Exercise-1

Marked questions are recommended for Revision.

PART - I : OBJECTIVE QUESTIONS

1. What possibly can be the ratio of the de Broglie wavelengths for two electrons each having zero initial energy and accelerated through 50 volts and 200 volts ?
(A) 3 : 10 (B) 10 : 3 (C) 1 : 2 (D) 2 : 1

2. The speed of a proton is one hundredth of the speed of light in vacuum. What is its de-Broglie wavelength? Assume that one mole of protons has a mass equal to one gram [h = 6.626×10^{-27} erg sec] :
(A) 13.31×10^{-7} Å (B) 1.33×10^{-3} Å
(C) 13.13×10^{-5} Å (D) 1.31×10^{-2} Å

3. An α-particle is accelerated through a potential difference of V volts from rest. The de-Broglie's wavelength associated with it is
(A) $\sqrt{\frac{150}{V}}$ Å (B) $\frac{0.286}{\sqrt{V}}$ Å (C) $\frac{0.101}{\sqrt{V}}$ Å (D) $\frac{0.983}{\sqrt{V}}$ Å

4. The uncertainity in position and velocity of a particle are 10^{-10} m and 5.27×10^{-24} ms^{-1} respectively. Calculate the mass of the particle (h = 6.625×10^{-34} Joule sec.)
(A) 0.099 Kg (B) 0.089 Kg (C) 0.99 Kg (D) Can not predict

5. The de Broglie equation suggests that an electron has
(A) Particle nature (B) Wave nature
(C) Particle-wave nature (D) Radiation behaviour

6. It the uncertainity in position of a moving particle is 0 then find out ΔP
(A) 0 (B) 1 (C) ∞ (D) Can not predict

7. Which of the following has least de Broglie λ
(A) e^- (B) p (C) CO_2 (D) SO_2

8. The orbital with zero orbital angular momentum is :
(A) s (B) p (C) d (D) f

9. Which of the following is electronic configuration of Cu^{2+} (Z = 29) ?
(A) $[Ar]4s^1 3d^8$ (B) $[Ar]4s^2 3d^{10} 4p^1$
(C) $[Ar]4s^1 3d^{10}$ (D) $[Ar] 3d^9$

10. 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

11. Which of the following ions has the maximum number of unpaired d-electrons?
(A) Zn^{2+} (B) Fe^{2+} (C) Ni^{3+} (D) Cu^+

12. The total spin resulting from a d^7 configuration is :
(A) 1 (B) 2 (C) 5/2 (D) 3/2

13. Given is the electronic configuration of element X :

K	L	M	N
2	8	11	2

The number of electrons present with ℓ = 2 in an atom of element X is :
(A) 3 (B) 6 (C) 5 (D) 4

14. The possible value of ℓ and m for the last electron in the Cl^{-} ion are :
(A) 1 and 2 (B) 2 and +1 (C) 3 and –1 (D) 1 and –1

15.✍ For an electron, with n = 3 has only one radial node. The orbital angular momentum of the electron will be
(A) 0 (B) $\sqrt{6}\ \frac{h}{2\pi}$ (C) $\sqrt{2}\ \frac{h}{2\pi}$ (D) 3

16. The correct set of quantum no. for the unpaired electron of chlorine.

	n	ℓ	m		n	ℓ	m
(A)	2	1	0	(B)	2	1	1
(C)	3	1	1	(D)	3	0	0

17. Which of the following quantum number has not been derived from Schrodinger wave equation :
(A) Principal quantum number (n)
(B) Subsidiary quantum number (ℓ)
(C) Magnetic quantum number (m)
(D) Spin quantum number (s)

18. 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) $\frac{\sqrt{3}h}{\pi}$

19.* The correct representation of electronic configuration of Nitrogen atom is :

	1s	2s	2p
(A)	↑↓	↑↓	↑ ↑ ↑
(B)	↑↓	↑↓	↓ ↓ ↓
(C)	↑↓	↑↓	↑ ↓ ↓
(D)	↑↓	↑↓	↓ ↑ ↑

20.* Which of the following statements is/are INCORRECT :
(A) The value of magnetic quantum number (m) cannot exceed the value of principal quantum number (n) for the same electron.
(B) If the electronic configuration of $_6C$ is written as $1s^6$, then Aufbau's principle has been violated.
(C) The $+\frac{1}{2}$ and $-\frac{1}{2}$ values of spin quantum number denote clockwise and anticlockwise spin of electrons on its axis respectively.
(D) The maximum number of electrons in a particular subshell, for which value of azimuthal quantum number is ℓ, is given by ($4\ell+2$).

PART - II : SUBJECTIVE QUESTIONS

1. How many unpaired electrons are there in Ni^{+2} ion if the atomic number of Ni is 28.

2. Write the electronic configuration of the element having atomic number 56.

3. Given below are the sets of quantum numbers for given orbitals. Name these orbitals.
(a) n = 3, ℓ = 1 (b) n = 5, ℓ = 2 (c) n = 4, ℓ = 1
(d) n = 2, ℓ = 0 (e) n = 4, ℓ = 2

4.✍ Point out the angular momentum of an electron in,
(a) 4s orbital
(b) 3p orbital
(c) 4^{th} orbit (according to Bohr model)

5.✍ Which of the following sets of quantum numbers are impossible for electrons? Explain why in each case.

