Atomic Structure

DPP-3 Solutions

Ashish Bibyan

B.Tech (IIT Delhi)

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1.

Sol. m = mass of electron, Z = atomic number of element, e = charge on the electron, n = integer (quantum number), h = Planck's constant, k = Coulomb's law constant.

2. **0.529 Å**

Sol. For the first orbit, n=1. Substituting the values of the other constants in the equation

$$r = 0.529\frac{n^2}{Z}\ \text{Å}$$

For H atom Z = 1

$\therefore$ r = 0.529 Å.

3. **(a) r_1 = 0.176Å, r_2 = 0.704Å**

(b) 1.41 × 10^{-17}J

(c) 2.83 × 10^{-17}J

Sol. (a) We know that

$$r_n = 0.529 \times \frac{n^2}{Z}\ \text{Å}$$

$$\therefore \text{for } Li^{2+}\ r_1 = 0.529 \times \frac{1^2}{3} = 0.176\text{Å}$$

$$r_2 = 0.529\,\frac{(2)^2}{3} = 0.704\ \text{Å}$$

(b) Total energy = – 2.178 × 10^{-18} $\frac{Z^2}{n^2}$ J/atom.

$$TE_1 = -2.178 \times 10^{-18}\,\frac{(3)^2}{(1)^2}$$

$$TE_1 = -1.906 \times 10^{-17}\ \text{J/atom}$$

$$TE_2 = -\,2.178 \times 10^{-18}\,\frac{(3)^2}{(2)^2}$$

TE_2 = – 4.9005 × 10^{-18} J/atom

$$\Delta\,(\text{T.E.}) = -4.9005 \times 10^{-18} - (-1.906 \times 10^{-17})$$

= 1.41 ×10^{-17} J/atom

(c) Potential Energy = 2 × Total Energy

$\therefore$ (P.E.) = 2 Δ (T.E.)

= 2 (1.41 × 10^{-17})

= 2.83 × 10^{-17} J.

4. **(a) – 3.4 eV**

Sol. E_1 = – 13.6eV.

$$\&\ E_2 = \frac{E_1}{n^2} \Rightarrow E_2 = \frac{-13.6}{(2)^2} = -3.4\text{eV}.$$

$$E_3 = -\frac{13.6}{9} \Rightarrow E_3 = 1.5\text{eV}$$

$\therefore$ Only option (a) is correct.

5. **7.197 ×10^{19} sec^{-1}**

Sol. $E = \frac{nhc}{\lambda}$

$$25 = \frac{n \times 6.6 \times 10^{-34} \times 3 \times 10^8}{0.57 \times 10^{-6}}$$

n = 7.197 ×10^{19} quantas/sec.

6. **4.41 × 10^{14} s^{-1}, 2.91 × 10^{-19}J**

Sol. K.E. = Zero.

$E_{incident} = E_{threshold}$

$$\frac{hc}{\lambda_{incident}} = h\nu_0$$

$$\therefore\ \nu_0 = \frac{3 \times 10^8}{6800 \times 10^{-10}} = 4.41 \times 10^{14}\ \text{hz.}$$

Work function, $W_0 = h\nu_0$

= 6.6 × 10^{-34} × 4.41 × 10^{14}

= 2.91 × 10^{-19}J

7. **486 nm**

Sol.

$$\frac{1}{\lambda} = R_H\left(\frac{1}{{n_1}^2} - \frac{1}{{n_2}^2}\right)z^2$$

$$\frac{1}{\lambda} = R_H\left(\frac{1}{2^2} - \frac{1}{4^2}\right)$$

$$\frac{1}{\lambda} = \frac{3R_H}{16}$$

$$\lambda = \frac{16}{3}\,\frac{1}{R_H}$$

$$\lambda = \frac{16}{3} \times 911.5\ \text{Å}$$

λ = 4861.3 Å

≃ 486 nm

8. **15 emission lines**

Sol. Maximum number of emission lines

$$= \frac{(n_2 - n_1 + 1)\,(n_2 - n_1)}{2}$$

$$= \frac{(6-1+1)\,(6-1)}{2} = 15$$

9. **(a)**

10. **(a)**

11. **(c)**

$$r_n = 0.53 \frac{n^2}{Z} \text{ Å}$$

$$= 0.53 \frac{(1)^2}{3} = 0.17 \text{ Å}.$$

12. **(c)**

Sol. Time taken to complete one revolution $= \frac{2\pi r}{v}$

$$r \propto \frac{n^2}{Z} \text{ Å}$$

$$v \propto \frac{Z}{n} \text{ m/s}.$$

$\therefore$ Time taken to complete one revolution $\propto \frac{n^3}{Z^2}$

when n = 1 radius = R.

when n = 2 radius = 4R. (for same atom)

$$\therefore \quad \frac{t_1}{t_2} = \frac{(1)^3}{(2)^3}$$

$$\frac{t_1}{t_2} = \frac{1}{8}$$

13. **(c)**

Sol. Time of revolution $\propto \frac{n^3}{Z^2}$.

$\Rightarrow$ frequency = 1/T

$\therefore$ frequency $\propto \frac{1}{n^3}$.