HL Answers to Electrons in atoms questions

1. (a) i. The second main energy level contains s and p sub-levels. The s sub-level is full after two electrons have been added successively (Li & Be). The p sub-level is then successively filled until six electrons have been added to give Ne. After Ne the third level starts to be filled (3s) showing that the maximum number of electrons that can occupy the 2p sub-level is 6.

ii. It is easier to remove a p electron from Al ([Ne]$3s^2 3p^1$) than it is to remove an s electron from Mg ([Ne]$3s^2$).

iii. K has a very low IE with the configuration [Ar]$4s^1$ so the 4s fills before the 3d sub-level.

iv. The regular increase from B to N then the drop between N and O shows that the three p orbitals are filled singly before the electrons are paired up.

(b) The values will all be higher and the graph is shifted to the left by 1 atomic number so the peaks will be given by Li^+, Na^+ and K^+ but the basic shape will remain the same.

2. i. For the 4th ionization energy the equation is $V^{3+}(g) \rightarrow V^{4+}(g) + e^-$ and for the 5th ionization energy the equation is $V^{4+}(g) \rightarrow V^{5+}(g) + e^-$. The V^{4+} ion will attract electrons more strongly than the V^{3+} ion so the 5th electron will be harder to remove.

ii. Both the 4th and the 5th ionisation energies involve the loss of 3d electrons. The 5th ionization gives the V^{5+} ion with an electronic configuration of $1s^2 2s^2 2p^6 3s^2 3p^6$ i.e. the same as the noble gas argon. It will be much more difficult to remove the 6th electron as it involves removal of a 3p electron and the 3p level is much more strongly attracted to the nucleus than a 3d electron.

3. i. $E = hv = hc/\lambda = (6.63 \times 10^{-34} \times 3.00 \times 10^{8})/9.12 \times 10^{-8} = 2.18 \times 10^{-18}$ J for one electron.

$= 2.18 \times 10^{-18} \times 6.02 \times 10^{23} = 1.31 \times 10^{6}$ J mol^{-1} = 1310 kJ mol^{-1}(to 3 SF)

ii. The convergence line in the ultraviolet spectrum is due to the transition from n = ∞ to the lowest level n = 1 which is the level occupied by the one hydrogen electron in the ground state. The convergence line in the visible spectrum is due to the transition from n = ∞ to n = 2.

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