Set	n	ℓ	m	s
(i)	1	0	1	$+\frac{1}{2}$
(ii)	3	0	0	$-\frac{1}{2}$
(iii)	1	2	2	$+\frac{1}{2}$
(iv)	4	3	–3	$+\frac{1}{2}$
(v)	5	2	1	$-\frac{1}{2}$
(v)	3	2	1	0

6.✍ Find the total spin and spin magnetic moment of following ion.
(i) Fe^{+3} (ii) Cu^{+}

Exercise-2

✍ **Marked Questions may have for Revision Questions.**

OBJECTIVE QUESTIONS

1.✍ The Uncertainity in the momentum of an electron is 1.0×10^{-5} kg m s^{-1}. The Uncertainity in its position will be: (h = 6.626×10^{-34} Js)
(A) 1.05×10^{-28} m (B) 1.05×10^{-26} m (C) 5.27×10^{-30} m (D) 5.25×10^{-28} m

2. A ball weight 25 g moves with a velocity of 6.6×10^{4} cm/sec then find out the de Broglie wavelength.
(A) 0.4×10^{-33} cm (B) 0.4×10^{-31} cm (C) 0.4×10^{-30} cm (D) 0.4×10^{20} cm

3. Calculate the uncertainity in velocity of a cricket ball of mass 150 g if the uncertainity in its position is of the order of 1 Å (h = 6.6×10^{-34} Kg m^{2} s^{-1})
(A) 3.499×10^{-24} ms^{-1} (B) 3.499×10^{-21} ms^{-1} (C) 3.499×10^{-20} ms^{-1} (D) 3.499×10^{-30} ms^{-1}

4. Which orbital is non-directional.
(A) s (B) p (C) d (D) All

5. For which orbital angular probability distribution is maximum at an angle of 45° to the axial direction-
(A) $d_{x^2-y^2}$ (B) d_{z^2} (C) d_{xy} (D) P_x

6.✍ If n and ℓ are respectively the principal and azimuthal quantum numbers, then the expression for calculating the total number of electrons in any orbit is -
(A) $\sum_{\ell=1}^{\ell=n} 2(2\ell+1)$ (B) $\sum_{\ell=1}^{\ell=n-1} 2(2\ell+1)$ (C) $\sum_{\ell=0}^{\ell=n+1} 2(2\ell+1)$ (D) $\sum_{\ell=0}^{\ell=n-1} 2(2\ell+1)$

7.✍ The quantum numbers $+\frac{1}{2}$ and $-\frac{1}{2}$ for the electron spin represent :
(A) Rotation of the electron in clockwise and anticlockwise direction respectively.
(B) Rotation of the electron in anticlockwise and clockwise direction respectively.
(C) Magnetic moment of the electron pointing up and down respectively,
(D) Two quantum mechanical spin states which have no classical analogue.

8. What are the values of the orbital angular momentum of an electron in the orbitals 1s, 3s, 3d and 2p -

(A) 0, 0, $\sqrt{6}\,\hbar$, $\sqrt{2}\,\hbar$
(B) 1, 1, $\sqrt{4}\,\hbar$, $\sqrt{2}\,\hbar$
(C) 0, 1, $\sqrt{6}\,\hbar$, $\sqrt{3}\,\hbar$
(D) 0, 0, $\sqrt{20}\,\hbar$, $\sqrt{6}$

9. After np orbitals are filled, the next orbital filled will be :

(A) (n + 1) s
(B) (n + 2) p
(C) (n + 1) d
(D) (n + 2) s

10. Which of the above statement (s) is/are **false.**

I. Orbital angular momentum of the electron having n = 5 and having value of the azimuthal quantum number as lowest for this principle quantum number is $\frac{h}{\pi}$.

II. If n = 3, ℓ = 0, m = 0, for the last valence shell electron, then the possible atomic number may be 12 or 13.

III. Total spin of electrons for the atom $_{25}Mn$ is $\pm\frac{7}{2}$.

IV. Spin magnetic moment of inert gas is 0

(A) I, II and III
(B) II and III only
(C) I and IV only
(D) None of these

11. In case of $d_{x^2-y^2}$ orbital

(A) Probability of finding the electron along x-axis is zero.
(B) Probability of finding the electron along y-axis is zero.
(C) Probability of finding the electron is maximum along x and y-axis.
(D) Probability of finding the electron is zero in x-y plane

12. Which of the following statements is/are correct for an electron of quantum numbers n = 4 and m = 2 ?

(A) The value of ℓ may be 2.
(B) The value of ℓ may be 3.
(C) The value of s may be +1/2.
(D) All of these

