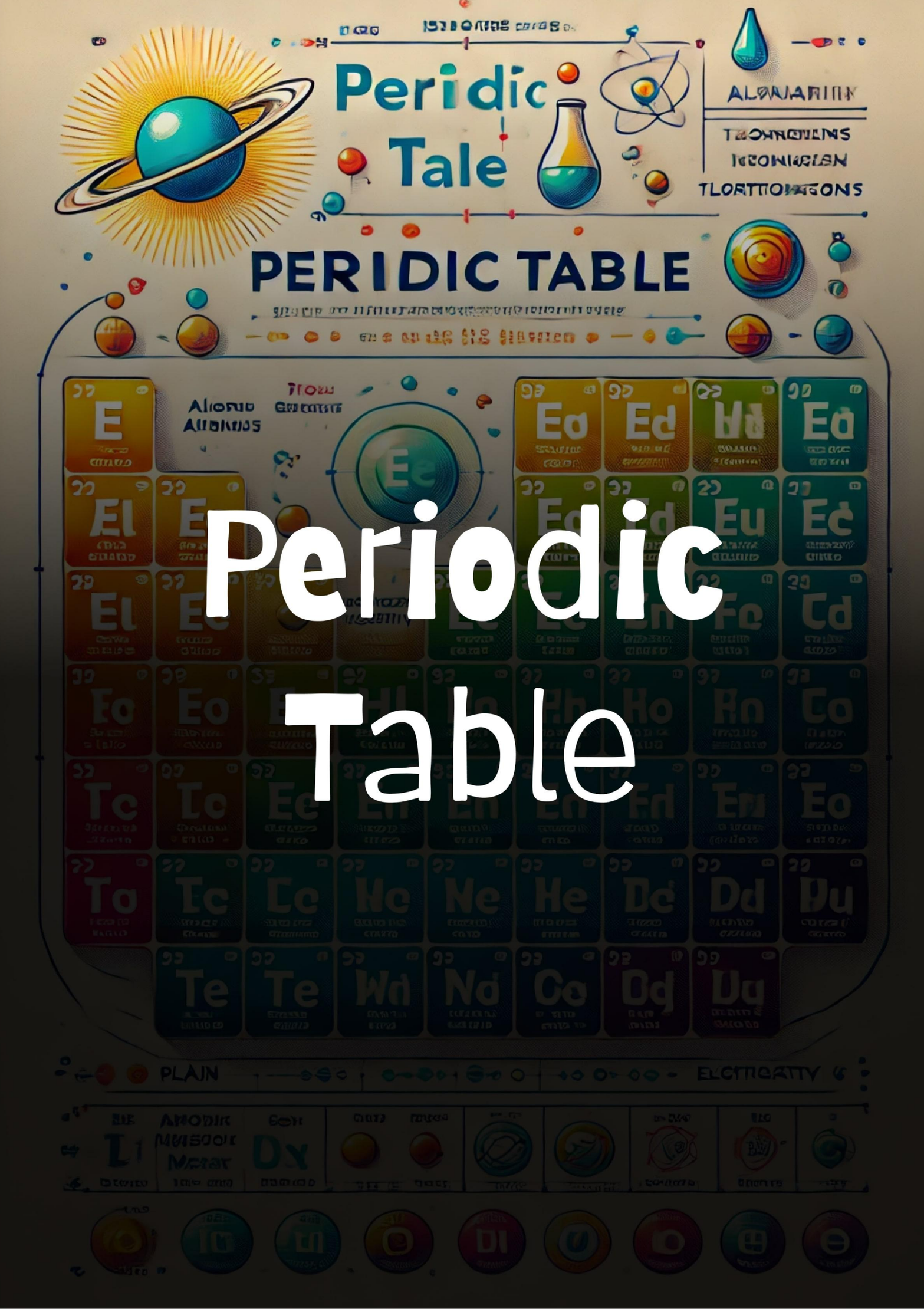


# * Periodic Table *

## * History of Periodic Table

① Prout's Hypothesis - According to him all elements are made up of Hydrogen and its isotopes.

eg- ${}^{7}_{3}Li$ → यह तो Hydrogen से बना है। eg $({}_1H^1) \rightarrow 7$
or ${}_1H^1 + 2\ {}_1H^3$ or $4\ {}_1H^1 + 3\ {}_1H^3$

| Atomic wt of any element | = n x atomic wt of one Hydrogen atom. |
|---|---|

But according to prout atomic wt will be integer.
Demerit / Failure - Atomic wt can be fractional also.
eg. Chlorine $Cl^{35.5}$
Strontium 87.5

② Lavoisier classification - (Father of Chemistry)
He arranged elements into metals & non-metals.

