HINTS & SOLUTIONS

Atomic Structure

[Set-2]

SECTION-A

1. (iii): $\Delta E = \frac{hc}{\lambda} = 2.18\times10^{-18} Z^2\left[\frac{1}{n_L^2} - \frac{1}{n_H^2}\right] J$

2. (ii): $E_1 = \frac{hc}{\lambda_1}$ $E_2 = \frac{hc}{\lambda_2}$

$$\frac{E_1}{E_2} = \frac{\lambda_2}{\lambda_1}$$

$$\lambda_1 = \lambda_2 \frac{E_2}{E_1} = \lambda_2 \frac{50}{25}$$

$$\boxed{\lambda_1 = 2\lambda_2}$$

3. (iv): For d-electron, $l = 2$

$$L = \sqrt{\ell(\ell+1)}\frac{h}{2\pi} = \sqrt{2(2+1)}\frac{h}{2\pi}$$

$$L = \sqrt{6}\frac{h}{2\pi}$$

4. (iii): $\Delta x = \Delta p$

$$\therefore \quad \Delta x.\Delta p = \frac{h}{4\pi}$$

$$(\Delta p)^2 = \frac{h}{4\pi}$$

$$(m\Delta v)^2 = \frac{h}{4\pi}$$

$$v^2 = \frac{h}{m^2 4\pi}$$

$$\Delta v = \frac{1}{2m}\sqrt{\frac{h}{\pi}}$$

5. (ii): $n \rightarrow$ size and energy of orbital

$l \rightarrow$ shape of orbital

$m \rightarrow$ orientation of orbital

$m_s \rightarrow$ spin of electron

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6. (i): $_{19}K$: [Ar]$4s^1$ $\rightarrow$ This is the electron with highest energy is K

$(n + l)$ for 4s = 4 and $(n + l)$ value of 3d is 5.

7. (ii): 1st line in the Lymen series will requires the minimum energy and maximum wavelength. The maximum wavelength of the limiting line is

$$\frac{1}{\lambda} = 1.097 \times 10^7 \left[\frac{1}{1^2} - \frac{1}{\infty^2}\right] = 1.097 \times 10^7 \, m^{-1}$$

$$\lambda = \frac{1}{1.097 \times 10^7}$$

$$\lambda = 0.911 \times 10^{-7} \, m$$

$$\lambda = 91.1 \, nm$$

8. (i): For s-orbital, orbital angular momentum, L is zero means, the probability of finding electrons is same in all directions.

9. (iii): Total number of nodes = n – 1

For 3d, no. of nodes = 3 – 1 = 2

For 4f, no. of nodes = 4 – 1 = 3

10. (iv): Number of radial nodes $n - l - 1$

For $2p_x, 2p_y, 2p_z$, $n = 2$, $\ell = 1$

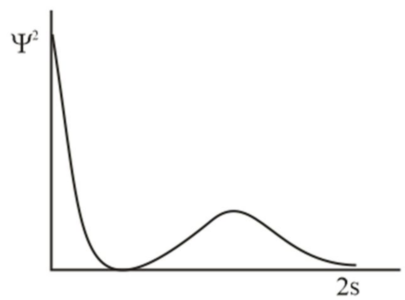
$\therefore$ number of radial nodes = 2 – 1 – 1 = 0

11. (i) This is a violation of Hund's rule which states that "no pairing of electrons starts in the degenerate atomic orbital until and unless each one is singly filled".

(ii) ψ^2 determines the probability of finding the electron in a given region in space.

12. (i) **Heisenberg's uncertainty principle** states that "it is impossible to determine the position and momentum of an object simultaneously with 100% accuracy".

(ii)



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OR

(i) Einstein applied the Planck's quantum theory first in studying photoelectric effect.

(ii) Two quantum numbers are required to define the subshell

Principal quantum number (n)

Azimuthal quantum number (*l*)

13. Second line in the Lymen series belongs to

$$n_L = 1 \longrightarrow n_H = 3$$

For He^+

$$\frac{1}{\lambda} = 1.097 \times 10^7 (2)^2 \left[\frac{1}{1^2} - \frac{1}{3^2}\right]$$

$$= 1.097 \times 10^7 \times 4 \times \frac{8}{9}$$

$$\lambda = \frac{9}{1.097 \times 10^7 \times 4 \times 8} = 2.56 \times 10^{-8}\ \text{m} = 256\text{Å}$$

The spectral line falls in the UV region of the spectrum

OR

$\lambda = 300\,\text{nm} = 3 \times 10^{-7}\ \text{m}$ and $E = 2\,\text{J}$

$$E = N\frac{hc}{\lambda}$$

N = number of photons $= \frac{E\lambda}{hc}$

$$N = \frac{2 \times 3 \times 10^{-7}}{6.62 \times 10^{-34} \times 3 \times 10^8}$$

$$N = 3.0 \times 10^{18}$$

14. m = 1 mg = 10^{-3} g = 10^{-6} kg

$$\Delta v = 5.5 \times 10^{-20}\ \text{m/s}$$

$$\Delta x . m\ \Delta v = \frac{h}{4\pi}$$

$$\Delta x = \frac{6.62 \times 10^{-34}}{4 \times 3.14 \times 10^{-6} \times 5.5 \times 10^{-20}}$$

$$\Delta x = 9.58 \times 10^{-10}\ \text{m}$$

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15. (i) $\lambda_A = 5 \times 10^{-8}$ m $\qquad \lambda_B = ?$

$$p_B = \frac{1}{2} p_A$$

$\lambda = \frac{h}{P}$ (de-Broglie equation)

$$\frac{\lambda_B}{\lambda_A} = \frac{p_A}{p_B} = 2$$

$$\lambda_B = 2\lambda_A = 2 \times 5 \times 10^{-8} = 10 \times 10^{-8} \text{ m}$$

(ii) $1s^2\ 2s^2\ 2p^5$

1s	2s	2p		
↑↓	↑↓	↑↓	↑↓	↑

(iii) (a) 2s has lower energy than 2p due to low $(n + l)$ value

(b) 4d, n + l = 4 + 2 = 6

5f, n + l = 5 + 3 = 8

4d has a lower energy than 5*f*.

OR

(i) (a) Principal quantum number (n) and azimuthal quantum number (*l*)

(b) Principal quantum number (n)

(c) Azimuthal quantum number (*l*)

(d) Magnetic quantum number (m)

(ii) $4d^6$

4d is a d-subshell in the 4th shell or 4th energy level containing six electrons, out of which four are unpaired

4d				
↑↓	↑	↑	↑	↑

(iii) In H-atom, energy depend only on the principal quantum numbers.

(a) 3s has higher energy than 1s

(b) 3p has higher energy than 2p

(c) both will have same energy as n is same

(d) both will have same energy as n is same.

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