13. Which of the following statement(s) is (are) correct?

(A) The electronic configuration of Cr is [Ar] $(3d)^5(4s)^1$. (Atomic number of Cr = 24)
(B) The magnetic quantum number may have negative values.
(C) In silver atom, 23 electrons have a spin of one type and 24 of the opposite type. (Atomic number of Ag = 47)
(D) All of these

14. Two unpaired electrons present in carbon atom are different with respect to their

(A) Principle quantum number
(B) Azimuthul quantum number
(C) Magnetic quantum number
(D) Spin quantum number

15. Number of electron having the quantum numbers n = 4, ℓ = 0, $s = -\frac{1}{2}$ in Zn^{+2} ion is/are :

(A) 1
(B) 0
(C) 2
(D) 5

16. Spin angular momentum for unpaired electron in sodium (Atomic No. = 11) is

(A) $\frac{\sqrt{3}}{2}$
(B) 0.866 $h/2\pi$
(C) $-\frac{\sqrt{3}}{2}\frac{h}{2\pi}$
(D) None of these

17. **Statement-1 :** For n = 3, ℓ may be 0, 1 and 2 and 'm' may be 0, ± 1 and ± 2.
Statement-2 : For each value of n, there are 0 to (n – 1) possible values of ℓ; for each value of ℓ, there are 0 to $\pm\ell$ values of m.

(1) Statement-1 is true, statement-2 is true; Statement-2 is a correct explanation for statement-1.
(2) Statement-1 is true, statement-2 is true; Statement-2 is NOT a correct explanation for statement-1.
(3) Statement-1 is true, statement-2 is false.
(4) Statement-1 is false, statement-2 is true.

18. **Statement-1 :** The possible number of electrons in a subshell is $(4\ell + 2)$
Statement-2 : The possible number of orientations of a sub-shell are $(2\ell + 1)$
(1) Statement-1 is true, statement-2 is true; Statement-2 is a correct explanation for statement-1.
(2) Statement-1 is true, statement-2 is true; Statement-2 is NOT a correct explanation for statement-1.
(3) Statement-1 is true, statement-2 is false.
(4) Statement-1 is false, statement-2 is true.

Exercise-3

*** Marked Questions may have more than one correct option.**

PART - I : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

1. The orbital angular momentum of an electron in 2s-orbital is : **[JEE 1996]**
(1) $+\frac{1}{2}\frac{h}{2\pi}$ (2) zero (3) $\frac{h}{2\pi}$ (4) $\sqrt{2}\frac{h}{2\pi}$

2. A compound of Vanadium has a magnetic moment of 1.73 BM. Work out the electronic configuration of the Vandium ion in the compound. **[JEE 1997]**

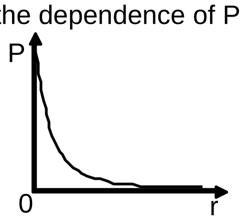
3. Find the orbital angular momentum of electron if it is in 2p orbital of H in terms of $\frac{h}{2\pi}$.
[JEE 2005, 4/144]

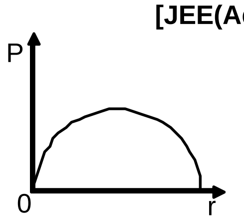
4. The maximum number of electrons that can have principal quantum number, n = 3, and spin quantum number, $m_s = -1/2$, is **[JEE 2011, 4/180]**

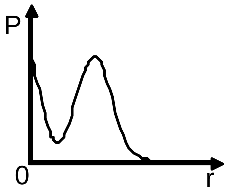
5. In an atom, the total number of electrons having quantum numbers n = 4, $|m_\ell| = 1$ and $m_s = -1/2$ is **[JEE(ADVANCED)-2014, 3/120]**

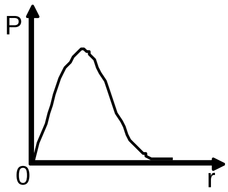
6. Not considering the electronic spin, the degeneracy of the second excited state (n = 3) of H atom is 9, while the degeneracy of the second excited state of H^- is : **[JEE(ADVANCED)-2015, 4/168]**

7. P is the probability of finding the 1s electron of hydrogen atom in a spherical shell of infinitesimal thickness, dr, at a distance r from the nucleus. The volume of this shell is $4\pi r^2 dr$. The qualitative sketch of the dependence of P on r is: **[JEE(Advanced) 2016, 3/124]**

(A)


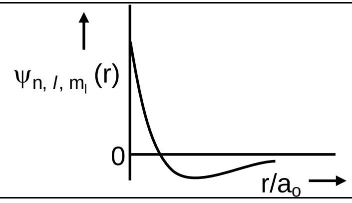
(B)


(C)


(D)


Answer Q.8, Q.9 and Q.10 by appropriately matching the information given in the three columns of the following table.

The wave function, ψ_{n,l,m_l} is a mathematical function whose value depends upon spherical polar coordinates (r, θ, ϕ) of the electron and characterized by the quantum numbers *n*, *l* and m_l. Here r is distance from nucleus, θ is colatitude and ϕ is azimuth. In the mathematical functions given in the Table, Z is atomic number and a_o is Bohr radius.

