ALLEN CAREER INSTITUTE KOTA (RAJASTHAN) path to success

1.15

1.1 — 1.20

PERIODIC TABLE

1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIII 8	10	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 0
1 H Hydrogen 1.0079																	2 He Helium 4.00260
3 Li Lithium 6.941	4 Be Beryllium 9.01218											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.00674	8 O Oxygen 15.9994	9 F Fluorine 18.998403	10 Ne Neon 20.1797
11 Na Sodium 22.989768	12 Mg Magnesium 24.305											13 Al Aluminum 26.981539	14 Si Silicon 28.0855	15 P Phosphorus 30.973762	16 S Sulfur 32.066	17 Cl Chlorine 35.4527	18 Ar Argon 39.948
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.95591	22 Ti Titanium 47.88	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938	26 Fe Iron 55.847	27 Co Cobalt 58.9332	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.732	32 Ge Germanium 72.64	33 As Arsenic 74.92159	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.94	43 Tc Technetium 98.9072	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.9055	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.71	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.90447	54 Xe Xenon 131.29
55 Cs Cesium 132.90543	56 Ba Barium 137.327	57 La Lanthanum 138.9055	72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.9665	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.98037	84 Po Polonium [208.9824]	85 At Astatine 209.9871	86 Rn Radon 222.0176
87 Fr Francium 223.0197	88 Ra Radium 226.0254	89 Ac Actinium 227.0278	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [268]	110 Ds Darmstadtium [269]	111 Rg Roentgenium [272]	112 Cn Copernicium [277]	113 Nh Nihonium [286]	114 Fl Flerovium [289]	115 Mc Moscovium [290]	116 Lv Livermorium [298]	117 Ts Tennessine 294	118 Og Oganesson 295

Lanthanide Series	58 Ce Cerium 140.115	59 Pr Praseodymium 140.90765	60 Nd Neodymium 144.24	61 Pm Promethium 144.9127	62 Sm Samarium 150.36	63 Eu Europium 151.9655	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92534	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93032	68 Er Erbium 167.26	69 Tm Thulium 168.93421	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967
Actinide Series	90 Th Thorium 232.0381	91 Pa Protactinium 231.03588	92 U Uranium 238.0289	93 Np Neptunium 237.0482	94 Pu Plutonium 244.0642	95 Am Americium 243.0614	96 Cm Curium 247.0703	97 Bk Berkelium 247.0703	98 Cf Californium 251.0796	99 Es Einsteinium [254]	100 Fm Fermium 257.0951	101 Md Mendelevium 258.1	102 No Nobelium 259.1009	103 Lr Lawrencium [262]

Alkali Metals | Alkaline Earths | Transition Metals | Basic Metals | Semi-Metals | Nonmetals | Halogens | Noble Gases | Lanthanides | Actinides

PERIODIC TABLE

INTRODUCTION

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

DEVELOPMENT OF PERIODIC TABLE

(A) Lavoisier Classification :

Metal (Loose e^-)	Non Metal (Accept e^-)
$Na \rightarrow Na^+ + e^-$	$F + e^- \rightarrow F^-$
$K \rightarrow K^+ + e^-$	$Cl + e^- \rightarrow Cl^-$

Drawback or Limitation :

(a) As the number of element increases this classification became insufficient for the study of elements.

(b) There are few elements which have the properties of both metals as well as non-metals and they are called metalloids. Lavoisier could not decide where to place the metalloids.

DEVELOPMENT OF PERIODIC TABLE

(B) Prout's hypothesis (Unitary theory) :

He simply assumed that all the elements are made up of hydrogen, so we can say that

Atomic weight of element = n × (Atomic weight of one hydrogen atom)

$$\boxed{\text{Atomic weight of H} = 1}$$

where n = number of hydrogen atom = 1, 2, 3,....

Drawback or Limitation :

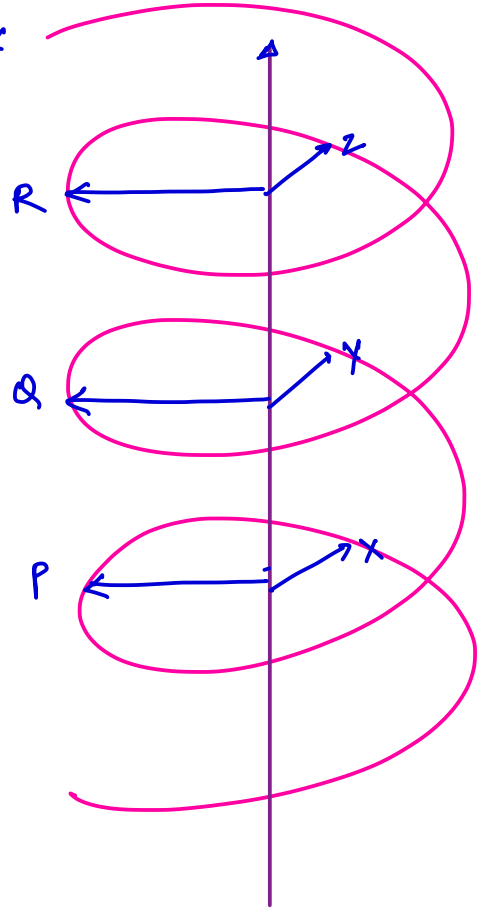
(i) Every element can not be formed by Hydrogen.

(ii) Atomic weight of all elements were not found as the whole numbers.

Ex. Chlorine (atomic weight 35.5)

and Strontium (atomic weight 87.6)

Chancourtis helix



→ x, y, z have property

→ P, Q, R have same property

(C) Dobereiner triad rule :

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

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

Ex.

Li	Na	K
7	23	39

$$\left[x = \frac{7+39}{2} = 23\right]$$

where x=average atomic weight

(iii) Other examples –

(K, Rb, Cs), (P, As, Sb),
(S, Se, Te), (H, F, Cl),
(Cl, Br, I), (Ca, Sr, Ba)

Atomic mass

X A_1
Y A_2
Z A_3

$A_2 \approx \frac{A_1 + A_3}{2}$

"Same period elements can't be a triads"

DEVELOPMENT OF PERIODIC TABLE

- **How to check triad :**

(1) Belongs to same group.

(2) Difference of atomic number in two elements should be same (8, 8 or 18, 18)

Drawback or Limitation :

All the known elements could not be arranged as triads. It is not applicable for d and f-block elements.

Illustration 1.
Is Fe, Co, Ni a dobereiner triad ?

Solution.
No, these elements belong to same period.

DEVELOPMENT OF PERIODIC TABLE

Illustration 2.

Atomic weight of an element X is 39, and that of element Z is 132. atomic weight of their intermediate element Y, as per dobereiner triad, will be

(1) 88.5 (2) 93.0 (3) 171 (4) 85.5

Solution. Ans. (4)

$$\frac{39+132}{2}=85.5$$

Illustration 3.

Which of the following is not a dobereiner triad

(1) Li, Na, K (2) Mg, Ca, Sr

(3) Cl, Br, I (4) S, Se, Te

Solution. Ans. (2)

The difference in atomic number are different

DEVELOPMENT OF PERIODIC TABLE

(D) Newland octave rule

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

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

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

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

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

DEVELOPMENT OF PERIODIC TABLE

Drawback or Limitation :

(a) Valid only upto Ca, because after Ca due to presence of d-block elements there is difference of 18 elements instead of 8 element.

(b) After the discovery of Inert gases and including them into the periodic table it becomes the 8th element from Alkali metal so this law had to be dropped out.

Illustration 1.

Which of the following set of elements obey Newland's octave rule –

(1) Na, K, Rb
(2) F, Cl, Br
(3) Be, Mg, Ca
(4) B, Al, Ga

Ans. (3)

Illustration 2.

For which of the pair Newland's octave rule is not applicable –

(1) Li, Na
(2) C, Si
(3) Mg, Ca
(4) Cl, Br

Ans. (4)

DEVELOPMENT OF PERIODIC TABLE

(E) Lothar meyer's curve :

(i) Plotted a curve between atomic weight and atomic volume of different elements.

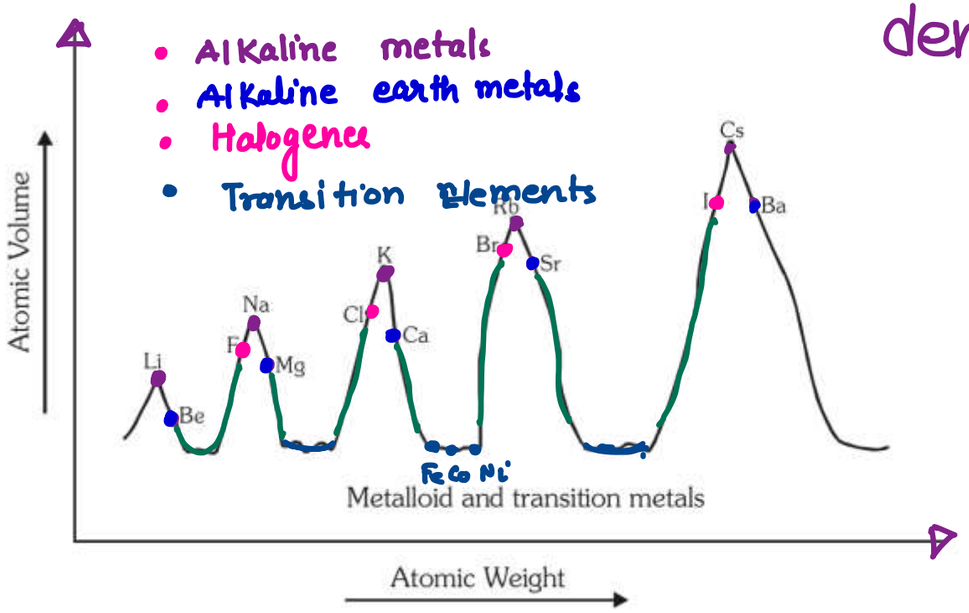
(ii) The following observations can be made from the curve –

(a) Most electropositive elements i.e. alkali metals (Li, Na, K, Rb, Cs) occupy the peak positions.

(b) Less electropositive i.e. alkaline earth metal (Be, Mg, Ca, Sr, Ba) occupy the descending positions.

(c) Metalloids (Si, Ge, As, Sb, Te, Po, At) and transition metals occupy bottom part.

(d) Most electronegative i.e. halogens (F, Cl, Br, I) occupy the ascending positions.



density = $\frac{\text{mass}}{\text{volume}}$

Volume = $\frac{\text{mass}}{\text{density}}$

$y = \left(\frac{1}{\text{density}}\right)x$

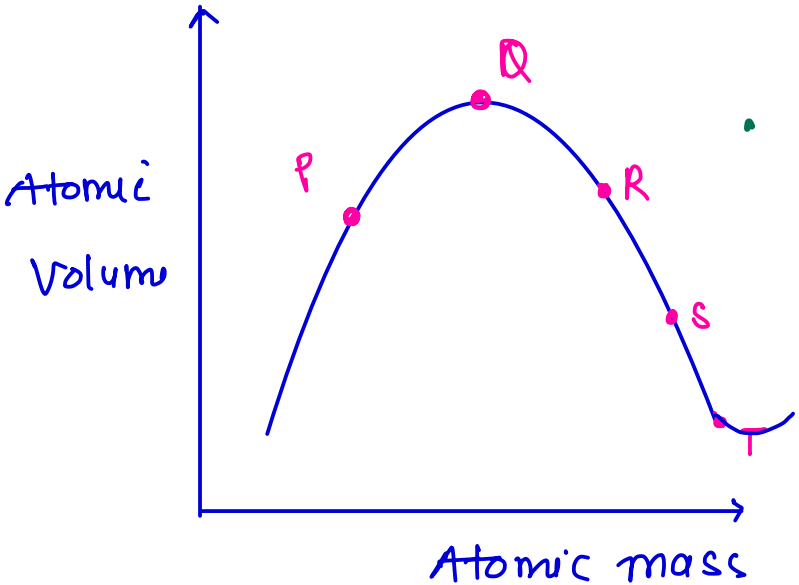
DEVELOPMENT OF PERIODIC TABLE

Note : Elements having similar properties occupy similar positions.

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

Periodic function : When the elements are arranged in the increasing order of their atomic weight, elements having similar properties gets repeated after a regular interval.

Ex. Match the column for given graph



Column I	Column II
	(i) Li
P (iv, ix)	(ii) Mg
	(iii) Na
Q (i, iii)	(iv) Cl
	(v) Ni
R (ii, viii)	(vi) S
	(vii) Fe
S (vi)	(viii) Ca
T (v, vii)	(ix) Br

DEVELOPMENT OF PERIODIC TABLE

(F) Mendeleev's Periodic Table :

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

(ii) Characteristics of Mendeleev's periodic table :

(a) Based on atomic weight.

(b) 63 elements were known, noble gases were not discovered.

(c) First scientist to classify the elements in a systematic manner i.e. in horizontal rows and in vertical columns.

(d) Horizontal rows → periods → 7 periods

(e) Vertical columns → groups → 8 groups

→ 1 – 7th → contains two subgroups

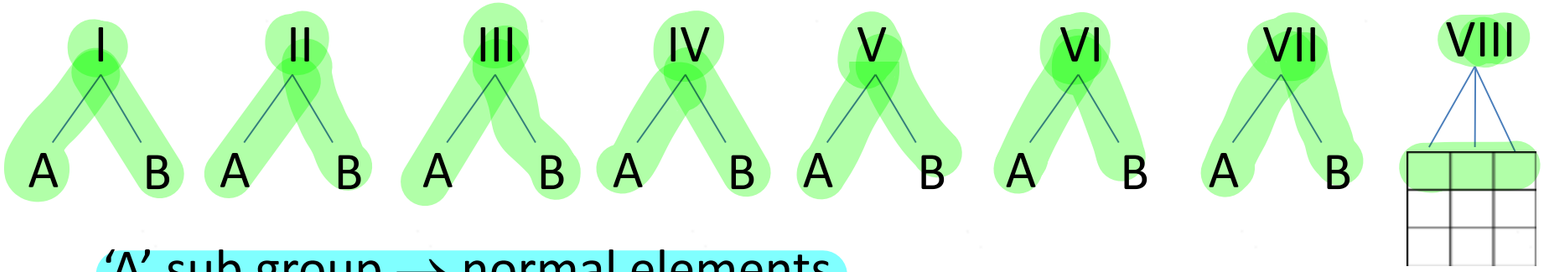
→ 8th → that contains 3 Element

Groups	I	II	III	IV	V	VI	VII	VIII
Oxides Hydrides	RO RH	RO RH_2	R_2O_3 RH_3	RO_2 RH_4	R_2O_5 RH_3	RO_3 RH_2	R_2O_7 RH	RO_4
Periods ↓	A B	A B	A B	A B	A B	A B	A B	Transition series
1	H 1.008							
2	Li 6.939	Be 9.012	B 10.81	C 12.011	N 14.007	O 15.999	F 18.998	
3	Na 22.99	Mg 24.31	Al 29.98	Si 28.09	P 30.974	S 32.06	Cl 35.453	
4 First series: Second series:	K 39.102 Cu 63.54	Ca 40.08 Zn 65.37	Sc 44.96 Ga 69.72	Ti 47.90 Ge 72.59	V 50.94 As 74.92	Cr 50.20 Se 78.96	Mn 54.94 Br 79.909	Fe 55.85 Co 58.93 Ni 58.71
5 First series: Second series:	Rb 85.47 Ag 107.87	Sr 87.62 Cd 112.40	Y 88.91 In 114.82	Zr 91.22 Sn 118.69	Nb 92.91 Sb 121.75	Mo 95.94 Te 127.60	Tc 99 I 126.90	Ru 101.07 Rh 102.91 Pd 106.4
6 First series: Second series:	Cs 132.90 Au 196.97	Ba 137.34 Hg 200.59	La 138.91 Tl 204.37	Hf 178.49 Pb 207.19	Ta 180.95 Bi 208.98	W 183.85		Os 190.2 Ir 192.2 Pt 195.09

4th period

DEVELOPMENT OF PERIODIC TABLE

(f)



'A' sub group → normal elements

'B' sub group → transition elements

(g) The elements belonging to same group exhibit similar properties.

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

(a) Study of elements : Become easier.

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

Eka Aluminium	– Gallium(Ga)	Eka Boron	- Scandium(Sc)
Eka Silicon	– Germanium(Ge)	Eka Manganese	– Technetium(Tc)

B C Be

Illustration 1.

Which of the following element was present in Mendeleev's periodic table?

(1) Sc (2) Tc

(3) Ge (4) None of these

Solution.

Ans. (4) These elements were added after Mendeleev's periodic table.

$E = \frac{A}{n}$

$\text{valency} = \frac{A}{E}$

Q. The elements which are cited as an example to prove the validity of mendeleev's periodic law are

(1) H, He (2) Ga, Sc

(3) Co, Ni (4) Zr, Hf

Solution.

Ans. (2)

Dulong petit's law

Atomic mass (A) × specific heat capacity (Cal.) = 0.64

Atomic mass =

Be. → E = 4.5

valency = 2.5 ≈ 2

A = 4.5 × 2

A = 9

(c) Correction of doubtful atomic weights :

Correction were done in atomic weight of some elements.

Example:- U, Be, In, Au, Pt

u Beimaan Insaan Aur Pitega

(iv) Demerits of Mendeleev's periodic table :

(a) Position of hydrogen

(b) Position of isotopes

(c) Anomalous pairs of elements :There were some pairs of element which did not follow the increasing order of atomic weights.

Example:-

Aamir Khan	Teri Icha	Coke Nahi	Thanda Paani
Ar K	Te I	Co Ni	Th Pa
39.9 39.1	127.5 127	58.9 58.6	232 231

DEVELOPMENT OF PERIODIC TABLE

(d) Like elements were placed in different groups :

Pt — VIII

Au — IB

(e) Unlike elements were placed in same group :

Group-I

IA — IB

Li

Na(Bridge element)

More reactive	K	Cu	Less reactive
Alkali metal	Rb	Ag	Coinage metal → metals used for coins.
Normal elements	Cs	Au	Transition element
	Fr		

Cs → soft, reactive

Au → hard, inert

DEVELOPMENT OF PERIODIC TABLE

(f) It was not clear that **'lanthanides** and **Actinides'** are related with IIIA group or IIIB group.

(g) Cause of periodicity : Why physical and chemical properties repeated in a group.

