

PERIODIC TABLE_C2_IE_EA_EN

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Ques. Compare the IE of these species.

(a) Li^+ (b) He^+ (c) He

$\text{Li}^+ \rightarrow 1s^2$; $\text{He} \rightarrow 1s^2$; $\text{He}^+ \rightarrow 1s^1$

So $\text{Li}^+ > \text{He}^+ > \text{He}$ (In same element stability is not taken into account here $E_3 > E_2 > E_1$)

Ques. Compare the IE of these species.

(a) S^{-2} (b) S^- (c) S (d) S^{+2}

		Z/e
S:-	[Ne] $3s^2 3p^4$	16/16
S^- :-	$3p^5$	16/17
S^{-2} :-	$3p^6$	16/18
S^{+2} :-	$3s^2 3p^2$	16/14

$\text{S}^{+2} > \text{S} > \text{S}^- > \text{S}^{-2}$ (for same element)

Ques. Compare the IE of this species K, Fe, P, Cl

$\text{K} \rightarrow [\text{Ar}] 4s^1$; $\text{Fe} \rightarrow [\text{Ar}] 3d^6 4s^2$

$\text{P} \rightarrow [\text{Ne}] 3s^2 3p^3$; $\text{Cl} \rightarrow 3p^5$

$\text{K} \rightarrow$ s-block

$\text{Fe} \rightarrow$ d-block

$\text{P} \rightarrow$ } p-block

$\text{Cl} \rightarrow$ }

$\text{P} > \text{d} > \text{s}$ -block I.E.

$\text{Cl} > \text{P} > \text{Fe} > \text{K}$

Ques. Compare the IE of this species F^- , Cl^- , Br^- , I^-

$[\text{F}^- > \text{Cl}^- > \text{Br}^- > \text{I}^-] \rightarrow$ Wrong

Exception-

$\text{F} + e^- \rightarrow \text{F}^- + 80\text{cal}$

$\text{Cl} + e^- \rightarrow \text{Cl}^- + 90\text{cal}$

$\text{Br} + e^- \rightarrow \text{Br}^- + 60\text{cal}$

$\text{I} + e^- \rightarrow \text{I}^- + 40\text{cal}$

Due to high e- affinity of chlorine atom I.E of $\text{Cl}^- >$ I.E of F^-

Ques. Compare the IE of S^- , Se^- , O^-

$\text{S}^- > \text{Se}^- > \text{O}^-$

E.A of O is low

Prediction of possible number of ionization in a species:-

No. of possible ionization in a species = total no. of e_s^- present in it

e.g.

C \rightarrow can have 6 possible number of ionisation

$\text{O}^{-2} \rightarrow (8 + 2) = 10$

$\text{Na}^+ \rightarrow (11 - 1) = 10$

$\text{O}^{+2} \rightarrow (8 - 2) = 6$

Prediction of group number, oxidation State, valency and formula of compound using successive IE value:-

During successive ionization process certain increases IE value $\geq (4-5)$ times indicates the differentiating e- present in penultimate shell. From this data the valence e-, group number, O.S. can be predicted.

Ques. Element (Y_{gas}) has following successive IE value $E_1 = 20\text{KJ}$, $E_2 = 50\text{KJ}$, $E_3 = 120\text{KJ}$, $E_4 = 600\text{KJ}$, $E_5 = 1500\text{KJ}$, $E_6 = 4000\text{KJ}$

Find out O.S. group no, valency and formula of its sulphate.

	E_1 }	2-3
valance e- = 3	E_2 }	
group no. = 13	E_3 }	2-3
valency = 3	E_4 }	5
O.S = +3	E_5 }	2-3

formula of sulphate:- $\text{M}_2(\text{SO}_4)_3$

Ques. 1st (E_1) and 2nd I.E. (E_2) of Mg vapour = 20 & 50 ev/atom, calculate energy in KJ required to ionize 4.8 g of Mg vapour to Mg^{+2} ion.

