



HINTS & SOLUTIONS

EXERCISE - 1

PART - I

- $$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{V_2}{V_1}} = \sqrt{\frac{200}{50}} = \frac{2}{1}$$
- $$\lambda = \frac{h}{mv} = 1.33 \times 10^{-3} \text{ \AA}$$
- For an α particle, $\lambda = \frac{0.101}{\sqrt{V}} \text{ \AA}$.
- $$\Delta X \cdot \Delta P \cong \frac{h}{4\pi}$$

$$m(\Delta X \cdot \Delta V) = \frac{h}{4\pi} \Rightarrow m = 0.099 \text{ Kg}$$
- An electron has particle and wave nature both.
- $$\Delta X \cdot \Delta P \geq \frac{h}{4\pi}$$

$$\Delta X \rightarrow 0 \Rightarrow \Delta P \rightarrow \infty$$
- $$\lambda = \frac{h}{mv} \Rightarrow \lambda \propto \frac{1}{m}$$
- Orbital angular momentum = $\sqrt{\ell(\ell+1)} \frac{h}{2\pi} = 0$.
 $\therefore \ell = 0$ (s orbital).
- Cu : $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$.

$\therefore \text{Cu}^{2+} : 1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$ or $[\text{Ar}]3d^9$.
- Magnetic moment = $\sqrt{n(n+2)} = \sqrt{24}$ B.M.
 \therefore No. of unpaired electron = 4.
 $\text{X}_{26} : 1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$.
 To get 4 unpaired electrons, outermost configuration will be $3d^6$.
 \therefore No. of electrons lost = 2 (from $4s^2$).
 $\therefore n = 2$.
- $\text{Zn}^{2+} : [\text{Ar}] 3d^{10}$ (0 unpaired electrons).

$\text{Fe}^{2+} : [\text{Ar}] 3d^6$ (4 unpaired electrons) maximum.

$\text{Ni}^{3+} : [\text{Ar}] 3d^7$ (3 unpaired electrons).

$\text{Cu}^+ : [\text{Ar}] 3d^{10}$ (0 unpaired electrons).
- $d^7 : 3$ unpaired electrons.

\therefore Total spin = $\pm \frac{n}{2} = \pm \frac{3}{2}$.

- $\text{X}_{23} : 1s^2 2s^2 2p^6 3s^2 3p^6 3d^3 4s^2$.

No. of electron with $\ell = 2$ are 3 ($3d^3$).
- $\text{Cl}_{17}^- : [\text{Ne}] 3s^2 3p^6$.

Last electron enters 3p orbital.
 $\therefore \ell = 1$ and $m = 1, 0, -1$.
- Number of radial nodes = $n - \ell - 1 = 1$, $n = 3$.
 $\therefore \ell = 1$.
 Orbital angular momentum

$$= \sqrt{\ell(\ell+1)} \frac{h}{2\pi} = \sqrt{2} \frac{h}{2\pi}$$
- $\text{Cl}_{17} : [\text{Ne}] 3s^2 3p^5$.

Unpaired electron is in 3p orbital.
 $\therefore n = 3, \ell = 1, m = 1, 0, -1$.
- Only Spin quantum number (s) is not derived from Schrodinger wave equation.
- $n = 4, m = -3$

\therefore only possible value of ℓ is 3.
 \therefore Orbital angular momentum

$$= \sqrt{\ell(\ell+1)} \frac{h}{2\pi} = \frac{2\sqrt{3}h}{2\pi} = \frac{\sqrt{3}h}{\pi}$$
- Only (A) and (B) arrangements follow Hund's rule.
- (B) If the electronic configuration of ${}^6\text{C}$ is written as $1s^6$, then Pauli exclusion principle has been violated.

(D) The $+\frac{1}{2}$ and $-\frac{1}{2}$ values of spin quantum number denote two quantum mechanical spin states, which have no classical analogue.

PART - II

- Ni Atomic No : 28
 $\text{Ni} : [\text{Ar}] 3d^8 4s^2$; $\text{Ni}^{2+} [\text{Ar}] 3d^8 4s^0$

↑↓	↑↓	↑↓	↑	↑	□
3d					4s

No. of unpaired electron = 2
- Atomic No. 56
 Electronic configuration: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2$.



