




PERIODIC
TABLE_C1_INTRODUCTION_SIZE
VARIATION_IONIZATION
ENERGY



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Periodic Classification

IUPAC name of element (At no. >100)

Digit	IUPAC name	symbol
0	nil	n
1	un	u
2	bi	b
3	tri	t
4	quad	q
5	pent	p
6	hex	h
7	hept	s
8	oct	o
9	enn	e

The name of element always end with suffix: -ium

101 → un + nil + un + ium → unnilunium → Uun

102 → un + nil + bi + ium → unnilbium → Uub

103 → un + nil + tri + ium → unniltrium → Unt

104 → un + nil + quad + ium → unnilquadium → Uuq

107 → un + nil + sept + ium → unnilseptium → Uns

110 → un + un + nil + ium → unnillium → Uun

Note: 'nnn' should be considered as 'nn'

115 → un + un + pent + ium → ununpentium → Uup

120 → un + bi + nil + ium → unnilbium → Ubn

190 → un + en + nil + ium → unennilium → Uen

Prediction of group no & name of block of different element:-

1. S-block element:-

✓ The last e⁻ must enter into s-subshell of s block element.

✓ S-subshell has 2e⁻ → 2 subgroups- (a) IA (ns¹)
(b) IIA (ns²)

e.g K=19 e⁻ = 1s²2s²2p⁶3s²3p⁶4s¹ → IA

(s-block) 4th period

Mg → 12e⁻ = 1s²2s²2p⁶3s² → IIA

3rd period s-block

2. p-block element:-

- ✓ The last e⁻ must enter into p subshell.
- ✓ P subshell has 6e⁻ s
- ✓ It has 6 groups → IIIA, IVA, VA, VIA, VIIA & zero group

←←←←←
snp s²np s²np s²np s²np s²np

- ✓ Group no of p-block = (ns+np)e⁻

e.g

3-IIIA → 10+3=13th group

4-IVA → 10+4=14th group

5-VA → 10+5=15th group

6-VIA → 10+6=16th group

7-VIIA → 10+7=17th group

8-VIIIA → 10+8=18th group

Ques:

P₁₅ = 1s²2s²2p⁶3s²3p⁵

Period=3, group=s+p=2+3=5=VA & p-block (gr 15)

Se₃₄ = 1s²2s²2p⁶3s²3p⁶4s²3d¹⁰4p⁴

→ p-block → 4th period → group = (s+p)e⁻ = 2+4=6=VIA (gr 16)

3. d-block element:-

- ✓ The last e⁻ enter must into penultimate d-subshell
- ✓ d-subshell has 10e⁻
- ✓ d-block has 10 vertical column or group
- ✓ Group no of d-block element depends on = [ns²+(n-1)d]e⁻

Ques: Fe=26, Mo=42, Ag=47?

(i) Fe₂₆ :- 1s²2s²2p⁶3s²3p⁶3d⁶4s²3d⁶

✓ d-block element (w.r.t last e⁻ added)

✓ 4th period

✓ Group=2+6 = 8e⁻ = 8 (On the basis of s and d electrons)

(ii) Mo₄₂ :- 1s²2s²2p⁶3s²3p⁶3d¹⁰4s¹4p⁶4d⁵5s¹

✓ d-block elements

✓ 5th period

✓ Group = (1+5)e⁻ = 6e⁻ = 6

4. f-block elements:-

- ✓ The last e⁻ enter into f-subshell.
- ✓ f-subshell has maximum e⁻ = 14
- ✓ All the 28 f-block elements are separately placed below the modern periodic table in 2 separate rows.
- ✓ Lanthanoid → 4f series elements → rare earth element.

- actinoids \rightarrow 5f series element \rightarrow radioactive element.

General electronic configuration of different block element:-

- s-block $\rightarrow ns^{1-2}$ $n \rightarrow (n-1)$ [transition]
- p-block $ns^2 np^{1-6}$ $n \rightarrow n-2$ [inner transition]
- d-block $ns^{1,2} (n-1)d^{1-10}$ (more appropriate)
[ns^0 = for Pd]
- $ns^{1,2} (n-1)d^{1-10} ns^1 = Cr, MO, Cu$
- f-block $\rightarrow ns^2, (n-2)f^{1-14}, (n-1)d^{0,1}$

Classification of element:-

1. normal element:-

Elements of s and p-block are called normal elements, because they produce compound using their normal valency. e^- enter into their outer shell using normal $(n+1)$ rule.

