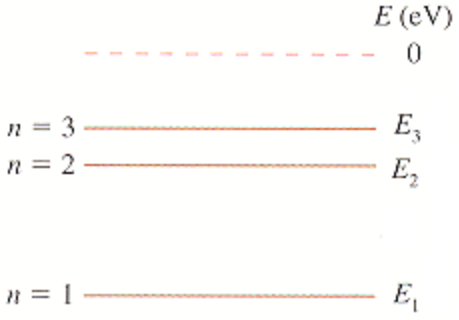
Q- The first three energy levels of the fictitious element X are E_1 = -3.8 eV, E_2 = -1.7 eV, and E_3 = -1.2 eV. Element X has one electron in the ground state.

(a) What is the ionization energy of element X?



The ground state energy of electron is its minimum energy (negative) and the maximum energy is zero (free). It means that to make the electron free from the nucleus or for ionization the energy must be zero hence the ionization energy will be equal to the ground level energy but positive and by giving this energy the total energy of electron becomes zero and it will go out of the atom.

Hence the ionization energy is 3.8 eV.

(b) Calculate the (i) shortest and (ii) next-shortest wavelengths observed in the absorption spectrum of element X.

The energy of photon is given by hc/λ and hence for the wavelength to be shortest, the energy difference between the level to be maximum, thus for the shortest wavelength we have

$h*c/\lambda_1 = (3.8 - 1.2)*1.6*10^{-19}$ J

gives $\lambda_1 = (6.63*10^{-34})*(3*10^8)/(2.6*1.6*10^{-19}) = 4.78*10^{-7}$ m = 478 nm

For the next shortest wavelength, we have

$h*c/\lambda_2 = (3.8 - 1.7)*1.6*10^{-19}$ J

gives $\lambda_2 = (6.63*10^{-34})*(3*10^8)/(2.1*1.6*10^{-19}) = 5.92*10^{-7}$ m = 592 nm

(c) An electron with a speed of 1.1 ×10^6 m/s collides with an atom of element X. Shortly afterward, the atom emits a 2482 nm photon. What was the electron's speed after the collision? Assume that, because the atom is so much more massive than the electron, the recoil of the atom is negligible.

If the speed of the electron after collision is v_2 then conserving energy we have

The loss of energy of electron = energy of the emitted photon

Or $(1/2)m\ v_1^2 - (1/2)m\ v_2^2 = h\ c/\lambda$

Or $0.5*9.11*10^{-31}[(1.1*10^6)^2 - v_2^2] = 6.63*10^{-34}*3*10^8/\ (2482*10^{-9})$

Or $[(1.1*10^6)^2 - v_2^2] = 1.76*10^{11}$

gives $v_2 = 1.017*10^6$ m/s