Column 1	Column 2	Column 3
(I) 1s orbital	(i) $\psi_{n,l,m_l} \propto \left(\frac{Z}{a_o}\right)^{\frac{3}{2}} e^{-\left(\frac{Zr}{a_o}\right)}$	(P) 
(II) 2s orbital	(ii) One radial node	(Q) Probability density at nucleus $\propto \frac{1}{a_o^3}$
(III) $2p_z$ orbital	(iii) $\psi_{n,l,m_l} \propto \left(\frac{Z}{a_o}\right)^{\frac{5}{2}} re^{-\left(\frac{Zr}{2a_o}\right)} \cos\theta$	(R) Probability density is maximum at nucleus
(IV) $3d_{z^2}$ orbital	(iv) xy-plane is a nodal plane	(S) Energy needed to excite electron from n = 2 state to n = 4 state is $\frac{27}{32}$ times the energy needed to excite electron from n = 2 state to n = 6 state

8. For He^+ ion, the only **INCORRECT** combination is **[JEE(Advanced) 2017, 3/122]**
(A) (I) (i) (S) (B) (II) (ii) (Q) (C) (I) (iii) (R) (D) (I) (i) (R)

9. For the given orbital in Column 1, the only **CORRECT** combination for any hydrogen-like species is **[JEE(Advanced) 2017, 3/122]**
(A) (II) (ii) (P) (B) (I) (ii) (S) (C) (IV) (iv) (R) (D) (III) (iii) (P)

10. For hydrogen atom, the only **CORRECT** combination is **[JEE(Advanced) 2017, 3/122]**
(A) (I) (i) (P) (B) (I) (iv) (R) (C) (II) (i) (Q) (D) (I) (i) (S)

PART - II : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

JEE(MAIN) OFFLINE PROBLEMS

1. Which of the following ions has the maximum magnetic moment? **[AIEEE 2002, 3/225]**
(1) Mn^{+2} (2) Fe^{+2} (3) Ti^{+2} (4) Cr^{+2}.

2. Uncertainity in position of a particle of 25 g in space is 10^{-15} m. Hence, Uncertainity in velocity (in m.sec^{-1}) is: (plank's constant, h = 6.6 × 10^{-34} Js) **[AIEEE 2002, 3/225]**
(1) 2.1 × 10^{-18} (2) 2.1 × 10^{-34} (3) 0.5 × 10^{-34} (4) 5.0 × 10^{-24}

3. The de-Broglie wavelength of a tennis ball of mass 60 g moving with a velocity of 10 m/s is approximately (planck's constant, h = 6.63 × 10^{-34} J-s) **[AIEEE 2003, 3/225]**
(1) 10^{-33} m (2) 10^{-31} m (3) 10^{-16} m (4) 10^{-25} m

4. The numbers of d-electrons retained in Fe^{2+} (atomic number Fe = 26) ion is **[AIEEE 2003, 3/225]**
(1) 3 (2) 4 (3) 5 (4) 6

5. The orbital angular momentum for an electron revolving in an orbit is given by $\sqrt{\ell(\ell+1)}\,\frac{h}{2\pi}$. This momentum for an s-electron will be given by **[AIEEE 2003, 3/225]**

(1) $+\frac{1}{2}.\frac{h}{2\pi}$ (2) Zero (3) $\frac{h}{2\pi}$ (4) $\sqrt{2}.\frac{h}{2\pi}$

6. Which of the following set a of quantum numbers is correct for an electron in 4f orbital? **[AIEEE 2004, 3/225]**

(1) n = 4, l =3, m = +4, s = +1/2 (2) n = 4, l = 4, m = –4, s = –1/2
(3) n = 4, l = 3, m = +1, s = +1/2 (4) n = 3, l=2, m =–2, s = +1/2

7. Consider the ground state of Cr atom (Z = 24). The numbers of electrons with the azimuthal quantum numbers, □ = 1 and 2 are, respectively **[AIEEE 2004, 3/225]**

(1) 12 and 4 (2) 12 and 5 (3) 16 and 4 (4) 16 and 5

8. In a multi-electron atom, which of the following orbitals described by the three quantum numbers will have the same energy in the absence of magnetic and electric field ? **[AIEEE 2005, 3/225]**

(i) n = 1, l = 0, m = 0 (ii) n =2, l = 0, m = 0 (iii) n = 2, l = 1, m = 1
(iv) n = 3, l = 2, m =1 (v) n = 3, l = 2, m = 0
(1) (iv) and (v) (2) (iii) and (iv) (3) (ii) and (iii) (4) (i) and (ii)

9. Which of the following statements in relation to the hydrogen atom is correct ? **[AIEEE 2005, 4½/225]**

(1) 3s, 3p and 3d orbitals all have the same energy
(2) 3s and 3p orbitals are of lower energy than 3d orbital
(3) 3p orbital is lower in energy than 3d orbital
(4) 3s orbital is lower in energy than 3p orbital

10. Uncertainity in the position of an electron (mass = 9.1×10^{-31} Kg) moving with a velocity 300 m.sec^{-1}, Accurate upto 0.001%, will be : (h = 6.63×10^{-34} J-s) **[AIEEE 2006, 3/165]**