2. Representative elements:-

Elements of s and p-block are called representative elements because

- their outer shell e^- represents their group number,
- their outer shell e^- decides their chemical properties of all other or behaviour.

3. Typical elements:-

Elements of second and third period are called typical elements because they describe the properties of all other elements present in their own group.

4. Bridge elements:-

Elements of 3rd period are called bridge element because they co-relate the properties of element present in sub group A and subgroup B of same group.

e.g. the bridge element between

- IIA & IIB = Mg
- IIIA & IIIB = Al
- IVA & IVB = Si

5. Transition element:-

- The element in which outer shell orbitals and penultimate $(n-1)$ d-orbital remain incomplete in

atomic or ionic state are called transition element.

- Mostly d block elements are called transition elements.

N.B - elements of gr 12 (Zn, Cd, Hg) should not be considered as transition metal due to their full field the orbital in atomic form and ionic form.

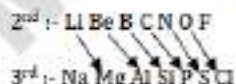
e.g. Group 11 metals are called transition metal because they contain incomplete orbital in ionic state.

6. Inner transition element:-

f block elements (lanthanoids and actinoids) are called inner transition element because the last e^- enter into anti penultimate f subshell or $(n-2)$ f-subshell.

7. diagonal relationship:-

The elements of 2nd period resemble in most of their properties [atomic size, ionic radius, electron negativity, I.E. & polarizing power ($\frac{\text{charge}}{\text{radius}}$)] with the elements placed diagnostic to them in 3rd period. this is called diagonal relationship.



(Note: Out of the above mentioned elements only Li, Be and B shows the diagonal relationship)

This arises due to same nuclear charge or ionic potential or $\frac{\text{charge}}{\text{size}}$.

Important informations:

- Gr I elements \rightarrow alkali metals
- Gr II elements \rightarrow alkaline earth metals
- Gr 13 elements \rightarrow buffer elements.

Because separation of metals and nonmetals take place in periodic table w.r.t these elements.

- Gr 14 elements \rightarrow no specific name, called carbon gr.
- Gr 15 elements \rightarrow pnictogens /suffocating elements
- Gr 16 elements \rightarrow Chalcogens
- Gr 17 elements \rightarrow halogens

\downarrow
sea derived

- ✓ Gr 18 - Zero group elements → aerogens (He has some ores)
- ✓ He → sun gas
- ✓ He (II) → quantum mechanical liquid (its conducting power is 800 times more than Cu)
- ✓ Ne → new gas/beacon light (because it can early penetrate through mist and fog)
- ✓ Ar → lazy gas
- ✓ Kr → hidden gas/ hindrance gas (difficult to isolate from air)
- ✓ Xe → strange gas (due to its compound forming ability under specific condition)
- ✓ Rn → radioactive gas

Periodic properties:-

1. Shielding effect/screening effect:-

The net reduction in force of attraction associated with an e^- from the nucleus due to the intervention or interference of e^- present in inner shells and same shell is called shielding effect or screening effective. → on moving way from the nucleus, nuclear charge (number of protons) for each e^- remain same, but effective nuclear charge (ENC) varies.
→ shielding effect of s,p,d,f subshell of same subshell or penetration power of subshell $\propto \frac{1}{\text{number of nodes/places}}$

shielding effect orders: $s > p > d > f$

d and f subshell have poor shielding effect or negligible shielding effect or else may remain away from the nucleus

Effective nuclear charge (Z_{eff}) = $z - \sigma$

z = nuclear charge/number of protons
 σ = shielding constant / Slater constant

for H atom, $\sigma = 0$, hence, $Z_{eff} = Z$

Calculation of slaters constant (σ) for s p subshell e^- :-

- ✓ e^- of $(n+1)$ shell provide = 0 unit towards σ
- ✓ each e^- of n-shell provide = 0.35 unit towards σ
- ✓ each e^- of $(n-1)$ shell provide = 0.85 unit towards σ
- ✓ the rest e^- core shell provide = 1 unit each towards σ

Ques. Calculate σ & Z' for 3p subshell e^- of Ca atom?

