁻ from an isolated gaseous atom is called ionisation energy

Mathematically,

$$IP = \frac{13.6 \times Z^{*2}}{n^2}$$

$Z^* = Z_{eff} = Z - \sigma$

Factors affecting IP:

i) Size: $IP \propto \frac{1}{size}$

Si ↓ IP ↑

Si ↑

IP ↓

ii) σ : $IP \propto \frac{1}{\sigma}$ where σ is shielding effect (repulsive)

iii) Penetration effect: $s > p > d > f$

This effect can create exception but its valid only for consecutive element (change of atomic no should be 1)

eg: IP of Be, B and C i.e $[2s^2]$ $[2s^2 2p^1]$ $[2s^2 2p^2]$ C > Be > B.

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iv) Stability of configuration :

Extra stable configuration (half and full filled) have higher IP then expected. but only for ~~consecutive~~ consecutive element.

eg: $F > \boxed{N > O}$

$[2p^5]$ $[2p^3]$ $[2p^4]$

half filled

Q Give the IP order of IInd period element.

Li, Be, B, C, N, O, F, Ne

IInd period: $Li < \boxed{B < Be} < C < \boxed{O < N} < F < Ne$

III period: $Na < \boxed{Al < Mg} < Si < \boxed{S < P} < Cl < Ar$

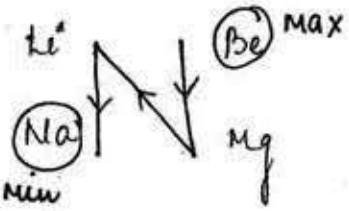
s^2 (Stable) half filled

Block wise Variation :

S block

The adjacent 4 elements of S- block show N-symmetry because left to right variation is generally more

eg:



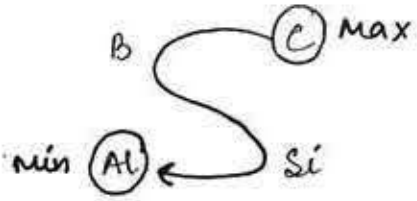
P - block

In p- block, shell variation is more imp.

∴ S- symmetry is followed in adjacent four elements.

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eg:



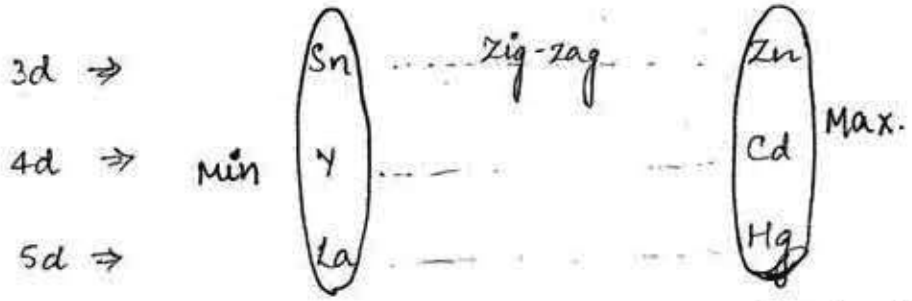
(Top → Bottom)

B	C
Al	Si
Ga	Ge
In	Sn
Tl	Pb

$\therefore$ B > Tl > Al ≃ Ga > In

$\therefore$ C > Si > Ge > Pb > Sn

d-block



due to stability of e⁻ configuration.

(Top → bottom)

i) Sc > Y > La

ii) 5d > 3d > 4d

5d > 4d > 3d

* -ve charges has more repulsion ∴ less IP
* charge is dominant over configuration
* (Non-metals)$_{IP}$ > (Metals)$_{IP}$ (take e⁻)

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Q) Write down the IP order for following atoms.

i) Be, B, N, O

B < Be < O < N

ii) F, Cl, O, S

iii) Mg, Al, Cl

iv) F^-, F

$F^- < F$

v) Ne^+, Ne

$Ne < Ne^+$

vi) ~~O_2~~ O^{-2}, O

$O^{-2} < O$

C, Sn, Pb

B, Al, In, Tl

F, Cl, Na, K

ii) I, K

I > Li > K

Zn Ga Zn > Ga

Cd > In

Hg > Tl

Cr < W

Sc > Zn

Sc, Y, La

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Sc, Mn, Zn

Tc, Cd, Y

I^+, I^-, I°

H, He^+, Li^{+2}

Lu, Ag, Au

Applications of I.P :

i) Cs is used in photocells due to its low I.P.