Q.1 Mendeleev's periodic law is based on -

(1) Atomic number (2) Atomic weight

(3) Number of neutrons (4) None of the above

Ans. **(2)**

Q.2 The first attempt to classify elements systematically was made by -

(1) Mendeleev (2) Newland

(3) Lothar Meyer (4) Dobereiner

Ans. **(1)**

DEVELOPMENT OF PERIODIC TABLE

PERIODIC TABLE

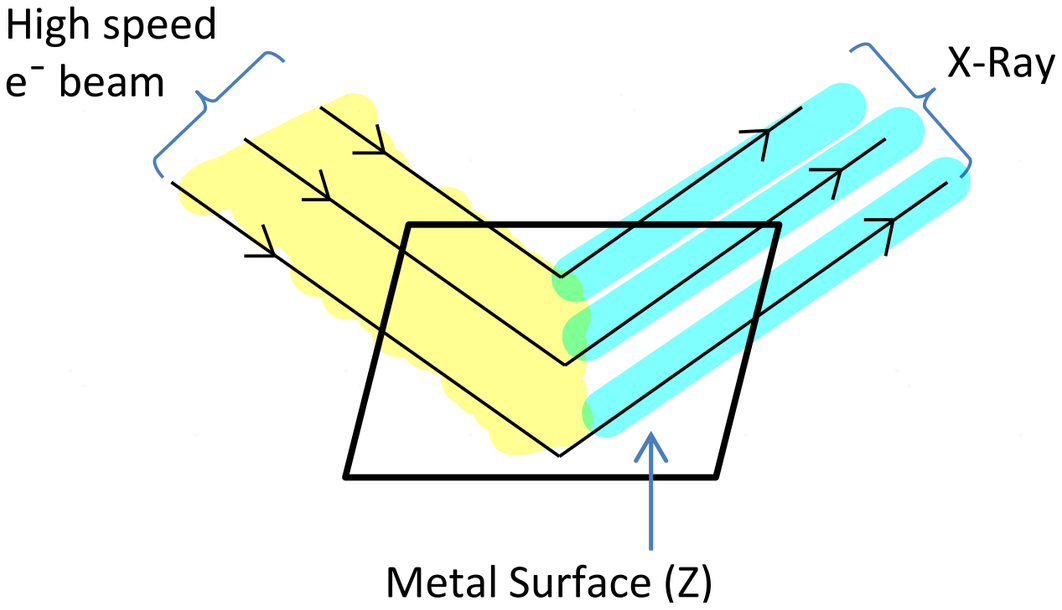
(G) Modern periodic table (Modified Mendeleev's Periodic Table) :

(i) Proposed by Moseley.

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

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

In spectrum
→ wavelength (λ)
→ frequency (ν)



finger print
+
unique

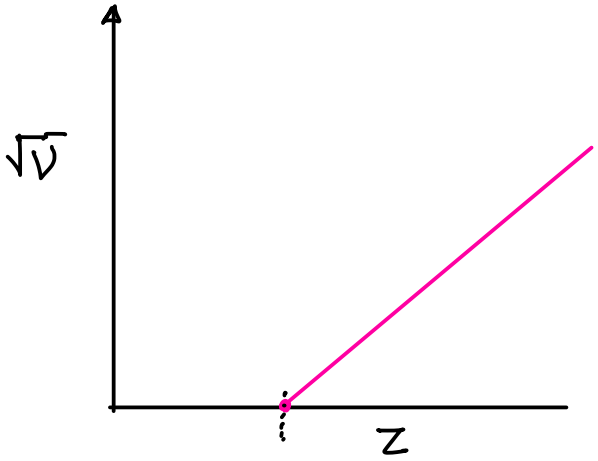
Light → spectrum
VIBGYOR

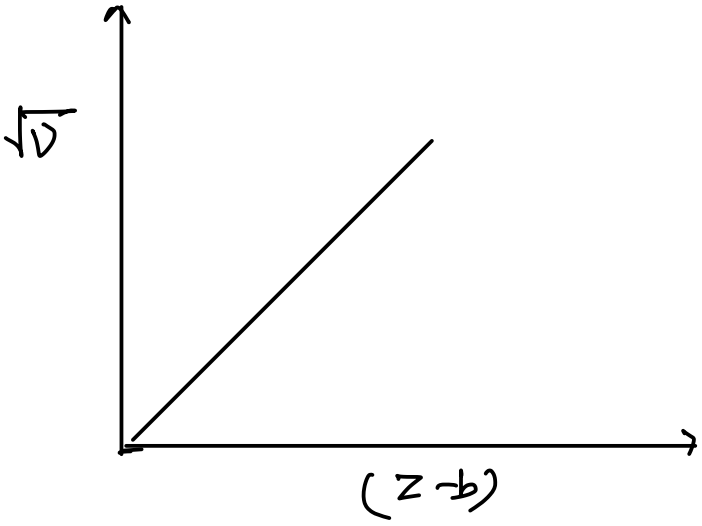
He found out that $\sqrt{\nu} \propto Z$

where ν = frequency of X-rays, Z = atomic number.

$$\sqrt{\nu} = a(Z-b)$$

a, and b are mosley Constant





DEVELOPMENT OF PERIODIC TABLE

- (iv) Modern periodic law : The physical & chemical properties of elements are the periodic function of their atomic number.

(v) Characteristics of modern periodic table :

(a) 9 vertical columns called groups.

(b) I to VIII group + 0 group of inert gases.

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

(d) 7 horizontal rows called periods.

period → 1 – 7

groups →
- 1 – 7 → A, B — Seperate. $7 \times 2 = 14$
- 8th → A, B, C — Seperate $1 \times 3 = 3$
- zero inert gas $1 \times 1 = 1$

18

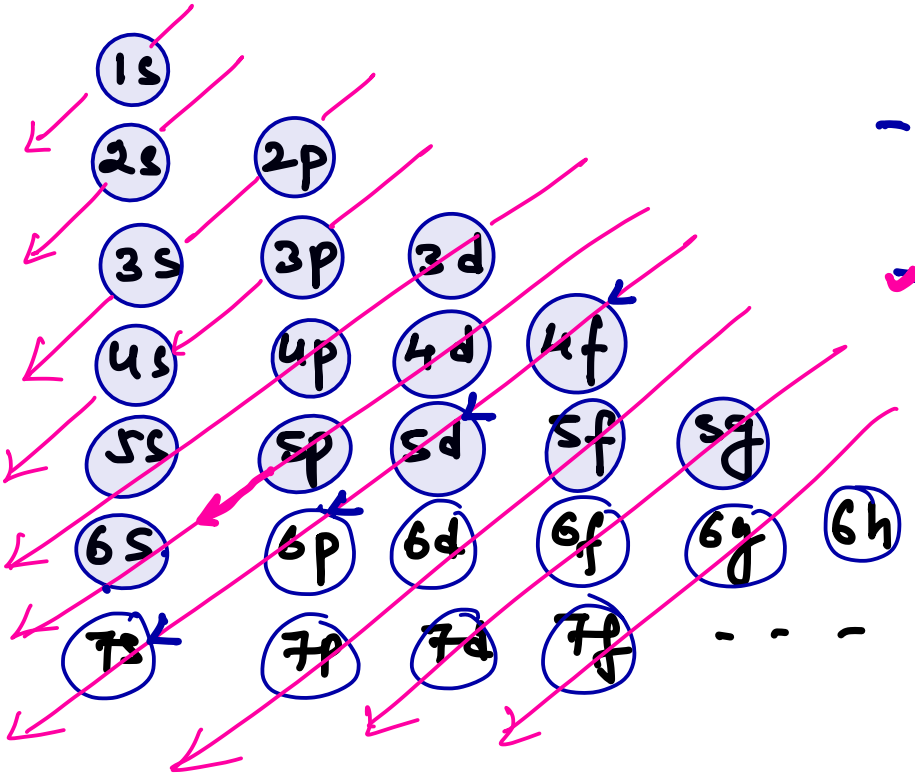
Merits →

- Isotopes ✓
- Anamolous pair ✓
- Coinage metals and Alkali metals ✓
- Inert gas ✓
- unlike Element ✓

Demerits →

- * Position of hydrogen ✗
- Place of Lanthanoid and Actinides ✗

- **Long form of periodic table :-**
- Logic behind Long form of periodic table.



Rule. No. 1

- Write Electronic configuration
- when shell changes period changes.
- Each electron represent one Element

EC	period No.	orbital	electrons	Element
1s	1	$1 = (1)^2$	2	2
2s, 2p	2	$4 = (2)^2$	8	8
3s, 3p,	3	$4 = (2)^2$	8	8
4s, 3d, 4p	4	$9 = (3)^2$	18	18
5s, 4d, 5p	5	$9 = (3)^2$	18	18
6s, 4f, 5d, 6p	6	$16 = (4)^2$	32	32
7s 5f, 6d 7p	7	$16 = (4)^2$	32	32
8s 5g 6f, 7d 8p	8	$25 = (5)^2$	50	50
	9	$25 = (5)^2$	50	50
	10	$36 = (6)^2$	72	72

LONG FORM / PRESENT FORM OF MODERN PERIODIC TABLE

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

(ii) This model is proposed by Rang & Werner

ns (n-2)f (n-1)d np

(iii) 7 periods and 18 groups

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

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

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

(vi) Elements belonging to same group have same number of electrons in the outermost shell so their properties are similar.

ELECTRONIC CONFIGURATION

s – Subshell ⇒ [↑↓] ⇒ 2 electrons

p – Subshell ⇒ [↑↓][↑↓][↑↓] ⇒ 6 electrons

d – Subshell ⇒ [↑↓][↑↓][↑↓][↑↓][↑↓] ⇒ 10 electrons

f – Subshell ⇒ [↑↓][↑↓][↑↓][↑↓][↑↓][↑↓][↑↓] ⇒ 14 electrons

Periods number (n)	Subshells
1st	1s
2nd	2s 2p
3rd	3s 3p
4th	4s 3d 4p
5th	5s 4d 5p
6th	6s 4f 5d 6p
7th	7s 5f 6d 7p

s & p = n^{th} value
d = $(n-1)^{th}$ value
f = $(n-2)^{th}$ value

ELECTRONIC CONFIGURATION

$_{1}H$ = $1s^1$

$_{2}He$ = $1s^2$

$_{3}Li$ = $1s^2\ 2s^1$

$_{4}Be$ = $1s^2\ 2s^2$

$_{5}B$ = $1s^2\ 2s^2\ 2p^1$

$_{6}C$ = $1s^2\ 2s^2\ 2p^2$

$_{7}N$ = $1s^2\ 2s^2\ 2p^3$

$_{8}O$ = $1s^2\ 2s^2\ 2p^4$

$_{9}F$ = $1s^2\ 2s^2\ 2p^5$

$_{10}Ne$ = $1s^2\ 2s^2\ 2p^6$

$_{11}Na$ = $1s^2\ 2s^2\ 2p^6\ 3s^1$

$_{12}Mg$ = $1s^2\ 2s^2\ 2p^6\ 3s^2$

$_{13}Al$ = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$

$_{14}Si$ = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$

$_{15}P$ = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$

$_{16}S$ = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$

$_{17}Cl$ = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

$_{18}Ar$ = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

$_{19}K$ = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$

$_{20}Ca$ = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$

$_{21}Sc$ = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^1$

$_{22}Ti$ = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^2$

$_{23}V$ = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^3$

ELECTRONIC CONFIGURATION

$_{24}Cr$ = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ \boxed{4s^2\ 3d^4}$ Half filled stable

On rearranging

$_{24}Cr$ = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^1$ ✓

$_{25}Mn$ = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^5$

$_{26}Fe$ = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^6$

$_{27}Co$ = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^7$

$_{28}Ni$ = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^8$

$_{29}Cu$ = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ \boxed{4s^2\ 3d^9}$ Full filled stable

On rearranging

$_{29}Cu$ = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$ ✓

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

EXCEPTIONAL CONFIGURATION

IMPORTANT *

(1) $_{24}Cr \rightarrow {}_{18}[Ar]\ 3d^5\ 4s^1$

(2) $_{29}Cu \rightarrow {}_{18}[Ar]\ 3d^{10}\ 4s^1$

(3) $_{46}Pd \rightarrow {}_{36}[Kr]\ 4d^{10}\ 5s^0$

(4) $_{57}La \rightarrow {}_{54}[Xe]\ 6s^2\ 5d^1$

(5) $_{89}Ac \rightarrow {}_{86}[Rn]\ 7s^2\ 6d^1$

(6) $_{64}Gd \rightarrow {}_{54}[Xe]\ 6s^2\ 5d^1\ 4f^7$

DESCRIPTION OF PERIODS

Period No.	Outer shell No.	Period Subshell				No. of elements	Name of Period
1	1	1s				2	Shortest
2	2	2s			2p	8	Short
3	3	3s			3p	8	Short
4	4	4s		3d	4p	18	Long
5	5	5s		4d	5p	18	Long
6	6	6s	4f	5d	6p	32	Longest
7	7	7s	5f	6d	7p	32	Longest
n	n	ns → (n-2)f → (n-1)d → np					

Q. In 6th period of the modern periodic table, electronic energy levels are in the order of :-

(1) 6s, 4f, 5d, 6p (2) 6s, 6p, 4f, 5d

(3) 4f, 5d, 6s, 6p (4) None

Ans. (1)

1 H Hydrogen 1.008																		2 He Helium 4.003
3 Li Lithium 6.94	4 Be Beryllium 9.012											5 B Boron 10.81	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
11 Na Sodium 22.990	12 Mg Magnesium 24.305											13 Al Aluminum 26.982	14 Si Silicon 28.085	15 P Phosphorus 30.974	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.630	33 As Arsenic 74.922	34 Se Selenium 78.97	35 Br Bromine 79.904	36 Kr Krypton 83.798
37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium [97]	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.414	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	53 Te Tellurium 127.60	53 I Iodine 126.904	54 Xe Xenon 131.293
55 Cs Cesium 132.905	56 Ba Barium 137.327	* 57 - 70	71 Lu Lutetium 174.967	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	78 Ir Iridium 192.217	79 Pt Platinum 195.084	80 Au Gold 196.997	81 Hg Mercury 200.592	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [209]	85 At Astatine [210]	86 Rn Radon [222]
87 Fr Francium [223]	88 Ra Radium [226]	** 89 - 102	103 Lr Lawrencium [262]	104 Rf Rutherfordium [267]	105 Db Dubnium [270]	106 Sg Seaborgium [269]	107 Bh Bohrium [270]	108 Hs Hassium [270]	109 Mt Meitnerium [278]	110 Ds Darmstadtium [281]	111 Rg Roentgenium [281]	112 Cn Copernicium [285]	113 Nh Nihonium [286]	114 Fl Flerovium [289]	115 Mc Moscovium [289]	116 Lv Livermorium [293]	117 Ts Tennessine [293]	118 Og Oganesson [294]

*Lanthanide series	57 La Lanthanum 138.905	58 Ce Cerium 140.116	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.242	61 Pm Promethium [145]	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.500	67 Ho Holmium 164.930	68 Er Erbium 167.259	69 Tm Thulium 168.934	70 Yb Ytterbium 173.045
**Actinide series	89 Ac Actinium [227]	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium [237]	94 Pu Plutonium [244]	95 Am Americium [243]	96 Cm Curium [247]	97 Bk Berkelium [247]	98 Cf Californium [251]	99 Es Einsteinium [252]	100 Fm Fermium [257]	101 Md Mendelevium [258]	102 No Nobelium [259]

← s block →

Atomic no.																		
	1 H Highly																	2 He He
+2	3 Li	4 Be Beer											5 B Bears	6 C Can	7 N Never	8 O Oh,	9 F Fairy	10 Ne never
+8	11 Na Nasty	20 Mg Mugs											13 Al Always	14 Si Silly	15 P Put	16 S She	17 Cl Clowns	18 Ar arrived;
+8	19 K Kids	20 Ca Can	21 Sc Scary	22 Ti Tiny	23 V vicious	24 Cr creature	25 Mn and Mean	26 Fe Female	27 Co Come	28 Ni Nightly	29 Cu Club	30 Zn Z	31 Ga Give	32 Ge German	33 As Arsenic	34 Se Sell	35 Br Broil	36 Kr Krum
+18	37 Rb Rub	38 Sr Serve	39 Y Yet,	40 Zr (z)sir	41 Nb Neb.	42 Mo Most	43 Tc Technicians	44 Ru Rub	45 Rh Rhodes	46 Pd Pale	47 Ag Silver	48 Cd Cadillac	49 In Indians	50 Sn Snatch	51 Sb in Silver Bullet	52 Te The	53 I Innocent	54 Xe exited with
+18	55 Cs Cats'	56 Ba Bar	57 ~~Lu~~ La* Larry's	72 Hf Half	73 Ta Taken,	74 W wendy	75 Re reached	76 Os out	77 Ir	78 Pt	79 Au	80 Hg	81 Tl Trouble	82 Pb Lead?	83 Bi Bibs	84 Po poles	85 At Aster/ Ants	86 Rn Roh
+32	87 Fr Fur	88 Ra Rats	89 Ac**	104 Unq	105 Unp	106 Unh	107 Uns	108 Uno	109 Une	110 Uun	111 Uuu	112 Uub						

d-block

lanthanide

ununnilium / nilquadium

ununbium

← p block →

f-block

Lanthanides

57 La Ladies	58 Ce Can't	59 Pr Put	60 Nd Nickels	61 Pm Properly in	62 Sm Slot machines	63 Eu Every	64 Gd Girl
	65 Tb Trips	66 Dy Daily	67 Ho However	68 Er Every	69 Tm Time	70 Yb You	71 Lu Look

Actinides

89 Ac	90 Th Three	91 Pa Planets :	92 U Uranus	93 Np Neptune	94 Pu Pluto.	95 Am Amy	96 Cm Cured
	97 Bk Berkeley,	98 Cf California	99 Es Einstein's	100 Fm Fermi	101 Md Made	102 No Noble	103 Lr Laws

(1)	H है	Li ली	Na ना	K की	Rb रब	Cs से	Fr फरिश्ता
(2)		Be बेटा	Mg मगों	Ca कार	Sr स्कूटर	Ba बाप	Ra राजी
(13)		B बैंगन	Al आलू	Ga गाजर	In इन	Tl थैला	
14)		C कटे	Si सीता	Ge जी	Sn सुने	Pb प्रभु	
15)		N नूमी बैंड	P पाकिस्तान	As आस्ट्रेलिया	Sb सब	Bi बिकाऊ	
16)		O old	S style	Se से	Te टे	Po पो	
17)		F फिर	Cl कल	Br बाहर	I आयी	At आटा	
18)	He है	Ne ना	Ar अगर	—	Kr कर	Xe Xero	Rn Run

4th/3d →	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
	सचिन	तेन्दुलकर	very	क्रेजी	मैन	फिर	क्यो	नही	कप	जीता
5th/4d	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd
	यारी	जरा	निभा	मौत	तक	रुकावट	राह	पेड़	आग में	कूद
6th/5d	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg
	ला	हफ	ता	बरना	रे	उससे	इधर	पिटाई	और	होगी