$$\begin{aligned} \text{Ca} &\rightarrow 1s^2 2s^2 2p^6 3s^2 3p^4 4s^2 \\ \text{Ca} &\rightarrow (1s)^2 (2s2p)^6 (3s3p)^4 (4s)^2 \\ \sigma &= (7 \times 0.35) + (8 \times 0.85) + (2 \times 1) \\ \sigma &= 2.45 + 6.80 + 2 = 11.25 \\ Z' &= Z - \sigma = 20 - 11.25 \end{aligned}$$

Ques. Calculate σ and Z' for 4s e^- of As (=33)

$$\begin{aligned} \text{As} &\rightarrow 1s^2 2s^2 2p^6 3s^2 3p^4 4s^2 3d^{10} 4p^3 \\ \text{As} &\rightarrow (1s)^2 (2s2p)^6 (3s3p)^4 (3d)^{10} (4s4p)^3 \\ \sigma &= (0.35 \times 4) + (0.85 \times 18) + (1 \times 9) + (1 \times 2) \\ &= 15.30 + 8 + 12 \\ &= 26.70 \\ Z' &= 33 - 26.70 = 6.3 \end{aligned}$$

Calculation of σ for d and f subshell (σ for d & f block elements):-

- ✓ electron of $(n+1)$ shell provide → 0 toward σ
- ✓ each of e^- of nd, nf subshell → 0.35 towards σ
- ✓ Rest e^- of ns, np, $(n-1)$ shell, $(n-2)$ shell = 1 towards σ

Ques. Calculate Z' & σ for 3d e^- of Fe atom

$$\begin{aligned} \text{Fe} &\rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6 \\ \text{Fe} &\rightarrow (1s)^2 (2s2p)^6 (3s3p)^6 (3d)^6 (4s)^2 \\ \sigma &= (0.35 \times 5) + (1 \times 8) + (1 \times 8) + (1 \times 2) \\ \sigma &= 1.75 + 18 = 19.75 \\ Z' &= z - \sigma = 26 - 19.75 = 6.25 \end{aligned}$$

Ques. calculate σ & Z' for d e^- of Cu^+ and Cu^{+2}

$$\begin{aligned} \text{Cu} &\rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1 \\ \text{Cu}^+ &\rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} \\ \text{Cu}^{+2} &\rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 3d^9 \\ \text{Cu}^+ &\rightarrow \sigma = (9 \times 0.35) + 18 = 21.5 \\ Z' &= 29 - 21.5 = 7.85 \\ \text{Cu}^{+2} &\rightarrow \sigma = (8 \times 0.35) + 18 = 20.8 \\ Z' &= 29 - 20.8 = 8.2 \end{aligned}$$

	Cu^+	Cu^+
$Z' \rightarrow$	8.2	7.85
	$3d^9$	$3d^{10}$

but here, we give priority to Z^* so more attraction towards nucleus is Cu^{+2} , so Cu^{+2} is more stable than Cu^+

$\text{Cu}^{+2} > \text{Cu}^+$ (stability) explain on the basis of z value not on the basis of stability of full field shell.

Ques. Calculate Z^* & σ for He.

$$\text{He} \rightarrow 1s^2, \quad \sigma = 1 \times 0.30$$

$$Z^* = Z - \sigma = 2 - 0.30 = 1.70$$

For He $\sigma = 0.30$, $Z^* = 1.70$ (due to the absence of inner shell in the atom)

S block

$$\text{Li} \rightarrow 3 \rightarrow 2s^2 \rightarrow Z^* = 3 - (2 \times 0.85) = 1.3$$

$$\text{Na} \rightarrow 11 \rightarrow 3s^1 \rightarrow Z^* = 11 - (8 \times 0.85 + 2) = 2.2$$

$$\text{K} \rightarrow 19 \rightarrow 4s^1 \rightarrow Z^* = 19 - (8 \times 0.85 + 10 \times 1) = 2.2$$

$$\left. \begin{array}{l} \text{Rb} \rightarrow 37 \\ \text{Cs} \rightarrow 55 \\ \text{Fr} \rightarrow 87 \end{array} \right\} Z^* = 2.2$$

In moving down the group in s and p-block nuclear charge for each new element increases, but effective nuclear charge (z^*) nearly remains constant.

In moving down the group in d and f-blocks in N.C. increases and ENC increases at the lower part of the group due to the negligible shielding effect of d and f subshell e⁻.