$\text{Mg} \rightarrow \text{Mg}^+$, $E_1 = 20$ ev/atom

$\text{Mg}^+ \rightarrow \text{Mg}^{+2}$, $E_2 = 50$ ev/atom

$\text{Mg} \rightarrow \text{Mg}^{+2}$, $E = 70$ ev/atom = 70×46.45 KJ/mole

1 mole $\text{Mg} \rightarrow 70 \times 96.45$ KJ/mole

4.8 g $\text{Mg} \rightarrow (70 \times 96.45 \times \frac{4.8}{24})$ KJ/mole

Ques. E_1 , E_2 , E_3 for Al vapour respectively 10, 25, 65 KJ/ mole, calculate the energy in ev per atom required to ionise 2.7 g of Al vapour to Al^{+3} ion

Energy, $\text{Al}_{\text{vap}} \rightarrow \text{Al}^{+3} = 10 + 25 + 65 = 100$ KJ/mole

1 ev/atom = 96.45 KJ/mole

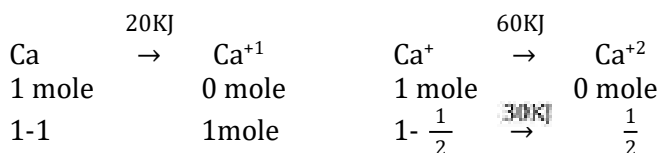
Al 1 mole $\rightarrow 100$ KJ/mole

2.7 g $\rightarrow \frac{100}{27} \times 2.7 = 10$ KJ/mole

Ques. E_1 & E_2 for Ca vapour are respectively 20 & 60 KJ/mole. Calculate the % of Ca^{+2} vapour results using energy 50 KJ energy in the ionization process of Ca vapour. Given $1\text{ev/atom} = 96.45 \text{ KJ/mole}$.

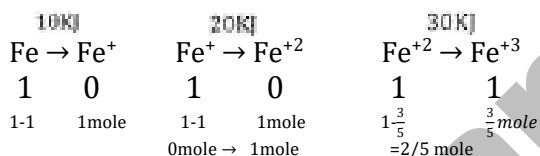
$$\times \left\{ \begin{array}{l} \text{Ca} \rightarrow \text{Ca}^{+2}, E = 20 + 60 = 80 \text{ KJ/mole} \\ 80 \text{ KJ} \rightarrow 100\% \\ 50 \text{ KJ} \rightarrow \frac{100}{80} \times 50 = 62.5\% \end{array} \right.$$

The approach is wrong, be careful, The correct one is:



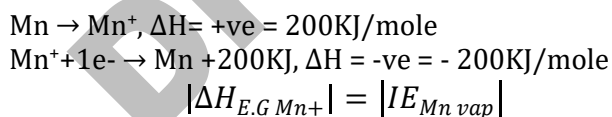
(60 KJ could have produced = 1 mole Ca^{+2}
 Hence, 30 KJ could have produced = $\frac{1}{2}$ mole Ca^{+2})
 $\therefore \text{Ca}^{+2} = \frac{1}{2} \text{mole} \times 100 = 50\%$

Ques. E_1, E_2, E_3 for Fe vapour are respectively 10, 20 and 50 KJ/mole. Calculate the % of Fe^{+1} ion & Fe^{+3} ion produced using 60 KJ energy in ionization process of Fe vapour.



50 KJ produced = 1 mole Fe^{+3}
 30 " " $\frac{30}{50}$ mole
 % of $\text{Fe}^{+1} = 0$ mole, $\text{Fe}^{+3} = 60\%$, $\text{Fe}^{+2} = 40\%$

Ques. The first I.E. of Mn(vap) is +200KJ/mole calculate the e - gain enthalpy Mn^+ iron.



$$\therefore \Delta H_{\text{EA of Mn}^{2+}} = -200 \text{ KJ/mole}$$

Variation of I.E. in s and p block elements:-

- Atomic size decrease
 E.N.C (Z^*) (increase)
 I.E → increase(period)
- i. atomic size (increase)
 - ii. Z_{eff} remains same
 - iii. I.E ↓ (decrease)