* Metallic character $\propto \frac{1}{IP}$

(ii) Reducing Properties :

Generally metals having low sublimation energy and IP accompanied with high hydration are good reducing agent.

∵ The reducing properties depends on (SE, IP and hydration) ∴ It does have a straight variation.

$$M(s) \xrightarrow{(SE)} M(g) \xrightarrow{(IP)} M^+(g) \xrightarrow{H_2O} M^+(aq) + (H.E.)$$

* Li is a best reducing agent due to high hydration enthalpy of Li^+ ion.

For better reducing properties : low SE (endo)
low IP (endo)
high H.E (exo)

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iii) Stability of oxidation state :

$$M \xrightarrow{IP_1} M^{+1} \xrightarrow{IP_2} M^{+2}$$

Rule 1: If the difference b/w two successive IP is less than 11 eV, higher oxidation state is more stable

eg: Mg^{+2} is more stable than Mg^{+1}

Rule: If the difference b/w two successive IP is more than 16 eV, the lower O.S. is more stable.

* If there is a sudden jump in nth IP, then in general stable O.S. will be (n-1)

Q.

Elements		IE_1	IE_2	IE_3
P	P^+	99	1079	1361
Q	Q^{+2}	142	216	1647
R	R^{+1}	112	1723	1964
S		973	1214	1469
T		361	498	627

i) which two element must belong to the same group of periodic table. P & R

ii) which element form the oxide of the type MO ~~E~~ Q

iii) when P, Q and R, reacts seperately with ~~C~~ F what is the formula of the compound obtained

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iv) which element is most likely to be an inert gas (5)

Electron Affinity =

When a e^- is added to a neutral gaseous atom, then in most cases, the energy is released (exothermic), which is called E.A.

$$A + e^- \longrightarrow A^- + \text{energy} \rightarrow EA$$

It can be exothermic or endothermic depending on the nature of A.

> Nowadays, e^- gain enthalpy ΔH_{eg} which has opposite sign as that of affinity.

ΔH_{eg} — (−ve) → exo; (+ve) → endo

> For a given change,

$$A + e^- \longrightarrow A^- + (10\ eV) \rightarrow \text{IP of } A^- \text{ OR } \text{EA of } A$$

$$\therefore \boxed{\text{EA of } A = \text{IP of } A^-}$$

Factors affecting E.A

i) $E.A \propto \frac{1}{\text{size}}$

E.A ↑

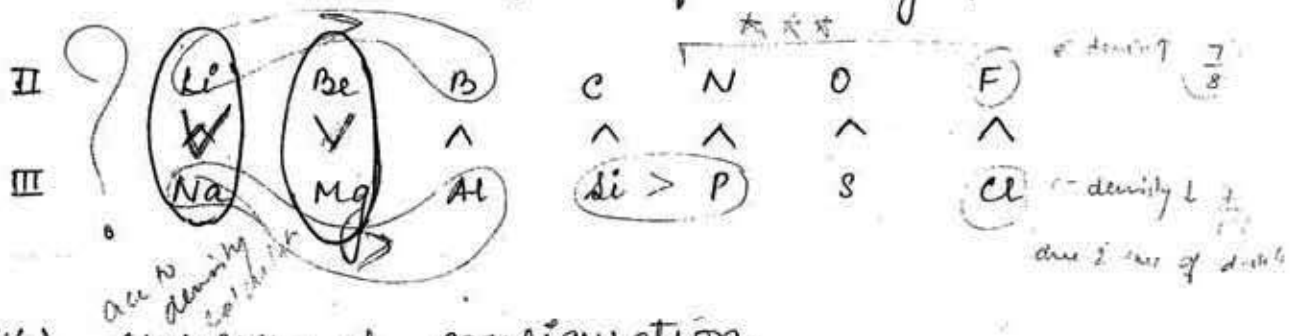
E.A ↓

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(ii) e⁻ density : $EA \propto \frac{1}{e^- \text{ density}}$ [dominating in II and III period.]

b/w II and III period, the e⁻ density decrease and ∴ the size increases.