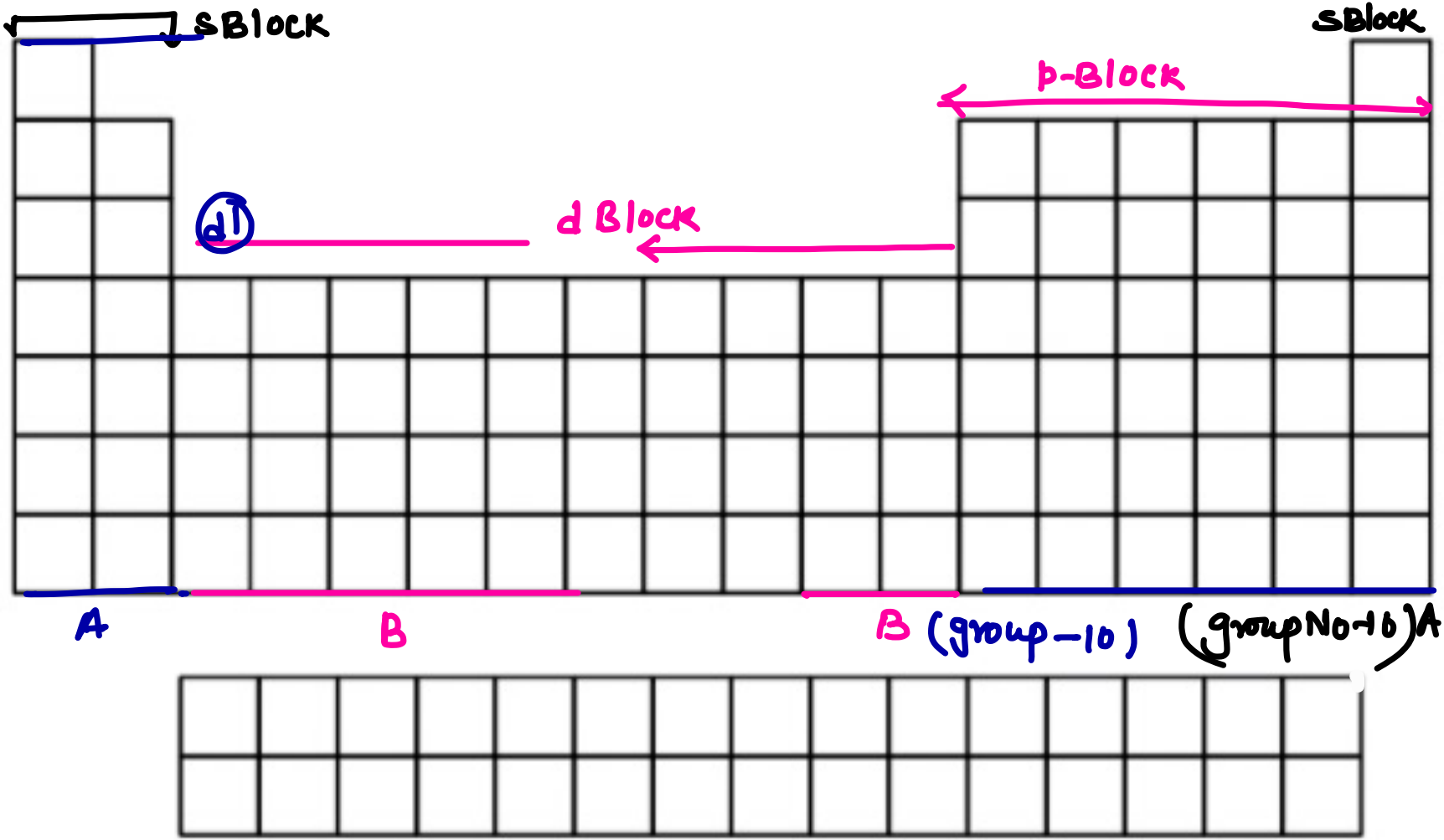
f-Block

→ Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho
सीने पर नदिया प्रेम की समाई यू गदगद तब दिल हुआ

Er Tm Yb Lu
और तुम अब लौटे

Th Pa U Np Pu Am Cm Bk Cf
→ थोड़े पापड़ यू नापो पके आम कम बिके कैफे मे

Es Fm Md No Lr
रश फरमाए मोडोना नोट लेकर.


SBlock
SBlock
p-Block
d Block
A
B
B (group-10)
(group No-10) A

DESCRIPTION OF GROUPS

1st/IA/Alkali metals

↳ because oxide and hydroxide are basic in Nature.

$H = 1s^1$

$Li = 1s^2, 2s^1$

$Na = 1s^2, 2s^2 2p^6, 3s^1$

$K = 1s^2, 2s^2 2p^6, 3s^2 3p^6, 4s^1$

- Gen. elec. configuration = ns^1
- Number of valence shell e^- = 1

2nd/IIA/Alkaline earth metals

- oxide and hydroxide are basic.

$Be = 1s^2, 2s^2$

$Mg = 1s^2, 2s^2 2p^6, 3s^2$

$Ca = 1s^2, 2s^2 2p^6, 3s^2 3p^6, 4s^2$

(n = Number of shell)

- Gen. elec. configuration = ns^2
- Number of valence shell e^- = 2

$\left[BeO \mid Be(OH)_2 \right]$ Amphotaric

GENERAL ELECTRONIC CONFIGURATION OF s-block = ns^{1-2}

[ ], ns^1

[ ], ns^2

DESCRIPTION OF GROUPS

13th/IIIA/Boron Family

$B = 1s^2, 2s^2\ 2p^1$

$Al = 1s^2, 2s^2\ 2p^6, 3s^2\ 3p^1$

$Ga = 1s^2, 2s^2\ 2p^6, 3s^2\ 3p^6\ 3d^{10}, 4s^2\ 4p^1$

- G.E.C = $ns^2\ np^1$
- Number of valence shell e^- = 3

$[\ ], ns^2, (n-2)f^{14}, (n-1)d^{10}, np^1$

14th/IVA/Carbon Family

$C = 1s^2, 2s^2\ 2p^2$

$Si = 1s^2, 2s^2\ 2p^6, 3s^2\ 3p^2$

$Ge = 1s^2, 2s^2\ 2p^6, 3s^2\ 3p^6\ 3d^{10}, 4s^2\ 4p^2$

- G.E.C = $ns^2\ np^2$
- Number of valence e^- = 4

$[\ ], ns^2, (n-2)f^{14}, (n-1)d^{10}, np^2$

GENERAL ELECTRONIC CONFIGURATION OF p-block = $ns^2\ np^{1-6}$

DESCRIPTION OF GROUPS

15th/VA/Pnicogen | Nitrogen

(Used in fertilizer as urea)

$N = 1s^2, 2s^2\ 2p^3$

$P = 1s^2, 2s^2\ 2p^6, 3s^2\ 3p^3$

$As = 1s^2, 2s^2\ 2p^6, 3s^2\ 3p^6\ 3d^{10}, 4s^2\ 4p^3$

- G.E.C= $ns^2\ np^3$
- Number of valence shell e^- = 5

[ ], $ns^2, (n-2)f^{14}, (n-1)d^{10}, np^3$

16th/VIA/Chalcogen | oxygen → ore forming

(Ore forming)

$O = 1s^2, 2s^2\ 2p^4$

$S = 1s^2, 2s^2\ 2p^6, 3s^2\ 3p^4$

$Se = 1s^2, 2s^2\ 2p^6, 3s^2\ 3p^6\ 3d^{10}, 4s^2\ 4p^4$

- G.E.C = $ns^2\ np^4$
- Number of valence shell e^- = 6

[ ], $ns^2, (n-2)f^{14}, (n-1)d^{10}, np^4$

GENERAL ELECTRONIC CONFIGURATION OF p-block = $ns^2\ np^{1-6}$

DESCRIPTION OF GROUPS

17th/VIIA/Halogens

(Salt forming)

- F = $1s^2$, $2s^2$ $2p^5$
- Cl = $1s^2$, $2s^2$ $2p^6$, $3s^2$ $3p^5$
- Br = $1s^2$, $2s^2$ $2p^6$, $3s^2$ $3p^6$ $3d^{10}$, $4s^2$ $4p^5$
- G.E.C= ns^2 np^5
- Number of valence shell e^- = 7

18th/Zero group/Inert gases / Noble gases

- He = = $1s^2$
- Ne = $1s^2$, $2s^2$ $2p^6$
- Ar= $1s^2$, $2s^2$ $2p^6$, $3s^2$ $3p^6$
- Kr = $1s^2$, $2s^2$ $2p^6$, $3s^2$ $3p^6$ $3d^{10}$, $4s^2$ $4p^6$
- G.E.C = ns^2 np^6 (except He)
- Number of valence shell e^- = 8

GENERAL ELECTRONIC CONFIGURATION OF p-block = ns^2 np^{1-6}

NOMENCLATURE OF ELEMENTS

IUPAC gave names to elements above atomic number 100 as follows –

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

In all the elements suffix is – ium

102
↓
Unnilbium (Unb)

115
Ununpentium (Uup)

118
ununoctium (Uuo)

117
ununseptium

NOMENCLATURE OF ELEMENTS

Atomic No.	IUPAC Name	Symbol	Elemental Name	Symbol
101	Un nil unium	Unu	Mendelevium	Md
102	Un nil bium	Unb	Nobelium	No
103	Un nil trium	Unt	Lawrencium	Lr
104	Un nil quadium	Unq	Rutherfordium	Rf
105	Un nil Pentium	Unp	Dubnium	Db
106	Un nil hexium	Unh	Seaborgium	Sg
107	Un nil septium	Uns	Bohrium	Bh
108	Un nil octium	Uno	Hassium	Hs
109	Un nil ennium	Une	Meitnerium	Mt
110	Un unnilium	Uun	Darmstadtium	Ds

BOHR'S CLASSIFICATION

ALLEN CAREER INSTITUTE KOTA (RAJASTHAN) path to success

$Z = 120$

inert gas

118

Alkali

119

Alkali earth metal.

120

→ discovery of which mimum atomic Number leads to change in periodic Table

121 → 122

Ans ($Z = 122$)

$\longrightarrow$

(8s) (5g) (6f) (7d) (8p)

↓

$8s^2$, $5g^1$

G-Block

BOHR'S CLASSIFICATION

÷ Identification of period and group No of Element ÷

(1) If atomic Number of Element Given

→ Atomic Number of Inert gases with their Period No

Period No	1	2	3	4	5	6	7
	He	Ne	Ar	Kr	Xe	Rn	UUO
(Z)	2	10	18	36	54	86	118

→ if Given Atomic No (Z)

i) 57 — 71 → period No = 6th, group No = 3 / IIIB

ii) 89 → 103 → period No = 7th, group No = 3 / IIIB

BOHR'S CLASSIFICATION

1) If Given atomic Number Near to the inert gas which has atomic Number greater given atomic Number.

- [Atomic Number Of nearest inert gas > given atomic Number.]

- period No of element = Period No of inert gas.
- group No of element = 18 − differen in Atomic No of element and inert gas

Ex. given $Z = 34$

Kr → 36
Kr → 4th period

difference = 2

period No = 4th period
group No = 18 − 2 = 16

BOHR'S CLASSIFICATION

ii) If Given atomic of element is near to inert gas which atomic Number lower than given atomic Number.

✔ [Atomic Number Of nearest inert gas < given atomic Number.]

period No of element = period No of inert gas +1

group No of element = difference in Atomic No of element and inert gas.

Ex. Z=37

Kr → 36
Kr → 4th period , difference = 1

period No = 4+1 = 5

group No = 1

BOHR'S CLASSIFICATION

Ex. Find the period No and group No for given Atomic Number of elements.

1) 63 → [57-71]
   → period = 6
   → group = 3 III B

2) 116 → UUo [118].
   Period No = 7
   group No = 18−2 = 16 / VI A

3) 29 [Kr = 36] − 4th
   Period No = 4
   group No = 18−7 = 11 / I B

4) 86 → [Rn], Period No = 6
   group No = 18 / 0

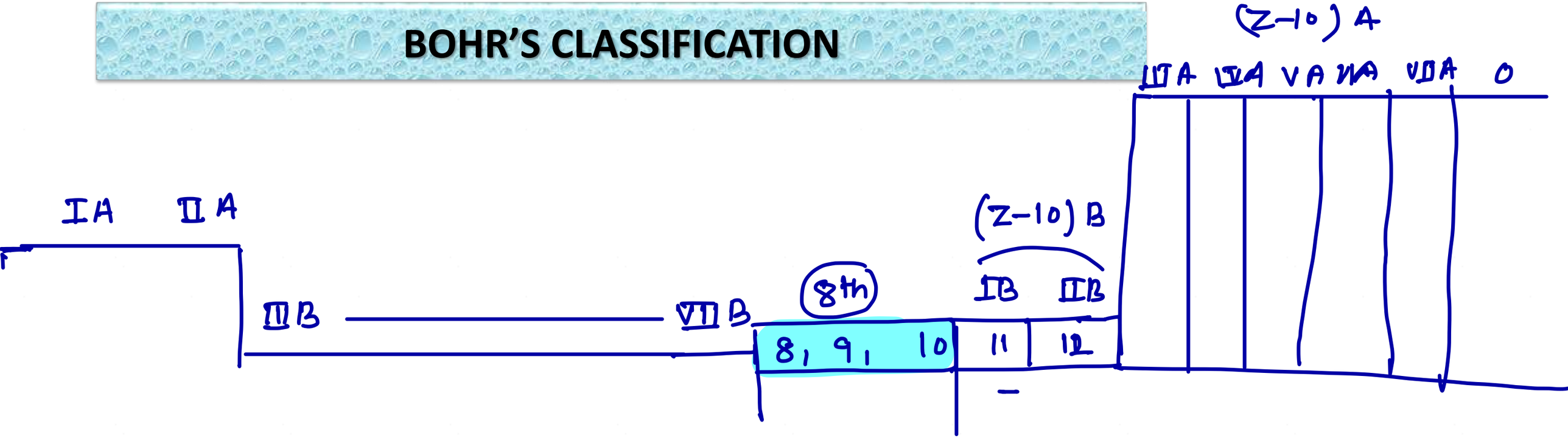
(5) 97 [89 − 103]
   → period No = 7
   → group No = 3 / III B

(6) 31 → Kr [36] 4th
   period = 4
   group = 18−5 = 13 / III A

(7) 47 → Xe [54] 5th period
   period No = 5th
   group No = 18−7 = 11 / I B

(8) 12 → [Ne = 10] 2nd period
   → period No = 2+1 = 3 / II A
   group No = 2

BOHR'S CLASSIFICATION



BOHR’S CLASSIFICATION

IDENTIFICATION OF GROUP, PERIOD AND BLOCK

ALLEN CAREER INSTITUTE KOTA (RAJASTHAN) path to success

When atomic number is given

Period No. = Period no. of next inert gas

Ex. z = 12 (Period no. = 3 , next inert gas $_{18}Ar$)

Step I : 71 ≥ Z ≥58 Lanthanoids (6th Period , f block , Group IIIB)

Ex. z = 65

Sol. - Period = 6th

block = f

Group = IIIB

s - block	d - block	p - block	f - block
1-2	3-12	13-18	3/IIIB

103 ≥ Z ≥ 90 Actinoids (7th Period , f block , Group IIIB)

Ex. Z = 101

Sol. Period = 7th

block = f

Group = IIIB

1st	$_{2}He$
2nd	$_{10}Ne$
3rd	$_{18}Ar$
4th	$_{36}Kr$
5th	$_{54}Xe$
6th	$_{86}Rn$
7th	$_{118}Uuo$

IDENTIFICATION OF GROUP, PERIOD AND BLOCK

ALLEN CAREER INSTITUTE KOTA (RAJASTHAN) path to success

Step II : Z = 104 to 118 (Period number = 7)

Group number = last two digits in atomic number of element

Ex. Z = 104

Sol. - Period = 7th

Group = 4

block = d

IDENTIFICATION OF GROUP, PERIOD AND BLOCK

ALLEN CAREER INSTITUTE KOTA (RAJASTHAN) path to success

Step III :

Group number = 18 + given atomic number – atomic number of next noble gas

Ex. Z = 21

Sol. - Period = 4th

Group = 18 + 21 – 36 = 3

block = d

If the value of this formula is negative,

then use 32 instead of 18 in formula

Ex. Z = 55

Sol. - Period = 6th

Group = 55 + 18 – 86 = -13

Group = 55 + 32 – 86 = 1

block = s

QUESTIONS

ALLEN CAREER INSTITUTE KOTA (RAJASTHAN) path to success

Q.1 The element with atomic number Z = 115 will be placed in :-

(1) 7th period, IA group

(2) 8th period, IVA group

(3) 7th period, VA group

(4) 6th period, VB group

Ans. (3)

Q.2 From atomic number 58 to 71, elements are placed in ;-

(1) 5th period and III A group

(2) 6th period and III B group

(3) 5th period and IIA group

(4) 7th period and IV B group

Ans. (2)

BOHR'S CLASSIFICATION

(B) When Electronic configuration of Element is given :-

Given Electronic configuration must be in ground state.

given = $1s^2, 2s^2, 2p^6, 3s^2, 3p^3, 3d^1$ [Excited state]

G.S → $1s^2, 2s^2, 2p^6, 3s^2, 3p^4$

$ns^2, (n-2)f^{14}, (n-1)d^{10}, np^6$

→ highest value give period No. = n

group No is decided According to Block.

BOHR'S CLASSIFICATION

i) For S-Block : GEC = [ ], $ns^{1/2}$

period No = n

group No = No of electrons in ns shell

ii) For d-Block : GEC = [ ] $(n-1)d^{1-10}$ $n^{0/1/2}$

period No = n

group No = No of electrons in ns + no of electrons (n-1)d shell

(iii) f-Block element : GEC, [ ] ns^2, $(n-2)f^{1-14}$ $(n-1)d^{0/1}$

period No = n

group No = 3 / III B

BOHR'S CLASSIFICATION

(IV) - P-Block Element GEC = [ ] ns^2, $(n-2)f^{14}$, $(n-1)d^{10}$, np^{1-6}

period No = n

group No = 12 + No of electrons in np-subshell

f Block.

Exo [X] = [Xe], $6s^2$, $4f^7$, $5d^1$

period No = 6

group No = 3 | IIIB

[Y] = [Ar], $3d^8$, $4s^2$

d-Block → period No = 4

d-Block → group No = 8+2 = 10

BOHR'S CLASSIFICATION

Q- Determine the group No and period No for following elements : given electronic configuration

i) $[Xe], 6s^2$ → Block - s-Block, period No = 6, group No = 2 / IIA

ii) $[Xe], 4f^9, 5d^0, 6s^2$ → f Block period No = 6, group No = 3 / IIIB

iii) $[Ar], 3d^{10}, 4s^2, 4p^2$ → P-Block period No = 4, group No = 14 / IVA

iv) $[Kr], 4d^{10}, 5s^1, 5p^3$ → P-Block, period No = 5, group No = 14 / IVA

GS = $[Kr], 4d^{10}, 5s^2, 5p^2$

v) $[Ar], 3d^5, 4s^1$ → d Block → period No = 4 group No = 6 / VIB

ELECTRONIC CONFIGURATION

ALLEN CAREER INSTITUTE KOTA (RAJASTHAN) path to success

When electronic configuration is given

- **Period number (n)** = Highest shell number.

