Q1 2. Explain why Mg^{+2} is smaller in size than O^{2-} ion although both have the same electronic structure

Soln. This statement can be explained from effective nuclear charge.

The electronic configuration of Mg^{+2} and O^{2-} ions are given below.

$Mg^{+2} \longrightarrow 1s^2 2s^2 2p^6$

$O^{2-} \longrightarrow 1s^2 2s^2 2p^6$

The effective nuclear charge of both ions are following

$$2^* (Mg^{+2}) \longrightarrow 12 - (0.35 \times 7 + 0.85 \times 2)$$
$$= 12 - 4.15$$
$$= 7.85$$

$$2^* (O^{2-}) \longrightarrow 8 - (0.35 \times 7 + 0.85 \times 2)$$
$$= 8 - 4.15$$
$$= 3.55$$

From the calculation it is seen that both of the ions have same number of electrons, but the effective nuclear charge of Mg^{+2} ion is greater than that of O^{2-} ion.

We know that the greater effective nuclear charge is smaller in size. So Mg^{+2} ions is smaller in size than O^{2-} ion.

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02. Q What is effective Nuclear charge (Zeff)

Soln: Effective nuclear charge, Zeff is defined as the actual nuclear charge, Z minus the screening effect caused by the electrons intervening between the nucleus and outer electrons.

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

Here, σ is a constant which is called the screening constant. Z is the actual nuclear charge.

Greater is the number of electrons intervening between the nucleus and the other electrons, more will be the magnitude of σ and hence the magnitude of effective nuclear charge, Zeff will decrease.

3Q. Calculate the effective nuclear charge experienced by the 4S electron in potassium atom.

Soln. The electronic configuration of K atom (Z=19) is $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$ and this atom has 4 shells in all. Eventually the magnitude of Zeff experienced by 4s electron is given below.

$$Z_{eff} = Z - \sigma$$
$$= Z - \{(0.85 \times \text{No of electrons in 3rd shell}) + (1.00 \times \text{Total Number of electrons in the inner shells})\}$$
$$= 19 - \{0.85 \times 8 + 1.0 \times (2+8)\}$$
$$= 19 - \{6.80 + 10\}$$
$$= 2.20$$

So, Zeff

Q2. Calculate the effective nuclear charge of the last electron in an atom whose configuration is $1s^2 2s^2 2p^6 3s^2 3p^5$

Soln: Evidently the atomic number, Z of the element having this configuration is 17 and it has three shells in all.

$Z_{eff} = Z - \sigma$

$= 17 - [(0.35 \times$ No. of electrons left in 3rd shell$) +$ $(0.85 \times$ No. of electrons in 2nd shell$) + (1.00 \times$ Total Number of electrons in the inner shell$)]$

$= 17 - [(0.35 \times 6) + (0.85 \times 8) + (1 \times 2)]$

$= 17 - 10.2 = 6.8$

** Rule of σ **

(a) All electrons in groups outside the electron chosen $= 0$

(b) All other electrons in the same group as chosen one $= 0.35$ (or 0.30 for 1s electron)

(c) All electrons in shell immediately inside $= 0.85$

(d) All electrons further inside $= 1.00$

5** Q. By emitting which electron V^{+2} ion formed.?

Soln. The E.C of vanadium is given below ——

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

From the Slatter rules

$Z^*_{4s} = 23 - [0.35 \times 1 + 0.85 \times 11 + 1.00 \times 10]$

$= 3.30$

And, $Z^*_{3d} = 23 - [0 \times 2 + 0.35 \times 2 + 0.85 \times 8 + 1.00 \times 10]$

$= 5.50$

Hence the value of Z^* in 3d orbital is more than 4s. So it is easy to remove electron from 4s orbital.

b Q. What is shielding effect?

Soln: The decrease in the attraction force exerted by the nucleus on the valence shell electron, which is obviously due to the presence of the electrons lying between the nucleus and valence shell electrons, (called intervening electrons) is called shielding effect or screening effect.

In the other words, the intervening electrons screen or shield the valence shell electrons from the nucleus.

Factors affecting the Magnitude of Shielding Effect:

① No. of inner — shell electrons or inner shells

Greater is the number of inner shell electrons or inner shells, greater is the magnitude of shielding effect caused by the inner electrons on the valence — shell electrons.

⑪ Type of the orbital occupied by the electrons.

— Penetration power decreasing ⟶

Values of n: ns > np > nd > nf (same)

Values of l: 0, 1, 2, 3

— Increasing ⟶

7 Q. Cl^- ion is larger than Cl atom. Explain this term.

Soln. The electronic configuration of Cl^- and Cl are given below

$Cl^-(18) \longrightarrow 1s^2 2s^2 2p^6 3s^2 3p^6$

$Cl(17) \longrightarrow 1s^2 2s^2 2p^6 3s^2 3p^5$

$Z^*(Cl^-) \longrightarrow 17 - (0.35\times7 + 0.85\times8 + 1.\times2)$

$= 17 - 11.25$

$= 5.75$

$Z^*(Cl) \longrightarrow 17 - (0.35\times6 + 0.85\times8 + 1\times2)$

$= 17 - 10.9$

$= 6.1$

Above the calculation we see the effective nuclear charge of Cl^- is less than Cl
We know that the smaller effective nuclear charge of a molecule is larger in size. Hence Cl^- ion is larger than Cl atom.

8 * Q. Na^+ ion is smaller than Na - atom and Cl^- ion is larger than Cl atom. Explain.

Soln. The electronic configuration of Na^+ and Na are given below:

$Na^+(10) \longrightarrow 1s^2 2s^2 2p^6$

$Na(11) \longrightarrow 1s^2 2s^2 2p^6 3s^1$

$Z^*(Na^+) \longrightarrow 11 - (0.85\times7 + 1.0\times2)$

$= 3.05$

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And

$Z^*(Na) \rightarrow 11 - (0 \times 0.35 + 0.85 \times 8 + 1.0 \times 2)$

$= 11 - 8.8$

$= 2.20$

Above the calculation we see that effective nuclear charge of Na^+ is greater than that of Na.
We know that, the greater effective nuclear charge is smaller in size so Na^+ ion is smaller in size than Na

See the upper portion of the Answer script →

09 Q. ** Effective nuclear charge increase as the atomic number in a period are increased. Explain why

Soln: When we proceed from left to right across a period, the atomic number increases by one at each next element and the next element has one more valence electron with its effective repultion equal to 0.35 and therefore the effective nuclear charge increases by $1 - 0.35 = 0.65$ from member to member consequently the effective nuclear charge of each next atom is greater by 0.65 than the previous atom. as for example

Element of 2nd period:

	Li	Be	B	C	N	O	F	Ne
Z_{eff} :	1.30	1.95	2.60	3.25	3.90	4.55	5.20	5.85