4.Quantum numbers
SOLUTIONS
TEACHING TASK

- **JEE MAIN LEVEL QUESTIONS**

1. Which of the following statements regarding the principal quantum number (n) is FALSE?
   a) It determines the size of the electron cloud.
   b) It specifies the energy level of an electron in an atom.
   c) It can have fractional values.
   d) It correlates with the period number in the periodic table.

Answer:C
Solution:n is always a positive integer (1, 2, 3, ...).
True statements:
a) Higher n = larger orbital size.
b) Energy increases with n.
d) Period number = highest n with electrons.

2. In an atom, if the principal quantum number (n) of an electron is increased:
   a) The energy of the electron decreases.
   b) The energy of the electron increases.
   c) The size of the electron cloud decreases.
   d) The probability of finding the electron closer to the nucleus increases.

Answer:B
Solution:Higher n = higher energy (less tightly bound).

3. Principal, azimuthal and magnetic quantum numbers are respectively related to :-
   A) size, orientation and shape B) size, shape and orientation
   C) shape, size and orientation D) none of these

Answer:B
Solution:Principal (n): Size/energy level.
Azimuthal (l): Orbital shape (s, p, d, f).
Magnetic (m): Spatial orientation.

4. Which of the following pairs of quantum numbers is NOT possible for an electron in an atom?
   a) n = 4, l = 2 b) n = 3, l = 3 c) n = 2, l = 1 d) n = 1, l = 2

Answer:B,D
Solution: l must be $0 \leq l \leq n-1$.
b) l=3 is invalid for n=3 (max l=2).
d) l=2 is invalid for n=1 (max l=0).

5. The possible set of quantum no. for the unpaired electron of chlorine is :

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

Answer:C
Solution:Chlorine (Z=17): $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$.

Unpaired electron is in 3p orbital:

n=3, l=1 (p-orbital), m=1 (one of the three p orientations)

6. Which of the following statements regarding the azimuthal quantum number is FALSE?
   a) It determines the shape of the orbital.
   b) It can have integer values ranging from 0 to n-1.
   c) It specifies the energy level of the electron.
   d) It correlates with the angular momentum of the electron.

Answer:C

Solution:Principal (n) determines energy level, not l.

6. If the principal quantum number n=5 and the azimuthal quantum number *l*=3, how many electrons can occupy the corresponding sublevel?
   a) 2 b) 6 c) 10 d) 14

Answer:D

Solution:l=3 $\rightarrow$ f-subshell (7 orbitals, 2 electrons each).

Total electrons = 7 × 2 = 14.

7. An electron in an atom is described by the quantum numbers n = 3 and l = 1. How many possible orientations of this orbital are there in space?
   a) 1 b) 3 c) 5 d) 7

Answer:B

Solution:l=1 $\rightarrow$ p-orbital with m = -1, 0, +1 (3 orientations).

8. 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) The value of l may be 0, 1, 2, 3

Answer:A,B,C

Solution:.m=2 requires l $\geq$2 (since |m| $\leq$ l).

Valid l values: 2, 3 (not 0 or 1).

Spin (s) is always ±½.

9. If the magnetic quantum number of an electron is -3, what is its angular momentum quantum number (*l*)?
   a) 0 b) 1 c) 2 d) 3

Answer:D

Solution:Rule: |m| $\leq$ l $\rightarrow$ l must be $\geq$ 3.

10. Which of the following sets of quantum numbers is NOT allowed for an electron in an atomic orbital?
    a) n = 2, l = 1, m_l = 0 b) n = 3, l = 1, m_l = 2
    c) n = 4, l = 2, m_l = -2 d) n = 1, l = 0, m_l = 1

Answer:B,D

Solution:b) |m|=2 > l=1.

d) m=1 is invalid for l=0 (s-orbital).

11. In a magnetic field, an electron with a magnetic quantum number ml = -2 will experience which of the following orientations?
    a) It aligns with the magnetic field.
    b) It aligns opposite to the magnetic field.
    c) It aligns perpendicular to the magnetic field.
    d) It experiences no effect from the magnetic field.