- **Block identification** :

(i) If np electron present then p - block ($ns^2\ np^{1-6}$)

group number = 12 + np electrons

Ex. $1s^2$, $2s^2\ 2p^6$, $3s^2\ 3p^3$

$ns^2\ np^3$

Sol. Period = 3rd

block = p

Group = 12 + 3 = 15

ELECTRONIC CONFIGURATION

(ii) If np electron absent then s/f/d block

If $(n-2)f^0\ (n-1)d^0\ ns^{1-2}$ = s block

group number = ns electrons

Ex. $1s^2, 2s^2\ 2p^6, 3s^2$

ns^2

Sol. Period = 3rd

block = s

Group = ns electrons = 2

ELECTRONIC CONFIGURATION

(iii) If $(n-2)f^{1-14}\ (n-1)d^{0-1}\ ns^2$ = f block

group number = IIIB

Ex. $_{54}[Xe]\ 6s^2\quad 5d^1\quad 4f^7$

$ns^2\quad (n-1)d^1\quad (n-2)f^7$

Sol. Period = 6th

block = f

Group = IIIB

ELECTRONIC CONFIGURATION

(iv) If $(n-1)d^{1-10}\ ns^{0-2}$ (d-block)

group number = (n–1)d electron + ns electron

Ex. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^2$

$(n-1)d^5\ ns^2$

Sol. Period = 4th

block = d

Group = 5 + 2 = 7

QUESTIONS

Q.1 The atom having the valence shell electronic configuration $4s^2\ 4p^2$ would be in:-

(1) Group II A and period 3
(2) Group II B and period 4
(3) Group IV A and period 4
(4) Group IV A and period 3

Ans. (3)

Q.2 The element having electronic configuration $4f^{14}\ 5d^0\ 6s^2$ belongs to :-

(1) d–block, 12th group
(2) f–block, III B group
(3) f–block, 14th group
(4) s–block, 2nd group

Ans. (2)

Q.3 Which of the following electronic configuration does not belong to same block as others :-

(1) [Xe] $4f^{14}\ 5d^{10}\ 6s^2$
(2) [Kr] $4d^{10}\ 5s^2$
(3) [Kr] $5s^2$
(4) [Ar] $3d^6\ 4s^2$

Ans. (3)

QUESTIONS

Q. Which of the following set of elements belongs to same period :-

(1) Zn, Cd, Hg (2) Fr, Ra, U

(3) K, Ca, Ag (4) None

Ans. (2)

Q. $4d^3\ 5s^2$ configuration belongs to which group :-

(1) IIA (2) IIB

(3) V B (4) III B

Ans. (3)

Q. The electronic configuration of elements X and Z are $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$ and $1s^2\ 2s^2\ 2p^5$ respectively. What is the position of element X with respect to position of Z in the periodic table -

(1) Just below Z (2) Just above Z

(3) Left to the Z (4) right to the Z

Ans. (1)

QUESTIONS

Q. Identify group, period and block

(a) [Xe] $4f^{14}\ 5d^{10}\ 6s^2\ 6p^3$

Ans. **n=6, Period No. = 6, block = p, Group = 15th, = VA**

(b) [Xe] $4f^{14}\ 5d^{10}\ 6s^2\ 6p^6\ 7s^2$

Ans. **n=7, Period No. = 7, block =s, Group = IIA**

(c) [Xe] $4f^{14}\ 5d^2\ 6s^2$

Ans. **n=6, Period No. = 6, block =d, Group = 2 + 2 =4th = IV B**

BOHR'S CLASSIFICATION

Inert gases	Normal or representive elements	Transition element	Inner transition element
Outermost shell complete	Outermost shell incomplete	n & n-1 shells incomplete either in atomic or ionic form	n, (n-1), (n-2) shells incomplete
	s & p block element except inert gas	all d block element except = IIB (Zn, Cd, Hg, Uub)	f block elements
6 element	38 element	36 elements	28 elements
$ns^2\ np^6$	$ns^{1-2}\ np^{0-5}$		

Q. 1 Which of the following set of atomic numbers represent representative element

(1) 5, 13, 30, 53 (2) 11, 33, 58, 84

(3) 5, 17, 31, 54 (4) 9, 31, 53, 83

Ans. (4)

ALLEN CAREER INSTITUTE KOTA (RAJASTHAN) path to success

: SOME IMPORTANT DEFINITIONS :

- **Normal or Representative Element:** These are the element in which only 1 shell is partially filled rest all are completely filled. Ex. → S-Block Element and p-Block element (except inert gases).

- **Transition Element:** The element in which two shells are partially filled.

  Ex- d-Block Elements – (Zn, Cd, Hg)

BOHR'S CLASSIFICATION

- **Iner Transition Elements:** these are the element in which three shells are partially filled.

  Ex- f-Block element

- **Inert Gases:** These are the elements in which all shell are completely filled:

BOHR'S CLASSIFICATION

- **Transuranic Element:** Element having atomic No greater than Uranium (92).

  Ex = $Z > 92$

  - all are synthetic Elements.

- **Rare Earth Elements:** All Lanthanoids are called rare Earth Elements.

- **Typical Elements:** the Elements which gives complete information of group and having least atomic No.

BOHR'S CLASSIFICATION

1st 2nd	Li	$(1s^2, 2s^2, 2p^0, \cancel{2d})$
	Na	
	K	
	Rb	
	Cs	

they have all ability to be typical elements.

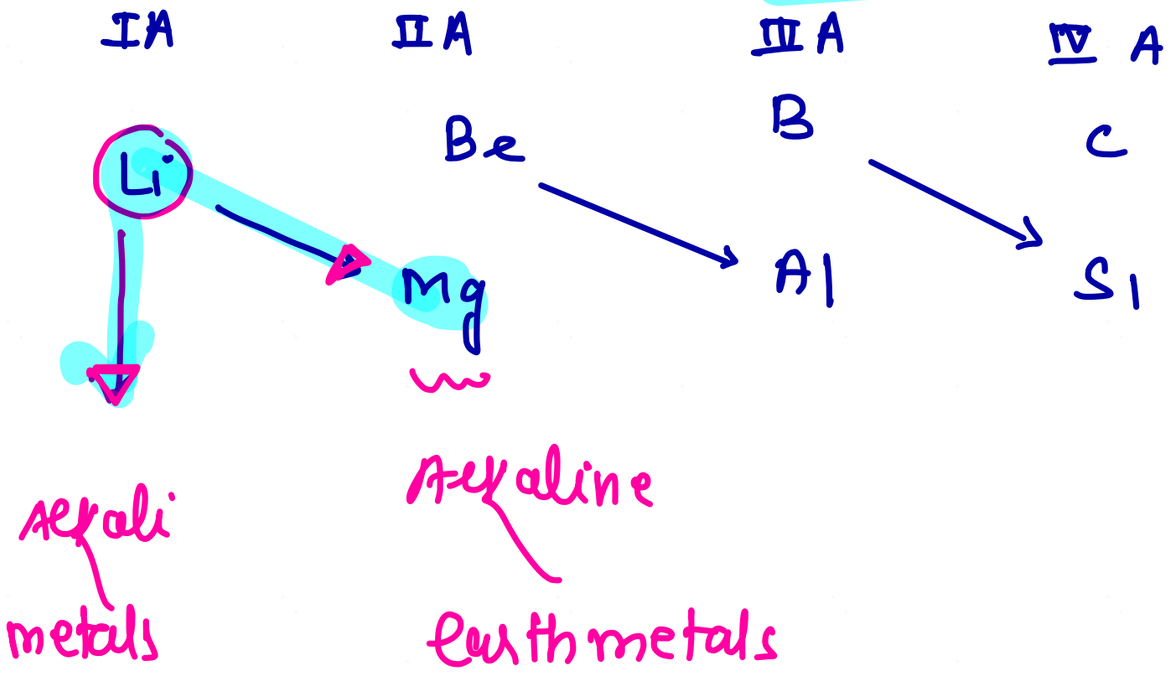
↳ problem → very small
↳ absence of d-subshell
Excitation is not possible
×

thats why typical Elements are elements of 3rd period.

BOHR'S CLASSIFICATION

- **Bridge Element** : these elements were defined in medeleeve periodic table.

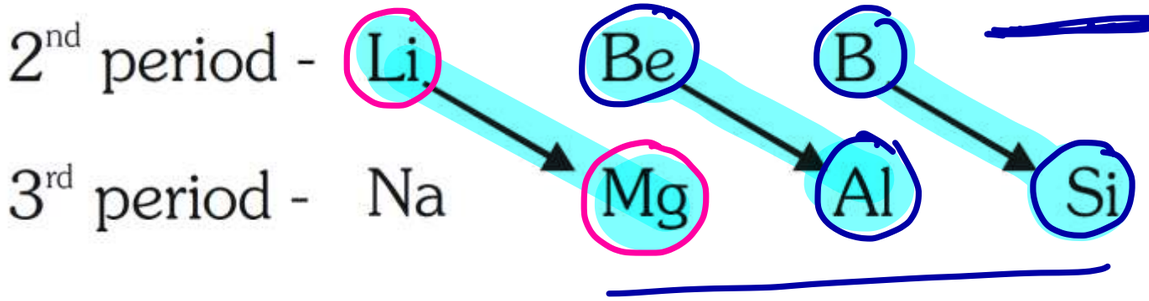
→ 2nd period. Elements are called bridge elements.



BOHR’S CLASSIFICATION

SOME IMPORTANT POINTS

(1) Diagonal Relationship: 2nd period elements (Li, Be, B) Shows diagonal relationship with 3rd period elements (Mg, Al, Si). Because of same ionic potential value they shows similarity in properties.



digonal relationship property reduces

(2) Typical Elements: 3rd period elements are know as typical elements because they represent the properties of their respective group.

Na, Mg, Al, Si, P, S, Cl

SOME IMPORTANT POINTS

(3) Transuranic Elements: Elements having atomic no. more then 92 are man-made and radioactive , they are made up Uranium by nuclear reactions.

			f-block	d-block
Th	Pa	U	Np——Lr	Unq——Uub
90	91	92	93 103	104 112

First man made element is - **Tc**

First man made lanthanoid is - **Pm**

All actinoids are radioactive.

All lanthanoids are not artificial / man made (except Pm)

SOME IMPORTANT POINTS

(4) Group containing most electro positive elements - GROUP IA. (1st)

(5) Group containing most electro negative elements - GROUP VIIA (17th)

(6) Group containing maximum number of gaseous elements - GROUP ZERO(18th)

(7) Group in which elements have generally ZERO valency - GROUP ZERO(18th)

(8) **In the periodic table**
Number of Gaseous elements - 11 (H, N, O, F, Cl + Noble gases)

Number of Liquid elements - 6 (Cs, Fr, Ga, Hg, Br, Uub)

Bromine is the only non-metal which exists in liquid form.
Number of Solid elements - 95 (if discovered elements are 112)

SOME IMPORTANT POINTS

(9) 0/18 group have all the elements in gaseous form.

(10) 2nd period contains maximum number of gaseous elements - N, O, F, Ne

(11) IIIB/3rd group is called longest group having 32 elements including 14 Lanthanides and 14 Actinides

Sc
Y
La.....Lanthanides (14)
Ac.....Actinides (14)

(12) Radioactive elements whose name based on planets-Np, Pu.

(13) Name given by - (i) Lawrence Berkeley Lab- $_{103}Lr$ (ii) Seaborg's group- $_{106}Sg$

SOME IMPORTANT POINTS

Q. Which of the following statement is wrong :-

(1) All the actinides are synthetic (man made) elements
(2) In the Lanthanides last electron enters in 4f orbitals
(3) 3rd period elements are typical elements
(4) Lanthanum is d - block element

Ans. (1)

Q. Which of the following statement is wrong :-

(1) Total no. of liquid elements in the periodic table.....Six
(2) First metal element in the periodic table is....Li
(3) All type of elements are present in 6th period
(4) Iodine is a gaseous element.

Ans. (4)

SOME IMPORTANT POINTS

ALLEN CAREER INSTITUTE KOTA (RAJASTHAN) path to success

Q. Uranium (At No. - 92) is the last natural element in the periodic table. If the last element of the periodic table which is recently discovered is Uub. What will be the total number of transuranic elements in the periodic table :-

(1) 21 (2) 20

(3) 11 (4) 12

Ans. (2)

Q. Which of the following statement is not correct for given electronic configuration $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ 5d^{10}\ 6s^2$

(1) It belongs to IIB group and 6th period

(2) It is liquid at room temperature

(3) It is a transition element

(4) It is used in thermometres

Ans. (3)

MAGIC NO.

Grp.1	Grp.2	Grp.3	Grp.4-12	Grp.13-17	Grp.18
2	–	–	–	–	8
8	8	–	–	8	8
8	8	–	–	18	18
18	18	18	18	18	18
18	18	18	32	32	32
32	32	32	32	32	32

PERIODICITY

(A) In a period, the ultimate orbit remain same, but the number of e^- gradually increases.
In a group, the number of e^- in the ultimate orbit remains same, but the values of n increases.

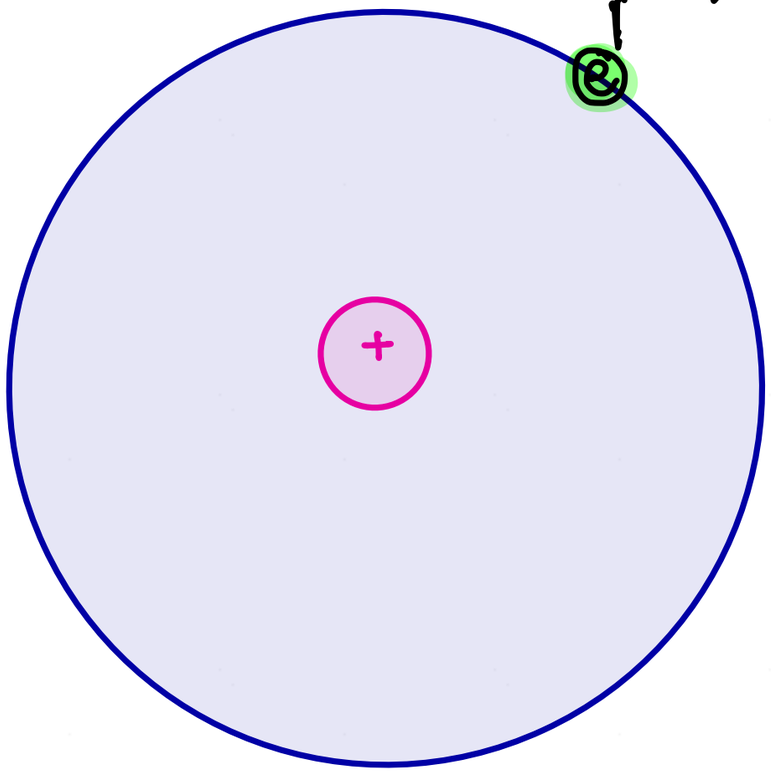
(B) CAUSES OF PERIODICITY :

(a) Same outermost shell electronic configuration coming at regular intervals.
(b) Similar properties occur at intervals of 2, 8, 8, 18, 18 and 32. These numbers are called as magic numbers.

BOHR'S CLASSIFICATION

- Nuclear charge (Z): positive charge present in Nucleus of an atom:

Nuclear charge = +Ze



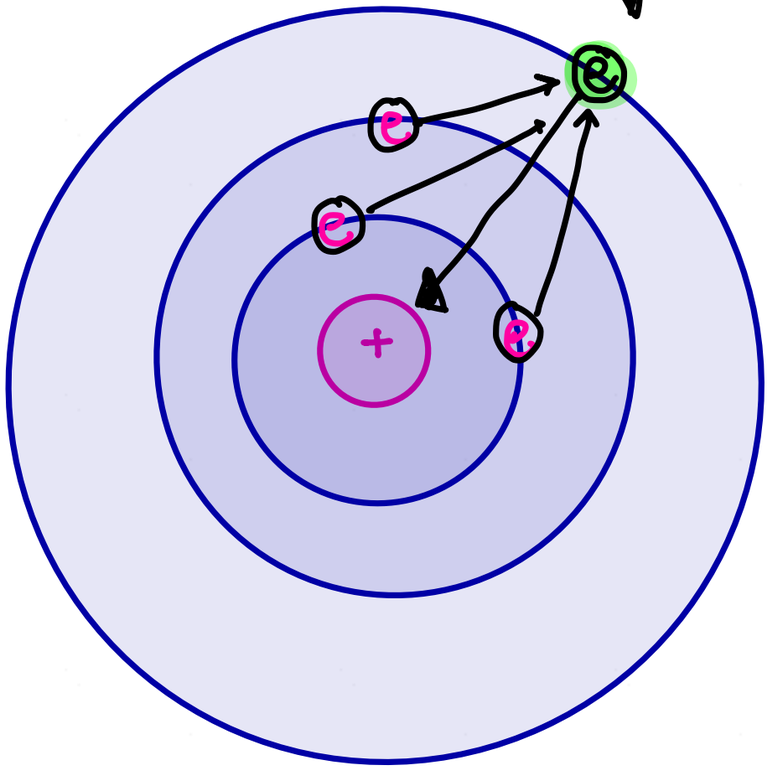
unielectron

How much attractive force does it feel

↓

→ it is equivalent the attractive force applied by No of protons present in Nucleus.

BOHR'S CLASSIFICATION



How much attractive force feel

It is less than equivalent force applied by the protons present in the nucleus.

multielectron

$Z_{eff.} = Z - \sigma$

Effective Nuclear charge = Nuclear charge − Shielding Constant

BOHR'S CLASSIFICATION

- In a multielectron species the positive charge experienced by outer most electron is effectively less a compared to unielectron species. this effect is known as shielding or Screening effect.

- the value of shielding effect is determined by a Constan (σ) called shielding constant.

→ $n < (n-1) < (n-3) < (n-4)$ - - - order of shieding

→ $nf < nd < np < ns$ order of shielding

BOHR'S CLASSIFICATION

: Calculation of σ SLATER RULE :

(A) For electron present in s or p subshell:

Rule:

Rule-1 : write Electronic Configuration

Rule-2 : find out for which you are going to calculate and indicate n, n-1) etc.

Ex. find Z_{eff} for last e^- in Cl.

[Cl]. $1s^2, 2s^2, 2p^6, 3s^2, 3p^5$

[Cl]. : $(1s^2)(2s^2, 2p^6)(3s^2, 3p^5)$

	(n-2)	(n-1)	n
e^-	2	8	7

BOHR'S CLASSIFICATION

Rule.3 follow the shielding order given bellow and Calculate σ

Shell	$\leftarrow$	(n-2)	(n-1)	n	n+1
σ / e^-	1	1	0.85	0.35	0

$$\sigma = 6 \times 0.35 + 8 \times 0.85 + 2 \times 1$$

$$\sigma = 2.10 + 6.80 + 2$$

$$\sigma = 10.90$$

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

$$= 17 - 10.9$$

$$Z_{eff} = 6.1$$

BOHR'S CLASSIFICATION

HW

Ex: Calculate $Z_{effective}$ for following ?

(1) 3s electron of Mg

Mg : $(1s^2)$ $(2s^2, 2p^6)$ $(3s^2)$

$(n-2)$ $n-1$ n

$\sigma = 1 \times 0.35 + 8 \times 0.85 + 2 \times 1$

$= 0.35 + 6.8 + 2$

$= 9.15$, $Z_{eff} = 12 - 9.15$

$= \underline{2.85}$

ii) 3p electron of phosphorous.