The e⁻ density is observed to be the dominating factor due to which EA of IIIrd period element is higher compared to IInd period element with exception of Be, Mg pair.



(iii) Stability of configuration

For the stable configuration, EA is very low and in most of the cases, the e⁻ addition becomes endothermic for stable configuration.

Q) Explain why

i) e⁻ addition to Be, Mg and N is endothermic.

(ii) EA of Si > P

iii) EA of Li > B

iv) EA of Na > Al

i) Be = $2s^2$
Mg = $3s^2$
N = $2p^3$
→ Reasons : Stable e⁻ configuration

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[Be and Mg] → due to stable configuration
→ good shielding of s-e⁻
→ The new e⁻ has to enter in high energy sublevel (p-subshell)

[N] → stable configuration (half filled)
→ high e⁻ density

ii) EA of Si > P

Si : $3s^2 3p^2$, now if we add an e⁻ it will be $3s^2 3p^3$ (highly stable)

P : $3s^2 3p^3$, and we we add an e over here it will be $3s^2 3p^4$ (unstable)

iii) EA of Li > B (Li is metal whereas B is non-metal)

(Li).

$2s^1 + e^- \longrightarrow 2s^2$ { $2s^2$ is an stable config.

B

$2s^2 2p^1 + e^- \longrightarrow 2s^2 2p^2$ { and in B e⁻ will enter in bit higher level

iv) EA of Na > Al

due to stable configuration

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MRT Q) Give the order of EA of IInd period element excluding (Be) and (N) (endo)

$F > O > C > \boxed{Li > B}$

MRT Q) Give the order of EA of IIIrd period element excluding (Mg)

$Cl > S > \boxed{Si > P} > \boxed{Na > Al}$

Q) Find the exo/endo changes

i) $O \xrightarrow{+e^-} O^-$ (exo)

ii) $N + e^- \longrightarrow N^-$ (endo)

iii) $O^- \xrightarrow{+e^-} O^{-2}$ (endo) repulsion

iv) $O \xrightarrow{+2e^-} O^{-2}$ (endo)

v) $N^- \longrightarrow N$ (exo)

vi) $O^+ \longrightarrow O$ (exo)

☆ vii) $Na^+ \longrightarrow Na$ (endo)? exo

viii) $P \longrightarrow P^{-3}$ (endo)

ix) $S \longrightarrow S^{-2}$ (endo)

x) $N^{-3} \longrightarrow N$ (exo)

* If we have 2 compare IP of 2 Anions
→ 1st correct it into EA
eg $e^- - I^-$ (IP)

F Cl (EA)
$Cl > F$ (EA)
$Cl^- > F^-$ (IP)
e⁻ density

* iv) $O \xrightarrow[\text{exo}]{+e^-} O^- \xrightarrow[\text{endo}]{+e} O^{-2}$

less — more

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Compare the EA/IP of following Atoms / ions

i) $O > O^-$ (IP)

ii) $F^- < Cl^-$ (IP)

iii) $N^- < N$ (IP)

iv) $P^- > N^-$ (IP) [IP of P^- is endo and N^- is exo]

v) $O^- < S^-$ (IP)

** vi) F, Cl, Br, I (EA)

** vii) O, S, Se, Te (EA)

***** viii) Cu, Ag, Au (EA).

ix) B, Al, Cl (EA)

x) B, C, Si, Al (EA) ∵ min (B) C ($sp^2 \rightarrow sp^3$)

Al (Si) Max

viii) ****

Gold is a 5d element having high nuclear charge and poor shielding and ∴ forms stable Auride ions due to which gold show halogen like property.

eg: CsAu is an ionic compound consisting of $Cs^+ + Au^-$

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* Density factor should not be considered an important one while comparing IP of neutral elements

Applications :

i) Anion for tendency $\propto$ EA

* high EA is a common identity of reactive Nonmetals. while low ~~EA~~IP is an identity of reactive metal.

ii) Oxidising power of halogens :

Halogens are good oxidising agent which can be shown as :

$$X\{X \xrightarrow{BDE} X \xrightarrow{e} X^- + (EA) \xrightarrow{H_2O} X^-(aq) \quad (H.E)$$

BDE : $Cl_2 > Br_2 > F_2 > I_2$

EA : $Cl > F > Br > I$

* HE : $F^- > Cl^- > Br^- > I^-$

*** $F_2 > Cl_2 > Br_2 > I_2$ Overall oxidising power

~~HE is~~ The contribution of HE is very high. towards the oxidising power trend and :.

