ARJUNA NEET BATCH

Classification of Elements & Periodicity in Properties

LECTURE-04

By:- Ashima Gupta

Objective of today's class

Periodic Trends: 1. Atomic Size

ARJUN

Quick Revision:

- **Blockwise electronic configuration**

$n \rightarrow$ Principal Q. No

1. s-block (Gp 1 & 2)

   General outer E.C. = ns^{1-2}

2. p-block (Gp 13–18)

   General outer E.C. = $ns^2 np^{1-6}$ {Except He : $1s^2$}

3. d-block (Gp 3–12)

   General outer E.C. = $(n-1)d^{1-10} ns^{0-2}$

④ f-block → Group 3/III B → correct

Lanthanoids : $(n-2)f^{1-14}(n-1)d^{0-1}ns^2$ (n=6) → 6th period

Actinoids : $(n-2)f^{0-14}(n-1)d^{0-2}ns^2$ (n=7) → 7th period

DPP-3 Q

Normal Elements (s-block + p-block) (except noble gases)

In NCERT

General E.C. can be best represented as : $\boxed{ns^{1-2}\ np^{0-5}}$

Pg 79 Gp 3 → IIIA is given in NCERT

Method to predict the period, group and block of a given element

Following steps are followed to predict the group, period and block of the element:

1. Electronic configuration of the element is written following various rules.
2. Period of the element is represented by the principal quantum number of the valence shell.
3. Block of the element is predicted on the basis of sub-shell which receives the last electron.
4. Group is predicted from the no. of electrons in the outermost or penultimate shell as follows:

(a) In case the element belongs to s-block, then the group = (no. of valence electrons)

(b) In case the element belongs to p-block, then the group = (10 + total no. of valence electrons)

(c) In case the element belongs to d-block, then the group = no. of electrons in (n – 1) d-subshell and n s-subshell.

TRICK

No. of valence e^-s

s-block
- Gp 1 : 1
- Gp 2 : 2

p-block
- Gp 13 : 3
- Gp 14 : 4
- Gp 15 : 5
- Gp 16 : 6

No. of valence e^-s

- Gp 17 : 7
- Gp 18 : 8 (except He)

ARJUN

$_{17}Cl \rightarrow$ Gp 17

p-block

Q An element have an E.C. $1s^2 2s^2 2p^6 3s^2 3p^5$, then to which group it belongs?

(1) 3 (2) 15

(3) 17 (4) 14

Group No. = 10 + valence e^-s

= 10 + 7

= 17

valence e^-s = 4

Q An element X belongs to group 14 and 2nd period of the periodic table. The atomic no. of X is

2 shells

(1) 6 (2) 14

(3) 32 (4) 50

$_6C : 1s^2 2s^2 2p^2$

The Modern Periodic Table of the Elements

H — Symbol
1 — Atomic Number
1.008 — Atomic Wigiht
Hydrogen — Name

( ) = Estimates

Coinage metals

	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIIIB	10	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	H 1 1.008 Hydrogen																	He 2 4.00
2	Li 3 6.94	Be 4 9.01											B 5 10.81	C 6 12.01	N 7 14.01	O 8 16.00	F 9 19.00	Ne 10 20.18
3	Na 11 22.99	Mg 12 24.31											Al 13 26.98	Si 14 28.09	P 15 30.97	S 16 32.07	Cl 17 35.45	Ar 18 39.95
4	K 19 39.10	Ca 20 40.08	Sc 21 44.96	Ti 22 47.88	V 23 50.94	Cr 24 52.00	Mn 25 54.94	Fe 26 55.85	Co 27 58.93	Ni 28 58.69	Cu 29 63.55	Zn 30 65.39	Ga 31 69.72	Ge 32 72.61	As 33 74.92	Se 34 78.96	Br 35 79.90	Kr 36 83.80
5	Rb 37 85.47	Sr 38 87.62	Y 39 88.91	Zr 40 91.22	Nb 41 92.91	Mo 42 95.94	Tc 43 (97.9)	Ru 44 (101.07)	Rh 45 (102.91)	Pd 46 (106.42)	Ag 47 (107.87)	Cd 48 (112.41)	In 49 114.82	Sn 50 118.71	Sb 51 121.76	Te 52 127.60	I 53 126.90	Xe 54 131.29
6	Cs 55 132.91	Ba 56 137.33	La 57 138.91	Hf 72 178.49	Ta 73 180.95	W 74 183.85	Re 75 186.21	Os 76 190.2	Ir 77 192.22	Pt 78 195.08	Au 79 196.97	Hg 80 200.59	Tl 81 204.38	Pb 82 207.2	Bi 83 208.98	Po 84 (209)	At 85 (210)	Rn 86 (222)
7	Fr 87 223.02	Ra 88 226.02	Ac 89 227.03	Rf 104 (261)	Db 105 (262)	Sg 106 (263)	Bh 107 (262)	Hs 108 (265)	Mt 109 (266)	Ds 110 (269)	Rg 111 (272)	Cn 112 (277)	Nh	Fl 114 (287)	Mc	Lv 116 (289)	Ts	Og