Answer:B

Solution:The magnetic quantum number (m_l) describes the orbital's orientation in a magnetic field.

Negative m_l values indicate opposition to the external field (higher energy state).

m_l= -2 (d-orbital) aligns antiparallel to the field.

12. The quantum numbers + 1/2 and – 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.

Answer:D

Solution:Spin states (±½) are intrinsic quantum properties with no classical equivalent.

13. In which of these options do both constituents of the pair have the same spin magnetic moment?
   A) Zn^{2+} and Cu^{+} B) Co^{2+} and Ni^{2+} C) Mn^{4+} and Co^{2+} D) Mg^{2+} and Sc^{+}

Answer:A,C

Solution:A) Zn^{2+} and Cu^{+}

Zn^{2+}"[Ar] $3d^{10}$ $\rightarrow$ 0 unpaired electrons

Cu^{+}: [Ar] $3d^{10}$ $\rightarrow$ 0 unpaired electrons $\rightarrow$ Same spin magnetic moment (both 0 BM)

B) Co^{2+} and Ni^{2+}

Co^{2+}: [Ar] $3d^7$ $\rightarrow$ 3 unpaired electrons

Ni^{2+}: [Ar] $3d^8$ $\rightarrow$2 unpaired electrons $\rightarrow$ Different spin magnetic moments

C) Mn^{4+} and Co^{2+}

Mn^{4+} : [Ar] $3d^3$ $\rightarrow$ 3 unpaired electrons

Co^{2+}: [Ar] $3d^7$ $\rightarrow$ 3 unpaired electrons $\rightarrow$ Same number of unpaired electrons $\rightarrow$ same spin magnetic moment

D) Mg^{2+} and Sc^{+}

Mg^{2+}: [Ne] $\rightarrow 3s^{\circ}$ $\rightarrow$ 0 unpaired

Sc^{+}: [Ar] $3d^1$ $\rightarrow$ 1 unpaired $\rightarrow$Different spin magnetic moments

14. The magnitude of the spin angular momentum of an electron is given by
   A) $S = \sqrt{s(s+1)}\frac{h}{2\pi}$ B) $S = s\ \frac{h}{2\pi}$ C) $S = \frac{\sqrt{3}}{2} \times \frac{h}{2\pi}$ D) $S = \pm\ \frac{1}{2} \times \frac{h}{2\pi}$

Answer:C

Solution:$S = \sqrt{s(s+1)}\frac{h}{2\pi}$

s=1/2

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

15. 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 $\sqrt{20}\hbar$, $\sqrt{6}$

Answer:A

Solution:orbital angular momentum $= \sqrt{l(l+1)}(\frac{h}{2\pi})$

For 1s, l=0,orbital angular momentum $= \sqrt{l(l+1)}(\frac{h}{2\pi}) = \sqrt{0(0+1)}(\frac{h}{2\pi}) = 0$

For 3s, l=0,orbital angular momentum $= \sqrt{l(l+1)}(\frac{h}{2\pi}) = \sqrt{0(0+1)}(\frac{h}{2\pi}) = 0$

For 3d, l=2,orbital angular momentum $= \sqrt{l(l+1)}(\frac{h}{2\pi}) = \sqrt{2(2+1)}(\frac{h}{2\pi}) = \sqrt{6}\hbar$

For 2p, l=1,orbital angular momentum $= \sqrt{l(l+1)}(\frac{h}{2\pi}) = \sqrt{1(1+1)}(\frac{h}{2\pi}) = \sqrt{2}\hbar$

16. The correct set of four quantum numbers for the valence electron of Rubidium (Z = 37) is

A) n = 5, l = 0, m = 0, s = + $\frac{1}{2}$ B) n = 5, l = 1, m = 0, s = + $\frac{1}{2}$

C) n = 5, l = 1, m = 1, s = + $\frac{1}{2}$ D) n = 6, l = 0, m = 0, s = + $\frac{1}{2}$

Answer:A
Solution:Rb (37): [Kr]$5s^1$ (valence electron in 5s).
5s orbital:
n=5, l=0 (s-orbital), m=0, s=+½.