F_2 is a best oxidant

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Q. Which halogen can evolve O_2 from water when it comes in contact with it.

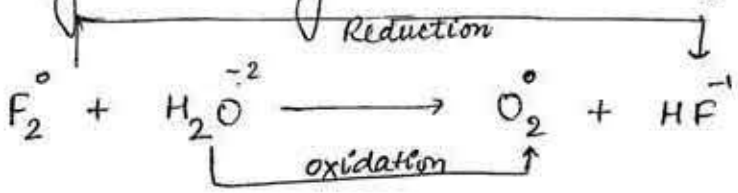
~~i)~~ F

ii) Cl

iii) Br

iv) I

* Water is not a good oxidant or reductant but F_2 being a strong oxidant, oxidize water into O_2



* $F_2 > Cl_2 > Br_2 > I_2$ (O.A)

$F^- < Cl^- < Br^- < I^-$ (R.A.) (aq)

Q. conc. H_2SO_4 is a moderate O.A which two salt can be oxidised by i) NaF, NaCl

~~ii)~~ NaBr, NaI

iii) NaCl, NaBr

iv) NaF, NaI

> Conc H_2SO_4 can oxidise Bromide and Iodide salt but fail to oxidise F^- and Cl^-

Acid/Base
- $NaF + \text{conc. } H_2SO_4 \longrightarrow HF$
- $NaCl + \text{conc. } H_2SO_4 \longrightarrow HCl$

Redox
- $NaBr + \text{conc. } H_2SO_4 \longrightarrow$ ~~H~~Br_2 (brown vapour)
- $NaI + \text{conc. } H_2SO_4 \longrightarrow$ I_2 (violet vapour)

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Q. Which of the following reactions occur spontaneously

i) $\overset{SOA}{F_2} + \overset{SRA}{Br^-} \longrightarrow \overset{WRA}{F^-} + \overset{WOA}{Br_2}$

ii) $\overset{SOA}{Cl_2} + \overset{SRA}{I^-} \longrightarrow \overset{WRA}{Cl^-} + \overset{WOA}{I_2}$

iii) $\overset{WRA}{KF} + \overset{WOA}{Br_2} \longrightarrow \overset{SRA}{KBr} + \overset{SOA}{F_2}$

iv) $KCl + I_2 \longrightarrow KI + Cl_2$

Electronegativity

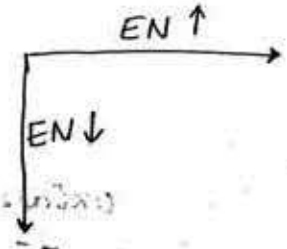
It is the tendency of an atom to attract the shared pair of e^- towards itself

- According to electronegativity, equilisation principle, the combining atom have the tendency to attain a common constant value of EN i.e in HCl molecule, after bond formation

$$(EN)_H^{+\delta} = (EN)_{Cl}^{-\delta}$$

Factors affecting EN:

i) $EN \propto \frac{1}{size}$



ii) $EN \propto Z_{eff}$

iii) $EN \propto$ s-character $(sp > sp^2 > sp^3)$

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eg:

$H-C\equiv C-H$ $\quad$ $CH_2=CH-H$ $\quad$ CH_3-CH_2-H

C_{sp} $>$ C_{sp^2} $>$ C_{sp^3}

(*?) Only terminal alkynes have acidic character because H is connected to sp hybridised atom.