(1) 19.2×10^{-2} m (2) 5.76×10^{-2} m (3) 1.92×10^{-2} m (4) 3.84×10^{-2} m

11. The 'spin-only' magnetic moment [in units of Bohr magneton (μ_β)] of Ni^{2+} in aqueous solution would be (Atomic number : Ni = 28) **[AIEEE 2006, 3/165]**

(1) 2.84 (2) 4.90 (3) 0 (4) 1.73

12. Which of the following set of quantum numbers represents the highest energy of an atom ? **[AIEEE 2008, 3/105]**

(1) n = 3, l = 0, m = 0, s = $+\frac{1}{2}$ (2) n = 3, l = 1, m =1, s = $+\frac{1}{2}$
(3) n = 3, l = 2, m = 1, s = $+\frac{1}{2}$ (4) n = 4, l = 0, m = 0, s = $+\frac{1}{2}$

13. Calculate the wavelength (in nanometer) associated with a proton moving at 1.0×10^3 m s^{-1} (Mass of proton = 1.67×10^{-27} kg and h = 6.63×10^{-34} J-s) : **[AIEEE 2009, 4/144]**

(1) 0.40 nm (2) 2.5 nm (3) 14.0 nm (4) 0.032 nm

14. In an atom, an electron is moving with a speed of 600 m/s with an accuracy of 0.005%. Certainity with which the position of the electron can be located is (h = 6.6×10^{-34} kg m^2 s^{-1}, mass of electron, e_m = 9.1×10^{-31} kg): **[AIEEE 2009, 4/144]**

(1) 5.10×10^{-3} m (2) 1.92×10^{-3} m
(3) 3.83×10^{-3} m (4) 1.52×10^{-4} m

15. The electrons identified by quantum numbers n and □ : **[AIEEE 2012, 4/120]**

(a) n = 4, □ = 1 (b) n = 4, □ = 0 (c) n = 3, □ = 2 (d) n = 3, □ = 1
can be placed in order of increasing energy as :
(1) (c) < (d) < (b) < (a) (2) (d) < (b) < (c) < (a)
(3) (b) < (d) < (a) < (c) (4) (a) < (c) < (b) < (d)

16. The correct set of four quantum numbers for the valence electrons of rubidium atom (Z = 37) is : **[JEE(Main)2014, 4/120]**

(1) 5, 0, 0, $+\frac{1}{2}$ (2) 5, 1, 0, $+\frac{1}{2}$ (3) 5, 1, 1, $+\frac{1}{2}$ (4) 5, 0, 1, $+\frac{1}{2}$

17. A stream of electrons from a heated filament was passed between two charged plates kept at a potential difference V esu. If e and m are charge and mass of an electron, respectively, then the value of $\frac{h}{\lambda}$ (where λ is wavelength associated with electron wave) is given by: **[JEE(Main) 2016, 4/120]**

(1) 2meV (2) $\sqrt{meV}$ (3) $\sqrt{2meV}$ (4) meV

18. The radius of the second Bohr orbit for hydrogen atom is :
(Planck's Const. h = 6.6262 × 10^{-34} Js; mass of electron = 9.1091 × 10^{-31} kg; charge of electron e = 1.60210 × 10^{-19} C; permittivity of vacuum $\in_0$ = 8.854185 × 10^{-12} $kg^{-1}m^{-3}A^2$) **[JEE(Main) 2017, 4/120]**
(1) 4.76 Å (2) 0.529 Å (3) 2.12 Å (4) 1.65 Å

JEE(MAIN) ONLINE PROBLEMS

1. The de-Broglie wavelength of a particle of mass 6.63 g moving with a velocity of 100 ms^{-1} is : **[JEE(Main) 2014 Online (12-04-14), 4/120]**
(1) 10^{-33} m (2) 10^{-35} m (3) 10^{-31} m (4) 10^{-25} m

2. If the principal quantum number n = 6, the correct sequence of filling of electrons will be : **[JEE(Main) 2015 Online (10-04-15), 4/120]**

(1) ns→np→(n – 1)d→(n – 2)f (2) ns→(n – 1)d→(n – 2)f→np
(3) ns→(n – 2)f→np→(n – 1)d (4) ns→(n – 2)f→(n – 1)d→np

3. At temperatuere T, the average kinetic energy of any particle is $\frac{3}{2}$KT. The de Broglie wavelength follows the order : **[JEE(Main) 2015 Online (11-04-15), 4/120]**
(1) Visible photon > Thermal neutron > Thermal electron
(2) Thermal proton > Thermal electon > Visible photon
(3) Thermal proton > Visible photon > Thermal electron
(4) Visible photon > Thermal electron > Thermal neutron

4. The total number of orbitals associated with the principal quantum number 5 is: **[JEE(Main) 2016 Online (09-04-16), 4/120]**
(1) 5 (2) 20 (3) 25 (4) 10

5. Aqueous solution of which salt will not contain ions with the electronic configuration $1s^22s^22p^63s^23p^6$? **[JEE(Main) 2016 Online (10-04-16), 4/120]**
(1) NaCl (2) CaI_2 (3) NaF (4) KBr