17. 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

Answer:B
Solution:Zn^{+2} (Z=30): [Ar]$3d^{10}$ (no electrons in n=4).

$4s^0$ is empty in Zn^{+2} $\rightarrow$ No electrons match the given quantum numbers.

JEE ADVANCED LEVEL QUESTIONS

MULTI CORRECT ANSWER TYPE

1. Regarding the principal quantum number (n), which of the following statements are true? Select all that apply.
   a) It cannot have negative values.
   b) It determines the energy level of an electron.
   c) It indirectly influences the size of the atom.
   d) It directly determines the shape of the atomic orbital.

Answer:A,B,C
Solution:a) n is always a positive integer (1, 2, 3, ...).

b) Higher n = higher energy (less tightly bound).
c) Larger n = larger orbital size $\rightarrow$ bigger atomic radius.

d) False: Orbital shape is determined by azimuthal quantum number (l), not n.

2. Which of the following aspects are determined by the principal quantum number (n) in an atom? Select all that apply.
   a) The energy of the electron. b) The size of the electron cloud.
   c) The number of subshells within an energy level.
   d) The orientation of the orbital.

Answer:A,B,C

Solution:a) Energy increases with n.
b) Orbital size scales with n (e.g., 2s > 1s).
c) For a given n, there are n subshells (l = 0 to n-1).
d) False: Orientation is determined by magnetic quantum number (m_l).

3. Which of the following information is correct about magnetic quantum number?
   A) It gives the number of permitted orientation of subshells.
   B) It tells about the zeeman effect.
   C) It is denoted by the letter 'm' D) Nne of the above

Answer:A,B,C

Solution:A) For a given l, m_l ranges from -l to +l (e.g., l=1 $\rightarrow$ 3 orientations).
B) Zeeman effect splits spectral lines in a magnetic field based on m_l
C) Standard notation is m_l or simply m.

4. Which of the following sets of quantum numbers are possible for an electron in a d orbital?
   a) n = 3, l = 2, m_l = 0 b) n = 4, l = 2, m_l = -1
   c) n = 3, l = 2, m_l = 2 d) n = 2, l = 2, m_l = 1

Answer:A,B,C

Solution:

d-orbital requires $l = 2$.

- a/b/c) Valid combinations:
  - $n \geq 3$ (since $l = 2$ starts at $n = 3$).
  - m_l can be $-2, -1, 0, +1, +2$.
- d) Invalid: $n = 2$ cannot have $l = 2$ (max $l = n - 1 = 1$).

5. Which of the following is incorrect about l value If n = 3 ?
   A) 0 B) 1 C) 2 D) 3

Answer:D

Solution:For n=3, l can be 0, 1, or 2 (since l ranges from 0 to n-1).
l=3 is not allowed for n=3.

REASON AND ASSERTION TYPE

A) Both (A) and (R) are true and (R) is the correct explanation of(A)

B) Both (A) and (R) are ture and (R) is not the correct explanation of (A)

C) (A) is true but (R) is false D) (A) is false but (R) is true

6. Assertion: At higher values of n, the electron cloud expands further from the nucleus, leading to larger atomic size.

Reason: The principal quantum number (n) indirectly influences the size of the atom.

Answer:A

Solution: Larger n $\rightarrow$ higher energy levels $\rightarrow$electron cloud spreads further $\rightarrow$ larger atomic size

7. Assertion: For any given value of n, the maximum number of electrons that can occupy that energy level is given by $2n^2$.

Reason: The principal quantum number (n) dictates the maximum number of electrons that can occupy a specific energy level in an atom.