Certain deviation arises in a half filled and full filled arrangement

Group:-

1 → $(IE)_1 \rightarrow \text{Li} > \text{Na} > \text{K} > \text{Rb} > \text{Cs}$
 2 → $(IE)_1 \rightarrow \text{Be} > \text{Mg} > \text{Ca} > \text{Sr} > \text{Ba}$

13 → oscillating trend (Exception)

$IE_1 \rightarrow \text{B} > \text{Al} < \text{Ga} > \text{In} < \text{Tl}$

⇒ **(B > Tl > Ga > Al > In)**, Final order, remember

$IE_2 \rightarrow \text{B} > \text{Ga} > \text{Tl} > \text{In} > \text{Al}$

14 → $\text{C} > \text{Si} > \text{Ge} > \text{Pb} > \text{Sn}$

15 → $\text{N} > \text{P} > \text{As} > \text{Sb} > \text{Bi}$

16 → $\text{O} > \text{S} > \text{Se} > \text{Te} > \text{Po}$

17 → $\text{F} > \text{Cl} > \text{Br} > \text{I}$

zero → $\text{He} > \text{Ne} > \text{Ar} > \text{Kr} > \text{Xe}$

Note: I.E. (5d > 3d > 4d) VVI***

$\text{Hg} > \text{Zn} > \text{Cd}$
 $\text{Au} > \text{Cu} > \text{Ag}$

$$I.E \propto \frac{1}{\text{reactivity}}$$

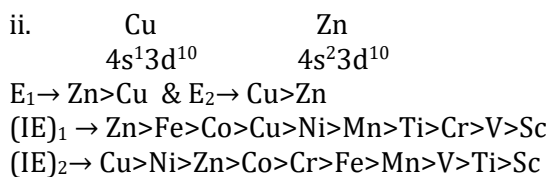
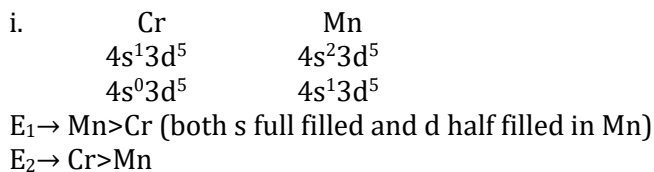
Period:-

2nd → $IE_1 \rightarrow \text{Ne} > \text{F} > \text{N} > \text{O} > \text{C} > \text{Be} > \text{B} > \text{Li}$
 $2p^3 \quad 2s^2$

3rd → $IE_2 \rightarrow \text{Ar} > \text{Cl} > \text{P} > \text{S} > \text{Si} > \text{Mg} > \text{Al} > \text{Na}$
 $3p^3 \quad 3s^2$

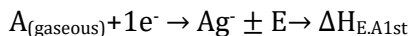
I.E of 3d-series element:-

Due to irregular variation in atomic size, effective nuclear charge (Z^*) and Shielding effect across a period in d-series, I.E also follow irregular trend



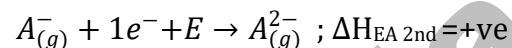
4. Electron affinity electron gain enthalpy:-

- ✓ It is an e- gain process
- ✓ It is an isolate phenomenon
- ✓ It is a process of anion formation
- ✓ The amount of energy released (or absorbed) gain when an e- is added to an isolated gaseous atom to produce unit negative atom is called its 1st e- gain enthalpy.



$\Delta H_{EA\ 1st} = -ve$ or $+ve$; $-ve$ is more appropriate

The amount of energy absorbed when an e- is added to an uni negative anion to produce di negative anion is called its second e- gain enthalpy or electron affinity.