P : $(1s^2)$ $(2s^2, 2p^6)$ $(3s^2, 3p^3)$

$(n-2)$ $(n-1)$ n

$\sigma = 4 \times 0.35 + 8 \times 0.85 + 2 \times 1$

$\sigma = 10.2$

$Z_{eff} = 15 - 10.2 = 4.8$

BOHR'S CLASSIFICATION

HW = (iii) 4s electron of chromium

(iv) 2p electron of Carbon

iii) calculate z_{eff} for 3d $\bar{e}$ of Mn

iv) Calculate z_{eff} for 3d $\bar{e}$ of Ni

BOHR'S CLASSIFICATION

(iii) Zeff. of 4s of Cr (24)

$Cr = (1s^2)(2s^2, 2p^6)(3s^2, 3p^6, 3d^5)(4s^1)$

$(n-3)$ $(n-2)$ $(n-1)$ n

$\sigma = 13 \times 0.85 + 8 \times 1 + 2 \times 1$

$\sigma = 11.05 + 10$

$\sigma = 21.05$

$Z_{eff} = Z - \sigma$

$= 24 - 21.05$

$= 2.95$

BOHR'S CLASSIFICATION

(iv) $C = (1s^2)(2s^2, 2p^2)$

$(n-1)$ n

$\sigma = 3 \times 0.35 + 2 \times 0.85$

$\sigma = 1.05 + 1.70$

$\sigma = 2.75$

$Z_{eff} = Z - \sigma = 6 - 2.75$

$Z_{eff.} = 3.25$

BOHR'S CLASSIFICATION

(V) $Mn(25) = (1s^2, 2s^2, 2p^6, 3s^2, 3p^6)(3d^5), 4s^2$

$(n-1)$ n

$\sigma = 4 \times 0.35 + 18 \times 1$

$\sigma = 1.40 + 18$

$\sigma = 19.4$

$Z_{eff.} = Z - \sigma$

$= 25 - 19.4$

$Z_{eff.} = 5.6$

BOHR'S CLASSIFICATION

(VI) $Ni\ (28) = (1s^2, 2s^2, 2p^6, 3s^2, 3p^6), (3d^8), 4s^2$

$(n-1)$ n

$\sigma = (7 \times 0.35) + 18 \times 1$

$\sigma = 2.45 + 18$

$\sigma = 20.45$

$Z_{eff} = Z - \sigma$

$= 28 - 20.45$

$= 7.55$

BOHR'S CLASSIFICATION

(B) for d and f- subshell :

Rule

Rule-1 write Electronic Configuration

Rule:2. Group the subshell for which your are going to calculate σ and assign that n and rest all subshells assign (n-1)

Example : Find effective v.e of Cu^+

Cu^+ : $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^{10}, 4s^0$

$(1s^2, 2s^2, 2p^6, 3s^2, 3p^6)(3d^{10})$

(n-1) n

BOHR'S CLASSIFICATION

follow the following table and calculate σ

shell	n-1	n
σ/e	1	0.35

$\sigma = 9 \times 0.35 + 18 \times 1$

$\sigma = 3.15 + 18$

$\sigma = 21.15$

$Z_{eff} = 29 - 21.15$

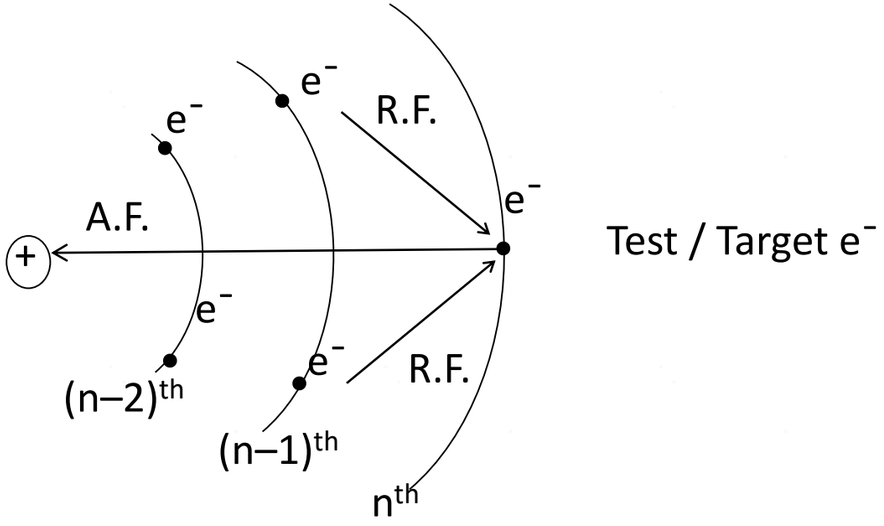
$= 7.85$

<u>Note</u>: shielding constant for hydrogen and hydroge like species is zero.

: shielding constant for He, and $H^{\ominus}$ is 0.30

SCREENING OR SHIELDING EFFECT (σ)

R.F. (Repulsion force)
A.F. (Attraction force)



Repulsion force applied by remaining electrons on the outermost shell test/target electron is known as screening or shielding effect (σ).

EFFECTIVE NUCLEAR CHARGE (Z_{eff})

Reduced attraction force or net attraction force applied by nucleus on the outermost shell test e^- / target e- is known as effective nuclear charge (Z_{eff})

Net attraction = $f_{att} - f_{rep}$

Z = Atomic No. / nuclear charge

σ = Screening / Shielding constant

$$Z_{eff} = (Z - \sigma)$$

SLATER'S RULE TO CALCULATE SCREENING CONSTANT (σ)

(a) For single electron species $\sigma = 0$

(b)

Shell	n^{th}	$(n-1)^{th}$	$(n-2)^{th}$ and Rest all
σ	$0.35/e^-$	$0.85/e^-$	$1/e^-$

Ex. find Zeffective for valence e^- of Mn. (25)

Step-1

$$\underset{(n-3)}{(1s^2)}\ \underset{(n-2)}{(2s^2, 2p^6)}\ \underset{(n-1)}{(3s^2, 3p^6, 3d^5)}\ \underset{n}{(4s^2)}$$

1

n-3	n-2	n-1	n
1	1	0.85	0.35

$$\sigma = 1\times0.35 + 13\times0.85 + 8\times1 + 2\times1$$

$$Z_{eff} = Z - \sigma = 25 - \sigma$$

Ex find the Zeff of 3p electron of Mn (25)

$$\underset{(n-2)}{1s^2},\ \underset{(n-1)}{(2s^2, 2p^6)},\ \underset{n}{(3s^2, 3p^6, 3d^5)}\ \underset{(n+1)}{(4s^2)}$$

$$\sigma = \left(12\times0.35 + 8\times0.85 + 2\times1\right)$$

d/f Ex. Find the Zeffective for 3d e^- of Mn.

Soln $(1s^2, 2s^2, 2p^6, 3s^2, 3p^6)(3d^5), (4s^2)$

$(n-1)$ n $(n+1)$

	$n-1$	n	$n+1$
	1	0.35	0

$\sigma = 4 \times 0.35 + 18 \times 1$

$Z_{eff} = ?$

SLATER'S RULE TO CALCULATE SCREENING CONSTANT (σ)

ALLEN CAREER INSTITUTE KOTA (RAJASTHAN) path to success

$_3Li = 1s^2\ 2s^1$
(n-1) (n)
$\sigma = (2*0.85) + (0*0.35)$
$\sigma = 1.70$
$Z_{eff} = Z - \sigma$
$= 3 - 1.70$
$= 1.30$

$_4Be = 1s^2\ 2s^2$
(n-1) (n)
$\sigma = (2*0.85) + (1*0.35)$
$\sigma = 2.05$
$Z_{eff} = Z - \sigma$
$= 4 - 2.05$
$= 1.95$

$_5B = 1s^2\ 2s^2\ 2p^1$
(n-1) (n)
$\sigma = (2*0.85) + (2*0.35)$
$\sigma = 2.40$
$Z_{eff} = Z - \sigma$
$= 5 - 2.40$
$= 2.60$

$Sc^{21} =$ $3d^1, 4s^2$
Ti^{22} $3d^2$ $4s^2$
(n-1) n
0.85 0.35

$_{11}Na = 1s^2\ 2s^2\ 2p^6\ 3s^1$
(n-2) (n-1) (n)
$\sigma = (2*1.00) + (8*0.85) + (0*0.35)$
$\sigma = 8.8$
$Z_{eff} = Z - \sigma$
$= 11 - 8.8$
$= 2.20$

Group	Element	Li	Na	K	Rb	Cs	Fr
	Z_{eff}	1.30	2.20	2.20	2.20	2.20	2.20
Period	Element	Be	B	C	N	O	F
	Z_{eff}	1.95	2.60	3.25	3.90	4.55	5.20

$Z+1 - 0.85$
$= Z + 0.15$

Result :

1. From top to bottom in a group Zeff remain constant.
2. From left to right in a period Zeff increases by .65.

BOHR'S CLASSIFICATION

0.30

Zeff increases by factor = 0.65

Zeffective increases by factor 0.15

1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIIIB	9 VIIIB	10 VIIIB	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1 H Hydrogen 1.008																	2 He Helium 4.002602
3 Li Lithium 6.94	4 Be Beryllium 9.012182											5 B Boron 10.81	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998403163	10 Ne Neon 20.1797
11 Na Sodium 22.98976928	12 Mg Magnesium 24.305											13 Al Aluminium 26.9815385	14 Si Silicon 28.085	15 P Phosphorus 30.973761998	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.948
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955908	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938044	26 Fe Iron 55.845	27 Co Cobalt 58.933194	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.630	33 As Arsenic 74.921595	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 83.798
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90584	40 Zr Zirconium 91.224	41 Nb Niobium 92.90637	42 Mo Molybdenum 95.95	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.414	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60	53 I Iodine 126.90447	54 Xe Xenon 131.293
55 Cs Caesium 132.90545196	56 Ba Barium 137.327	57 - 71 Lanthanoids	72 Hf Hafnium 178.49	73 Ta Tantalum 180.94788	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.084	79 Au Gold 196.966569	80 Hg Mercury 200.592	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98040	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)	89 - 103 Actinoids	104 Rf Rutherfordium (267)	105 Db Dubnium (268)	106 Sg Seaborgium (269)	107 Bh Bohrium (270)	108 Hs Hassium (269)	109 Mt Meitnerium (278)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (282)	112 Cn Copernicium (285)	113 Nh Nihonium (286)	114 Fl Flerovium (289)	115 Mc Moscovium (289)	116 Lv Livermorium (293)	117 Ts Tennessine (294)	118 Og Oganesson (294)

0.65

0.65

Zeff ↓

57 La Lanthanum 138.90547	58 Ce Cerium 140.116	59 Pr Praseodymium 140.90766	60 Nd Neodymium 144.242	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92535	66 Dy Dysprosium 162.500	67 Ho Holmium 164.93033	68 Er Erbium 167.259	69 Tm Thulium 168.93422	70 Yb Ytterbium 173.045	71 Lu Lutetium 174.9668
89 Ac Actinium (227)	90 Th Thorium 232.0377	91 Pa Protactinium 231.03588	92 U Uranium 238.02891	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (266)

BOHR'S CLASSIFICATION

Be → B

2, 2, 2, 3

Z = 4 Z = 5

1 e^- is more that present in nth shell

$\Delta Z = 1$

$\Delta\sigma = 0.35$

$= \sigma = 0.35$

Z_{eff} increases = 0.65

BOHR'S CLASSIFICATION

Sc ——————— Ti

2, 8, 9, 2

$1s^2, 2s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^1, 4s^2$

$Z = 21$

2, 8, 10, 2

$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^2, 4s^2$

$Z = 22$

1e⁻ is added in $(n-1)^{th}$ shell

$\Delta Z = 1$

$\Delta\sigma = 0.85$

Z_{eff} increases effectively $= 0.15$

BOHR'S CLASSIFICATION

$s > p > d > f$

महामक्कार

f-Block Element :-

Pm

$Z = 61$

$[Xe], 4f^5, 5d^0\ 6s^2$

54

(n-2)

Sm

$Z = 62$

$[Xe], 4f^6, 5d^0\ 6s^2,$

$\Delta Z = 1$

$\Delta\sigma = 1$

1e⁻ is added in (n-2)th shell which gives $\sigma = 1$

Zeff increases by = 0

BOHR'S CLASSIFICATION

* According to slater Zeff. remains constant in f-Block but due to poor shielding of f electrons ($\sigma \downarrow$) Zeff. increases contineously.

Zeff. contineously increases.

57 **La** Lanthanum 138.90547	58 **Ce** Cerium 140.116	59 **Pr** Praseodymium 140.90766	60 **Nd** Neodymium 144.242	61 **Pm** Promethium (145)	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.964	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.92535	66 **Dy** Dysprosium 162.500	67 **Ho** Holmium 164.93033	68 **Er** Erbium 167.259	69 **Tm** Thulium 168.93422	70 **Yb** Ytterbium 173.045	71 **Lu** Lutetium 174.9668
89 **Ac** Actinium (227)	90 **Th** Thorium 232.0377	91 **Pa** Protactinium 231.03588	92 **U** Uranium 238.02891	93 **Np** Neptunium (237)	94 **Pu** Plutonium (244)	95 **Am** Americium (243)	96 **Cm** Curium (247)	97 **Bk** Berkelium (247)	98 **Cf** Californium (251)	99 **Es** Einsteinium (252)	100 **Fm** Fermium (257)	101 **Md** Mendelevium (258)	102 **No** Nobelium (259)	103 **Lr** Lawrencium (266)

Exceptions : (1)

(5) B = $1s^2, 2s^2, 2p^1$

8 e^- Added → 2 e^- in s-subsh
→ 6 e^- in p-subsh.

(13) Al = $1s^2, 2s^2, 2p^6, 3s^2, 3p^1$

(31) Ga = $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^{10}, 4s^2, 4p^1$

18 e^- Added → 2 e^- in s-subshell
→ 6 e^- in p-subshell
→ 10 e^- in d-subshell

मकबार

$$Z_{eff}(Ga) > Z_{eff}(Al)$$

BOHR'S CLASSIFICATION

Exception No.02 : this exception is applicable from 4th group to 14th group.

period		
4th	Ti (22)	
		18e⁻ Added → 2e⁻ of s, 6e⁻ of p, 10e⁻ of d
5th	Zr (40)	
		32e⁻ Added → 2e⁻ of s, 6e⁻ of p, 10e⁻ of d, 14 e⁻ of f
6th	Hf (72)	

नटामकार

Zeff (6th period Element) > Zeff (5th period Element

QUESTIONS

Q. In sodium atom, the screening is due to :-

(1) $3s^2, 3p^6$

(2) $2s^1$

(3) $1s^2, 2s^2\ 2p^6$

(4) $1s^2, 2s^2$

Ans. (3)

Q. According to Slater's rule, order of effective nuclear charge for last electron in case of Li, Na and K :-

(1) Li > Na > K

(2) K > Na > Li

(3) Na > Li > K

(4) Li < Na = K

Ans. (4)

Z_{eff}

ALLEN CAREER INSTITUTE KOTA (RAJASTHAN) path to success

For same shell shielding effect has the order as

$\boxed{s > p > d > f}$ **(due to penetration effect)**

Zeff. ⇒ (Na^+ > Na)

Zeff for different ions

$$Z_{eff} \propto \frac{\text{positive charge}}{\text{negative charge}}$$

(i) Z_{eff} for different ions of an element

(ii) Z_{eff} for isoelectronic species.

Zeff. ⇒ N > N^{-3}

(i) Z_{eff} for different ions of an element

Ex. $N^+ > N > N^- =$ Zeff

(ii) Z_{eff} of isoelectronic species

Ex. $H^- < Li^+ < Be^{+2} < B^{+3}$ ($2e^-$ species)

- $N^{-3} < O^{-2} < F^- < Na^+ < Mg^{+2}$ ($10e^-$ species)

Catagory of Isoelectronic

→ $Z_{eff} \propto \frac{\text{+ve charge}}{\text{−ve charge}}$.

QUESTIONS

Q. Screening effect is not observed in :

(1) He^{+} (1)
(2) Li^{+2} (1)
(3) H (1)
(4) All of these

Ans. (4)

Q. Determine the correct order of Z_{eff}?

(1) $Co < Co^{2+} < Co^{+3}$
(2) $Ca^{2+} < K^{+} < Sc^{3+}$
(3) $I^{+} < I < I^{-}$
(4) $O^{-} > O > O^{2-}$

Ans. (1)

s > p > d > f

Variation of Zeff. In periodic table

ALLEN CAREER INSTITUTE KOTA (RAJASTHAN) path to success

(1) In s & p Block on going left to right Zeff. increases by a factor of 0.65

(2) In d block ~~on~~ going left to right Zeff increases by a factor of 0.15

(3) In f-Block Zeffective remains constant according to Slater rule but due to poor shielding of f-electrons Zeff. increases continuously..

$(n-2)f$ $(n-1)d$, ns^2

Variation of Zeff. In periodic table

ALLEN CAREER INSTITUTE KOTA (RAJASTHAN) path to success

$Z_{eff} = Z - \sigma$

Exception

(1) $B\ (5) = 1s^2, 2s^2, 2p^1$

$Al\ (13) = 1s^2, 2s^2, 2p^6, 3s^2, 3p^1$

8 e^- added
2 e^- of s subshell
6 e^- of p-subshell

$Ga\ (31) = 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^{10}, 4s^2, 4p^1$

18 e^- added
2 e^- of s subshell
6 e^- of p-subshell
10 e^- of d-subshell

↳ मस्कार

$$\boxed{Z_{eff}(Ga) > Z_{eff}(Al)}$$

Variation of Zeff. In periodic table

ALLEN CAREER INSTITUTE KOTA (RAJASTHAN) path to success

Exception ② this exception applicable from 4th group to 14th group b/w 5th and 6th period.

$$\boxed{Z_{eff}\,(\text{6th period element}) > Z_{eff}\,(\text{5th period element})}$$

Ti (22) → Zr (40): 18 e^- added
- 2 e^- in s-subshell
- 6 e^- in p-subshell
- 10 e^- in d-subshell

Zr (40) → Hf (72): 32 e^- added
- 2 e^- in s-subshell
- 6 e^- in p-subshell
- 10 e^- in d-subshell
- 14 e^- in f-subshell

महाभक्कार

Variation of Zeff. In periodic table

ALLEN CAREER INSTITUTE KOTA (RAJASTHAN) path to success

Exception -3 → d-Block Element

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
$3d^1 4s^2$	$3d^2 4s^2$	$3d^3 4s^2$							$3d^{10}, 4s^2$

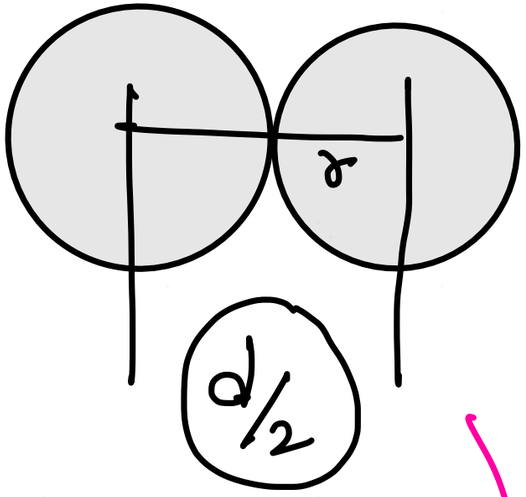
Zeff dominating.