6. The de-Broglie's wavelength of electron present in first Bohr orbit of 'H' atom is : **[JEE(Main) 2018 Online (15-04-18), 4/120]**

(1) 0.529 Å (2) 2π × 0.529 Å (3) $\frac{0.529}{2\pi}$ Å (4) 4 × 0.529 Å

7. Which of the following combination of statements is true regarding the interpretation of the atomic orbitals? **[JEE(Main) 2019 Online (09-01-19), 4/120]**
(a) An electron in an orbital of high angular momentum stays away from the nucleus than an electron in the orbitals of lower angular momentum.
(b) For a given value of the principal quantum number, the size of the orbit is inversely proportional to the azimuthal quantum number.
(c) According to wave mechanics, the ground state angular momentum is equal to $\frac{h}{2\pi}$.
(d) The plot of Ψ Vs r for various azimuthal quantum numbers, show peak shifting towards higher value.
(1) (b), (c) (2) (a), (c) (3) (a), (d) (4) (a), (b)

8. If the de Broglie wavelength of the electron in n^{th} Bohr orbit in a hydrogenic atom is equal to $1.5\ \pi a_0$ (a_0 is Bohr radius), then the value of n/z is: **[JEE(Main) 2019 Online (12-01-19), 4/120]**
(1) 0.75 (2) 0.40 (3) 1.0 (4) 1. 50

Answers

EXERCISE - 1

PART - I

1.	(D)	**2.**	(B)	**3.**	(C)
4.	(A)	**5.**	(C)	**6.**	(C)
7.	(D)	**8.**	(A)	**9.**	(D)
10.	(A)	**11.**	(B)	**12.**	(D)
13.	(A)	**14.**	(D)	**15.**	(C)
16.	(C)	**17.**	(D)	**18.**	(D)
19.*	(AB)	**20.***	(BC)		

PART - II

1. 2

2. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^6\ 6s^2$

3. 3p, 5d, 4p, 2s, 4d

4. (a) 0, (b) $\frac{h}{\sqrt{2}\pi}$, (c) $\frac{2h}{\pi}$

5. Impossible sets of quantum numbers are (i), (iii), and (vi)

6. (i) + 5/2 or – 5/2, spin magnetic moment = $\sqrt{35}$ B.M. (ii) 0, 0

EXERCISE - 2

1.	(C)	**2.**	(A)	**3.**	(A)
4.	(A)	**5.**	(C)	**6.**	(D)
7.	(D)	**8.**	(A)	**9.**	(A)
10.	(A)	**11.**	(C)	**12.**	(D)
3.	(D)	**14.**	(C)	**15.**	(B)
16.	(B)	**17.**	(A)	**18.**	(A)

EXERCISE - 3

PART - I

1. (B)

2. No of unpaired e^-

V	$= 3d^3\ 4s^2$	3
V^+	$= 3d^3 4s^1$	4
V^{2+}	$= 3d^3 4s^0$	3
V^{3+}	$= 3d^2\ 4s^0$	2
V^{4+}	$= 3d^1\ 4s^0$	1

3. $\sqrt{2}\cdot\left(\frac{h}{2\pi}\right)$ **4.** 9 **5.** 6

6. 3 **7.** (D) **8.** (C)

9. (A) **10.** (D)

PART - II

JEE(MAIN) OFFLINE PROBLEMS

1.	(1)	**2.**	(1)	**3.**	(1)
4.	(4)	**5.**	(2)	**6.**	(3)
7.	(2)	**8.**	(1)	**9.**	(1)
10.	(3)	**11.**	(1)	**12.**	(3)
13.	(1)	**14.**	(2)	**15.**	(2)
16.	(1)	**17.**	(3)	**18.**	(3)

JEE(MAIN) ONLINE PROBLEMS

1.	(1)	**2.**	(4)	**3.**	(4)
4.	(3)	**5.**	(3)	**6.**	(2)

7. NTA answer was (3), but correct answer is (2).

8. (1)

HINTS & SOLUTIONS

EXERCISE - 1

PART – I

1. $\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{V_2}{V_1}} = \sqrt{\frac{200}{50}} = \frac{2}{1}$.

2. $\lambda = \frac{h}{mv} = 1.33 \times 10^{-3}$ Å

3. For an α particle, $\lambda = \frac{0.101}{\sqrt{V}}$Å.

4. $\Delta X .\Delta P \cong \frac{h}{4\pi}$

$m(\Delta X .\Delta V) = \frac{h}{4\pi} \Rightarrow m = 0.099$ Kg

5. An electron has particle and wave nature both.

6. $\Delta X .\Delta P \geq \frac{h}{4\pi}$

$\Delta X \rightarrow 0 \Rightarrow \Delta P \rightarrow \infty$

7. $\lambda = \frac{h}{mv} \Rightarrow \lambda \propto \frac{1}{m}$

8. Orbital angular momentum = $\sqrt{\ell(\ell+1)}\frac{h}{2\pi} = 0$.

$\therefore$ □ = 0 (s orbital).

