PHYSICAL CHEMISTRY

DPP

DAILY PRACTICE PROBLEMS

DPP No. 20

Total Marks : 35

Max. Time : 37 min.

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, ℓ = 2, m = –2, s = $+\frac{1}{2}$ (B) n = 4, ℓ = 4, m = –4, s = $-\frac{1}{2}$

(C) n = 4, ℓ = 3, m = +1, s = $+\frac{1}{2}$ (D) n = 4, ℓ = 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 $S = \sqrt{s(s+1)}\dfrac{h}{2\pi}$ where $s = +\dfrac{1}{2}$.

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

where n is the number of unpaired electron.

The magnetic moment of an atom, $\mu_s = \sqrt{n(n+2)}$ 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 $_{25}Mn^{x+}$ ion is $\sqrt{15}$ B.M. Then, the value of x is :

(A) 1 (B) 2 (C) 3 (D) 4

7. Spin only magnetic moment of $_{26}Fe^{2+}$ ion is same as :

(A) $_{26}Fe$ (B) $_{24}Cr^{2+}$ (C) $_{28}Ni^{4+}$ (D) All of these

8. Orbital angular momentum of an electron is $\sqrt{3}\dfrac{h}{\pi}$. 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 $[_{25}Mn^{4+}, _{24}Cr^{3+}, _{26}Fe^{3+}]$ is :

(A) $Fe^{3+} > Cr^{3+} = Mn^{4+}$ (B) $Fe^{3+} > Cr^{3+} > Mn^{4+}$

(C) $Cr^{3+} = Mn^{4+} > Fe^{3+}$ (D) $Fe^{3+} > Mn^{4+} > Cr^{3+}$

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

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1.	(D)	**2.**	(A)	**3.**	(C)	**4.**	(C)	**5.**	(D)
6.	(D)	**7.**	(D)	**8.**	(C)	**9.**	(A)	**10.**	32

11. (a) 0 × (± 1/2) = 0 (b) 0 × (± 1/2) = 0 (c) 1 × (± 1/2) = ± 1/2 (d) 3 × (± 1/2) = ± 3/2 (e) 5 × (± 1/2) = ± 5/2.

Hints & Solutions

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1. n = 4, m = – 3 ∴ only possible value of ℓ is 3.

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

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

$\sqrt{n(n+2)} = \sqrt{24}$ ⇒ 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), [Ar] $4s^2 3d^3$ unpaired electron = 3 ;
Cr (Z = 24), [Ar] $4s^1 3d^5$ unpaired electron = 6
Mn (Z = 25), [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 $\Rightarrow \frac{n}{2} = 3 \quad \Rightarrow n = 6$

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

6. 25^{Mn} – [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

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

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

9. Configuration of the following elements
Cr^{3+} – [Ar] $3d^3$
Mn^{4+} – [Ar] $3d^3$
Fe^{3+} – [Ar] $3d^5$
clearly
Fe^{3+} has 5 unpaired electrons and
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 = **± 1/2** × No. of Unpaired e^-