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Dep-I (H) - Periodic Properties

(Effective Nuclear Charge)

There are many Physical & Chemical properties of element which show periodic variation (group & period) with atomic number.

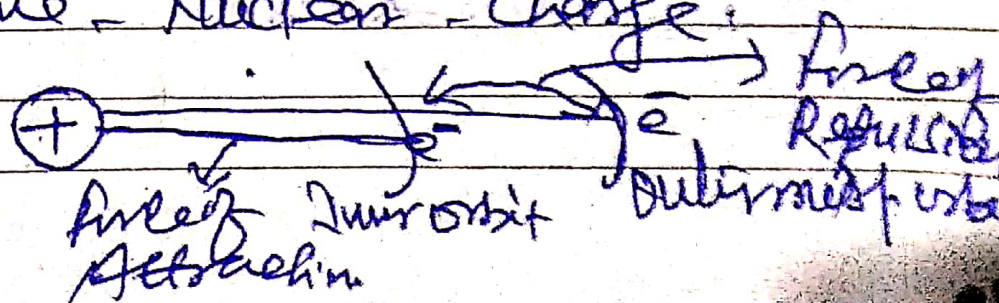
Their property varies in moving from left to right (in a period) & from top to bottom (in a group) are called periodic properties.

These are

- ① Effective Nuclear Charge (Z^*) & Screening Constant.
- ② Atomic Radius
- ③ Ionisation Energy
- ④ Electron Affinity
- ⑤ Electronegativity
- ⑥ Oxidising & Reducing behavior
- ⑦ Metallic & Non-metallic properties

① Effective Nuclear Charge (Z^*)

The actual charge of nucleus which operates upon the valency electrons (outermost electron of an atom) is called Effective Nuclear Charge.



$$Z^* = Z - S$$

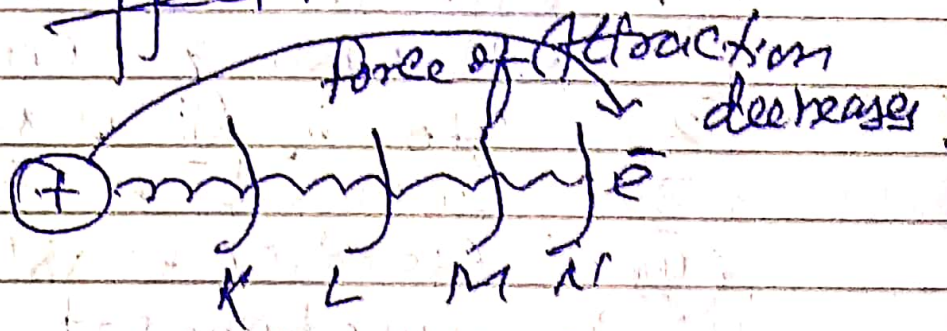
Z^* = Effective Nuclear Charge

Z = at. No

S = Screening / Shielding Const.

Shielding / Screening Effect (e)

The decrease in the force of attraction exerted by the nucleus upon the valence electrons due to the presence of electrons in the inner-shell is called Screening-effect.



Calculation of magnitude of Screening Const. —

The magnitude of Screening-Const depends upon the electrons presents in inner-shell. Higher the number of inner-electrons greater will be value of Screening Const. It is determined by Slater's Rule.

For ns or np - orbitals, electrons.

- ① Write Electronic Config. of elements in given order & group them
(1s) (2s 2p) (3s 3p) (3d) (4s 4p) (4d 4f)
(5s 5p) (5d 5f) etc
- ② Electrons to the right of (ns np) groups have no effect on shielding.
- ③ All the electrons in the (ns np) groups contributes for each electron its value given is 0.35 (0.30 only for 1s - remaining electrons)
- ④ All the electrons in (n-1)th shell - contributes 0.85 for each electrons towards Screening Const.
- ⑤ All the electrons in (n-2)th shell & rest all inner orbit contributes 1.00 for each.
- ⑥ for nd or nf - electrons.

Rules numbers ① to ③ remain same but Rule ④ & ⑤ is replaced by rule ⑥

- Page No. _____
Date _____
- (6) All the electrons in the groups lying left to the (nd, nf) groups contribute 1.0 for each toward screening const.

Some Examples:

- (1) Calculate Z^* value of last electron of Na.

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

$$\text{Value of } S.C. \rightarrow 2 \times 1.0 + 8 \times 0.85 + 0 \times 0.35$$

$$(S.C.) = 2 + 6.8 + 0$$

$$= 8.8$$

$$Z^* = Z - S$$

$$= 11 - 8.8 = 2.2$$

During Calculation of S.C. value the last electron upon which we calculate Z^* will be exempted.

The remaining electrons are taken to calculate S.C. value.

Thus, only 2.2 Charge of Nucleus operates upon the 11th electron of Na.

- (2) Calculate S.C. value upon last electron upon Cl.

$$\begin{aligned}
 417 - & \frac{(1s^2)(2s^2 2p^6)(2d^2 2p^6)}{\downarrow \quad \downarrow \quad \downarrow} \\
 & 2 \times 1.0 + 8 \times 0.85 + 6 \times 0.35 \\
 & = 2 + 6.8 + 2.10 \\
 \text{Shield} & = 10.90
 \end{aligned}$$

$$\begin{aligned}
 Z^* &= Z - S \\
 &= 17 - 10.9 = 6.1
 \end{aligned}$$

③ Calculation of Screening Constant in Zn
 (A) for 4s-electron (B) for 3d-electron

(a) for 4s-electron

$$\begin{aligned}
 & \frac{(1s^2)(2s^2 2p^6)(3s^2 3p^6)(3d^{10})(4s^2)}{\downarrow \quad \quad \quad \downarrow \quad \quad \downarrow} \\
 & 10 \times 1.0 + 18 \times 0.85 + 1 \times 0.35 \\
 & = 10 + 15.30 + 0.35 \\
 & = 25.65
 \end{aligned}$$

$$Z^* = 30 - 25.65 = 4.35$$

(b) for 3d-electron:

$$\begin{aligned}
 & \frac{(1s^2)(2s^2 2p^6)(2s^2 3p^6)(3d^{10})(4s^2)}{\downarrow \quad \quad \quad \downarrow \quad \quad \downarrow} \\
 & 18 \times 1.0 + 9 \times 0.35 \quad X \\
 & = 18 + 3.15 \\
 & = 21.15 \\
 & Z^* = 30 - 21.15 = 8.85
 \end{aligned}$$

X