3. (a) $n = 3, \ell = 1 \Rightarrow 3p$
 (b) $n = 5, \ell = 2 \Rightarrow 5d$
 (c) $n = 4, \ell = 1 \Rightarrow 4p$
 (d) $n = 2, \ell = 0 \Rightarrow 2s$
 (e) $n = 4, \ell = 2 \Rightarrow 4d$
4. Orbital angular momentum = $\sqrt{\ell(\ell+1)} \frac{h}{2\pi}$
 For 4s orbital, $\ell = 0$
 \therefore Angular momentum = $\sqrt{0(0+1)} \frac{h}{2\pi} = 0$.
 For 3p orbital, $\ell = 1$
 \therefore Angular momentum = $\sqrt{1(1+1)} \frac{h}{2\pi} = \frac{h}{\sqrt{2\pi}}$.
 For 4th orbit, Angular momentum
 $= \frac{nh}{2\pi} = \frac{4h}{2\pi} = \frac{2h}{\pi}$.
5. (i) $\ell = 0 \Rightarrow m = 0$ ($m \neq 1$)
 (iii) $n = 1 \Rightarrow \ell = 0$ ($\ell \neq 2$)
 (vi) $s = +1/2$ or $-1/2$ ($s \neq 0$)
6. (i) ${}_{26}\text{Fe}^{3+} : 1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$
 It contains 5 unpaired electrons $\therefore n = 5$
 \therefore Total spin = $\pm \frac{n}{2} = \pm \frac{5}{2}$
 Magnetic moment = $\sqrt{n(n+2)}$
 $= \sqrt{5(5+2)} = \sqrt{35} \text{ BM}$.
 (ii) ${}_{29}\text{Cu}^+ : 1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$
 It contains 0 unpaired electron
 \therefore Total spin = 0.
 \therefore Spin magnetic Moment = 0.
5. The lobes of d_{xy} orbital are at an angle of 45° with X and Y axis. So along the lobes, angular probability distribution is maximum.
6. Total number of electrons in an orbital = $2(2\ell+1)$.
 The value of ℓ varies from 0 to $n-1$.
 \therefore Total numbers of electrons in any orbit
 $= \sum_{\ell=0}^{\ell=n-1} 2(2\ell+1)$.
7. Spin quantum number does not come from Schrodinger equation.
 $s = +\frac{1}{2}$ and $-\frac{1}{2}$ have been assigned arbitrarily.
8. For 1s, 3s, 3d and 2p orbital, $\ell = 0, 0, 2, 1$ respectively.
 Orbital angular momentum = $\sqrt{\ell(\ell+1)} \hbar$.
9. After np orbital, $(n+1)$ s orbital is filled.
10. I : For $n = 5, l_{\min} = 0$.
 \therefore Orbital angular momentum
 $= \sqrt{\ell(\ell+1)} \hbar = 0$. (False)
 II : Outermost electronic configuration
 $= 3s^1$ or $3s^2$.
 \therefore Possible atomic number = 11 or 12 (False).
 III : $\text{Mn}_{25} = [\text{Ar}] 3d^5 4s^2$.
 \therefore 5 unpaired electrons.
 \therefore Total spin = $\pm \frac{5}{2}$ (False).
 IV : Inert gases have no unpaired electrons.
 \therefore spin magnetic moment = 0 (True).
11. The lobes of $d_{x^2-y^2}$ orbital are aligned along X and Y axis. Therefore the probability of finding the electron is maximum along x and y-axis.
12. $n = 4, m = 2$
 Value of $\ell = 0$ to $(n-1)$ but $m = 2$.
 $\therefore \ell = 2$ or 3 only
 Value of s may be $+1/2$ or $-1/2$.
13. (A) ${}_{24}\text{Cr} : [\text{Ar}] 3d^5 4s^1$
 (B) $m = -\ell$ to $+\ell$ through zero.
 (C) ${}_{47}\text{Ag} : 1s^2 2s^2 2p^6 3s^2 3p^4 3d^{10} 4p^6 5s^1 4d^{10}$.
 Since only one unpaired electron is present.
 \therefore 23 electrons have spin of one type and 24 of the opposite type.