Similarly, $\Delta H_{EA\ 3rd, 4th} = +ve$ (more)

- ✓ Formation of Cl⁻, H⁻, Br⁻, I⁻, C⁻, O⁻, P⁻ → exothermic process
- ✓ Formation of O⁻², N⁻³, P⁻³, C⁻⁴, As⁻³, S⁻², Se⁻² → endothermic process
- ✓ Formation of He⁻, Ne⁻, Ar⁻, Kr⁻, Xe⁻, **Be⁻, N⁻** → $2s^2\ 2p^3$

From He to Xe, electron affinity value is zero, but for Be and N it is endothermic process

- ✓ unit of e- gain enthalpy or affinity= ev/atom or KJ/mole or Kcal/mol

Factors affecting electron affinity:-

$$1. \text{Electron affinity (EA)} \propto \frac{1}{\text{atomic size}}$$

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

e.g.
 (E.A):- Cl > Br > I
 (E.A):- S > Se > Te

$$2. \text{EA} \propto \text{Effective nuclear charge (Z}^*)$$

e.g. (E.A) of $M^{+3} > M^{+2} > M^{+1}$
 $X > X^- > X^{2-}$

$$3. \text{E.A} \propto \frac{1}{\text{stability of } s^2, p^3, p^6 \text{ orbital}}$$

(∵ d, f- orbitals elements are metal. So they can't take e-)

N.B. → Elements having half filled and full filled atomic orbitals (s^2, p^3, p^6) maintain zero EA and positive 1st electron gain enthalpy value. $[(\Delta H_{eg})_1 = +ve]$

- i. E.A of He, Ne, Kr, Xe, Rn = zero
- ii. E.A of Be, Mg, Ca, Sr, Ba = Zero
 N, P, As, Sb, Bi = zero
 $\Delta H_{e.g.1st} N = +ve$ (due to absence of vacant d-orbitals in it)

Exception in Electron affinity :-

Non metals of 2nd period (F, O, N, C) maintain low value of E.A. than the non-metals of 3rd period of same group, due to

- i. their compact size
 - ii. high e- density
 - iii. absence of vacant d-orbital
- E.A. of F < Cl
 N < P
 O < S

- ✓ E.A of group 17 elements:-
- ✓ $17 \rightarrow Cl > F > Br > I$
- ✓ $16 \rightarrow S > Se > Te > Po > O$
- ✓ $15 \rightarrow Bi > Sb > As > P > N$
- ✓ Zero group → He > Rn > Xe > Kr = Ar > Ne
 $\begin{matrix} +48 & +68 & +77 & +96 & +116 \\ \text{KJ/mole} \end{matrix}$

$$(E.N.)_{\text{pauling scale}} = \frac{|IE| + |EA|}{2 \times 2.8}$$

Here pauling scale is more appropriate

$$(E.N.)_{\text{pauling}} = (E.N.)_{\text{mulliken}} \times \frac{1}{2.8}$$

Ques. What is E.N. of F in mulkin scale.

$$4 \times 2.8 = 11.2 \quad [(E)_{\text{mulliken}} = 2.8 \times (E.N.)_{\text{pauling}}]$$

VVI for numerical

$$E.N._{\text{pauling scale}} = \frac{IE + EA \text{ (ev/atom)}}{5.6}$$

$$= \frac{IE + EA \text{ (kcal/mol)}}{5.6 \times 23.06}$$

$$= \frac{IE + EA \text{ (KJ/mol)}}{5.6 \times 96.45}$$

$$E.N._{\text{pauling scale}} = \frac{IE + EA}{5.6} = \frac{IE + EA}{130} = \frac{IE + EA}{540}$$

Ques: Calculation of E.N. of elements using its covalent radius and its effective nuclear charge value (Z^*):-

$$(E.N.)_{\text{of } X_{\text{element}}} = 0.74 + \frac{0.359 \times Z_{\text{eff}}}{r^2}$$

This is Alred & Rochow Scale.