* Metal
(Tendency to loose e⁻)
↓
Electropositive in nature
eg - $Na_{(g)} \longrightarrow Na^{+}_{(g)} + e^{-}$

* Non-metal
(Tendency to accept e⁻)
↓
Electronegative in nature
eg - $Cl_{(g)} + e^{-} \rightarrow Cl^{-}_{(g)}$

Demerit / Failure - Failed after discovery of metalloid (properties of metal & non-metal both).

③ Dobereiner's Traid
Traid - set of three elements
He arranged the elements in set of three in such a way that atomic wt of middle element is arithmatic mean of other two element

Eg- Li 7 $\frac{7+39}{2} = \frac{46}{2}$ Cl 35.5 $\frac{127+35.5}{2}$
Na 23 Br 80
K 39 $\rightarrow$ $\rightarrow$ 23 I 127 = 81.25

Demerit ① All element do not follow Doberelner's Traid
eg. F 19
Cl 35.5 $\frac{19+80}{2} = 49.5$
Br 80

② It was only applicable for group

④ Newland law of octaves
Octave - eight (8)
Sa Re Ga Ma Pa Dha Ni Sa
1 2 3 4 5 6 7 8

→ First scientist who related properties of element with atomic mass
→ According to Newland when elements are arranged in increasing order of atomic wt then every 8th element will have same property like 1st element

1 2 3 4 5 6 7
Li Be B C N O F

8
Na Mg Al Si P S Cl

K Ca

Demerit - valid only upto calcium.
Failed after discovery of Inert gases

⑤ Lothar Mayer Curve - He plotted a curve betn atomic vol. (y-axis) & atomic wt (x-axis) for every element

atomic vol = $\frac{\text{mass}}{\text{density}}$ $\quad d = \frac{m}{V}$

Crest - Group 1 (alkali metals) Li, Na, K, Rb, Cs, Fr

→ Descending portion of Curve - Group 2 (Alkaline earth metals) Be, Mg, Ca, Sr, Ba

→ Ascending portion - Group 17 (Halogen) F, Cl, Br, I

→ Trough - metalloids or transition elements

Demerit - Different curve for different physical property.
- No practical use

* Mendeleev's Periodic Table

Mendeleev's Periodic Law - The physical and chemical properties of elements are periodic function of their atomic wt.

→ 63 elements were present

→ He arranged elements into 7 Horizontal rows & 8 vertical columns
1, 2, 3, 4, 5, 6, 7 I II III IV V VI VII VIII

→ Each group except VIII was subdivided into two groups (A & B)

| | I | | II | | III | | IV | | V | | VI | | VII | VIII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | A | B | A | B | A | B | A | B | A | B | A | B |
| 1 → | H | | | | | | | | | | | | | |
| 2 → | Li | | Be | | B | | C | | N | | O | | F | |
| 3 → | Na | | Mg | | Al | | Si | | P | | S | | Cl | |
| 4 → | K | Cu | Ca | Zn | □ | □ | Ti | | V | As | Cr | Se | Mn | Br | Fe Co Ni |
| 5 → | Rb | Ag | Sr | Cd | Y | In | Zr | Sn | Nb | Sb | Mo | Te | Tc | I | Ru Rh Pd<br>Os Ir Pt |
| 6 → | Cs | Au | Ba | Hg | La | Tl | | | | | W | | | | |
| 7 → | | | Ra | | | | Th | | | | U | | | | |

Group A → Main or normal elements - S & P block
Group B → Transition elements → D Block

* Merits of Mendeleev's Periodic Table

① He left some blank space for discovery of new elements
- eka Aluminium → Gallium (Ga)
- eka Boron → Scandium (Sc)
- eka Silicon → Germanium (Ge)
- eka manganese → Technium (Tc)

② He correct atomic weight of some elements which were wrongly calculated before

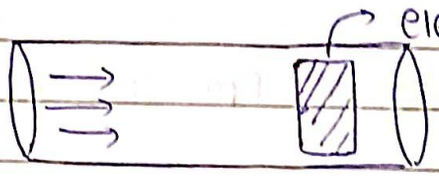
| U | Be | In | Au | Pt |
|---|---|---|---|---|
| Uranium | Berelium | Indium | Gold | Platinum |