$CH_3-C\equiv C-CH_3$ $<$ $CH_3-CH_2-C\equiv C-H$

Non terminal alkyne $\quad$ Terminal Alkyne

iv) Oxidation no:

EN $\propto$ (+) O.N.

eg: $P^{(+1)} < P^{(+3)} < P^{(+5)}$ (E.N)

Application of EN

i) Bond polarity $\propto$ Δ EN

$$\% \text{ ionic character} = 16\Delta + 3.5\Delta^2$$

Hany-Smith formula

>50% ionic character.

ii) Nature of oxide / Hydroxides:

In reference to the acid-base character, the properties of oxides and Hydroxides of same element is similar

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For a hydroxide M–O–H, nature can be acidic / basic depending upon EN of M. with increase in EN of M, acidic nature of hydroxide increases whereas, the basic nature increases when EN of M is low.

EN↑ ∴ Acidic nature of MOH ↑

EN↓

∴ Basic nature of MOH ↑

eg: $\overset{+2}{LiO}$ $\overset{+2}{BeO}$ $\overset{+3}{B_2O_3}$ $\overset{+4}{CO_2}$ $\overset{+5}{N_2O_5}$

Acidic nature ↑es

Nature of s- block oxides:

› All s-block oxides are Basic with the exception of BeO (amphoteric)

Nature of d- block oxides:

O.S	Nature
+1, +2, +3	Basic
+4	Amphoteric
+5, +6, +7, +8	Acidic

exception Cr^{+3} and Zn^{+2}

Note: $ZnCl_2$ is acidic in nature.

$$ZnCl_2 + H_2O \longrightarrow \underset{(WB)}{Zn(OH)_2} + \underset{(SA)}{HCl}$$

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Q) $Zn(OH)_2$ dissolves in excess of NaOH to give a salt that contains

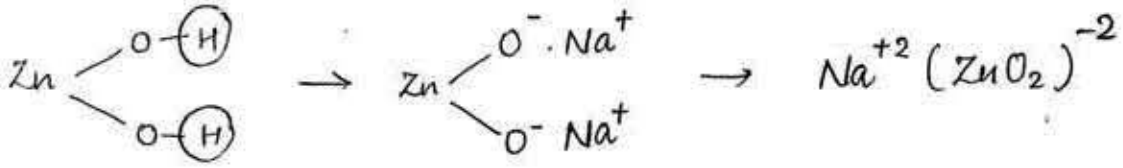
i) Zn in cationic part

~~ii)~~ Zn in anionic part

iii) Zn in both cationic and anionic part

iv) cannot be predicted.

$$Zn(OH)_2 \xrightarrow{NaOH}$$



P - block

Most oxides of p-block are acidic in nature with the exceptions of low oxidation members and metallic oxides.

* N_2O, NO, CO (Neutral)

* Oxides of Al, Ga, Sn, Pb are Amphoteric in nature

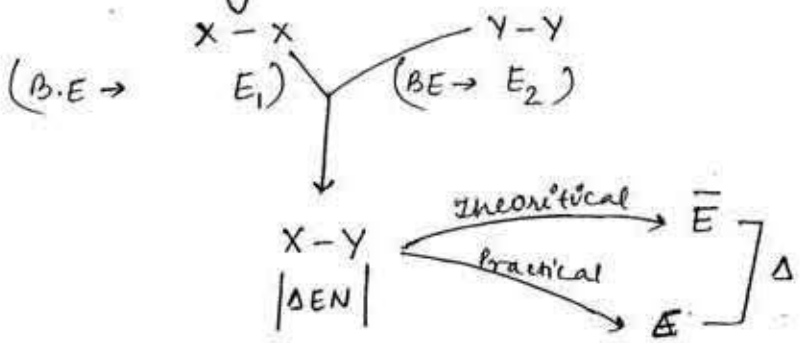
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* V_2O_5 is ~~matlb~~ mainly acidic but in few reactions, it shows amphoteric character

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Scales of EN

i) Pauling scale : It was based on bond enthalpy



$$\therefore \boxed{\Delta EN = 0.208\sqrt{\Delta}}$$

where $\Delta = (E - \bar{E})$ kcal mol^{-1} $\quad \because E > \bar{E}$ (due to considerations of EN)

ii) Mulliken's scale :

$$EN = \frac{1}{2}(IP + EA)$$

Limitation of this scale was that the correct values of EA is not known for no. of elements.

iii) Allred – Roschow scale :

According to this scale, EN is considered to be an attractive force b/w the nucleus and the shared e$^-$.

$$EN_{AR} = F_{att} = \frac{kq_1q_2}{r^2}$$

where $q_1 = Z_{eff} = Z - \sigma$

Limitation of this scale is that exact value of σ (mainly for heavier element) is not known.

