KSCP (2001/2002) : Quantum Theory

Q2 (a) See text

(b) All the ionization steps in Li atom

$$Li \xrightarrow[\text{(step 1)}]{IE_{I}} Li^{+} \xrightarrow[\text{(step 2)}]{IE_{II}} Li^{2+} \xrightarrow[\text{(step 3)}]{IE_{III}} Li^{3+}$$

2.1 → 2 → 1 → 0

Z (atomic no) = 3

Bohr Theory can be used for this step (step 3) since Li^{+} has a single electron.

$$\Delta E_{IE} = \frac{e^2}{2a_0}\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

$e = 4.8 \times 10^{-10}$ esu

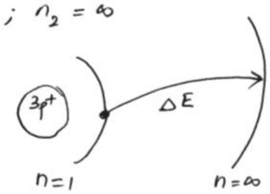
$a_0 = 0.529\ \text{Å} = 0.529 \times 10^{-8}$ cm

$Z = 3$

$n_1 = 1$; $n_2 = \infty$

$$= \frac{(4.8 \times 10^{-10}\ \text{esu})}{2 \times 0.529 \times 10^{-8}\ \text{cm}}\left[\frac{1}{1^2} - \frac{1}{\infty^2}\right]$$

$$= 2.18 \times 10^{-11}\ \text{erg}$$



$$\Delta E_{IE} = \left(\frac{2.18 \times 10^{-11}}{10^7}\right) \times 10^{-3}\ \text{kJ atom}^{-1}$$

$$= 2.18 \times 10^{-21}\ \text{kJ atom}^{-1}$$

$$= (2.18 \times 10^{-21})(6.022 \times 10^{23})\ \text{kJ mol}^{-1}$$

$$\Delta E_{IE} = 1312.8\ \text{kJ mol}^{-1}$$

∴ Third ionization energy for Li = 1312.8 kJ mol^{-1} (Ans) //

SI unit (Alternative Method)

Method I

$$\Delta E = (-2.18 \times 10^{-18}\ \text{J})\left[\frac{1}{1^2} - \frac{1}{\infty^2}\right]$$

$$= -2.18 \times 10^{-18}\ \text{J atom}^{-1}$$

$$= (-2.18 \times 10^{-18} \times 10^{-3} \times 6.022 \times 10^{23})\ \text{kJ mol}^{-1}$$

$$= 1312.8\ \text{kJ mol}^{-1}\ \text{(Ans)} //$$

Method II

$$\frac{1}{\lambda} = R_H\left[\frac{1}{1^2} - \frac{1}{\infty^2}\right]$$

$$\frac{1}{\lambda} = 109678\ \text{cm}^{-1}$$

$$\lambda = 9.12 \times 10^{-6}\ \text{cm}$$

$$= 9.12 \times 10^{-8}\ \text{m}$$

$$\Delta E = hc/\lambda$$

$$= \frac{(6.626 \times 10^{-34})(3.0 \times 10^{8})}{9.12 \times 10^{-8}}$$

$$\Delta E = 2.18 \times 10^{-18}\ \text{J atom}^{-1}$$

$$= (2.18 \times 10^{-18} \times 10^{-3} \times 6.022 \times 10^{23})\ \text{kJ}$$

$$\Delta E_{IE} = 1312.8\ \text{kJ mol}^{-1} //$$

KSCP (2001/2002) : Quantum Theory

Q3 (a) $Na(g) \longrightarrow Na^+(g) + e^-$ $IE = 496\ kJmol^{-1}$

$$\Delta E_{IE} = 496\ kJmol^{-1} = \frac{496 \times 10^3\ Jmol^{-1}}{6.022 \times 10^{23}\ atom\ mol^{-1}}$$

$$= 8.24 \times 10^{-19}\ Jatom^{-1}$$

$$\Delta E_{IE} = h\nu = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34}\ Js)(3.0 \times 10^8\ ms^{-1})}{\lambda}$$

$$\lambda = \frac{(6.626 \times 10^{-34})(3.0 \times 10^8)}{(8.24 \times 10^{-19}\ Jatom^{-1})}$$

$$= 2.41 \times 10^{-7}\ m$$

$$= 2.41 \times 10^{-7} \times 10^9\ nm$$

$$= 241\ nm\ (Ans)$$

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