* Demerit of Mendeleev's Periodic Table
① No separate position was given for Isotopes
② Position of Hydrogen was not fixed. (IA, VII A)
③ at some places order of atomic wt is Reversed to satisfy physical and Chemical properties.

| 40 | 39 | 127.6 | 127 | 58.9 | 58.6 |
|---|---|---|---|---|---|
| Ar | K | Te | I | Co | Ni |

* Modern Periodic Table
→ Proposed by Moseley

→ Moseley did an experiment in which he bombarded high speed electron on different metal surface & obtained x-Ray




observation | $\sqrt{\nu} \propto Z$ |

$\nu$ → Frequency
Z → atomic number

Modern Periodic law - Physical and Chemical properties of elements are periodic function of their atomic Number Means
if elements are arranged in increasing order of their atomic number then after a regular interval elements with similar properties are repeated.

Long form of periodic Table is contribution of Bohr & Bury Rang & Werner

→ It has 18 vertical columns (Groups)
7 Horizontal rows (periods)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | H | | | | | | | | | | | | | | | | | He |
| 2 | Li | Be | | | | | | | | | | | B | C | N | O | F | Ne |
| 3 | Na | Mg | | | | | | | | | | | Al | Si | P | S | Cl | Ar |
| 4 | K | Ca | Sc | Ti | V | Cr | Mn | Fe | Co | Ni | Cu | Zn | Ga | Ge | As | Se | Br | Kr |
| 5 | Rb | Sr | Y | Zr | Nb | Mo | Tc | Ru | Rh | Pd | Ag | Cd | In | Sn | Sb | Te | I | Xe |
| 6 | Cs | Ba | La | Hf | Ta | W | Re | Os | Ir | Pt | Au | Hg | Tl | Pb | Bi | Po | At | Rn |
| 7 | Fr | Ra | Ac | | | | | | | | | | | | | | | |

S Block — D-Block — P-Block

Lanthanides Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu
4f series

Actinides Th Pa U Np Pu Am Cm Bk Cf Es Fm Md No Lr
5f series

* Introduction to modern periodic table

S-Block - All the inner shells are complete
& last e⁻ falls in S subshell of outermost orbit

eg. 3 Li – $1s^2\ 2s^1$
11 Na – $1s^2\ 2s^2\ 2p^6\ 3s^1$
19 K – $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$

p- Block - All the inner shells are Fulfilled and last electron falls in 'p' subshell of outermost shell.

B - $1s^2\ 2s^2\ 2p^1$

Al - $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$

F - $1s^2\ 2s^2\ 2p^5$

P - $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$

D Block - Here pen ultimate shell & outermost shell are incomplete, last $e^-$ falls in d subshell of Pen-Ultimate Shell

26 Fe - $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^6$

21 Sc - $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^1$

30 Zn - $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}$

n → Outermost shell (Ultimate shell

n-1 → Pen ultimate shell

n-2 → Anti-pen ultimate shell.

F- Block - Anti penultimate, pen ultimate, outermost shell is incomplete

last $e^-$ falls in anti penultimate (n-2) shell.

Ce - $1s^2\ 2s^2\ 2p^6\ 3s^2, 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^6\ 6s^2\ 4f^2$

Exception of d - Block.

Pd - $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ \cancel{5s^2}\ 4d^8$

(46)

→ $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 4d^{10}$

Correct ⇒

* General Terminology

1) Normal or main or representative element
inner shell is complete and outermost shell is incomplete

| S Block + P Block except inert gas | → Representative / Normal / main. |
|---|---|

2) Typical element - element which represent properties of a group / family.
3rd period element except inert gas is known as typical element
eg. Na, Mg, Al, Si, P, S, Cl

Q) Why 2nd period elements are not considered as typical element ?
→ Small size.
→ Absence of d orbital
→ High ionization Energy

* Transuranic element
elements having atomic number is greater than 92 (Uranium)

* Transfermium element
element with atomic number > 100 (Fermium)

* Transition Elements
D Block - Group 3 - Group 12
Transition element - Group 3 - Group 11

The d-Block elements which has at least one unpaired electron either in ground state or in standard oxdn state