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EN of II and III scale on pauling scale:

(Δ=0.5)	Li	Be	B	C	N	O	F
	1	1.5	2.0	2.5	3.0	3.5	4.0
(Δ=0.3)	Na	Mg	Al	Si	P	S	Cl
	0.9	1.2	1.5	1.8	2.1	2.5	3.0

Development of Periodic Table :

Q.) Identify the Doberneir triad in following

i) Li, Na, K (8, 8)

ii) F, Cl, Br (8, 18)

iii)

iv) Cl, Br, I (18, 18)

v) Ti, Zr, Hf (18, 32)

vi) O, S, Se (8, 18)

> The element must belong to same group with same atomic no. difference

Q. Identify the pairs following Newland's octane rule

> It should belong to the same group

> Difference in atomic no must be 8.

i) F, Cl

ii) Cl, Br

iii) O, S

iv) Mg, Ca

v) Na, K

vi) K, Rb

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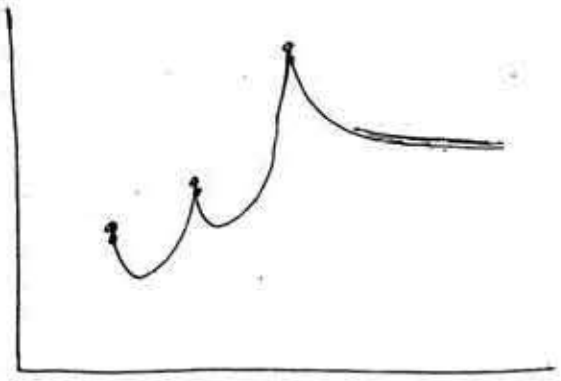
Q) Which positions were occupied by the following set of elements on Lothar Mayer curve

i) Alkali metals : Peak Portion

ii) Alkaline earthmetals : descending

iii) Halogens : ascending

iv) d-block elements : constant (flat part)



Q) In the Mendeleev's periodic table, empty spaces were left for the undiscovered elements. Identify the element.

Fe	Co	Ni	Sc	Ti	Tc	Ga	Al	Ge
✗	✗	✗	✓	✗	✓	✓	✗	✓
			↓		↓	↓		↓
			Eka B		Eka Mn	Eka Al		Eka Si

Al — Ga
B — Sc
Si — Ge
M — Tc

Q) Due to Mendeleev's table, Atomic weight of few elements were corrected, Name the element

Atomic weight = equivalent weight × valency

U, Be, In, Au, Pt ka bilmaan insaan aur pite

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Q) Which of the following were abnormal pair according to Mendeleev?

There are four pair showing abnormal sequence of atomic weight:

Ar > K

Te > I

Th > Pa

Co > Ni

Some important definitions:

i) Representative elements: s and p block element excluding inert gases. They can be representated by configuration $ns^{1-2}\ np^{0-5}$

ii) Transition elements: d-block elements which have vacancy of e⁻ in d-subshell in any of their stable state are called Transition element.

eg: Cu → $3d^{10}\ 4s^1$

Cu^{+1} → $3d^{10}\ 4s^0$

Cu^{+2} → $3d^9\ 4s^0$

∴ copper is a transition metal

Note: Zn, Cd and Hg always has d^{10} configuration and hence, these are non-transition d-block element

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iii) Typical element : IIIrd period elements are called Typical element as they characterise the properties of other elements in the same group.

iv) Bridge elements : Elements of IIIrd period like Na, Mg etc are called bridge elements because of formation of subgroups started right after them in the 4th period

v) Magic number : Numbers 2, 8, 18 and 32 (50, 72) are magic numbers, when one of these numbers is added to the atomic no of an element, a new element having similar property appears.

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