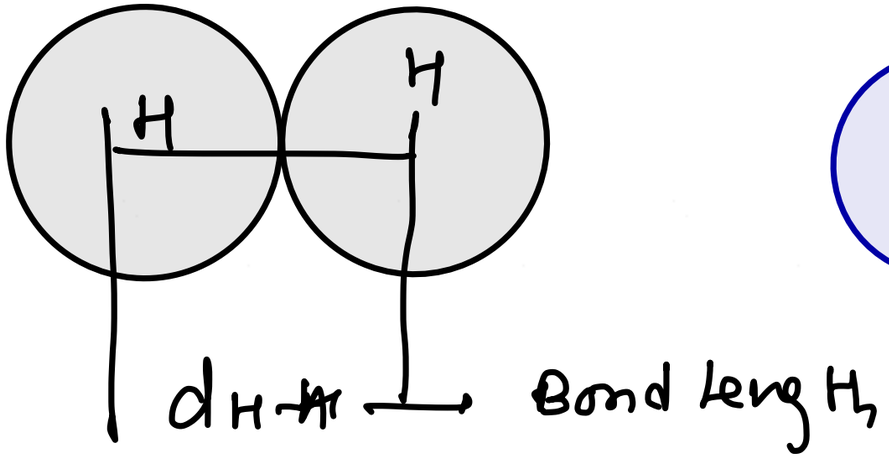
Zeff Effect is cancelled by Screening effect

Shielding Effect dominates

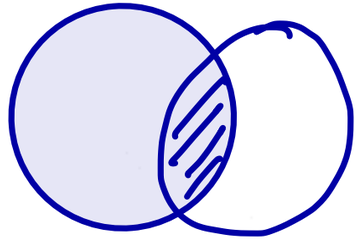
Variation of Zeff. In periodic table

metallic

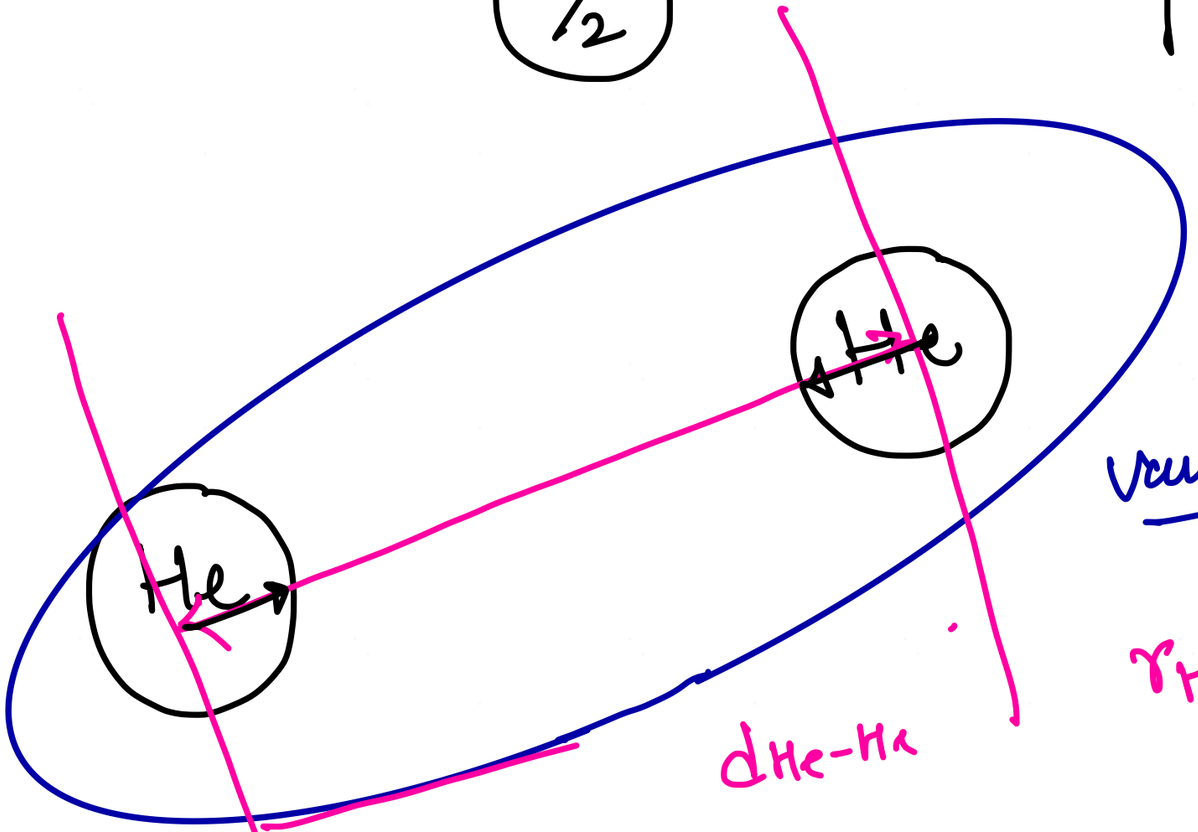




Co-valent



$$r_H = \frac{d_{H-H}}{2}$$



Vanderwaal

$$r_{He} = \frac{d_{He-He}}{2}$$

$$r_{VW} > r_M > r_{Cov.}$$

ATOMIC RADIUS

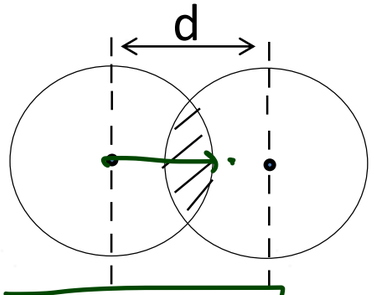
* Half of the inter nuclear distance b/w two adjacent same atoms.
* Atomic radius can be classified into three categories.

Atomic Radius

Covalent Radius

b/w non-metals

(by covalent bonding)

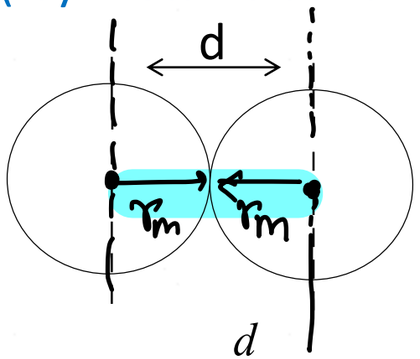


$$r_{covalent} = \frac{d}{2}$$

Metallic / Crystal Radius

b/w metals

(by metallic bonding)

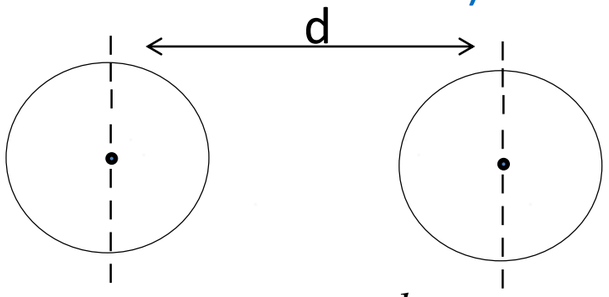


$$r_{Metallic} = \frac{d}{2}$$

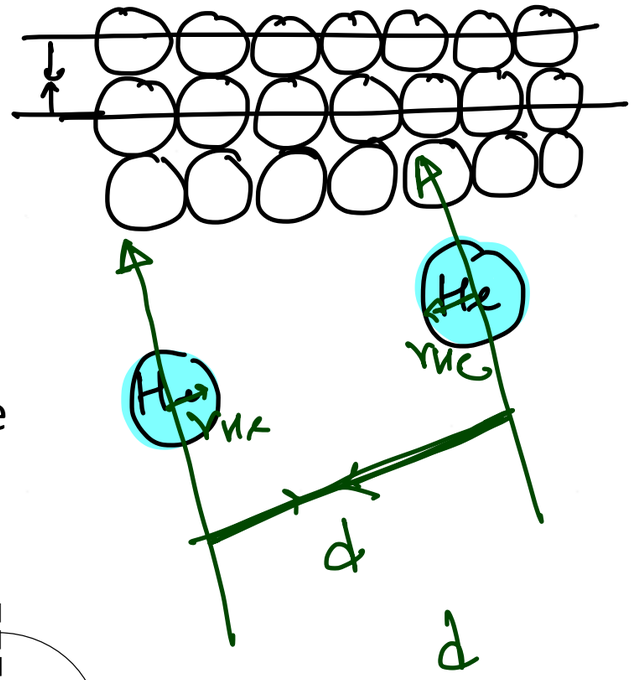
Vanderwall Radius

b/w inert gases & non-metal molecule

(by vanderwall force of attraction)



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



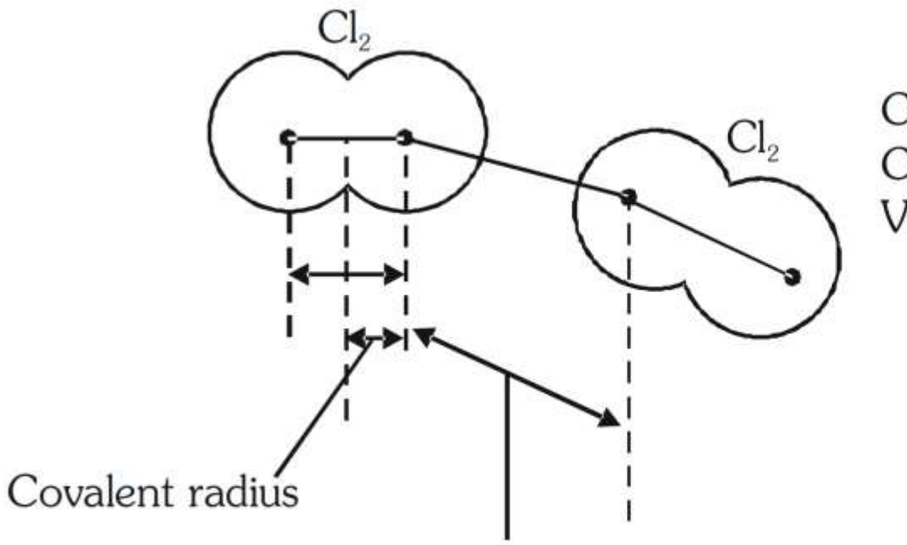
$2r_{He} = d$

$r_{He} = d/2$

Order of radius : $r_c < r_m < r_v$

Note : $r_{vanderwall} \cong 2 * r_{covalent}$

VANDERWALL RADIUS



Cl_2 molecules
Covalent radius = 0.99Å
Van der Waal's radius = 1.80Å

Ex. Mr X, Y, Z measures radius of an Atom A

X measure $r_A = 50$ pm

Y measures $r_A = 150$ pm

Z measure $r_A = 100$ pm

Who measures which radius

Solⁿ. Y - measures Vandwaal radius

X → measures Co-valent radius

Z → measure Metallic radius.

Radius of ions

A

Cation

A^+

Electron removed from outer shell ($\sigma = 0.35$)

sheding decreased by a factor 0.35

$$\boxed{r_{A^+} < r_A \quad \text{(always)}}$$

Anion (A^-)

Electron is added in outer shell ($\sigma = 0.35$)

Sheilding increased by factor 0.35

$$\boxed{r(A^-) > r(A)}$$

Note-1 If by adding e^-s a shell filled and new shell starts radius increases dractically.

Note-2 → If by removing e^- a shell is removed then radius decreases dractically.

IONIC RADIUS

(i) Cationic Radius

❖ Cationic radius is always smaller than neutral atom

$$\text{Size of cation} \propto \frac{1}{Z_{eff}} \qquad \frac{1}{Zeff}$$

Ex. (i) $Fe > Fe^{+2} > Fe^{+3}$

(ii) $Pb^{+2} > Pb^{+4}$

(iii) $Mn > Mn^{+2} > Mn^{+3} > Mn^{+4} > Mn^{+5} > Mn^{+6} > Mn^{+7}$

IONIC RADIUS

(ii) Anionic Radius

❖ Anionic radius is always greater than neutral atom.

Ex. $F < F^-$

$Cl < Cl^-$

$N < N^- < N^{-2} < N^{-3}$

$O < O^- < O^{-2}$

IONIC RADIUS

(c) Size of isoelectronic species :

❖ Those species having same number of e^- but different nuclear charge forms isoelectronic series.

Species	K^+	Ca^{+2}	S^{-2}	Cl^-
Z	19	20	16	17
e	18	18	18	18

Note : Gen. order of radius = $2e^- < 10e^- < 18e^- < 36e^- < 54e^- < 86e^- < 118e^-$

Order of radius : $(S^{-2} > Cl^- > K^+ > Ca^{+2})$, $(N^{3-} > O^{2-} > F^- > Na^+ > Mg^{+2} > Al^{+3})$

18 e^- 10 e^-

Note : ISOTOPES have similar radius

$^{37}Cl^- = {}^{35}Cl^-$

for isoelectronic species $\propto \frac{\text{No of electrons}}{\text{No of protons}}$

dominating

IONIC RADIUS

Q. Which of the following sequence is correct for decreasing order of ionic radius :.

(1) Se^{-2}, I^-, Br^-, O^{-2}, F^-

(2) I^-, Se^{-2}, O^{-2}, Br^-, F^-

(3) Se^{-2}, I^-, Br^-, F^-, O^{-2}

(4) I^-, Se^{-2}, Br^-, O^{-2}, F

Ans. (4)

Q. K+, Ar, Ca2+ and S2. contains _

(1) Same electronic configuration and atomic volume

(2) Different electronic configuration but same IP.

(3) Same electronic configuration but different atomic volume

(4) None

Ans. (3)

QUESTIONS

Q. Select the correct order of ionic radius?

(1) $Fe < Fe^{2+} < Fe^{+3}$ (2) $P^{3-} > S^{2-} > Cl^{-}$

(3) $Na^{+} > Mg^{2+} > K^{+}$ (4) $O^{2-} < F^{-} < Br^{-}$

Ans. (2)

Q. If the ionic radii of K^{+} and F^{-} are nearly the same (i.e. 1.34 Å) then the atomic radii of K and F respectively are :–

(1) 1.34 Å, 1.34 Å (2) 0.72 Å, 1.96 Å

(3) 1.96 Å, 0.72 Å (4) 1.96 Å, 1.34 Å

Ans. (3)

Variation of Zeff. In periodic table

Ex. If Radius of F^- is 140 pm then what will be the radius of F ?

(a) 160 pm (b) 165 pm ✓(c) 130 pm (d) 220 pm

Ex. If Radius of F^- and K^+ is 140 pm then which can't be radius of K

(a) 160 pm (b) 165 pm ✓(c) 130 pm (d) 220 pm

FACTORS AFFECTING ATOMIC SIZE ARE

(a) In a period

Atomic radius $\propto \dfrac{1}{Z_{eff}}$

L $\xrightarrow{\text{Zeff increases}}$ R

(b) In a group

Atomic radius $\propto$ number of shells

So Atomic Radius decreases.

Top

No of shell increases

Atomic Radius | Ionic Radius increases

bottom

(c) For ions

(i) For different ions of same element

(ii) For Iso electronic species

Atomic radius $\propto \dfrac{1}{Z_{eff}} \propto \dfrac{-ve}{+ve}$

PERIODIC VARIATION OF ATOMIC SIZE

i) Across a period : It decreases from left to right in a period as effective nuclear charge (Zeff)increases

H < He

2nd period Li > Be > B > C > N > O > F << Ne

3rd period Na > Mg > Al > Si > P > S > Cl << Ar

Inert gas atom has largest atomic radius in respective period.

Note : Maximum radius in a period – Noble gas

Minimum radius in a period - Halogen

Screening get neutrallised by Zeff.

Order of covalent radius :

K > Ca > Sc > Ti > V > Cr > Mn > Fe ≈ Co ≈ Ni < Cu < Zn > Ga > Ge > As > Se > Br << Kr

Zeff domi. Screening dominating

f block (Lanthanide series)

$La^{+3}_{57} > Ce^{+3}_{58} > Pr^{+3}_{59} > Nd^{+3}_{60} > Pm^{+3}_{61} > Sm^{+3}_{62} > Eu^{+3}_{63} > Gd^{+3}_{64} > Tb^{+3}_{65} >$

$Dy^{+3}_{66} > Ho^{+3}_{67}\ Er^{+3}_{68} > Tm^{+3}_{69} > Yb^{+3}_{70} > Lu^{+3}_{71}$

due to poor shielding of f electrons Zeff in f-Block contineous increases due to this radius contineously decreases. this is called Lanthanide contraction.

IN A GROUP

It increases from top to bottom in a group as number of shell increases

No exception group

s-Block		p-Block		
Grp.-1	Grp.-2	Grp.-16	Grp.-17	Grp.-18
Li	Be	O	F	He
^ Δr_1	^	^	^	^
Na	Mg	S	Cl	Ne
^ Δr_2	^	^	^	^
K	Ca	Se	Br	Ar
^ Δr_3	^	^	^	^
Rb	Sr	Te	I	Kr
^ Δr_4	^	^	^	^
Cs	Ba	Po	At	Xe

Group-3

Sc
^
Y
^
La

Group-15

N
^
P
^
As
^
Sb
^
Bi

$$\Delta r_1 > \Delta r_2 > \Delta r_3 > \Delta r_4 \simeq 0$$

Variation of Zeff. In periodic table

Group – 4 — 12 (d-Block)

Zeff (6th period element) > Zeff (5th period element).

4th period element < 5th period element ≈ 6th period element.

