Answer on Question #62190, Chemistry / General Chemistry

a) Calculate the ionisation energy of rubidium per atom, if light of wavelength 5.84 10^{-8} m produces electrons with a speed of 2.450 10^{6} ms $^{-1}$. [Hint: Assume that the threshold frequency refers to the frequency corresponding to the ionisation energy.

Solution:

Einstein's equation for the photoelectric effect

$$h\nu = K + W$$

Where, h is the Planck constant and v is the frequency of the incident photon. The W is the work function. The kinetic energy K of an ejected electron.

$$W = h\nu - K$$

Where,

$$\nu = \frac{c}{\lambda}$$

$$K = \frac{mv^2}{2}$$

Determine the energy:

$$W = h\frac{c}{\lambda} - \frac{mv^2}{2}$$

$$W = \frac{3 \cdot 10^8 m/s \times 6.626 \times 10^{-34}\text{Js}}{5.84 \cdot\ 10^{-8} m} - \frac{9.1 \cdot 10^{-31} kg \times (2.450\ \cdot 10^6\ \text{ms}^{-1}\ )^2}{2} = 6.6 \cdot 10^{-19} J$$

This is the energy required to ionize 1 atom of Rb

Answer: $6.6 \cdot 10^{-19} J$

b) Assume that the electron in Li^{2+} ion is in third orbit. Calculate: i) the radius of the orbit, and ii) the total energy of the electron. [Hint: Li^{2+} ion also has atomic spectra similar to hydrogen atom. while applying relevant equations, use Z = 3.]

Solution:

Radius of atom

$$E_n = -E_0 \frac{Z^2}{n^2} = -13.6\ eV \frac{9}{n^2}$$

The first Li^{2+} level that have the same energy as hydrogen atom is: n = 3, E_3=-13.6 eV.

The radius of the third orbit would be

$$r = n^2 \frac{r_1}{Z} = 9 \frac{0.5 \cdot\ 10^{-10} m}{3} = 1.5 \cdot 10^{-10} m = 1.5\ A°$$

The electron's total energy

$$E = \frac{Zke^2}{2r} = \frac{3 \times 9 \cdot 10^9 \times (1.6 \cdot 10^{-19})^2}{2 \times 1.5 \cdot 10^{-10}} = 23.04 \cdot 10^{-19}\ J$$

Answer: $1.5\ A°$; $23.04 \cdot 10^{-19}\ J$