3.091 Fall Term 2009

Homework Quiz #2B

solution outlines

Afternoon sections' question.

(a) In a gas discharge tube what is the minimum frequency (ν) of a photon capable of ionizing ground-state electrons in Li^{2+}?

here is the central concept: the energy of the incident photon must be at least as great as the ionization energy (I.E.)

Li^{2+} is a one-electron atom, so we can calculate the I.E. using the Bohr Model

$I.E. \;=\; E_\infty - E_1 \;=\; 0 - (-\frac{KZ^2}{n^2})$, where $Z = 3$ and $n = 1$ for the ground-state of Li^{2+} and K is the ground-state energy of atomic hydrogen

energy of incident photon is given by $E = h\nu$

$$\nu \;=\; \frac{KZ^2}{h} \quad \frac{(2.18\times10^{-18}\ J)(3)^2}{6.6\times10^{-34}} \;=\; 2.97\times10^{16}\ Hz$$

(b) Explain with reference to the relevant physical forces why the value of the 1st ionization energy of Li is less than the 3rd ionization energy of Li.

the 1st ionization represents the removal of one of the 3 electrons from neutral Li

the 3rd ionization represents the removal of the single electron from the Li^{2+} ion

in the second case, the single electron ***alone*** feels the pull of the positive charge of the nucleus

in the first case the same positive charge is felt by three electrons; hence, each electron feels a weaker pull than is the case with a lone electron under the influence of the same positive charge