30 Zn → $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}$

$Zn^{+2}$ → $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}$

29- Cu → $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^{10}$

$Cu^{+1}$ → $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}$

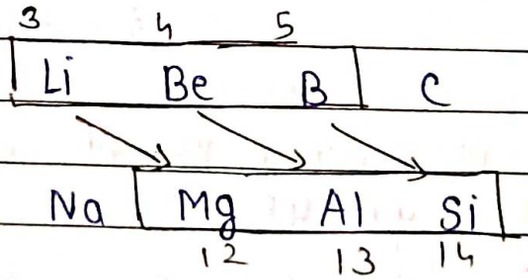
$Cu^{+2}$ → $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^9$

Except
Zn
Cd
Hg
↓
Group -12
no unpaired e⁻ (d)
not transition

* Inner Transition elements
→ All F Block elements are inner transition elements (क्योंकि ये transition element के अंदर पाए जाते हैं)

→ These are found in Group 3
" " " Period 6 → 4f orbital → 4f series → 58-71 ie Lu
" " " Period 7 → 5f orbital → 5f series → 90-103 Th
→ Last e⁻ falls in (n-2) f orbital.

* Diagonal Relationship
→ Some 2nd period elements (Li, Be, B) shows Diagonal relationship with 3rd Period element (Mg, Al, Si)




Reason for diagonal Relationship - Same ionic potential (ϕ)

ionic potential - $\frac{\text{charge}}{\text{size}}$

Q) Which of the following elements represent representative element

① $ns^{1-2}$ $np^{1-6}$ → inert gas

② $ns^{1-2}$ $np^{0-6}$ → inert gas

③ $ns^{1-2}$ $np^{1-5}$ → only P Block

✓④ $ns^{1-2}$ $np^{0-5}$ → S Block & P Block

* Study of Horizontal rows / periods

| Period | Subshell | | max $e^-$ | element | | name |
|---|---|---|---|---|---|---|
| 1 | 1s | | 2 | 2 | H-He | Shortest |
| 2 | 2s 2p | | 8 | 8 | Li-Ne | Short |
| 3 | 3s 3p | D Block | 8 | 8 | Na-Ar | Short |
| 4 | 4s 4p 3d | | 18 | 18 | K-Kr | long |
| 5 | 5s 5p 4d | F Block | 18 | 18 | Rb-Xe | long |
| 6 | 6s 6p 5d 4f | | 32 | 32 | Cs-Fr | longest |
| 7 | 7s 7p 6d 5f | | 32 | 32 | incomplete | incomplete |

Q) max no. of electron in 4th Period

4s 4p 3d

↓ ↓ ↓

1 3 5 = 9 orbital

= 18 $e^-$

= 18 element

Q. max no. of electron in 4th shell

4s 4p 4d 4f

1 3 5 7

= 16 = 32 $e^-$

= 32 element

Bahubali Trick

Max. no of element in a period = $XY^2$

X = no. of electron in an orbital (generally 2)

$Y = \frac{P+1}{2}$ ; P = odd

$Y = \frac{P+2}{2}$ ; P = even

P = Period no.

Q) Find max no of element than can be present in 8th Period assuming 2e⁻ are present in an orbital.

= $XY^2$

X = 2

$2 \times (5)^2$

= 50

$Y = \frac{P+2}{2}$ ; P = even

P = 8

$Y = \frac{8+2}{2}$

$\boxed{Y = 5}$

Q) max no. of element in 11th period

$XY^2$

$2 \times (6)^2$

$= \underline{72}$

$Y = \frac{P+1}{2}$ P = odd

$Y = \frac{11+1}{2}$ $Y = \frac{12}{2} = \boxed{Y = 6}$

Q) assume if an orbital holds 3 electron, then how many max electron can be found in 9th period

X = 3

$Y = \frac{P+1}{2}, \frac{9+1}{2} = 5$

$XY^2$

$3 \times (5)^2$

$\boxed{75}$

* IUPAC nomenclature of element having atomic no > 100

| | |
|---|---|
| 0 - Nil | 8 - oct |
| 1 - un | 9 - enn |
| 2 - bi | |
| 3 - tri | ① Add 'ium' at the end |
| 4 - quad | ② cannot place two 'i' together |
| 5 - pent | |
| 6 - hex | |
| 7 - sept | |