$$r = \text{radius in } \text{\AA}, Z^* = E.N.C = Z_{\text{effective}}$$

➤ **Calculation of E.N. of element using bond energy value:-**

$$X_A - X_B = 0.208 \sqrt{E_{A,B} - \sqrt{E_{A,A} \times E_{B,B}}} \text{ (Kcal/mole)}$$

$$= 0.1017 \sqrt{E_{A,B} - \sqrt{E_{A,A} \times E_{B,B}}} \text{ (KJ/mole)}$$

Ques. EN of hydrogen is = 2, calculate EN of F
Given, $E_{H-F} = 20 \text{ KJ/mol}$, $E_{F-F} = 10 \text{ KJ}$, $E_{H-H} = 2.5 \text{ KJ}$

$$E_F - E_H = \sqrt{E_{H-F} \sqrt{E_{F-F} \times E_{H-H}}} \times 0.1017$$

$$E_F - 2 = 0.1 \times \sqrt{20 - \sqrt{10 \times 2.5}}$$

$$E_F = 2 + 0.4 = 2.4 = X_F$$

Calculation of % ionic character and covalent character in covalent compound.

% of ionic characters = $16\Delta x + 3.5\Delta x^2$ (Hanny-Smith equn)

% of covalent character = 100 - % of ionic character.

Ques. Calculate % of ionic character in C–H bond

$$\text{Ans: } \Delta x = 2.5 - 2.1 = 0.4$$

$$\begin{aligned} \therefore \% \text{ of ionic character} &= (1.6 \times 0.4) + (3.5 \times (0.4)^2) \\ &= 6.4 + 3.5 \times 0.16 \\ &= 6.4 + 0.56 \\ &= 6.96 \end{aligned}$$

$$\% \text{ of covalent character} = 100 - 6.96 = 93.04$$

Ques. Calculate % of ionic character in H–F bond

$$\text{Ans: } \Delta x = 4 - 2.1 = 1.9$$

$$\begin{aligned} \% \text{ of ionic character} &= (1.6 \times 1.9) + (3.5 \times 3.61) \\ &= 30.4 + 12.6 \\ &= 43.03 \end{aligned}$$

Note: % of ionic character $\propto \Delta x$ value

covalent character $\propto \frac{1}{\Delta x \text{ value}}$

Prediction of ionic character (IC) and covalent character (CC) using Δx value (CC)

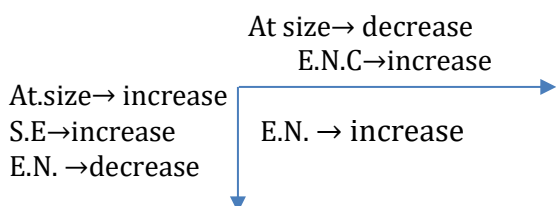
- ✓ if $\Delta x = 0 \rightarrow 100\% \text{ CC}$ (H–H, N≡N, Cl–Cl)
0% I.C. 0 = 0, F–F)
- ✓ If $\Delta x < 0.9 \rightarrow$ least polar \rightarrow maximum CC
0.7 (NCERT) (non-polar) negligible I.C
- ✓ of $\Delta x \geq 0.9$ but < 1.9 , then more covalent less ionic (polar bond)
- ✓ If $\Delta x = 1.9$ (polar molecule) \rightarrow 50% ionic & 50% covalent

- ✓ If $\Delta x > 1.9$ but < 2.5 → it is ionic compound, more IC less CC
- ✓ If $\Delta x \geq 2.5$ → ionic compound
 - 99.99% IC
 - 0.01% CC

Note: No such compound exist in the nature having 100% ionic character.

Variation of EN value along a group and across a period:-

(s & p-block)



In 2nd period, $\text{Li} < \text{Be} < \text{B} < \text{C} < \text{N} < \text{O} < \text{F}$
 3rd period, $\text{Na} < \text{Mg} < \text{Al} < \text{Si} < \text{P} < \text{S} < \text{Cl}$

N.B. → The most E.N. element is Fluorine.
 Least E.N. element in periodic table → Fr/Cs