Period \ group	4th	5th							12
4th	Ti	V						Cu	Zn
	∧	∧						∧	∧
5th	Zr	Nb						Ag	Cd
	≤	≤						≤	≤
6th	Hf	Ta						Au	Hg

Variation of Zeff. In periodic table

** group No (13)

$B < Al > Ga < In \approx Tl$

140pm

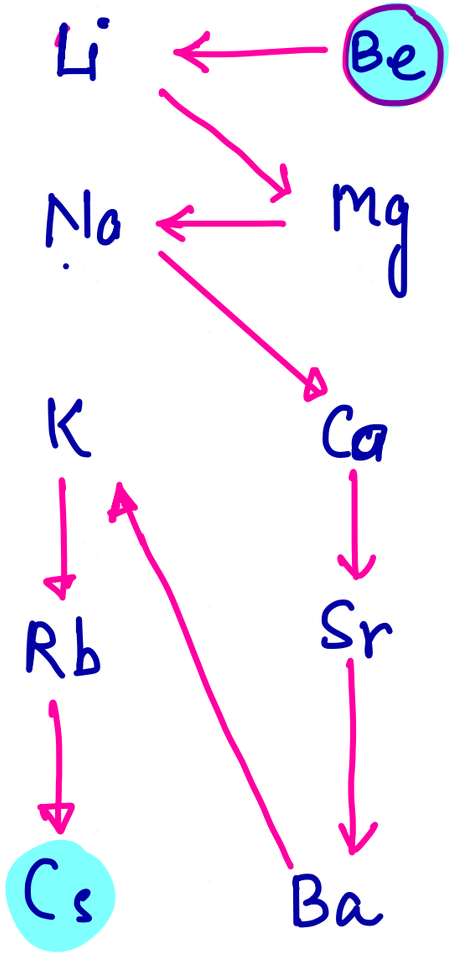
↓ 135pm

group No = 14

$C < Si < Ge < Sn \approx Pb$

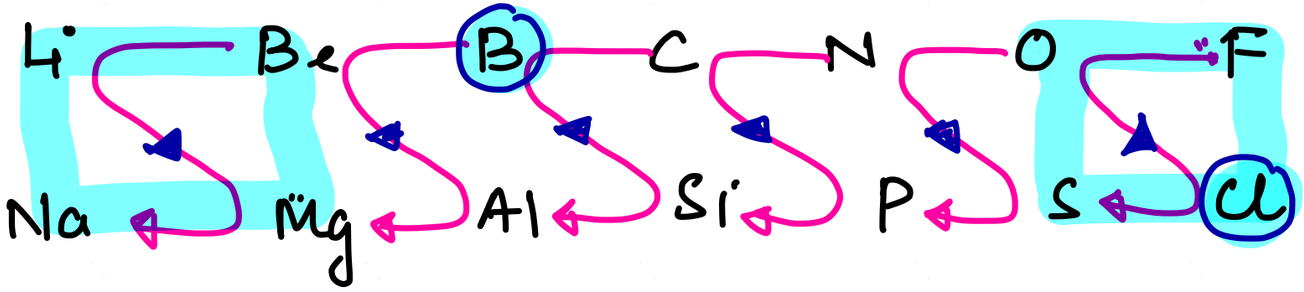
Variation of Zeff. In periodic table

Remember the Trends:



Be < Li < Mg < Na < Ca < Sr < Ba < K < Rb < Cs

$r_B < r_{Cl}$



Ex. Compare radius of :

(i) K, Ca, Sr, Rb

(ii) O, F, Cl, S

Ans

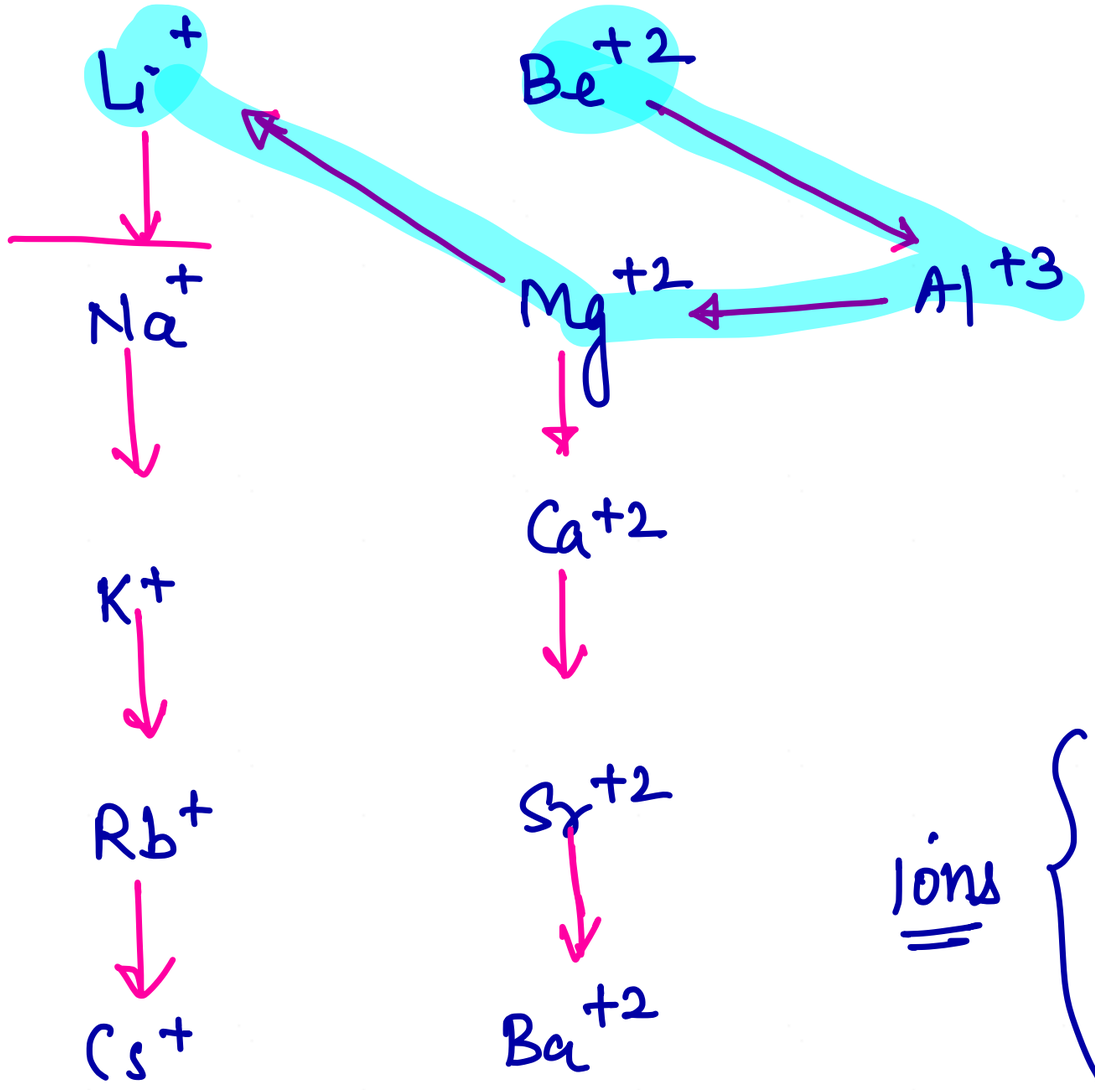
Ca < Sr < K < Rb

F < O < Cl < S

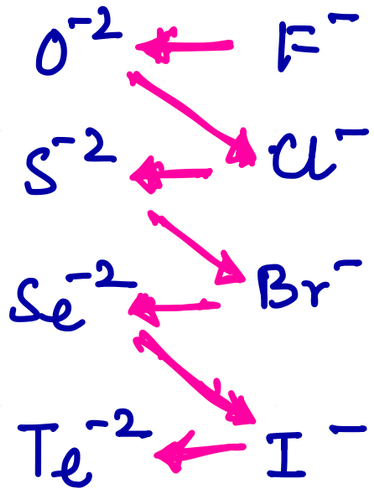
Note – all arrows are in increasing order.

Variation of Zeff. In periodic table

(I)



(II)



Ions

- Size $\propto$ No of electrons (dom.)
- Size $\propto \dfrac{1}{\text{No of proton}}$

Variation of Zeff. In periodic table

Ex. Compare the radius of following ?

(i) C O Ne $O < C << Ne$

ii) P Cl Ar $Cl < P << Ar$

iii) Sc V Cr $Sc > V > Cr$

iv) Fe Co Ni $Fe \simeq Co \simeq Ni$

v) Ni Cu Zn $Ni < Cu < Zn$

Variation of Zeff. In periodic table

$r_{Cl} > r_B$

B

Si > S > Cl

(vi) B Si S B < S < Si

vii) B Al Ga B < Ga < Al

viii) Na Rb Sr Na < Sr < Rb

ix) Zn Cd Hg Zn < Cd ≃ Hg [12th group]

x) Sc Y La Sc < Y < La [3rd group]

Variation of Zeff. In periodic table

Ex. Two Elements have Electronic configuration

$A = 1s^2, 2s^2, 2p^6, 3s^2, 3p^1$ (13) Al

$B = 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^{10}, 4s^2, 4p^1$ (31) Ga

- Compare their size

Ans (A > B)

Variation of Zeff. In periodic table

Ex:- Compare the size of following ?

i) $Al^{+3} < Mg^{+2} < Na^{+} < F^{-} < O^{-2} < N^{-3}$ [size $\propto \frac{-ve}{+ve}$]

e^-: 10, 10, 10, 10, 10, 10

ii) Y^{+3}, Sr^{+2}, Se^{-2}, Rb^{+}, Br^{-} [Radius $\propto \frac{-ve}{+ve}$]

$e^- =$ 36, 36, 36, 36, 36

$Se^{-2} > Br^{-} > Rb^{+} > Sr^{+2} > Y^{+3}$

iii) Be^{+2}, Mg^{+2}, Na^{+}, Se^{-2}, Te^{-2}, I^{-}, Br^{-}

2, 10, 10, 36, 54, 54, 36

$Be^{+2} < Mg^{+2} < Na^{+} < Br^{-} < Se^{-2} < I^{-} < Te^{-2}$

Variation of Zeff. In periodic table

iv) H^- , F^- , Cl^- , Br^- I^-

$F^- < Cl^- < Br^- < H^{\ominus} < I^-$

v) H^- Li^{+2} He^+ $H^- > He^+ > Li^{+2}$

vi) $Na^+ > Mg^{+2} > Al^{+3}$

$10e^-$ $10e^-$ $10e^-$

vii) $Li^{+} > Mg^{+2} > Al^{+3}$] exception

LANTHANIDE CONTRACTION

After La(57) , from 58–71 , e^- enters in 4f subshell, which apply very weak screening, due to which Z_{eff} increases and size remains almost same . This is known as Lanthanoid contraction

3d

no. of shells ↑

size↑

5th 4d

no. of shells↑ size↑

6th 5d

due to 4fe- Zeff ↑ size↓

↓↓

balance each other

4th

14th

Sc Ti ..... Zn

Y Zr .....Cd Sn

$_{57}$La $_{72}$Hf ..... Hg Pb

6th 58-71 ⇒ 4fe⁻ weak screening ⇒ σ↓ Z_{eff} ↑

TRANSITION CONTRACTION

In Ga(31) e^- enters in 3d subshell , which apply weak screening, due to which Z_{eff} increases, and size remains almost same, this is known as transition contraction.

B

$\wedge$

Al

no. of shells ↑
size ↑

≈

$_{31}Ga$

no. of shells ↑ size ↑
due to 3de- Zeff ↑ size ↓
↓↓
balance each other

(Ar) $3d^{10}\ 4s^1$
weak screening

According to value of radius by NCERT
Al > Ga

$r_{Al} > r_{Ga}$

Complete order : B < Al ≳ Ga < In ≲ Tl

$r_{Al} = 140$ pm

$r_{Ga} = 135$ pm

QUESTIONS

Q. Arrange the following in the increasing order of radius.

(i) C, Si, Ge, Sn, Pb

(ii) Cr, Mo, W

(iii) La^{+3}, Ce^{+3}, Gd^{+3}, Lu^{+3}

(iv) H^{-}, Li^{+}, Be^{+2}

(v) N, O, P, S

N O P S

Ans (i) C < Si < Ge < Sn ≃ Pb

(ii) 3d < 4d ≃ 5d

Cr < Mo ≃ W

(iii) $La^{+3} > Ce^{+3} > Gd^{+3} > Lu^{+3}$

(iv) $H^{-} > H^{+} > Be^{+2}$

(v) O < N < S < P

Q. The correct order of size would be:-

(A) Ni < Pd ≅ Pt

(B) Pd < Pt < Ni

(C) Pt > Ni > Pd

(D) Pd > Pt > Ni

QUESTIONS

Q. Which of the following has largest radius :-

(A) $1s^2\ 2s^2\ 2p^6\ 3s^2$ Mg

(B) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$ Al

(C) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$ P

(D) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$ Cl

Mg > Al > P > Cl

$16 + 2 = 18\ e^-$

Q. S^{-2} is not isoelectronic with :-

(A) Ar (B) Cl^- → $17 + 1 = 18$

(C) HS^- (D) Ti^{+3} → $22 - 3 = 19$

18

18

IONISATION ENERGY / ENTHALPY / POTENTIAL (IE/IP)

ALLEN CAREER INSTITUTE KOTA (RAJASTHAN) path to success

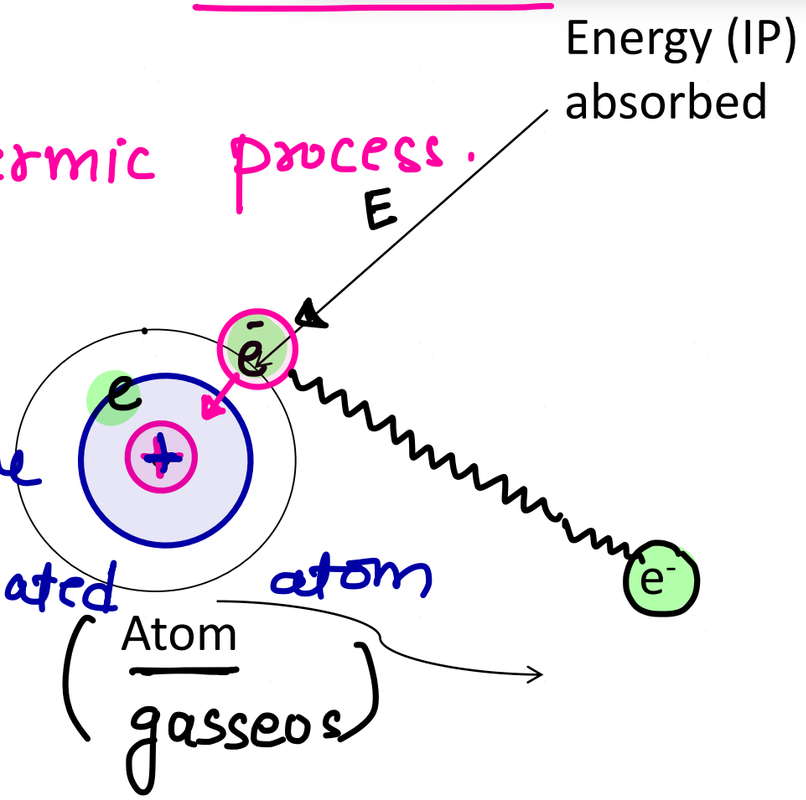
TABLE

$e = -1.6 \times 10^{-19}\ C$

(IE) **Definition:** Minimum energy required to remove most loosely bonded outer most shell e^- in ground state from an isolated gaseous atom is known as ionisation energy.

$X_{(g)} + e^- \rightarrow X^-_{(g)}$

- ionisation process is an endothermic process.



(IP). **Ionisation potential:** minimum amount of potential required to remove outermost electron from a gasseous isolated atom

$$\boxed{IE = e\,IP}$$

(ΔH_i) **Ionisation Enthalpy:** Ionisation energy measure for 1 mole atom at constant pressure. called ionisation enthalpy.

IONISATION ENERGY / ENTHALPY / POTENTIAL (IE/IP)

ALLEN CAREER INSTITUTE KOTA (RAJASTHAN) path to success
PERIODIC TABLE

Q- Identify the energy required in following process.

(i) $A(s) \longrightarrow A^+(g) + e^- \Rightarrow (E)$

Sol^n $A(s) \xrightarrow[E_{sub.}]{} A(g) \xrightarrow[IE_1(A)]{} A^+(g) + e^-$

$$E = E_{sub.} + IE_1(A)$$

(ii) $A(g) \longrightarrow A^+(g) + e \quad E$

$$E = IE_1(A)$$

IONISATION ENERGY / ENTHALPY / POTENTIAL (IE/IP)

ALLEN CAREER INSTITUTE KOTA (RAJASTHAN) path to success

(iii) $A^{+}(g) \longrightarrow A^{+2}(g) + e^{-}$ $\quad E$

$E = IE_2(A)$ OR $IE_1(A^{+})$

iv) $A(s) \longrightarrow A^{+2}(g) + 2e^{-}$ $\quad E$

$$A(s) \xrightarrow[E_{sub.}]{} A(g) \xrightarrow[IE_1(A)]{-e} A^{+}(g) \xrightarrow[IE_2(A) \text{ or } IE_1(A^{+})]{-e} A^{+2}(g)$$

$$\boxed{E = E_{sub} + IE_1(A) + IE_2(A)}$$

IONISATION ENERGY / ENTHALPY / POTENTIAL (IE/IP)

ALLEN CAREER INSTITUTE KOTA (RAJASTHAN) path to success
PERIODIC TABLE

Q- $M(s) \longrightarrow M^{+2}(g) + 2e^-$ 20000 KJ (E)

$M(g) \longrightarrow M^+(g) + e^-$ 1600 KJ

$M^+(g) \longrightarrow M^{+2}(g) + e^-$ 16000 KJ

$(IE_1(A) = IE_2(A)$ or $IE_1(A^+) =$

find out

i) $IE_1(M)$, $IE_2(M)$

ii) $IE_1(M^+)$

iii) $\Delta H_{sub}(M(s))$

Ans $IE_1(A) = 1600$ KJ

$IE_2(A) = 16000$ KJ

$IE_1(A^+) = 16000$ KJ

$$20000 = E_{sub} + 1600 + 16000$$

$$E_{sub} = 2400 \text{ KJ}$$

IONISATION ENERGY / ENTHALPY / POTENTIAL (IE/IP)

PERIODIC TABLE

HW If 1g of gaseous sample of Magnesium exposed to 50 KJ energy then find the moles of Mg, Mg^{+}, Mg^{+2} present in gaseous sample.

given $IE_1(Mg) = 720$ KJ/mol , $IE_2(Mg) = 1440$ KJ/mol.

Total energy = 50 KJ

Soln

$$Mg(g) \xrightarrow[-e]{} Mg^{+}(g) \xrightarrow[-e]{20\,J} Mg^{+2}(g)$$

given mol = $\frac{1}{24}$ mol

720 KJ for 1 mol $\left(\frac{1}{24}\right)$ 1440 KJ for 1 mol.

For $\frac{1}{24}$ mol = $720 \times \frac{1}{24} = 30$ KJ used

$-\frac{1}{24}$

0 mol

remaining energy = 20

IONISATION ENERGY / ENTHALPY / POTENTIAL (IE/IP)

PERIODIC TABLE

to $\frac{1}{24}$ mole $Mg^{+} \longrightarrow Mg^{+2}$

$\frac{1}{24} - \frac{1}{72}$ $\quad$ $\frac{1}{72}$

energy required $= 1440 \times \frac{1}{24} = 60$ KJ

60 KJ $\longrightarrow$ $\frac{1}{24}$ mol of Mg^{+} converted to Mg^{+2}

20 KJ $\longrightarrow$ $\frac{1}{24} \times \frac{20}{60} = \frac{1}{72}$ of Mg^{+} converted to Mg^{+2}

Remaing $\rightarrow$ $Mg = 0$ mol, $\quad Mg^{+} = \frac{1}{24} - \frac{1}{72} = \frac{1}{36}$ mol

$Mg^{+2} = \frac{1}{72}$ mol

IONISATION ENERGY / ENTHALPY / POTENTIAL (IE/IP)

PERIODIC TABLE

Ex. If 1g of gaseous sample of Magnesium is to convert all into $Mg^{+2}(g)$ find total amount of energy required.

given $IE_1(Mg) = 720\ KJ/mol$, $IE_2(Mg) = 1440\ KJ/mol$.

Soln

$$Mg(g) \xrightarrow{} Mg^{+}(g) \xrightarrow{} Mg^{+2}(g)$$

$\frac{1}{24}$ mol

$E_1 = \frac{1}{24} \times 720$

$= 30\ KJ$

$E_2 = \frac{1}{24} \times 1440$

$= 60\ KJ$

total energy $= 90\ KJ$

IONISATION ENERGY / ENTHALPY / POTENTIAL (IE/IP)

PERIODIC TABLE

Note - (i) Higher IE will always higher irrespective any explanation $IE_1 < IE_2 < IE_3 < IE_4 < \cdots$

ii) Ionisation process always endothermic.

Factors Affecting Ionisation energy

(i) $IE \propto Z_{eff} \propto \frac{1}{r}$

Along the period Z_{eff} increases so IE increases

(ii) $IE \propto \frac{1}{\text{No of shell}}$ As we go top to bottom No of shell increases IE decreases.