101 Unnilunium Unu

102 Unnilbium Unb

112 Ununbium Uub

117 Ununseptium Uus

104 Unnilquadium Unq

* Z - effective

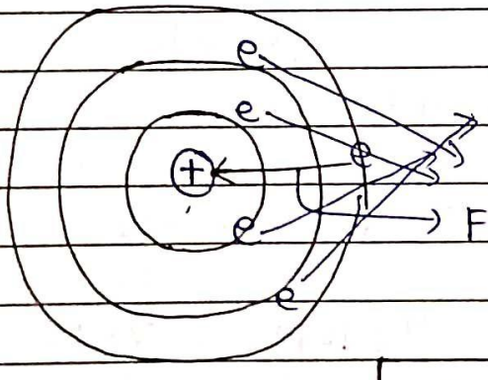
Effective nuclear charge

↳ nucleus का Charge

↳ proton & neutron

↓

nuclear charge



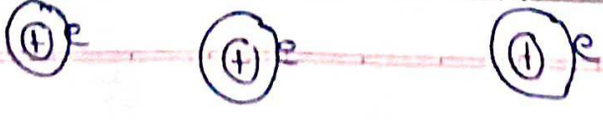

$F_{effective} = F_{attraction} - F_{repulsion}$

$F_{net\ attraction} = F_{attraction} - F_{repulsion}$

definition - The net attraction force experienced by nucleus on outermost electron is called z eff. or effective nuclear charge.

→ It is valid for single electron system

eg. H, $He^{+}$, $Li^{+2}$



$Z_{eff} = Z - \sigma$ → Slater's constant

↓ ↘

effective nuclear charge — Nuclear charge

**$Z_{eff}$ :- nucleus द्वारा actual attraction on outermost e⁻**

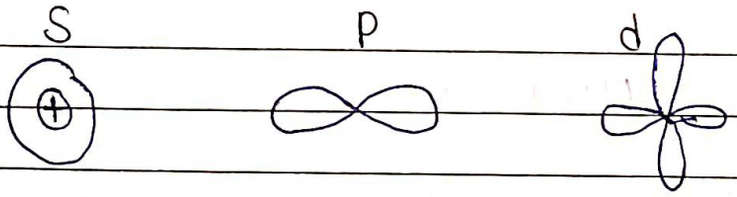
* Shielding effect / Screening effect

Inner electrons act as a shield betn inner nucleus & outer electron. Because of this shield nucleus has lesser attraction force on outer electron known as Shielding eff.

→ more the Shielding effect, less will be attraction force

→ Note. For subshell → S > P > d > f → Shielding effect order

poor Shielding → very poor Shielding




very complicated

Spherical less diffused — more diffused than S. — very much diffused Poor Shielding

Comparison of Z-effective.

① $Z_{eff} \propto \frac{1}{n}$

② Subshell S > P > d > f

Q.) Compare Zeff. in the following

4S 3d 4P 5f 1S 2P 6f 5d

$\Rightarrow Z_{eff} \propto \frac{1}{n}$ , S > P > d > f

1S > 2P > 3d > 4S > 4P > 5d > 5f > 6f

* Zeff in period & group

→ Zeff increases in a period from Left to right

→ Zeff. remains constant in a group from Top to bottom.

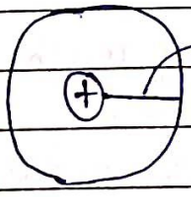
| Zeff ∝ +ve charge |
| --- |
| -ve charge |

Bahubali Trick

Q. Compare $H^- < Li^+ < Be^{+2} < B^{+3}$

Q. compare $N^+ > N > N^-$

* Atomic Radius / Atomic Size.




→ Radius

Concept: distance betn nucleus and outermost shell is called atomic Radius But we can't find the radius of an isolated atom. because :-

① Size of an atom is very small

② electron cloud surrounding the atom do not have sharp boundary

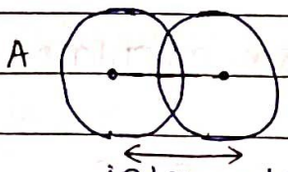
Therefore we will calculate atomic radius in bonded state.