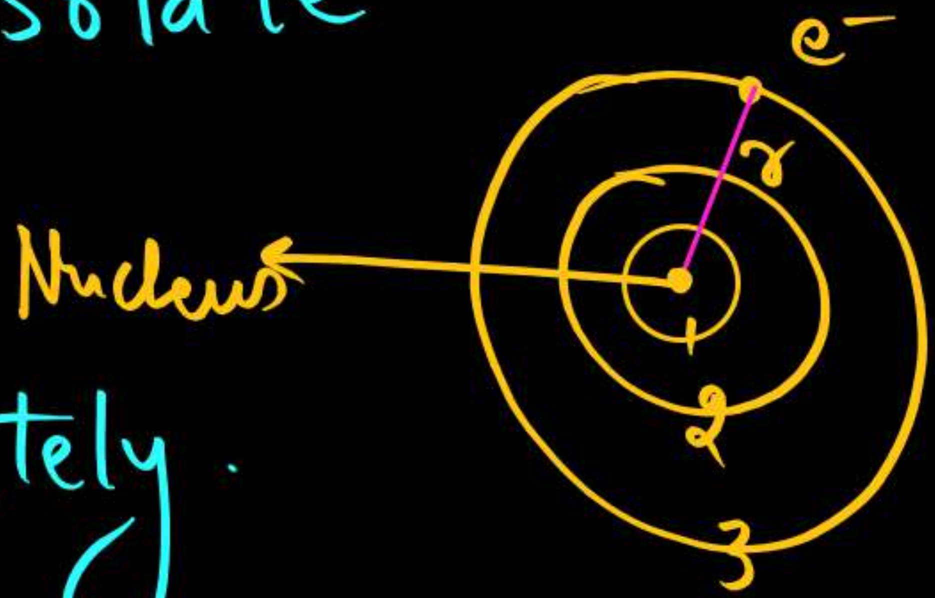
ALKALI METALS — ALKALI EARTH METALS — HALOGENS — NOBLE GASES

LANTHANIDES	Ce 58 140.12	Pr 59 140.91	Nd 60 144.24	Pm 61 (145)	Sm 62 150.36	Eu 63 152.97	Gd 64 157.25	Tb 65 158.93	Dy 66 162.50	Ho 67 164.93	Er 68 167.26	Tm 69 168.93	Yb 70 173.04	Lu 71 174.97
ACTINIDES	Th 90 232.04	Pa 91 231.04	U 92 238.03	Np 93 237.05	Pu 94 (240)	Am 95 243.06	Cm 96 (247)	Bk 97 (248)	Cf 98 (251)	Es 99 252.08	Fm 100 257.10	Md 101 (257)	No 102 259.10	Lr 103 262.11

Atomic Size

- **Atomic Radius:** It is the distance from the centre of the nucleus to the outermost shell containing e^-.

Note: It is impossible to isolate an atom & measure its radius accurately.

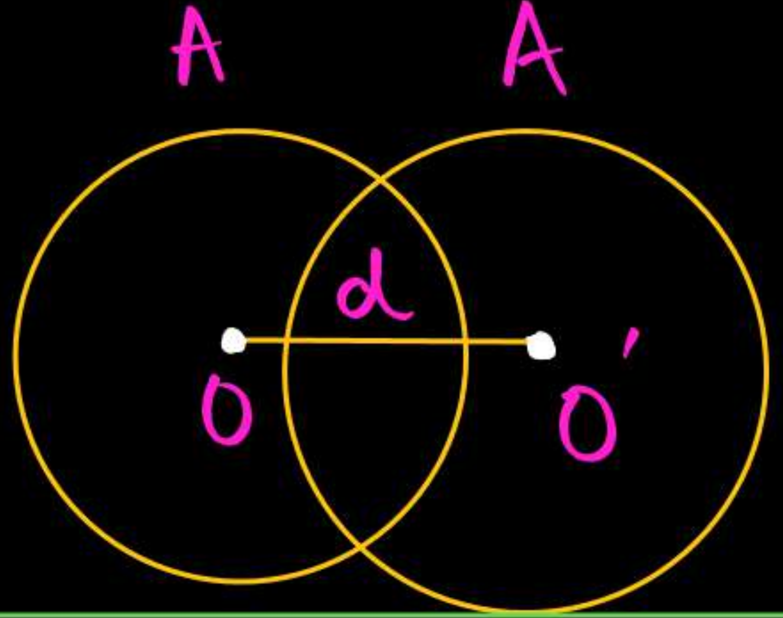


Unit of Atomic Radius: pm / Å [1 pm = 10^{-12} m
1 Å = 10^{-10} m]