IONISATION ENERGY / ENTHALPY / POTENTIAL (IE/IP)

PERIODIC TABLE

Check point :

stability of electronic configuration :

order of stability/IE $ns^1 < np^1 < ns^2 < np^2 < np^4 < np^3 < np^5 < np^6$

S-orbital is near to nucleus. So more energy required to remove e^-

np^3 is half filled so more stable than np^4 more energy required for e^- removal.

B < Be

Al < Mg

Ga < Ca

In < Sr

N > O

P > S

As > Se

Sb > Te

IONISATION ENERGY / ENTHALPY / POTENTIAL (IE/IP)

PERIODIC TABLE

- Variation of IE along the period :-

- 1st period :

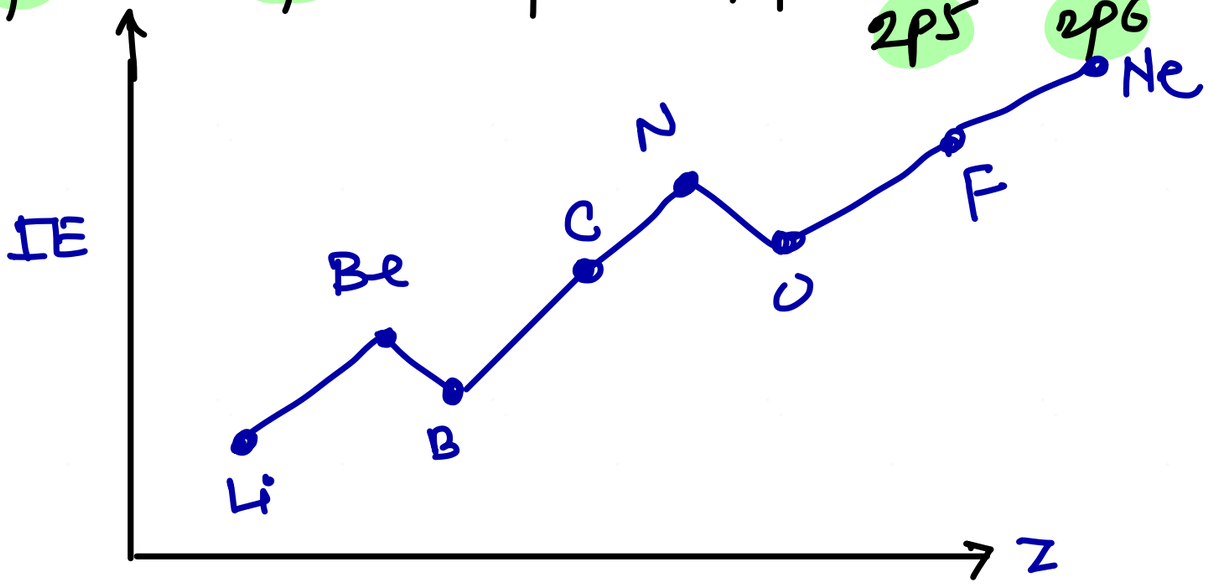
H	<	He	[IE]
$1s^1$		$1s^2$	

Highest IE of periodic Table He

- 2nd period :

Li	Be	B	C	N	O	F	Ne
$2s^1$	$2s^2$	$2s^2, 2p^1$	$2s^2, 2p^2$	$2s^2, 2p^3$	$2s^2, 2p^4$	$2s^2 2p^5$	$2s^2 2p^6$

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



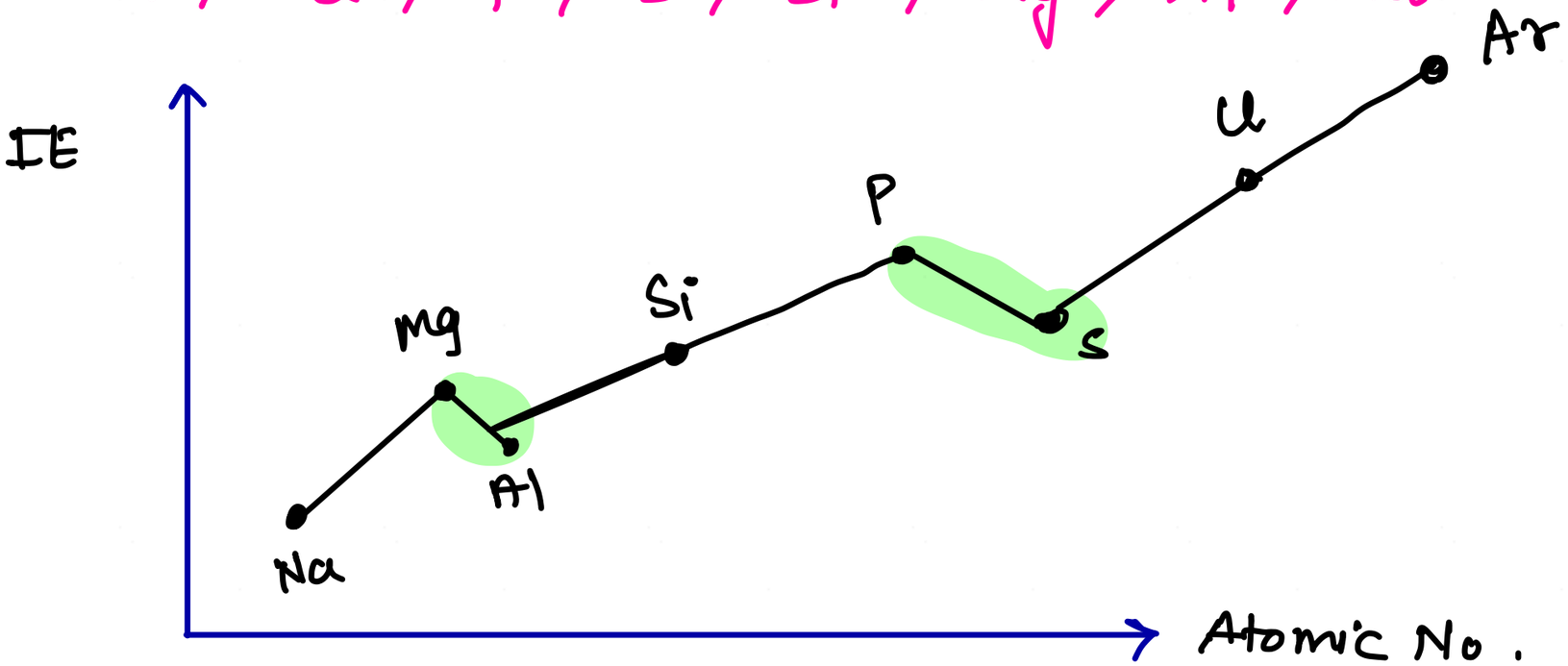
IONISATION ENERGY / ENTHALPY / POTENTIAL (IE/IP)

PERIODIC TABLE

3rd period :

Na	Mg	Al	Si	P	S	Cl	Ar
$3s^1$	$3s^2$	$3s^2, 3p^1$	$3s^2$ $3p^2$	$3s^2$ $3p^3$	$3s^2$ $3p^4$	$3s^2$ $3p^5$	$3s^2$ $3p^6$

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



IONISATION ENERGY / ENTHALPY / POTENTIAL (IE/IP)

PERIODIC TABLE

4th period

S Block	d Block	P-Block
K < Ca	Sc < Ti > V < Cr < Mn < Fe > Co > Ni < Cu < Zn	> Ga < Ge < As > Se < Br < Kr

learn from NCERT

IONISATION ENERGY / ENTHALPY / POTENTIAL (IE/IP)

PERIODIC TABLE

f Block :- in f-Block Zeff. Continuously increases so IE continuously increases

57 La Lanthanum 138.90547	58 Ce Cerium 140.116	59 Pr Praseodymium 140.90766	60 Nd Neodymium 144.242	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92535	66 Dy Dysprosium 162.500	67 Ho Holmium 164.93033	68 Er Erbium 167.259	69 Tm Thulium 168.93422	70 Yb Ytterbium 173.045	71 Lu Lutetium 174.9668
89 Ac Actinium (227)	90 Th Thorium 232.0377	91 Pa Protactinium 231.03588	92 U Uranium 238.02891	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (266)

IE Continuously increases

IONISATION ENERGY / ENTHALPY / POTENTIAL (IE/IP)

PERIODIC TABLE

Along the Group: No exception group

						He
Li	Be		N	O	F	Ne
Na	Mg		P	S	Cl	Ar
K	Ca	Sc	As	Se	Br	Kr
Rb	Sr	Y	Sb	Te	I	Xe
Cs	Ba	La	Bi			

No of shell increases

IE decreases.

IONISATION ENERGY / ENTHALPY / POTENTIAL (IE/IP)

PERIODIC TABLE

Exception 01

4th group ——— 12 group

d-Block

Z_{eff} (6th period) > Z_{eff} (5th period)

6th period Element > 4th period element > 5th period Element

Ti	V	Cu	Zn
Zr	Nb	Ag	Cd
Hf	Ta	Au	Hg

Hf > Ti > Zr Ta > V > Nb Au > Cu > Ag Hg > Zn > Cd

IONISATION ENERGY / ENTHALPY / POTENTIAL (IE/IP)

PERIODIC TABLE

Exception 02

13th group : dudu Effect

B > Al < Ga > In < Tl

Exception 03 :

group 14 : C > Si > Ge > Sn < Pb

IONISATION ENERGY / ENTHALPY / POTENTIAL (IE/IP)

PERIODIC TABLE

Ex. Arrange the following according to order of IE_1.

(i) B C N $\Rightarrow$ N > C > B

B: $2s^2$ $2p^1$

C: $2s^2$ $2p^2$

N: $2s^2$ $2p^3$

ii) Li Be B Be > B > Li

Li: $2s^1$

Be: $2s^2$

B: $2s^2$ $2p^1$

IONISATION ENERGY / ENTHALPY / POTENTIAL (IE/IP)

PERIODIC TABLE

(iii) P S Cl

$3s^2$ $3s^2$ $3s^2$

$3p^3$ $3p^4$ $3p^5$

Cl > P > S

iv) Pb > Sn

v) Li C Cl

$2s^1$ $2s^2, 2p^2$ $3s^2, 3p^5$

C > Li > Cl

v) Cu < Zn

$3d^{10}, 4s^1$ $3d^{10}, 4s^2$

IONISATION ENERGY / ENTHALPY / POTENTIAL (IE/IP)

PERIODIC TABLE

- Sc > Y > La group (3)
- Zn Cd Hg group (12)

  Hg > Zn > Cd.

- Tb < Yb < Lu (f-Block)

(IE/IP)

- Electron can not be removed from solid state of an atom, it has to be converted into gaseous form, Energy required for conversion from solid state to gaseous state is called Sublimation energy.

Q. Which of the following represent I^{st} IE?

(A) $Na(s) \longrightarrow Na^{+}(g)$ $E_{sub} + IE_1$

(B) $\frac{1}{2}F_2(g) \longrightarrow F^{+}(g)$ $= \frac{1}{2}(BDE)_{F-F} + IE_1$

(C) $Mg(g) \longrightarrow Mg^{+2}(g)$ $IE_1 + IE_2$

(D) $Xe_{(g)} \longrightarrow Xe^{+}(g)$ IE_1

Ans. (D)

- For any neutral atom, ionization energy is always an endothermic process. (ΔH = +ve)

- It is measured in eV/atom (electron volt/atom) or Kcal/mole or KJ/mole.

Q. $A \longrightarrow A^{+}$; E_1

$A^{+} \longrightarrow A^{+2}$; E_2

$A^{+2} \longrightarrow A^{+3}$; E_3

Correct order of IE is

(A) $E_1 > E_2 > E_3$

(B) $E_1 = E_2 = E_3$

(C) $E_1 < E_2 < E_3$

(D) $E_1 < E_2 = E_3$

Ans. (C)

Note :- (1) Ionisation process is always endothermic means energy is absorbed.

(2) Higher IE will always higher irrespective to any explanation

$IE_1(A) < IE_2(A) < IE_3(A)$ .....

Q. Compare the IE of following

i) B C N

$2p^1$ $2p^2$ $2p^3$

order = N > C > B

ii) Li Be B

$2s^1$ $2p^2$ $2p^1$

order = Be > B > Li

iii) P S Cl

$3p^3$ $3p^4$ $3p^5$

order Cl > P > S.

iv) Cu Zn

$4s^1$ $4s^2$

order = Zn > Cu

v) Sc Y La

3rd group

Sc > Y > La

vi) Zn Cd Hg

12th group [d-Block]

5d > 3d > 4d

order Hg > Zn > Cd

vii) Tb Yb Lu f Block.

Zeff ↑

order Tb < Yb < Lu

Note : IE for 2nd period element is greater than 3rd period elements.

Ex.

F	Cl	O	S
	p^4	p^5	
	O	F	
S		Cl	

order

F > O > Cl > S

Ex.

N	P	O	S
p^3		p^4	
N		O	2nd
P		S	3rd

N > O > P > S

Ex.

N	P	C	Si
	p^2	p^3	
	C	N	
Si		P	

N > C > P > Si

Ex.

B	Be	Al	Mg
	s^2	p^1	
	Be	B	
Mg		Al	

Be > B > Mg > Al

for two different element we see Z_{eff} and electronic configuration.

: **Note** for same element

$$IE \propto +ve \text{ charge}$$

$$IE \propto \frac{1}{-ve \text{ charge}}$$

Highest IE
He

Lowest IE
Cs

Ex. compare IE of

(1) Na^+ Mg^+

$2p^6$ $3s^1$

(2) $Ne < Ne^+$

$IE \propto +ve$ charge

(3) $O^+ > O > O^-$

(4) $B^+ > C^+$

$2s^2$ $2p^1$

FACTORS AFFECTING IONISATION ENERGY

(iii) Stability of half filled and fully filled orbitals

Half filled p^3, d^5, f^7 or fully filled p^6, d^{10}, f^{14} are more stable than others so it requires more energy

Ex.

	$_7N$		$_8O$
IP_1	$2p^3$	>	$2p^4$
	$\downarrow -e^-$		$\downarrow -e^-$
IP_2	$2p^2$	<	$2p^3$

Ex.

	$_{15}P$	>	$_{16}S$
IP_1	$3p^3$	>	$3p^4$
	$\downarrow -e^-$		$\downarrow -e^-$
IP_2	$3p^2$	<	$3p^3$

Note : This effect is applicable only for consecutive element ($\Delta z = 1$)

FACTORS AFFECTING IONISATION ENERGY

Order of attraction of subshells towards nucleus (Penetration power) is
s > p > d > f

Ex.	**Be**		**B**
IE_1	$1s^2, 2s^2$	>	$1s^2, 2s^2\ 2p^1$
	$\downarrow -e^-$		$\downarrow -e^-$
IE_2	$1s^2, 2s^1$	<	$1s^2, 2s^2$

Ex.	Mg		Al
IE_1	$3s^2$	>	$3s^2\ 3p^1$
	$\downarrow -e^-$		$\downarrow -e^-$
IE_2	$3s^1$	<	$3s^2$

Note : This effect is applicable only for consecutive element ($\Delta z = 1$)

VARIATION IN IONISATION ENERGY

(i) In a period : Zeff increases so removal of electron becomes difficult and ionisation energy increases.

Order of IE of 2nd period elements

Li	Be	B	C	O	N	F	Ne
$2s^1$	$2s^2$	$2p^1$	$2p^2$	$2p^3$	$2p^4$	$2p^5$	$2p^6$

IP_1 Li < B < Be < C < O < N < F < Ne

IP_2	Li	Be	B	C	O	N	F	Ne
	$1s^2$	$2s^1$	$2s^1$	$2p^1$	$2p^2$	$2p^3$	$2p^4$	$2p^5$

IP_2 Be < C < B < N < F < O < Ne < Li

Order of IE of 3rd period elements

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

Q. Arrange the correct order of IE_2 (second IE) for 2nd period elements.

VARIATION IN IONISATION ENERGY

Q. In which of the following pairs, the ionisation energy of the first species is less than that of the second :-

$p^4 < p^3$

(1) O-, O2- (2) S, P

(3) N, P (4) Be+, Be

Ans. (2)

Q. In the plot of the first ionisation energy against atomic number the peaks are occupied by :-

(1) Inert gases (2) Alkali metals

(3) Halogens (4) Transition elements

Ans. (1)

Q. The correct order of decreasing second ionisation enthalpy of Ti(22), V(23), Cr(24) and Mn(25) is :

(1) Mn > Cr > Ti > V (2) Ti > V > Cr > Mn

(3) Cr > Mn > V > Ti (4) V > Mn > Cr > Ti

Ans. (3)

VARIATION IN IONISATION ENERGY

(ii) In a group : Size increase so ionisation energy decrease.

s-Block		p-Block		
Grp.-1	**Grp.-2**	**Grp.-16**	**Grp.-17**	**Grp.-18**
Li	Be	O	F	He
v	v	v	v	v
Na	Mg	S	Cl	Ne
v	v	v	v	v
K	Ca	Se	Br	Ar
v	v	v	v	v
Rb	Sr	Te	I	Kr
v	v	v	v	v
Cs	Ba	Po	At	Xe

COMPARISON OF IONISATION ENERGY

Ex. Effect of lanthanide and transition contraction on IE

didi

Grp.-13 (Size)	Grp.-13 (IE)
B	B
^	v
Al ≈ Ga (T.C.)	Al
	^
	Ga
^	v
In ≈ Tl (L.C.)	In
	^
	Tl

COMPARISON OF IONISATION ENERGY

Ionisation Energy **Ga > Al** (due to Transition contraction)

Ionisation Energy of **5d > 4d** (due to lanthanide contraction)

Ex. Hf > Zr

Similarly in group 14 : **IE of Pb > IE of Sn** (due to lanthanide contraction)

Ex. Group 11

(size)	(IE)
Cu	Cu
∧	∨
Ag ≈ Au } L.C.	Ag
	∧
	Au

Maximum IP in d-block :- 5d

COMPARISON OF IONISATION ENERGY

Higher IE →

$$A \xrightarrow[IE_1]{} A^{+} \xrightarrow[IE_2]{} A^{+2} \xrightarrow[IE_3]{} A^{+3} \; - - -$$

If you want to compare nth IE then remove (n-1) electrons and see stability of electronic configuration

$$\boxed{s^1 < p^1 < s^2 < p^2 < p^4 < p^3 < p^5 < p^6}$$

COMPARISON OF IONISATION ENERGY

PERIODIC TABLE

Q - compare 2nd IE of Na and Mg.

Na	>	Mg
$2p^6, 3s^1$		$2p^6, 3s^2$
↓		↓
$2p^6$		$2p^6, 3s^1$

(ii) compare 3rd IE of B C N

B	C	N
$2s^2, 2p^1$	$2s^2, 2p^2$	$2s^2, 2p^3$
↓	↓	↓
$2s^1$	$2s^2$	$2s^2, 2p^1$

C > N > B

COMPARISON OF IONISATION ENERGY

PERIODIC TABLE

Q- Compare 4th IE of P S Cl

COMPARISON OF IONISATION ENERGY

PERIODIC TABLE

Q. Compare 3rd IE of Be B, C

COMPARISON OF IONISATION ENERGY

PERIODIC TABLE

HW

Q- Compare 5th IE of N O F

O > F > N