EXERCISE - 2

1. $\Delta p \cdot \Delta x = \frac{h}{4\pi}$
 $\Rightarrow \Delta x = \frac{6.62 \times 10^{-34}}{4 \times 3.14 \times 1 \times 10^{-5}} = 5.27 \times 10^{-30} \text{ m}$.
2. $\lambda = \frac{h}{mv} = 0.4 \times 10^{-33} \text{ cm}$
3. $\Delta x \cdot \Delta p \approx \frac{h}{4\pi} \Rightarrow \Delta v = 3.499 \times 10^{-24} \text{ ms}^{-1}$
4. s orbital is spherical so non-directional.



14. Two unpaired electrons present in carbon atom are in different orbitals. So they have different magnetic quantum number.
15. Electronic configuration of Zn^{2+} ion is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$ so no electron in 4s orbital.
16.
$$\sqrt{s(s+1)} \frac{h}{2\pi} = \sqrt{\frac{1}{2} \left(\frac{1}{2} + 1\right)} \frac{h}{2\pi}$$

$$= \frac{\sqrt{3}}{2} \frac{h}{2\pi} = 0.866 \frac{h}{2\pi}$$
17. For principle quantum number n
 $\ell = 0$ to $(n - 1)$ and $m = -\ell$ to ℓ including zero.

EXERCISE - 3

PART - I

1. Orbital angular momentum = $\sqrt{\ell(\ell+1)} \frac{h}{2\pi} = 0$
 (since $\ell = 0$ for s orbital).
3. For 2p, $\ell = 1$
 \therefore Orbital angular momentum
 $= \sqrt{\ell(\ell+1)} \frac{h}{2\pi} = \sqrt{2} \cdot \left(\frac{h}{2\pi}\right)$
4.

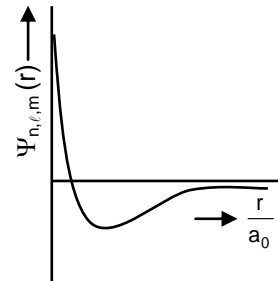
3s	3p	3d
↑↓	↑↓ ↑↓ ↑↓	↑↓ ↑↓ ↑↓ ↑↓ ↑↓

 So, electrons with spin quantum number = $-\frac{1}{2}$
 will be $1 + 3 + 5 = 9$.
5. $n = 4$, $m_\ell = 1, -1$
 Hence ℓ can be = 3, 2, 1
 i.e. H_f ; 2 orbitals
 H_d ; 2 orbitals
 H_p ; 2 orbitals
 Hence total of 6 orbitals, and we want $m_s = -\frac{1}{2}$,
 that is only one kind of spin. So, 6 electrons.
6. Energy order of orbitals of H is decided by only principle quantum number (n) while energy order of H^- is decided by $(n + \ell)$ rule:
 Electronic configuration of ' H^- ' is - $1s^2$ its Energy order is decided by $n+\ell$ rule.
 $H^- = 1s^2 2s^0 2p^0$
 Its 2nd excited state is 2p and degeneracy 2p is '3'.

7. For 1s electron in H-atom, plot of radial $4\pi r^2 R^2$ probability function ($4\pi r^2 R^2$) V/s r is as shown :



8. s-orbital is non directional so wave function will be independent of $\cos \theta$.
9. For 2s orbital no. of radial nodes = $n - \ell - 1 = 1$.