$A \leftarrow B$

TYPES OF ATOMIC RADIUS

1. Covalent Radius: It is half of the internuclear distance of a homonuclear diatomic molecule bonded with a single Covalent bond.



A_2

$A-A$

Stevenson-Schomaker Eq^n is used when there is a difference in electro-vity in a compound.

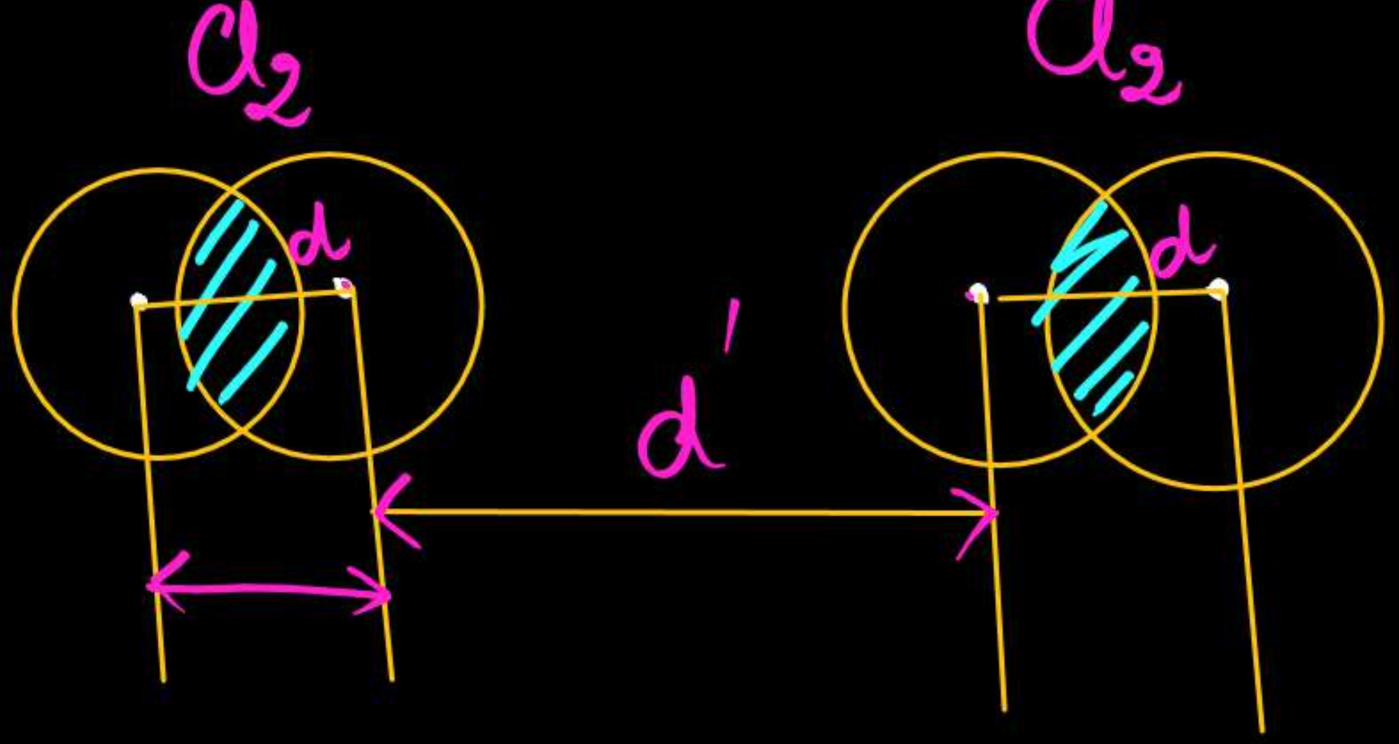
$$r_{A-B} = r_A + r_B - 0.09(\chi_A - \chi_B)$$