# Atomic radius

Covalent Radius | Vanderwaal Radius | metallic Radius | ionic Radius

* Covalent Radius

Half of internuclear distance between two bonded atoms




internuclear distance (d)

↓

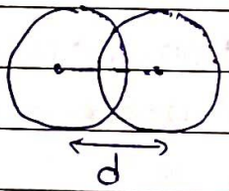
also called Bond length

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

Covalent Radius

① Homoatomic (same atom)

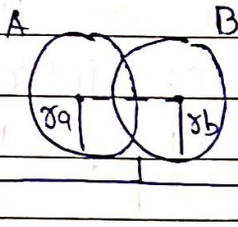
eg- $H_2$, $Cl_2$, $N_2$, $O_2$




$$\gamma_{cov.} = \frac{d}{2}$$

② Heteroatomic (different atom)

eg- HCl, HBr




$E_{NA} = E_{NB}$

↓

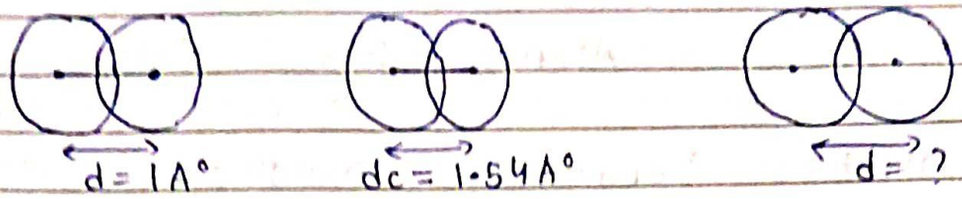
$$d = \gamma_a + \gamma_b$$

$E_{NA} \neq E_{NB}$

$$d = \gamma_a + \gamma_b - 0.09|E_{NA} - E_{NB}|$$

Schomaker & Stevenson Eqn

Q) X - X bond length is 1.00 A° and C-C bond length 1.54 A° If $E_{NX}$ is 3 and $E_{NC} = 2$ then find C-X bond length




$\gamma_x = 0.5\ A°$ $\gamma_c = 0.77A°$

$d = \gamma_c + \gamma_x - 0.09\,|EN_c - EN_x|$

$= 0.77 + 0.5 - 0.09\ (1)$

$= 1.27 - 0.09$

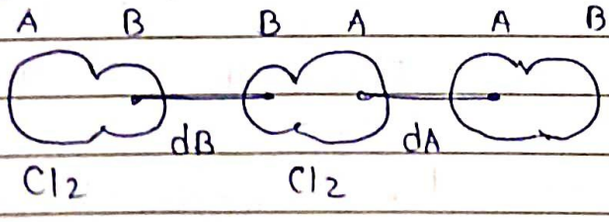
$= 1.18\ A°$

Note - double and triple bond are calculated in similar way.

| C - C | C = C | C ≡ C |
|---|---|---|
| 1.54 A° | 1.34 A° | 1.20 A° |
| $\gamma_c = \frac{1.54}{2}\ A°$ | $\gamma_c = \frac{1.34}{2}\ A°$ | $\gamma_c = \frac{1.20}{2}\ A°$ |
| $= 0.77\ A°$ | $= 0.68\ A°$ | $\gamma_c = 0.60\ A°$ |

* Vanderwall Radius

Half of internuclear distance of two non-bonded neighbouring atoms. (Two diff. non-polar molecule)

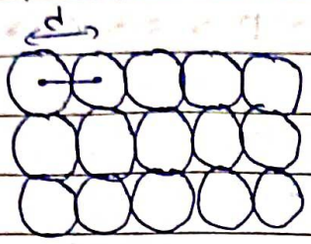



$\gamma_{vanderwall} = \frac{d_B}{2}$ ↓ B

$\gamma_{vanderwall} = \frac{d_A}{2}$ ↓ A

→ For inert gases vanderwall radius is prefered

* Metallic Radius:




$r_{metallic} = d/2$

Half of distance between nucleus of two nearest atoms in a metal

For same element

covalent Radius < metallic radius < Vanderwall Radius

V > M > C

* Variation of atomic Radius / size.

① Period : (no. of shell is constant)

$Z_{eff}$ → L to R → increases → size ↓

(net force of attraction)

② Group.

Top to bottom → size → increases → no. of shell increases

Period 1 - H < He

covalent Radius ↓ ↳ inert gas ↳ vanderwall Radius

Period 2 - Li Be B C N O F Ne

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

↑

inert gas

vanderwall Radius

Period 3 - Na Mg Al Si P S Cl Ar

Ar > Na > Mg > Al > Si > P > S > Cl >

Group

S-Block - No exception

Group 1 - Li < Na < K < Rb < Cs < Fr

Group 2 - Be < Mg < Ca < Sr < Ba < Ra.