10. For 1s orbital Ψ should be independent of θ , also it does not contain any radial node.

$$\frac{E_4 - E_2}{E_6 - E_2} = \frac{\frac{E_1}{16} - \frac{E_1}{4}}{\frac{E_1}{36} - \frac{E_1}{4}} = \frac{-\frac{3E_1}{4}}{-\frac{8E_1}{36}} = \frac{3 \times 36}{8 \times 16} = \frac{27}{32}$$

11. $E_{He^+} = -13.6 \times \frac{(2)^2}{n^2} = -3.4 = \frac{-13.6}{4}$
 $n^2 = 16$ so $n = 4$
 quantum number are
 $n = 4, \ell = 2, m = 0$
 so subshell is = d.
 angular node = $\ell = 2$
 Radial node = $[n - \ell - 1] = 4 - 2 - 1 = 1$

PART - II

OFFLINE PROBLEMS

1. Mn^{2+} has the maximum number of unpaired electrons (5) and therefore has maximum moment.
2. $\Delta x \cdot \Delta v = \frac{h}{4\pi m}$

$$\Delta v = \frac{6.6 \times 10^{-34}}{4 \times 3.14 \times 25 \times 10^{-5}}$$
 $\therefore \Delta v = 2.1 \times 10^{-18} \text{ ms}^{-1}$
3.
$$\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-34} \times 1000}{60 \times 10} = 11.05 \times 10^{-34} = 1.105 \times 10^{-33} \text{ metres.}$$



4. ${}_{26}\text{Fe} = 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^6, 4s^2$
 $\text{Fe}^{2+} = 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^6$
 The number of d-electrons retained in $\text{Fe}^{2+} = 6$.
 Therefore, (4) is correct option.

5. The value of l (azimuthal quantum number) for s-electron is equal to zero.

$$\text{Orbital angular momentum} = \sqrt{l(l+1)} \cdot \frac{h}{2\pi}$$

Substituting the value of l for s-electron

$$= \sqrt{0(0+1)} \cdot \frac{h}{2\pi} = 0$$

6. For 4f orbital electrons, $n = 4$

$$l = 3 \text{ (because } \begin{matrix} s & p & d & f \\ 0 & 1 & 2 & 3 \end{matrix})$$

$$m = +3, +2, +1, 0, -1, -2, -3$$

$$s = +1/2.$$

7. ${}_{24}\text{Cr} \rightarrow 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^5, 4s^1$

$$l = 1, l = 1, l = 2$$

(we know for p, $l = 1$ and for d, $l = 2$).

For $l = 1$, total number of electrons = 12

For $l = 2$, total number of electron = 5.

8. The electron having same principle quantum number and azimuthal quantum number will be the same energy in absence of magnetic and electric field.

$$(iv) n = 3, l = 2, m = 1$$

$$(v) n = 3, l = 2, m = 0$$

have same n and l value.

9. For hydrogen the energy order of orbital is $1s < 2s = 2p < 3s = 3p = 3d < 4s = 4p = 4d = 4f$

10. According to Heisenberg's uncertainty principle

$$\Delta x \times \Delta p = \frac{h}{4\pi}$$

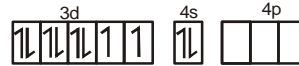
$$\Delta x \times (m \cdot \Delta v) = \frac{h}{4\pi}$$

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

$$\text{Here, } \Delta v = \frac{0.001}{100} \times 300 = 3 \times 10^{-3} \text{ ms}^{-1}$$

$$\therefore \Delta x = \frac{6.63 \times 10^{-34}}{4 \times 3.14 \times 9.1 \times 10^{-31} \times 3 \times 10^{-3}} = 1.29 \times 10^{-2} \text{ m.}$$

11. ${}_{28}\text{Ni} \rightarrow [\text{Ar}]3d^8 4s^2$



Number of unpaired electrons (n) = 2

$$\mu = \sqrt{n(n+2)} = \sqrt{2(2+2)} = \sqrt{8} \approx 2.84$$

12. The electron have $n + l$ higher value have higher energy.

$$n + l = 3 + 0 = 3$$

$$n + l = 3 + 1 = 4$$

$$n + l = 3 + 2 = 5 \text{ (highest energy)}$$

$$n + l = 4 + 0 = 4$$

13. As $\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-34}}{1.67 \times 10^{-27} \times 1 \times 10^3}$
 $= 3.97 \times 10^{-10} \text{ M}$
 $= 0.397 \times 10^{-9} \text{ M} \approx 0.40 \text{ nm.}$