electro-vity A

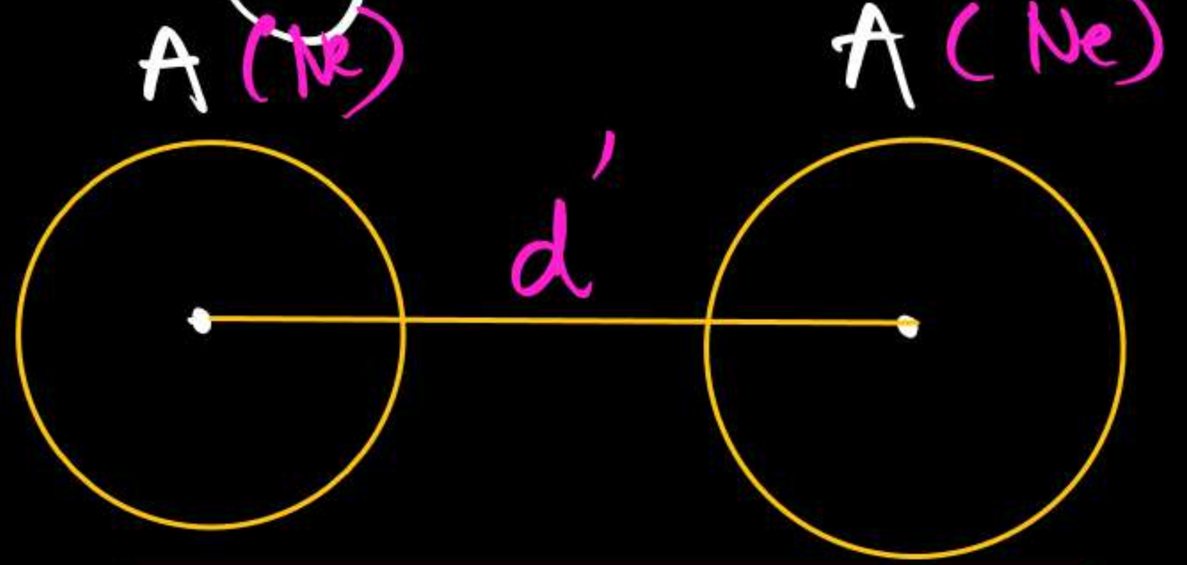
electro-vity B

$$\text{Covalent radius} = \frac{1}{2}OO' = \frac{d}{2}$$

2. van Der Waal's Radius: It is half of the internuclear distance between two identical non-bonded neighbouring atoms.



$$r_{cov.} = \frac{d}{2} \qquad r_{V.W.} = \frac{d'}{2}$$



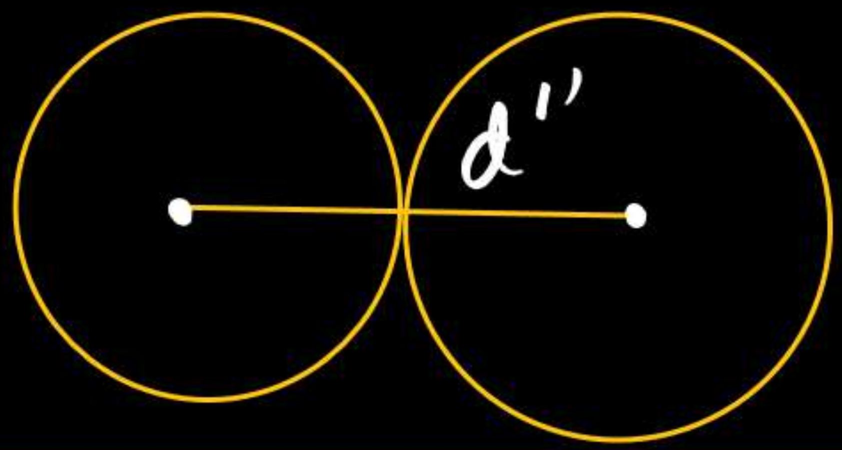
$$\boxed{r_{vander\ Waal} = \frac{d'}{2}}$$

Mathematically; for a given atom: $\boxed{r_{V.W.} > r_{cov.}}$

3. Metallic Radius: It is half of the internuclear distance b/w two adjacent atoms in the metal lattice.

Dec. order:

$$\boxed{r_{\text{vanderWaal}} > r_{\text{metallic}} > r_{\text{covalent}}}$$

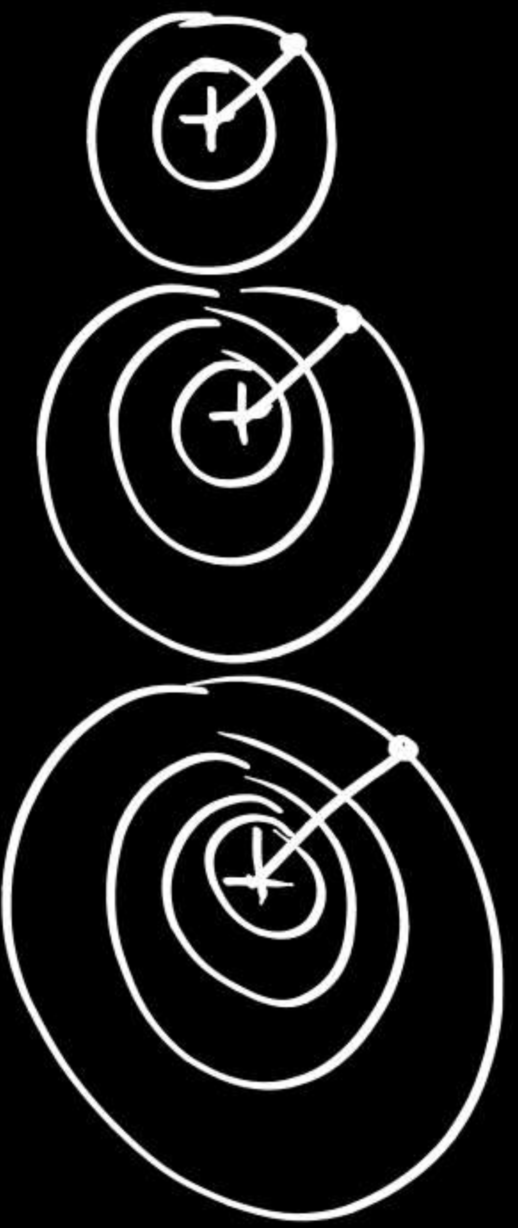


$$\boxed{r_{\text{metallic}} = \frac{d''}{2}}$$

- **Factors which affect the atomic radii:**

(1) No. of shells:

$$\boxed{\text{Atomic size} \propto \text{No. of shells}}$$



(2) Nuclear charge (Z): charge present on nucleus

↳ atomic no. = no. of protons

↳ It attracts the e^- towards itself & tries to decrease its size.

③ Shieding effect / Screening effect : It is the repulsion provided by inner shell e^-s to the outermost e^-.

→ The inner shell e^-s act as a shield / screen b/w the nucleus & the outermost e^-

→ tries to increase the size.