P - Block

G13 → Exception

G14 → C < Si < Ge < Sn < Pb

G15 → N < P < As < Sb < Bi

G16 → O < S < Se < Te < Po

G17 → F < Cl < Br < I < At

G18 → He < Ne < Ar < Kr < Xe

Group 13

B

Al

Ga

In

Tl

B

^

Ga

^

Al

^

In

^

Tl

Ga, Al → d-d contraction or Transition contraction

In, Tl → F-F contraction or Lanthanide contraction

d-d contraction / transition contraction

Be - 2nd Period

Al 3rd "

Ga 4th "

In 5th "

Th 6th "

Gallium → 3d e⁻ → Poor Shielding, Zeff ↑, Size ↓

→ d Block element → electron enters in d Subshell

↓

Poor Shielding

↓

Size कम

# F-F contraction / Lanthanide contraction

B - 2nd Period
Al - 3rd " ] → Galium का size Al से छोटा हो जाता है।
Ga - 4th "
In - 5th "
Tl - 6th " → f block - e⁻ enters in f subshell
↳ very poor shielding
Size is Reduced
In ≃ Tl (थोड़ा बड़ा)

Thalium का size Indium से लगभग बराबर हो जाता है

D - Block

| G3 | G4 | G5 | G6 | G7 | G8 | G9 | G10 | G11 | G12 |
|---|---|---|---|---|---|---|---|---|---|
| Sc | Ti | V | Cr | Mn | Fe | Co | Ni | Cu | Zn |
| ∧ | ∧ | ∧ | ∧ | ∧ | ∧ | ∧ | ∧ | ∧ | ∧ |
| Y | Zr | Nb | Mo | ~~Tc~~ Ru | ~~Rh~~ Ro | ~~Pd~~ Rh | ~~Ag~~ Pd | Ag | Cd |
| ∧ | ‖ | ‖ | ‖ | ‖ | ‖ | ‖ | ‖ | ‖ | ‖ |
| La | Hf | Ta | W | Re | Os | Ir | Pt | Au | Hg |
| ∧ | | | | | | | | | |
| Ac | | | | | | | | | |

5th period & 6th period → almost same size
↓
Lanthanide contraction

Group 3 - 4th period → 3d series
∧
5th period → 4d series
∧
6th period → 5d series

Group 4 - 12 - 4th period
∧
5th period
6th " period

Compare Size B C Al Si

| | |
|---|---|
| B | C |
| A | Si |

Al, Si > B, C

Al > Si > B > C.

Compare size N O P S

N O

P S

P > S N > O

* Ionic Radius

Ion (addition / removal of electron)

Removal of $e^-$ → Cation

$Na \longrightarrow Na^+ + e^-$

2,8,1 2,8

P = 11, e = 10 ] Proton is winner, Zeff ↑, Size ↓

Size of cation < Size of neutral

Addition of $e^-$ → anion.

$Cl + e^- \longrightarrow Cl^-$

2,8,7 + $e^-$ → 2,8,8

electron is winner, size ↑ [ P = 17, e = 18

Size of anion > Size of neutral

Size of anion > size of neutral > size of cation

$Li^+ < Na^+ < K^+ < Rb^+ < Cs^+$

$F^- < Cl^- < Br^- < I^-$

$N^{-3} < P^{-3}$

$Be^{+2} < Mg^{+2} < Ca^{+2} < Sr^{+2} < Ba^{+2}$

$O^{-2} < S^{-2} < Se^{-2} < Te^{-2}$

Bahubali Trick

| Ionic Radius of same element | ∝ | -ve charge<br>+ve charge |
|---|---|---|

$O^{-2} > O^{-1}$

$Mn > Mn^{+2} > Mn^{+4} > Mn^{+6} > Mn^{+7}$

$Fe > Fe^{+2} > Fe^{+3}$

$Sn^{+2} > Sn^{+4}$

$Pa^{+3} > P^{+5}$

$S^{-2} > S^{-1}$

$Cr^{+2} > Cr^{+3}$ $Cr^{+6}$

Isoelectronic Species

Species having same no. of electrons

| $C^{-4}$ | $N^{-3}$ | $O^{-2}$ | $F^-$ | Ne | $Na^+$ | $Mg^{+2}$ | $Al^{+3}$ |
|---|---|---|---|---|---|---|---|
| $10e^-$ | $10e^-$ | $10e^-$ | $10e^-$ | $10e^-$ | $10e^-$ | $10e^-$ | $10e^-$ |