9. Cu : $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$.

$\therefore$ Cu^{2+} : $1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$ or $[Ar]3d^9$.

10. Magnetic moment = $\sqrt{n(n+2)} = \sqrt{24}$ B.M.

$\therefore$ No. of unpaired electron = 4.

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.

11. Zn^{2+} : [Ar] $3d^{10}$ (0 unpaired electrons).

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

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

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

12. d^7 : 3 unpaired electrons.

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

13. X_{23} : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3\ 4s^2$.

No. of electron with □ = 2 are 3 ($3d^3$).

14. Cl_{17}^- : [Ne] $3s^2\ 3p^6$.

Last electron enters 3p orbital.

$\therefore$ □ = 1 and m = 1, 0, –1.

15. Number of radial nodes = n – □ – 1 = 1, n = 3.

$\therefore$ □ = 1.

Orbital angular momentum

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

16. Cl_{17} : [Ne] $3s^2\ 3p^5$.

Unpaired electron is in 3p orbital.

$\therefore$ n = 3, □ = 1, m = 1, 0, – 1.

17. Only Spin quantum number (s) is not derived from Schrodinger wave equation.

18. n = 4, m = – 3

$\therefore$ only possible value of □ is 3.

$\therefore$ Orbital angular momentum

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

19. Only (A) and (B) arrangements follow Hund's rule.

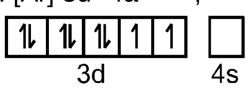
20. (B) If the electronic configuration of $_6C$ is written as $1s^6$, then Pauli exclusion principle has been violated.

(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

1. Ni Atomic No : 28

Ni : [Ar] $3d^8\ 4a^2$; Ni^{2+} [Ar] $3d^8\ 4s^0$



3d 4s

No. of unpairecd electron = 2

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

For 4s orbital, $\ell = 0$

$\therefore$ Angular momentum = $\sqrt{0\,(0+1)}\dfrac{h}{2\pi}$ = 0.

For 3p orbital, $\ell = 1$

$\therefore$ Angular momentum = $\sqrt{1\,(1+1)}\dfrac{h}{2\pi} = \dfrac{h}{\sqrt{2}\pi}$.

For 4[th] orbit, Angular momentum

$= \dfrac{nh}{2\pi} = \dfrac{4h}{2\pi} = \dfrac{2h}{\pi}$.

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) ${}_{26}Fe^{3+}$: $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^5$

It contains 5 unpaired electrons $\therefore$ n = 5

$\therefore$ Total spin = $\pm\dfrac{n}{2} = \pm\dfrac{5}{2}$

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

$= \sqrt{5(5+2)} = \sqrt{35}$ BM.

(ii) ${}_{29}Cu^{+}$: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}$
It contains 0 unpaired electron
$\therefore$ Total spin = 0.
$\therefore$ Spin magnetic Moment = 0.

EXERCISE - 2

1. $\Delta p.\Delta x = \dfrac{h}{4\pi}$

$\Rightarrow \Delta x = \dfrac{6.62\times10^{-34}}{4\times3.14\times1\times10^{-5}} = 5.27 \times 10^{-30}$ m.

2. $\lambda = \dfrac{h}{mv} = 0.4 \times 10^{-33}$ cm

3. $\Delta x\,.\,\Delta p \approx \dfrac{h}{4\pi} \Rightarrow \Delta v = 3.499 \times 10^{-24}\ ms^{-1}$

4. s orbital is spherical so non-directional.

5. The lobes of d_{xy} orbital are at an angle of 45º 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 comes from Schrodinger equation.
$s = +\dfrac{1}{2}$ and $-\dfrac{1}{2}$ have been assigned arbitrarily.

8. For 1s, 3s, 3d and 2p orbital, ℓ = 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 = 11or 12 (False).
III : Mn_{25} = [Ar] $3d^5\ 4s^2$.
$\therefore$ 5 unpaired electrons.
$\therefore$ Total spin = $\pm\dfrac{5}{2}$ (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 alligned 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 ℓ = 0 to (n – 1) but m = 2.
$\therefore$ ℓ = 2 or 3 only
Value of s may be +1/2 or – 1/2.

13. (A) $_{24}Cr$: $[Ar]3d^5 4s^1$
(B) m = –ℓ to +ℓ through zero.
(C) $_{47}Ag$: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^1 4d^{10}$.
Since only one unpaired electron is present.
∴ 23 electrons have spin of one type and 24 of the opposite type.

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. $\sqrt{s\,(s+1)}\,\dfrac{h}{2\pi} = \sqrt{\dfrac{1}{2}\left(\dfrac{1}{2}+1\right)}\,\dfrac{h}{2\pi}$

$= \dfrac{\sqrt{3}}{2}\,\dfrac{h}{2\pi} = 0.866\,\dfrac{h}{2\pi}$

17. For principle quantum number n
ℓ = 0 to (n – 1) and m = –ℓ to ℓ including zero.

18. Factual.

EXERCISE - 3

PART - I

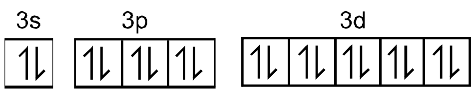
1. Orbital angular momentum = $\sqrt{\ell(\ell+1)}\,\dfrac{h}{2\pi} = 0$

(since ℓ = 0 for s orbital).