Atomic size :-

Atomic size refers to the distance between the nucleus and the shell upto which the nucleus can exert its influence.

Size of an atom cannot be correctly measured due to the following difficulties.

i. Most of the atom exist in bonded form or molecular form except zero group element.

ii. In a atom the e⁻ maintain different radial distance from the nucleus in a given shell due to elliptical nature of the path.

iii. Due to wave like motion of e⁻, it also maintain different radial distance even in the circular path.

iv. Most of the atom get polarized due to dipole attraction or dipole induced dipole attraction from surrounding molecules.

v. Hence, atomic size of an element can be measured in its different radius depending on the type of bond involved in it.

(A) Covalent radius:-

It is half of the distance between the inter nuclear axis of two bonded atoms forming a covalent bond.

$$\text{eg } r_{\text{H-atom}} = \frac{d_{\text{H-H}}}{2}$$

example

$$\text{i. } d_{\text{I-I}} = 2.4 \text{ \AA}$$

$$r_{\text{I}} = \frac{2.4}{2} = 1.2 \text{ \AA}$$

$$\text{ii. } d_{\text{O}_2} = 4.2 \text{ \AA}$$

$$r_{\text{O}} = 2.1 \text{ \AA}$$

$$\text{iii. } \text{N}_2 \Rightarrow \text{N} \equiv \text{N} (\sigma \text{ bond})$$

In a multiple bond founding molecules only σ bond considered to find out the covalent radius .

(head on overlapping occurs in σ bond (intermolecular axis))



Here is two circle A and B this two has r_A and r_B radius $r_A < r_B$.

$$d_{A-B} = r_A + r_B$$

If $\Delta\chi_{A-B} \geq 0.7$ or ≥ 0.9 (here charge separation occurs so more attraction, closeness is more, then it becomes more polar)

From Stevenson equation

$$d_{A-B} = r_A + r_B - 0.09 (X_A - X_B)$$

Ques. $d_{\text{C-H}}$ = intermolecular distance of C-H bond = 3.4 \AA, $d_{\text{H-H}} = 2.6 \text{ \AA}$ what is $r_{\text{C}} = ?$
($X_{\text{C}} = 2.5, X_{\text{H}} = 2.1$)

$$\Delta X_{\text{C-H}} = 2.5 - 2.1 = 0.4 < 0.7$$

$$\text{So, } d_{A-B} = r_{\text{C}} + r_{\text{H}} = r_{\text{C}} + \frac{d_{\text{H-H}}}{2}$$

$$\Rightarrow 3.4 = \pi_e + \frac{2.6}{2}$$

$$\pi_e = 3.4 - 1.3 = 2.1 \text{ \AA}$$

Q. $d_{H-F} = 2.6 \text{ \AA}$, $d_{H-Cl} = 1.8 \text{ \AA}$, $r_F = ?$

$$\Delta X_{H-F} = \Delta X_{H-Cl} - \Delta X_{Cl} = 4 - 2.1 = 1.9 > 0.7$$

$$d_{H-F} = r_H + r_F - 0.09(1.9)$$

$$r_F = d_{H-F} - r_H + 0.171$$

$$r_F = 1.871 \text{ \AA}$$

(B) Van der Waals radius:-

→ It is measured in elements held by van der Waals' force of attraction

→ Van der Waals radius can only be calculated in the solid state of an element

→ It is half the distance between the nucleus of two adjacently placed non bonded atom of neighbourly molecules.

→ For same element van der Waals radius > covalent radius (always)

→ Due to mono atomic nature the atomic size of zero group elements always measured in van der Waals radius

(C) Metallic radius:-

→ It can be calculated for elements involved in metallic bond

→ It is half the distance between the nucleus of two adjacently placed metal atom.

→ In metals 2 types of bonds (metallic and covalent bond) generally present

* In general atomic size refers to covalent radius

N.B- For noble gases atomic size prefer to van der Waals radius.