$$\boxed{\text{Screening power / Shielding power} : s > p > d > f}$$

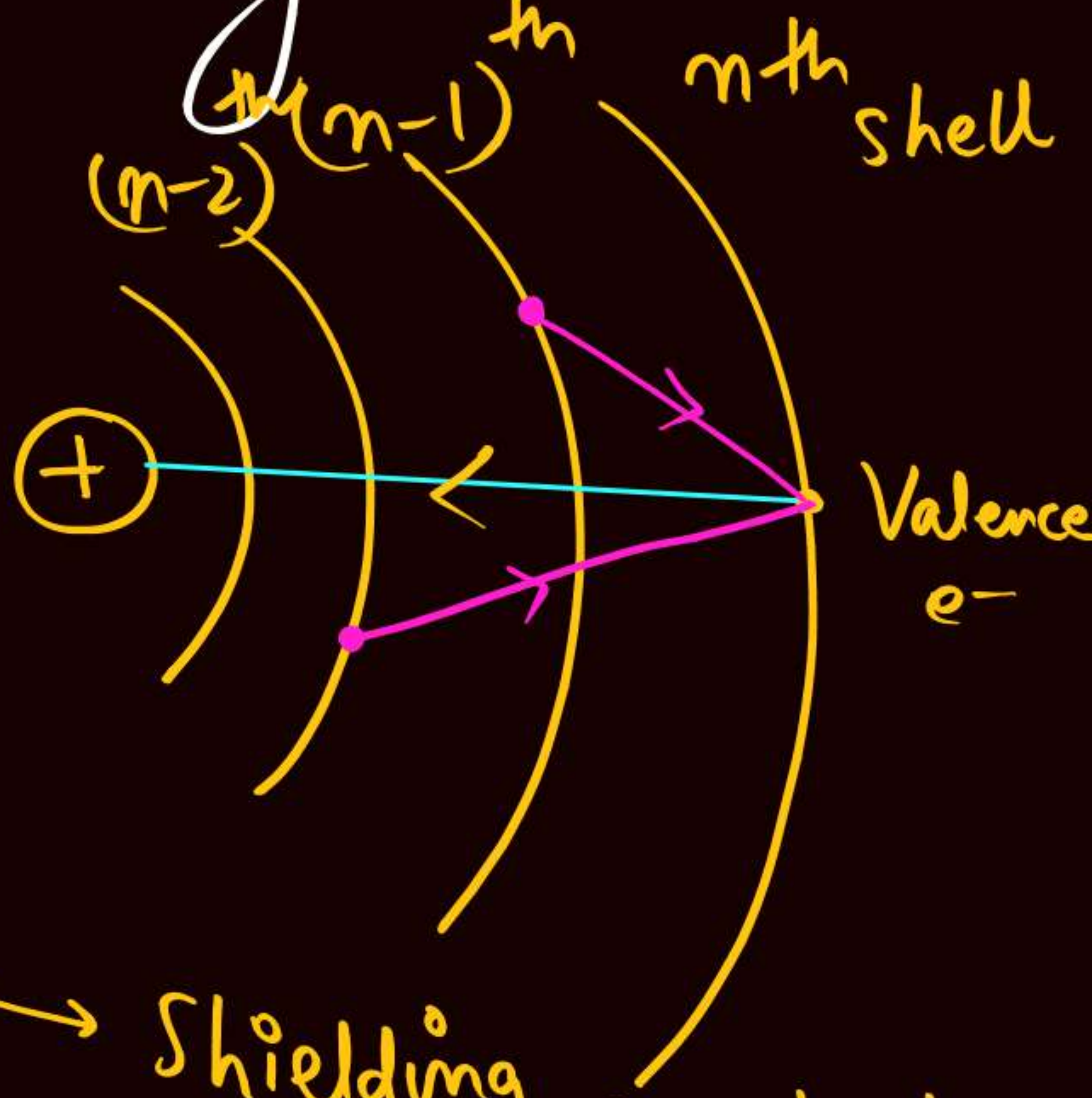
ARJUN

④ **Effective nuclear charge**: It is the actual / net force felt by the valence e^-

$\hookrightarrow Z_{eff} / Z^*$

Valence e^-

- Attractive force
- Repulsive force



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

$Z \rightarrow$ Nuclear charge or At. No.

$\sigma \rightarrow$ Shielding constant

$$\boxed{\text{Atomic size} \propto \frac{1}{Z_{eff}}}$$

- **Trend of atomic radii:**

⇒ On moving down the group; at. size generally increases due to the addition of new shell at each step.

⇒ On moving across the period; at. size decreases as e^-s get filled in the same shell; due to which Z_{eff} ↑se & size ↓

