

Topic : Atomic Structure

Type of Questions

M.M., Min.

Single choice Objective ('-1' negative marking) Q.1 to Q.4

(3 marks, 3 min.)

[12, 12]

Comprehension ('-1' negative marking) Q.5 to Q.9

(3 marks, 3 min.)

[15, 15]

Subjective Questions ('-1' negative marking) Q.10 to Q.11

(4 marks, 5 min.)

[8, 10]

1. The orbital angular momentum corresponding to $n = 4$ and $m = -3$ is :

- (A) 0 (B) $\frac{h}{\sqrt{2\pi}}$ (C) $\frac{\sqrt{6}h}{2\pi}$ (D) $\frac{\sqrt{3}h}{\pi}$

2. Spin magnetic moment of X^{n+} ($Z = 26$) is $\sqrt{24}$ B.M. Hence number of unpaired electrons and value of n respectively are :

- (A) 4, 2 (B) 2, 4 (C) 3, 1 (D) 0, 2

3. Spin magnetic moments of V ($Z = 23$), Cr ($Z = 24$), Mn ($Z = 25$) are x , y , z respectively. Hence :

- (A) $x = y = z$ (B) $x < y < z$ (C) $x < z < y$ (D) $z < y < x$

4. Which of the following sets of quantum numbers can be correct for an electron in 4f-orbital :

- (A) $n = 3, \ell = 2, m = -2, s = +\frac{1}{2}$ (B) $n = 4, \ell = 4, m = -4, s = -\frac{1}{2}$
 (C) $n = 4, \ell = 3, m = +1, s = +\frac{1}{2}$ (D) $n = 4, \ell = 3, m = +4, s = +\frac{1}{2}$

Comprehension # (Q.5 to Q.9)

Azimuthal quantum number (ℓ) : It describes the shape of electron cloud and the number of subshells in a shell.

* It can have values from 0 to $(n - 1)$ * value of ℓ subshell

0	s
1	p
2	d
3	f

* Number of orbitals in a subshell = $2\ell + 1$

* Orbital angular momentum $L = \frac{h}{2\pi} \sqrt{\ell(\ell+1)} = \hbar \sqrt{\ell(\ell+1)}$ $\left[\hbar = \frac{h}{2\pi} \right]$

Magnetic quantum number (m) : It describes the orientations of the subshells. It can have values from $-l$ to $+l$ including zero, i.e., total $(2l + 1)$ values. Each value corresponds to an orbital. s-subshell has one orbital,

p-subshell three orbitals (p_x , p_y and p_z), d-subshell five orbitals (d_{xy} , d_{yz} , d_{zx} , $d_{x^2-y^2}$, d_{z^2}) and f-subshell has seven orbitals.

Spin quantum number (s) : It describes the spin of the electron. It has values $+1/2$ and $-1/2$ signifying clockwise spinning and anticlockwise rotation of electron about its own axis.

Spin of the electron produces angular momentum equal to $S = \sqrt{s(s+1)} \frac{h}{2\pi}$ where $s = +\frac{1}{2}$.

Total spin of an atom = $+\frac{n}{2}$ or $-\frac{n}{2}$

where n is the number of unpaired electron.

The magnetic moment of an atom, $\mu_s = \sqrt{n(n+2)} \text{ B.M.}$

n – number of unpaired electrons, B.M. (Bohr magneton)

5. A d-block element has total spin value of $+3$ or -3 . Then, the spin only magnetic moment of the element is approximately :
 (A) 2.83 B.M. (B) 3.87 B.M. (C) 5.9 B.M. (D) 6.93 B.M.
6. Spin only magnetic moment of ${}_{25}\text{Mn}^{x+}$ ion is $\sqrt{15} \text{ B.M.}$. Then, the value of x is :
 (A) 1 (B) 2 (C) 3 (D) 4
7. Spin only magnetic moment of ${}_{26}\text{Fe}^{2+}$ ion is same as :
 (A) ${}_{26}\text{Fe}$ (B) ${}_{24}\text{Cr}^{2+}$ (C) ${}_{28}\text{Ni}^{4+}$ (D) All of these
8. Orbital angular momentum of an electron is $\sqrt{3} \frac{h}{\pi}$. Then, the number of orientations of this orbital in space are :
 (A) 3 (B) 5 (C) 7 (D) 9
9. The correct order of the magnetic moment of $[{}_{25}\text{Mn}^{4+}, {}_{24}\text{Cr}^{3+}, {}_{26}\text{Fe}^{3+}]$ is :
 (A) $\text{Fe}^{3+} > \text{Cr}^{3+} = \text{Mn}^{4+}$ (B) $\text{Fe}^{3+} > \text{Cr}^{3+} > \text{Mn}^{4+}$
 (C) $\text{Cr}^{3+} = \text{Mn}^{4+} > \text{Fe}^{3+}$ (D) $\text{Fe}^{3+} > \text{Mn}^{4+} > \text{Cr}^{3+}$
10. What is the maximum possible number of electrons in an atom with $(n + \ell = 7)$?
11. Predict total spin for each configuration :
 (a) $1s^2$ (b) $1s^2 2s^2 2p^6$ (c) $1s^2 2s^2 2p^5$
 (d) $1s^2 2s^2 2p^3$ (e) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^2$.