14. $\Delta x \times \Delta p = \frac{h}{4\pi}$

$$\Delta x \times [m \Delta v] = \frac{h}{4\pi}$$

$$\Delta v = \frac{600 \times 0.005}{100} = 0.03$$

$$\text{So } \Delta x [9.1 \times 10^{-31} \times 0.03] = \frac{6.6 \times 10^{-34}}{4 \times 3.14}$$

$$\Delta x = \frac{6.6 \times 10^{-34}}{4 \times 3.14 \times 9.1 \times 10^{-31} \times 0.03 \times 10^{-31}} = 1.92 \times 10^{-3} \text{ M.}$$

15. (a) 4 p (b) 4 s (c) 3 d (d) 3 p
 Acc. to $(n + l)$ rule, increasing order of energy (d) < (b) < (c) < (a)

16. $Z = 37$.

Rb is in fifth period.

$[\text{Kr}]5s^1$ is its configuration.

$$\text{So } n = 5, l = 0, m = 0, s = +\frac{1}{2} \text{ or } -\frac{1}{2}$$

17. K.E. = eV

$$\Rightarrow \lambda = \frac{h}{\sqrt{2meV}}$$

$$\Rightarrow \frac{h}{\lambda} = \sqrt{2meV}$$

18. $R = 0.529 \frac{n^2}{z} \text{ \AA} = 0.529 \frac{2^2}{1} \text{ \AA} = 2.12 \text{ \AA}$



ONLINE PROBLEMS

2. Following Aufbau principle for filling electrons.

3. De-broglie wavelength (for particles) = $\frac{h}{\sqrt{2m KE}}$

As temperature is same, KE is same.

So, $\lambda \propto \frac{1}{\sqrt{m}}$.

Hence $\lambda_{db}(\text{electron}) > \lambda_{db}(\text{neutron})$

4. $n = 5$

Possible subshell are

$\Rightarrow 5s, 5p, 5d, 5f, 5g$

\therefore Total number of orbital

$= 1 + 3 + 5 + 7 + 9 = 25$

5. NaF: $Na^+ = 1s^2 2s^2 2p^6$
 $F^- = 1s^2 2s^2 2p^6$

6. $2\pi r = n\lambda$ $\lambda = \frac{2\pi r}{n} = \frac{2\pi \times 0.529 \text{ \AA}}{1}$

7. $mvr = \frac{nh}{2\pi}$

According to wave mechanics, the ground state angular momentum is equal to $\frac{h}{2\pi}$.

8. $2\pi r = n\lambda$

$2\pi a_0 \frac{n^2}{Z} = n\lambda$

$2\pi a_0 \frac{n^2}{Z} = n \cdot 1.5\pi a_0$

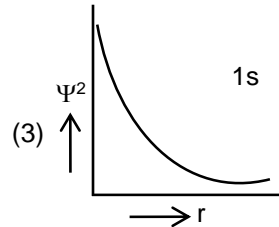
$\frac{n}{Z} = \frac{1.5}{2} = \frac{3}{4} = 0.75$

9. From $n + \ell$ rule the increasing order of energies of electrons will be IV < II < III < I

10. (1) Total energy of electron is minimum in first orbit i.e. at a_0 distance from nucleus.

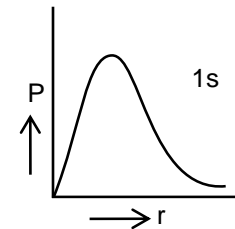
(2) P.E. = $-\frac{KZe^2}{r}$

K.E. = $\frac{1}{2} \frac{KZe^2}{r}$ |P.E.| = 2|K.E.]



Ψ^2 is maximum at nucleus

(4) Electron can be found at any distance from nucleus.



$P \Rightarrow$ Probability function.

11. By the graph since Ψ^2 is not zero at $r = 0$ it must be s orbital
 also $n - \ell - 1 = 1$
 $n = 2$ ($\because \ell = 0$)
 it is 2s orbital
12. $\Psi^2(r)$ is probability density of an electron and it is maximum at a & c.
13. Energies of the orbitals in the same subshell decrease with increase in the atomic number
 $E_{2s}(\text{H}) > E_{2s}(\text{Li}) > E_{2s}(\text{Na}) > E_{2s}(\text{K})$