3. For 2p, ℓ = 1
∴ Orbital angular momentum

$= \sqrt{\ell\,(\ell+1)}\,\dfrac{h}{2\pi} = \sqrt{2}\,.\left(\dfrac{h}{2\pi}\right)$.

4.



So, electrons with spin quantum number = $-\dfrac{1}{2}$ will be 1 + 3 + 5 = 9.

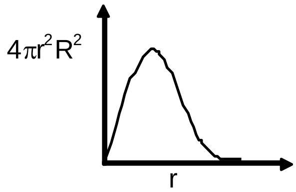
5. n = 4, m_ℓ = 1, –1
Hence ℓ can be = 3, 2, 1

i.e.	H_f	;	2 orbitals
	H_d	;	2 orbitals
	H_p	;	2 orbitals

Hence total of 6 orbitals, and we want $m_s = -\dfrac{1}{2}$, that is only one kind of spin. So, 6 electrons.

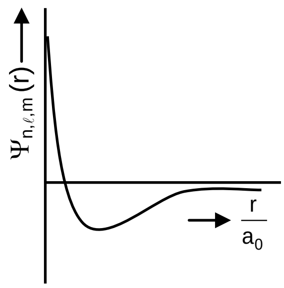
6. Energy order of orbitals of H is decided by only principle quantum number (n) while energy order of H^- is decided by (n + ℓ) rule:
Electronic configuration of 'H^-' is - $1s^2$ its Energy order is decided by n+ℓ rule.
$H^- = 1s^2 2s^0 2p^0$
Its 2nd excited state is 2p and degenery 2p is '3'.

7. For 1s electron in H-atom, plot of radial 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 θ.

9. For 2s orbital no. of radial nodes = n –ℓ– 1 = 1.



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

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

PART - II

JEE(MAIN) OFFLINE PROBLEMS

1. Mn^{2+} has the maximum number of unpaired electrons (5) andtherefore has maximum moment.

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

$\Delta v = \dfrac{6.6\times 10^{-34}}{4\times 3.14\times 25\times 10^{-5}}$

∴ $\Delta v = 2.1 \times 10^{-18}\ ms^{-1}$.

3. $\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-34} \times 1000}{60 \times 10}$

$= 11.05 \times 10^{-34} = 1.105 \times 10^{-33}$ metres.

4. $_{26}Fe = 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^6, 4s^2$

$Fe^{++} = 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^6$

The number of d -electrons retained in $Fe^{2+} = 6$.

Therefore, (4) is correct option.

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

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

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

□ = 3 (because $\begin{smallmatrix} s & p & d & f \\ 0 & 1 & 2 & 3 \end{smallmatrix}$)

m = + 3, + 2, + 1, 0, –1, –2, –3

s = + 1/2.

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

□ = 1, □ = 1, □ = 2

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

For □ = 1, total number of electrons = 12

For □ = 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 uncertainity principle

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

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

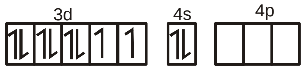
$\Rightarrow \Delta x = \frac{h}{4\pi m.\Delta v}$

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

$\therefore \quad \Delta x = \frac{6.63 \times 10^{-34}}{4 \times 3.14 \times 9.1 \times 10^{-31} \times 3 \times 10^{-3}}$

$= 1.29 \times 10^{-2}$m.

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



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 hegher energy.

n + l = 3 + 0 = 3

n + l = 3 + 1 = 4

n + l = 3 + 2 = 5 (highest energy)

n + l = 4 + 0 = 4

13. As $\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-34}}{1.67 \times 10^{-27} \times 1 \times 10^3}$

$= 3.97 \times 10^{-10}$ M

$= 0.397 \times 10^{-9}$ M = ~ 0.40 nm.

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

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

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

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

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

15. (a) 4 p (b) 4 s (c) 3 d (d) 3 p

Acc. to (n + □) rule, increasing order of energy

(d) < (b) < (c) < (a)

16. Z = 37.

Rb is in fifth period.

$[Kr]5s^1$ is its configuration.

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

17. K.E. = eV

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

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

18. $R = 0.529 \dfrac{n^2}{z}$ Å $= 0.529 \dfrac{2^2}{1}$ Å = 2.12 Å

JEE(MAIN) ONLINE PROBLEMS

2. Following Aufbau principle for filling electrons.

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

As temperature is same, KE is same.

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

Hence λ_{db} (electron) > λ_{db} (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. $2\pi r = n\lambda$ $\lambda = \dfrac{2\pi r}{n} = \dfrac{2\pi \times 0.529\text{Å}}{1}$

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

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

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

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

$2\pi a_0 \dfrac{n^2}{Z} = n1.5\pi\, a_0$

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