| Size of isoelectronic species | ∝ | -ve charge<br>+ve charge |
|---|---|---|

anion > neutral > cation

$S^{-2} > Cl^- > K^+ > Ca^{+2}$

$N^{-3} > O^{-2} > F^{-1} > Na^+ > Mg^{+2} > Al^{+3}$

$Li^+ > Be^{+3}$

* Ionization Energy

energy required to remove an $e^-$ from isolated gaseous atom $M(g) + IE \longrightarrow M^+(g) + e^-$ (Endothermic)

$\Delta H = +ve$

Successive IE- $M(g) + IE \rightarrow M^{+}(g) + e^{-}$

$M^{+}(g) + IE_2 \rightarrow M^{+2}(g) + e^{-}$

$M^{+2}(g) + IE_3 \rightarrow M^{+3}(g) + e^{-}$

Ionization energy $\propto$ oxidation state.

$IE_3 > IE_2 > IE_1$

Factors affecting IE

→ $IE \propto Z_{eff} \propto \frac{1}{\text{size}}$

→ Half & filled $e^-$ fulfilled are more stable · So IE is more.

→ S > P > d > F

Trend ~~Gro~~· Period- L to R → size ↓ - IE ↑

Group ↑ to B → size ↑ - IE ↓

H < He

Li (Be) B C (N) O F (Ne)

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

Na (Mg) Al Si (P) S Cl (Ar)

Na < Al < Mg < Si < S < P < Cl < Ar

Exception- Boron family

| | |
|---|---|
| B | C |
| V | V |
| Tl | Si |
| V | V |
| Ga | Ge |
| V | V |
| Al | Pb |
| V | V |
| In | Sn |

Compare $IE_1$ and $IE_2$ of O & N

O → $1s^2\ 2s^2\ 2p^4$ $\quad IE_1 \rightarrow N > O$
N → $1s^2\ 2s^2\ 2p^3$

O → $1s^2\ 2s^2\ 2p^3$ $\quad IE_2 \rightarrow O > N$
N → $1s^2\ 2s^2\ 2p^2$

* Electron gain Enthalpy
Energy released when an $e^-$ is added to isolated gaseous atom.

$\boxed{\Delta Eg = 1}$ $\quad A(g) + e^- \rightarrow A^-(g) \rightarrow \Delta H = -ve$ (exothermic)

$A^-(g) + e^- \rightarrow A^{-2}(g) \rightarrow \Delta H = +ve$ (endothermic)

$\Delta H_1 = -ve$ $\quad EA = +ve$ $\quad$ very high
$\Delta H_2 = +ve$ $\quad EA = -ve$

Factors affecting Electron gain Enthalpy
$\Delta H \propto Zeff \propto \frac{1}{Size}$

Half filled & full filled → more stable → very less $\Delta H_{eg}$

Period – Zeff ↑ → EA ↑
Group Size ↑ → EA ↓

$P_1$ H > He
$P_2$ Li [Be] B C [N] O F [Ne]
→ Ne < Be < N < B < Li < C < O < F

$P_3$ Na [Mg] Al Si [P] S Cl [Ar]
Ar < Mg < P < Al < Na < Si < S < Cl

Group

3rd Period → more affinity → than 2nd period

smallest size, extra e⁻, repulsion

| G13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|
| Al | Si | P | S | Cl |
| V | V | V | V | V |
| Ga | C | N | Te | F |
| V | V | V | V | V |
| In | Ge | As | Po | Br |
| V | V | V | V | V |
| Tl | Sn | Sb | O | I |
| V | V | V | | |
| B | Pb | Bi | | |

G16 < G17 → Affinity

* Electronegativity

→ attraction of covalent bonded shared pair of electron → EN

H — Cl

H — Cl

EN ∝ Zeff

$EN \propto \frac{1}{Size}$

EN ∝ % S

SP > SP² > SP³

50% 33% 25%

L to R - EN ↑

T to B - EN ↓

* Oxide.

L to R - Acidic nature ↑

T to B - Basic nature ↑