PERIOD →

GROUP ↓

Gp 1

Li	$1s^2\,2s^1$
Na	$3s^1$
K	$4s^1$
Rb	$5s^1$
Cs	$6s^1$
Fr	$7s^1$

size ↑

Gp 1 2 13 14 15 16 17 18

2nd period $_3Li$ $_4Be$ $_5B$ $_6C$ $_7N$ $_8O$ $_9F$ $_{10}Ne$

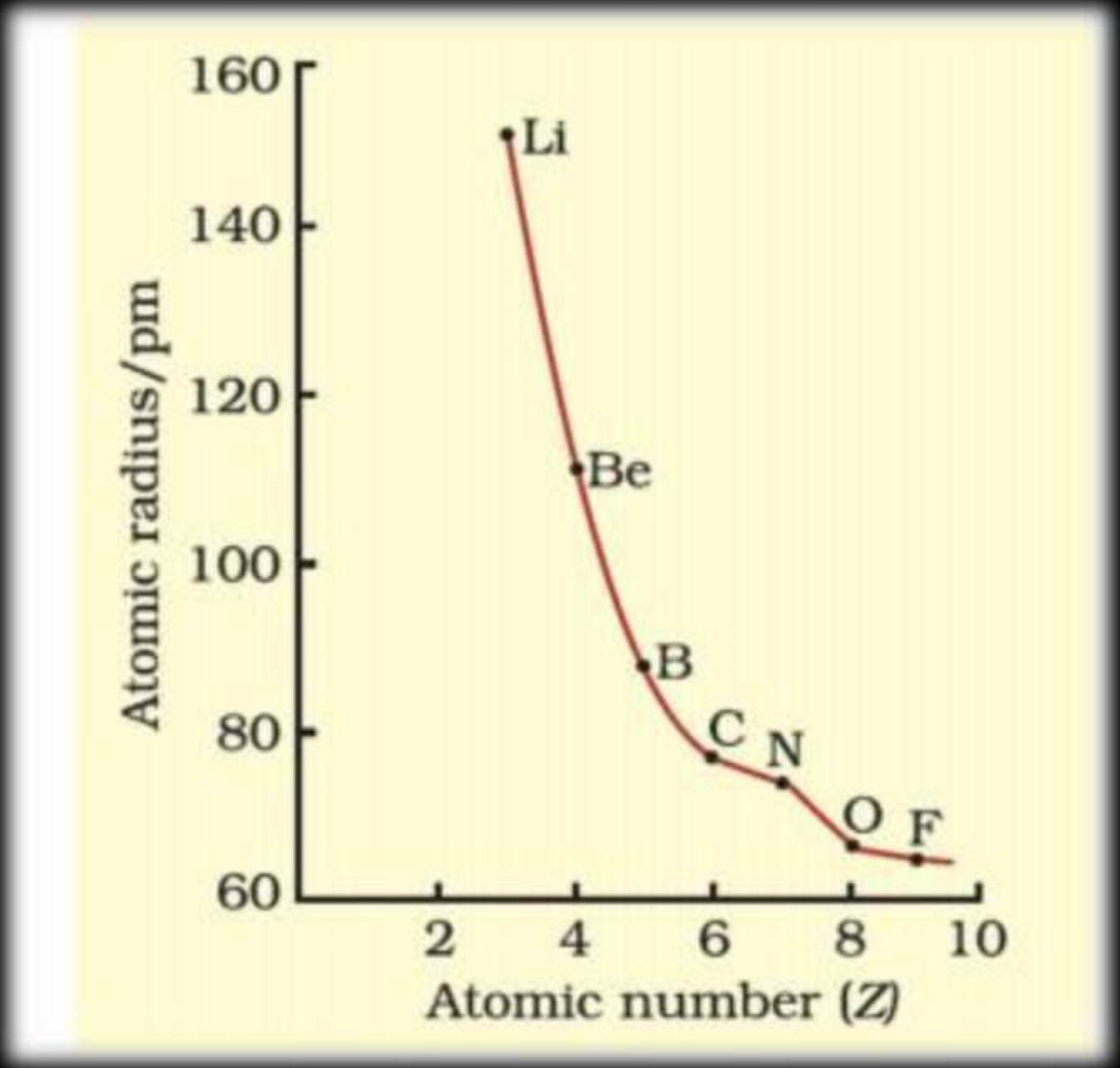
at. size ↓ size ↑

At. size ↓ ses till Gp 17 (Halogens) shells : same
& then ↑ ses to Noble gases (gp 18) Z_{eff} ↑

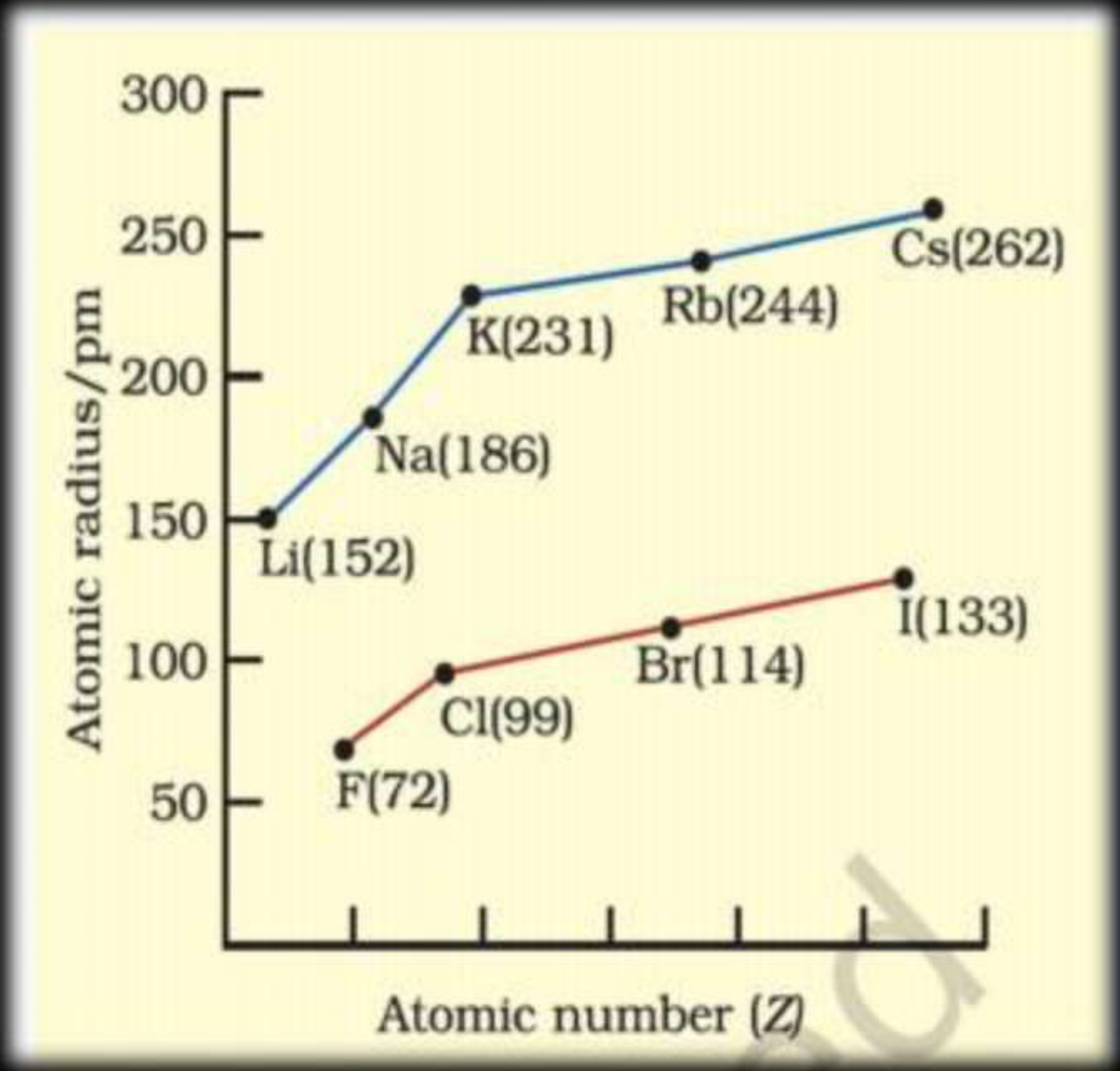
(diatomic) Halogens Noble Gases (monoatomic)