Ionic radius:-

→ It can be measured for element exist in ionic form (cationic or any ionic form)

$$\rightarrow \text{Ionic radius} \propto \frac{1}{z/e} \quad (z = \text{proton no.}, e = e^- \text{ no.})$$

$$\propto \frac{1}{z} \quad (\text{for isoelectronic species})$$

$$\begin{array}{cccccccc} \text{C}^4 > \text{N}^3 > \text{F}^- > \text{Ne} > \text{Na}^+ > \text{Mg}^{+2} > \text{Al}^{+3} \\ \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\ \text{Z} \rightarrow & 6 & 7 & 9 & 10 & 11 & 12 & 13 \end{array}$$

$$e^- \rightarrow \quad 10 \quad 10 \quad 10 \quad 10 \quad 10 \quad 10 \quad 10$$

Ques. compare the ionic radius of Ca^{+2} , Ar, P^{+3} , S^{+2} , Cl^-

$$\text{Ionic radius} \propto \frac{1}{z/e}$$

No. of e^- in all same. So ionic radius $\propto \frac{1}{z}$ (for isoelectronic species)

$$\text{P}^{+3} > \text{S}^{+2} > \text{Cl}^- > \text{Ar} > \text{Ca}^{+2}$$

$$\begin{array}{cccccc} \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\ 15 & 16 & 17 & 18 & 20 \end{array}$$

Ques. N^{+3} , O^{+2} , F, H compare the size of anion.

$$\frac{z}{e} = \frac{7}{10} > \frac{8}{10} > \frac{9}{10} > \frac{1}{1}$$

$\text{N}^{+3} > \text{O}^{+2} > \text{F}^- > \text{H}^+$ but $\text{N}^{+3} > \text{O}^{+2} > \text{H}^+ > \text{F}^-$ (exception)
smallest anion in periodic table → fluoride ion.

Q. Compare the Van der Waals' radius of the N_2 , O_2 , F_2 , Ne.

Atomic size decreases moving from left to right, across a period.

Hence, order of van der Waals' radius $\text{N}_2 > \text{O}_2 > \text{F}_2 > \text{Ne}$

Q. Compare the atomic size of this four species N_2 , O_2 , F_2 , Ne.

Atomic size means covalent radius but in neon atomic size means Van der Waals radius

So $\text{Ne} > \text{N}_2 > \text{O}_2 > \text{F}_2$

Variation of atomic size alone in a group in s & p block :-

On moving down the group in s & p block atomic size gradually increases.

- Due to addition of new shell to each new element.
- Increase in screening effect

N.B:- however Z^* value remain nearly same for all elements

Gr 1 \rightarrow Li < Na < K < Rb < Cs < Fr

Gr 2 \rightarrow Be < Mg < Ca < Sr < Ba < Ra

Gr 17 \rightarrow F < Cl < Br < I < At

Gr 16 \rightarrow O < S < Se < Te < Po

Across a period:-

On moving across a period in s and p block atomic size gradually decreases due to

i. Increase in effective nuclear charge (Z^* value)

ii. addition of e⁻ in same shell.

e.g. In the 2nd period atomic size follows the order:-

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

In third period, (Na > Mg > Ne > Si > P > S > Cl)

Q. Which has smallest atomic size?

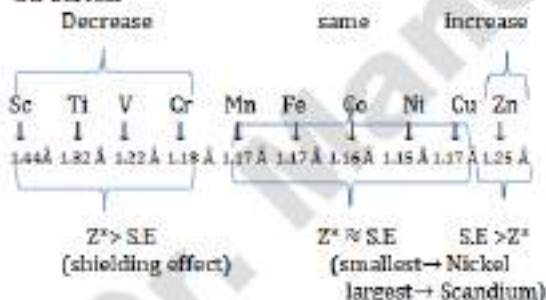
i. Li ii. Be iii. Na iv. Mg

Answer - Be

Variation of atomic size in d block elements:-

1. Across a period:- Atomic size varies in irregular trend on moving from left to right across a period due to the irregular variation of Z^* and shielding effect

3d-series:-



2. Along a group:-

Atomic size also varies in irregular trend on moving down the group in d-block due to irregular variation of Z^* and shielding effect

$S.E > Z^*$	3d
	\uparrow (increase)
	4d
$Z^* \approx S.E$	\uparrow (same)
	5d
	\uparrow (decrease)
	6d
$Z^* > S.E$	\uparrow (decrease)
	7d

Zr-Hf, twin element (appeared in 4d & 5d series)

Note: Twin elements appear in 4d and 5d series due to their nearly equal atomic size and atomic radius

Various of atomic size in 4f and 5f series:-

In 4f and 5f series, atomic size gradually decreases from $Ce_{140} \rightarrow Lu_{174}$ & $Th_{90} \rightarrow Lr_{103}$ due to the negligible shielding effect given by inner d and f subshell towards outershell e_s. These contraction in size in 4f-series is called lanthanoid contraction and 5f series is called actinoid contraction.