Answer Key

DPP No. # 20

1. (D) 2. (A) 3. (C) 4. (C) 5. (D)
6. (D) 7. (D) 8. (C) 9. (A) 10. 32
11. (a) $0 \times (\pm 1/2) = 0$ (b) $0 \times (\pm 1/2) = 0$ (c) $1 \times (\pm 1/2) = \pm 1/2$ (d) $3 \times (\pm 1/2) = \pm 3/2$ (e) $5 \times (\pm 1/2) = \pm 5/2$.

Hints & Solutions

DPP No. # 20

1. $n = 4, m = -3$ $\therefore$ only possible value of ℓ is 3.

$$\therefore \text{Orbital angular momentum} = \sqrt{\ell(\ell+1)} \frac{h}{2\pi} = \frac{2\sqrt{3}h}{2\pi} = \frac{\sqrt{3}h}{\pi}.$$

2. $Z = 26 \rightarrow [\text{Ar}]4s^2 3d^6$

$$\sqrt{n(n+2)} = \sqrt{24} \quad \Rightarrow \quad n = 4$$

In d orbital number of unpaired electron = 4, but element have charge so 4s electron have to be removed hence $n+ = 2$.

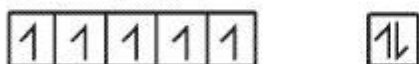
3. V ($Z = 23$), $[\text{Ar}] 4s^2 3d^3$ unpaired electron = 3 ;
 Cr ($Z = 24$), $[\text{Ar}] 4s^1 3d^5$ unpaired electron = 6
 Mn ($Z = 25$), $[\text{Ar}] 4s^2 3d^5$ unpaired electron = 5

4. For $n = 4$, $\ell \neq 4$, for $\ell = 3$, $m \neq 4$

5. Total spin = 3 $\Rightarrow \frac{n}{2} = 3 \Rightarrow n = 6$

i.e. magnetic moment = $\sqrt{n(n+2)} = \sqrt{6(6+2)} = \sqrt{48}$ B.M.

6. $25^{\text{Mn}} - [\text{Ar}] 3d^5 4s^2$



Given $\sqrt{n(n+2)} = \sqrt{15} \Rightarrow n = 3$

Hence to have '3' unpaired electrons Mn must be in '+4' state.

7. Magnetic moment = $\sqrt{n(n+2)}$

8. Orbital angular momentum of electron

$$= \sqrt{\ell(\ell+1)} \frac{h}{2\pi} \Rightarrow \sqrt{\ell(\ell+1)} \frac{h}{2\pi} = \sqrt{3} \frac{h}{\pi} \Rightarrow \ell = 3$$

$$\therefore \text{number of orientations} = 2\ell + 1 = 2 \times 3 + 1 = 7$$

9. Configuration of the following elements

$\text{Cr}^{3+} - [\text{Ar}] 3d^3$	clearly
$\text{Mn}^{4+} - [\text{Ar}] 3d^3$	Fe^{3+} has 5 unpaired electrons and
$\text{Fe}^{3+} - [\text{Ar}] 3d^5$	Cr^{3+} , Mn^{4+} has 3 unpaired electrons

10. Maximum possible number of electrons in an atom with $(n + \ell = 7) = 7s (2) + 6p (6) + 5d (10) + 4f (14) = 32$

11. total spin = $\pm 1/2 \times \text{No. of Unpaired } e^-$