eg F Ne F_2 Ne → V.W. radius

$r = 0.72 \mathring{A}$ $1.60 \mathring{A}$ → Covalent radius



Across the period



(Gp 1)

(Gp 17)

Down the group

3rd period : $\boxed{\text{Na} \quad \text{Mg}}$ Al Si
4th period : $\boxed{\text{K} \quad \text{Ca}}$ $\longrightarrow$ size $\downarrow$
size $\uparrow$

Questions

Q. Arrange the following in increasing order of radii:

- Na, Al, Mg, Si : Si < Al < Mg < Na
- Br, I, Cl, F : F < Cl < Br < I
- Ca, Sr, Ba, Be, Mg : Be < Mg < Ca < Sr < Ba
- Na, Mg, K, Ca : Mg < Na < Ca < K
- C, O, N, F, Be, Li, B : F < O < N < C < B < Be < Li

F
Cl
Br
I
size $\uparrow$

ARJUN

Exceptions:

1. Transition Elements

3d-series : $_{21}Sc$ $_{22}Ti$ $_{23}V$ $_{24}Cr$ $_{25}Mn$ $_{26}Fe$ $_{27}Co$ $_{28}Ni$ $_{29}Cu$ $_{30}Zn$

Sc to Mn: Size first ↓ses

$\boxed{Z_{eff} > \text{Shielding effect}}$

Fe to Ni: Size : almost constant

$\boxed{Z_{eff} \approx \text{shielding effect}}$

Cu, Zn: Size : ↑

$\boxed{Z_{eff} < \text{Shielding effect}}$

ARJUN

2. Lanthanoid Contraction

	Gp 3 (IIIB)		Gp 4
3d	Sc		Ti
4d	Y		Zr
5d	$_{57}$La	$\boxed{(\underset{58}{Ce} - \underset{71}{Lu})}$	$_{72}$Hf

size ↑ (Sc → La)

(Ce–Lu) → f-block

Gp 4: Ti → Zr: size ↑

Zr → Hf: size constant / decreases slightly

$\boxed{3d < 4d \approx 5d}$ (except IIIB)

Q Why Zr & Hf have similar radii?

A Due to Lanthanoid contraction.

Hf → 4f e⁻s → completely filled → poor screener

3. Transition Contraction

Q. Why Gallium has smaller size than Aluminium?

$\boxed{B < Ga < Al}$

Gp 13

B ✓

$_{12}Mg$ Al : $1s^2 2s^2 2p^6 3s^2 3p^1$

$_{20}Ca$ ($_{21}Sc$ —— $_{30}Zn$) Ga : $[Ar]^{18}\, 3d^{10} 4s^2 4p^1$

In

Tl

$3d^{10}$ → poor screener

↓

Valence e^- attracts towards nucleus

↓

size ↓

ARJUN

Thank You