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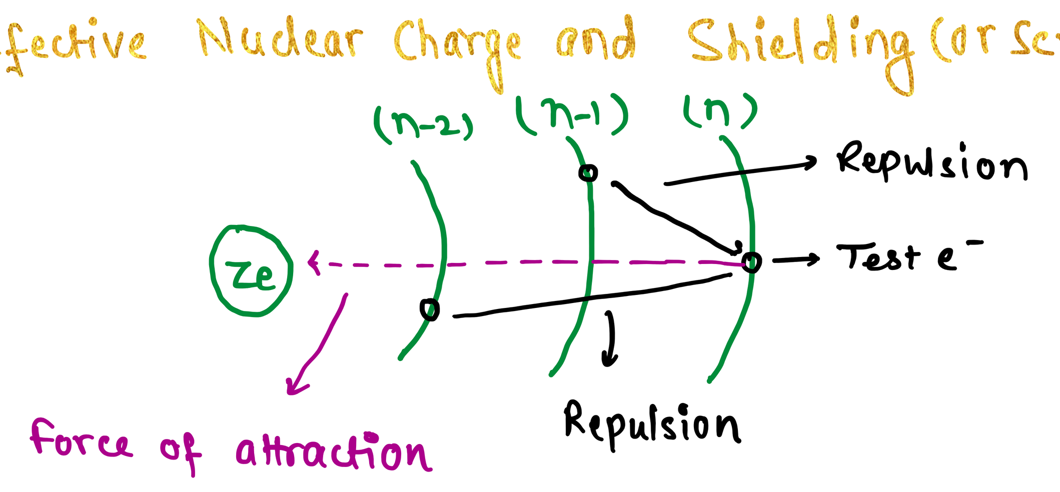
Effective Nuclear Charge and Shielding (or Screening) Effect:-



- As shown, the outer electron experiences two opposing forces:
  (i) force of attraction from nucleus.
  (ii) force of repulsion from inner electrons.

* Suppose inner electrons are not present there then force of attraction experienced by test electron must be greater than it actually experience because electronic repulsion weakens the force of attraction.
* This reduced nuclear charge or nuclear charge actually experienced by an electron is termed as effective nuclear charge

$$Z^* = Z - \sigma$$

where Z^* = Effective nuclear charge
Z = Atomic number σ = screening constant

* Effective nuclear charge is not same for all the electrons present in an atom and it varies with distance between electron and nucleus.

*** This effect in which inner electrons shield valence electron from the attraction due to nucleus is called shielding effect. It is also k/a screening effect as inner electrons creates a protective screen between nucleus and valence electrons.

* Calculation of shielding constant (σ):
  Slater's Rule

i) All electrons in the ns, np group shield valence electron to the extent of 0.35 each except for 1s for which a value of 0.3 seems to work better
ii) All electrons in (n-1) shell shield to an extent of 0.85 each
iii) All electrons in (n-2) or in the lower shell, shield completely and their contribution is 1.00 each.
(iv) Electrons in any group to the right of the (ns, np) group contribute nothing to shielding constant
(v) when electron being shielded is in an nd and nf group rule (i) & (iv) are same but rule (ii) & (iii) are changed. Here all the electrons in groups lying to the left of the nd or nf group contribute 1.00 each.

Thus σ = [0.35 × Number of electrons in n^{th} shell excluding test electron] + [0.85 × Number of electrons in $(n-1)^{th}$ shell] + [1.0 × Number of electrons in inner shell]

for example :-

$_7N$: $1s^2 2s^2 2p^5$ $\sigma = [.35 \times 4 + .85 \times 2] = 3.10$

$_{30}Zn$: $(1s)^2, (2s2p)^8, (3s3p)^8, (3d^{10}), (4s)^2$

$\sigma = [0.35 \times 1] + [0.85 \times 18] + [1.0 \times 10] = 25.65$

In $_{30}Zn$ 4s & 3d electrons experience different effective nuclear charge

for 4s => $\sigma = [10 \times 1 + 18 \times .85 + 1 \times .35] = 25.65$

for 3d-electron => $\sigma = [18 \times 1 + 9 \times .35] = 21.15$

* In homo diatomic molecule (covalent radii) => A_2 molecule

$$r_A = \frac{d_{A-A}}{2}$$

* In Hetero diatomic molecule (covalent radii)
  when difference is considerable in their E.N.

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

difference in EN on pauling scale.

factors affecting atomic radii
a) Effective nuclear charge
b) Size of valence shell
c) Multiplicity of bond
d) % ionic character

... shown below for II period.

Table 3.3

Z^* and σ for II period elements

Element	Atomic number	Calculation of σ: [0.35 × (No. of nth electrons) − 1]	[0.85 × No. of (n − 1)th electrons]	[1.0 × No. of inner electrons]	σ	$Z^* = Z - \sigma$
Li	3	—	0.85 × 2	—	1.70	1.30
Be	4	0.35 × 1	0.85 × 2	—	2.05	1.95
B	5	0.35 × 2	0.85 × 2	—	2.40	2.60
C	6	0.35 × 3	0.85 × 2	—	2.75	3.25
N	7	0.35 × 4	0.85 × 2	—	3.10	3.90
O	8	0.35 × 5	0.85 × 2	—	3.45	4.55
F	9	0.35 × 6	0.85 × 2	—	3.80	5.20
Ne	10	0.35 × 7	0.85 × 2	—	4.15	5.85

On moving down the group, the effective nuclear charge does not vary significantly and remains almost same. For gp. 1 (alkali metals) and gp. 2 (alkaline earth metals), Z^* is given below in the tables.

Table 3.4

Z^* for alkali metals

Element	Atomic number	Calculation of σ: [0.35 × (No. of nth electrons) − 1]	[0.85 × No. of (n − 1)th electrons]	[1.0 × No. of inner electrons]	σ	$Z^* = Z - \sigma$
Li	3	—	0.85 × 2	—	1.70	1.3
Na	11	—	0.85 × 8	2 × 1.0	8.80	2.2
K	19	—	0.85 × 8	10 × 1.0	16.80	2.2
Rb	37	—	0.85 × 8	28 × 1.0	34.80	2.2
Cs	55	—	0.85 × 8	46 × 1.0	52.80	2.2

Table 3.5

Z^* for alkaline earth metals

Element	Atomic number	Calculation of σ: [0.35 × (No. of nth electrons) − 1]	[0.85 × No. of (n − 1)th electrons]	[1.0 × No. of inner electrons]	σ	$Z^* = Z - \sigma$
Be	4	0.35 × 1	0.85 × 2	—	2.05	1.95
Mg	12	0.35 × 1	0.85 × 8	2 × 1.0	9.15	2.85
Ca	20	0.35 × 1	0.85 × 8	10 × 1.0	17.15	2.85
Sr	38	0.35 × 1	0.85 × 8	28 × 1.0	35.15	2.85
Ba	56	0.35 × 1	0.85 × 8	46 × 1.0	53.15	2.82