CH301H – Principles of Chemistry I: Honors
Fall 2013, Unique 52195

Quiz 1, 5 September 2013

The ionization energies for the three electrons of lithium are:

$IE_1 = 5.39$ eV atom^{-1} ← This is the e^- that is furthest from the nucleus.
$IE_2 = 75.64$ eV atom^{-1}
$IE_3 = 122.45$ eV atom^{-1}

$Li \rightarrow Li^+ + e^-$ $\quad IE_1 = 5.39$ eV/atom

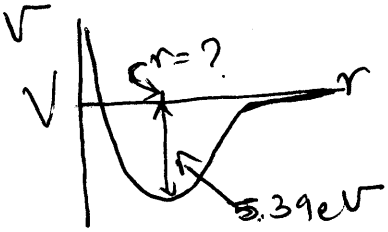
Based on the classical shell model of the atom, what is the distance, r, of the outermost electron of lithium from the nucleus? The following information may be helpful.

$q = 1.602 \times 10^{-19}$ C
$\varepsilon_0 = 8.854 \times 10^{-12}$ C^2 J^{-1} m^{-1}

Extra Credit (not much): Based on your assumptions to solve this problem, will the calculated distance be an upper or lower limit to the actual distance? Justify your answer.

If it takes 5.39 eV to ionize the outermost electron from Li, that means this electron is sitting in a PE well of 5.39 eV.

PE of this electron therefore equals -5.39 eV



We know $V = \frac{q_1 q_2}{4\pi\varepsilon_0 r} \Rightarrow r = \frac{q_1 \cdot q_2}{4\pi\varepsilon_0 V}$

$$r = \frac{(+1)(-1)\,(1.602\times10^{-19}\,C)^2}{4\pi\,(8.854\times10^{-12}\,C^2/Jm)(-5.39eV)} = 4.28\times10^{-29}\,\frac{Jm}{eV}\left(\frac{1eV}{1.602\times10^{-19}J}\right)$$

$$\boxed{r = 2.67\times10^{-10}\,m = 2.67\,\text{Å}}$$

EC Answer: This is assuming that classical electrostatics adequately describes the interaction and that the full Li^+ charge is not shielded from the electron. This is therefore an upper limit to the estimated radius.