Ce > Pr > Nd > Pm > Sm > Eu > Gd > Tb > Dy > Ho > Er > Tm > Yb > Lu

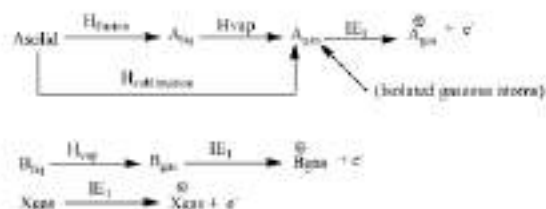
3. Ionization energy:-

\rightarrow Ionization is a process of forming cation from isolated gaseous atom

\rightarrow It is an e⁻ removing process

\rightarrow Ionization is always and endothermic process or energy absorbing process.

\rightarrow The minimum amount of energy required to remove the most loosely bond e⁻ from the outermost shell of an isolated gaseous atom to produce uni positive cation is called its first ionization energy.

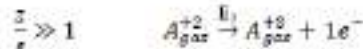
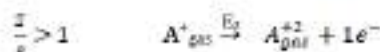


Unit of IE:-

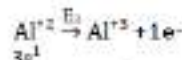
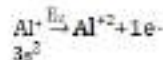
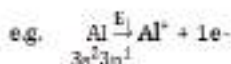
- ev/atom
- KJ/mole
- Kcal/mol

$$1 \text{ ev/atom} = 23.06 \text{ Kcal/mol} = 96.45 \text{ KJ/mole}$$

Successive ionization:- Process of removing e- one after from isolated gaseous atom to produce Unipositive, Bipositive, tripositive cations is called successive ionization.



During successive ionization, energy gradually increases i.e. $E_3 > E_2 > E_1$



(Note: In same element stability half filled, full filled is not seen)

N.B- During successive ionization of same element, stability of half filled and full filled orbitals in intermediate ion should not be taken into account.

Factors affecting ionization energy value:-

1. Atomic size:-

$$\text{Ionization energy of an element} \propto \frac{1}{\text{atomic size}}$$

$$\propto \frac{1}{\text{shielding effect}}$$

e.g.

In group 1: $\text{Li} > \text{Na} > \text{K} > \text{Rb} > \text{Cs}$

In group 2: $\text{Be} > \text{Mg} > \text{Ca} > \text{Sr} > \text{Ba}$

In group 17: $\text{F} > \text{Cl} > \text{Br} > \text{I}$ & so on.

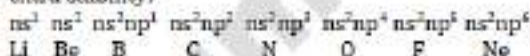
2. Effective nuclear charge (Z^*):-

$$IE \propto E. N. C.$$

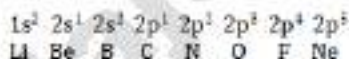
- $\text{Al}^{3+} > \text{Al}^{2+} > \text{Al}^+$
- $\text{S} > \text{S}^+ > \text{S}^{2+}$
- $\text{O} < \text{F} < \text{Ne}$

3. Stability half filled and full field orbitals:-

Elements having full filled or half filled p,d,f-subshell and full field s-subshell attain higher ionization energy value than their adjacent element due to their extra stability.

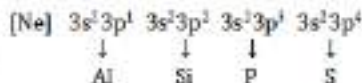


IE₁ - $\text{Ne} > \text{F} > \text{N} > \text{O} > \text{C} > \text{Be} > \text{B} > \text{Li}$



IE₂ - $\text{Li} > \text{Ne} > \text{O} > \text{F} > \text{N} > \text{B} > \text{C} > \text{Be}$

Q. Compare IE₁ of Al, Si, P & S



IE₁ $\text{P} > \text{S} > \text{Si} > \text{Al}$

IE₂ $\text{S} > \text{P} > \text{Al} > \text{Si}$

- $(IE)_{\text{non metal}} > (IE)_{\text{metal}}$
- IE of p > d > s-block elements

Q. Compare IE ?

(a) I (b) F (c) Fe (d) Ba

I & F → p block

Fe → d-block

Ba → s-block

$\text{F} > \text{I} > \text{Fe} > \text{Ba}$