HINTS & SOLUTIONS

Atomic Structure

[Set-1]

SECTION-A

1. (ii): $r_n = \frac{0.529}{Z} n^2$

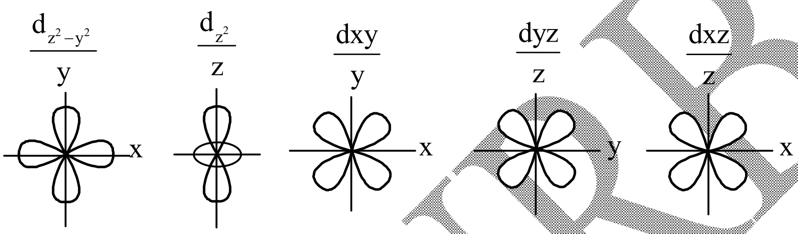
$r_n = \frac{n^2}{Z} r_H$

$r_n = r_H$ only where n = 2, Z = 2

i.e., Be^{3+}

2. (ii): In order to have least energetic photon electron should make a transition from n = 5 to n = 4.

3. (i):



4. (iii): $2p_x$, $2p_y$ and $2p_z$ all three have the same size, same shape and same energy but have different orientation in space.

5. (iii): Photon $\rightarrow$ shown dual nature, both momentum and wavelength

Electron $\rightarrow$ probability density

$\psi^2 \rightarrow$ always positive

n $\rightarrow$ n = 1 $\rightarrow$ K-shell, n = 2, L shell

n = 4, N-shell

6. (iv): For f-subshell, $l = 3$

$\therefore$ m = $(2l + 1)$, m = $(2 \times 3 + 1) = 7$, there are seven f-orbitals.

7. (i): Orbital angular momentum depends only on the azimuthal quantum number

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

For 4p, as well as for 3p, $l = 1$

$\therefore$ L will be same.

8. (ii) For H-atom, energy depends only on the principal quantum number.

3s (n = 3) has a higher energy than 2p(n = 2)

9. (iv):

$2p_z$

$n = 2$

$\ell = 1$

$m = 0$

10. (iii):

$_{17}Cl^-$	$1s^2$	$2s^2$	$2p_x^2$	$2p_y^2$	$2p_z^2$	$3s^2$	$3p_x^2$	$3p_y^2$	$3p_z^2$
n = 1	1	2	2	2	2	3	3	3	3
l =	0	0	1	1	1	0	1	1	1
n + *l*	1	2	3	3	3	3	4	4	4

8 electron in Cl– will have *n* + *l* = 3

11. Wave number of the longest wavelength transition in the Balmer series for H-atom is with minimum energy.

This is when $n_L = 2$, $n_H = 3$

$$\bar{v} = 1.097 \times 10^7 \left(\frac{1}{n_L^2} - \frac{1}{n_H^2}\right) m^{-1}$$

$$\bar{v} = 1.097 \times 10^7 \left(\frac{1}{2^2} - \frac{1}{3^2}\right) = 1.097 \times 10^7 \times \frac{5}{36}$$

$$\bar{v} = 1.52 \times 10^6 \ m^{-1}$$

OR

(i) $r_2 = \frac{n^2}{Z} \times 0.259 = \frac{(2)^2}{2} \times 0.529$

$r_{2(He^+)} = 1.058 Å$

(ii) $\frac{1}{2}$ (half)

12. (i) $_{29}Cu^{2+} : [Ar]3d^9$

(ii) $_{24}Cr : [Ar]3d^5 4s^1$

Both the species have unpaired electron present, hence both are paramagnetic and attracted towards the magnetic field.

13. $K.E = 4.55 \times 10^{-19} = \frac{mv^2}{2}$

$$v^2 = \frac{4.55 \times 10^{-19} \times 2}{9.1 \times 10^{-31}} = 10^{12}$$

$$v = 10^6 \text{ m/s}$$

$$\lambda = \frac{h}{mv} = \frac{6.62 \times 10^{-34}}{9.1 \times 10^{-31} \times 10^6}$$

$$\lambda = 7.27 \times 10^{-10} \text{m}$$

14. (i) **Pauli exclusion principle** states that "no two electrons in an atom can have the same set of four quantum numbers"

(ii) For 3p, n = 3, l = 1

(iii) For n = 4, l = 2 → 4d, can accommodate maximum five electrons with $m_s = +\frac{1}{2}$

OR

(i) **Hund's rule of maximum multiplicity** states that "no pairing of electrons starts in the degenerate atomic orbitals until and unless each one is singly filled"

(ii) $_{19}K : [Ar]4s^1$

The highest energy electron is in 4s. The four quantum number are

n = 4, l = 0, m = 0, $m_s = +\frac{1}{2}$

15. (i) 4p

Radial nodes = n – l – 1 = 4 – 1– 1 = 2

Angular nodes $l = 1$

(ii) Co : $1s^2\ 2s^2\ 2p_x^2\ 2p_y^2\ 2p_z^2\ 3s^2\ 3p_x^2\ 3p_y^2\ 3p_z^2\ 3d_{xy}^2\ 3d_{yz}^2\ 3d_{xz}^2\ 3d_{x^2-y^2}^1\ 3d_{z^2}^1\ 4s^2$

No. of orbital filled with one or more electrons equals to 15.

(iii) m = 100 g = 0.1 kg

$\Delta v = 50 \text{m/s}$

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

$$\Delta x = \frac{h}{4\pi m\ \Delta v} = \frac{6.62\times10^{-34}}{4\times3.14\times0.1\times50}$$

$$\Delta x = 1.054\times10^{-35}\ m$$

OR

$$mvr = n\frac{h}{2\pi}$$ ...(i) (Bohr postulate)

m = mass of an electron

v = speed of electron

r = radius of an orbit

$$2\pi r = n\frac{h}{mv}$$

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

$\therefore$ $\boxed{2\pi r = n\lambda}$

(ii) Electron is a microscopic particle, continuously in motion. Electron shows more of wave nature. Hence, the exact path of an electron cannot be traced around the nucleus.

(iii) $n_L = 2\ \ n_H = 4$

$$\Delta E = 2.18\times10^{-18}(1)^2\left[\frac{1}{2^2}-\frac{1}{4^2}\right] = 2.18\times10^{-18}\times\frac{3}{16}$$

$$\Delta E = 4.0875\times10^{-19}\ J$$