Answer:A

Solution:Assertion: Max electrons per level =$2n^2$ $\rightarrow$True

Reason: n dictates max number of electrons in a level$\rightarrow$ TrueAnd yes, the formula comes from the number of orbitals n^2, each holding 2 electrons

8. Assertion: The number of subshells within an energy level is equal to the principal quantum number (n).

Reason: The principal quantum number (n) is directly related to the number of subshells within an energy level.

Answer:A

Solution:Each n gives l=0 to n-1, i.e., n subshells (s, p, d...)

9. Assertion: Orbitals with higher values of l have more complex shapes than those with lower values of l.

Reason: The azimuthal quantum number (l) determines the shape of the orbital.

Answer:A

Solution:s (l=0): sphere, p (l=1): dumbbell, d (l=2): clover, f (l=3): complex shapes

10. Assertion: The magnitude of the angular momentum increases as the value of the azimuthal quantum number (l) increases.

Reason: The azimuthal quantum number (l) is related to the angular momentum of an electron in an atom.

Answer:A

Solution:Angular momentum magnitude: $L = \sqrt{l(l+1)}(\frac{h}{2\pi})$

11. Assertion: The azimuthal quantum number (l) can have integral values ranging from 0 to (n - 1), where n is the principal quantum number.

Reason: The value of l represents the number of angular nodes in the wave function of an electron in an atom.

Answer:C

Solution:Angular nodes = l only for some orbitals — but not the definition of l.

l defines shape of orbital, not angular nodes directly.

12. Assertion: The azimuthal quantum number (l) directly influences the energy of an atomic orbital.
    Reason: Orbitals with higher values of l have higher energy levels compared to those with lower values of l within the same principal energy level.

Answer:D

Solution:The azimuthal quantum number (l) does influence the energy of the orbitals, particularly in multi-electron atoms where electron-electron interactions occur, it is not the primary determinant of the energy level of the shell. The principal quantum number (n) is the main factor that dictates the energy levels

Higher l means higher energy within same shell $\rightarrow$True

e.g., 3s < 3p < 3d in multi-electron atoms

13. Assertion: In an atom, all electrons with the same principal quantum number (n) have the same magnetic quantum number (ml).
    Reason: The magnetic quantum number (m_l) depends on the subshell in which the electron is located, characterized by the azimuthal quantum number (l), in addition to the principal quantum number (n).

Answer:D

Solution:Assertion: All electrons with same n have same $m_l \rightarrow$ False

Reason: m_l depends on l, which depends on n $\rightarrow$ True

Electrons with same n can be in different l and hence different m_l values

14. Assertion: In a p orbital, the magnetic quantum number (ml) can have values of -1, 0, and +1.
    Reason: The magnetic quantum number (ml) for a p orbital corresponds to the possible orientations of the orbital in space along the x, y, and z axes.

Answer:A

Solution:Assertion: In p-orbital, m_l =-1,0,+1 $\rightarrow$ True

Reason: These correspond to x, y, z orientations $\rightarrow$ True

15. Assertion: The number of possible values for the magnetic quantum number (ml) in an orbital is equal to 2l + 1.
    Reason: The magnetic quantum number (ml) can take on integer values ranging from -l to +l, including zero, resulting in a total of 2l + 1 possible values.

Answer:A

Solution:Assertion: Number of m_l values = 2l + 1 $\rightarrow$ True

Reason: Directly follows from definition of magnetic quantum number $\rightarrow$True

STATEMENT TYPE

A) Both the statements ar **TRUE**

B) Both the statements are **FALSE**

C) Statement -I is **TRUE** and Statement -II is **FALSE**

D) Statement -I is **FALSE** and Statement -II is **TRUE**

16. **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.

Answer:A

Solution::For n=3, l may be 0 through ±1, and m may be 0 through ±2, respectively. For any number of n, there are 0 to (n -1) possible l values, and for each l value, there are 0 to ±l possible m values.

17. **Statement-1 :** Magnetic quantum number gives the orientation of the orbital.

Statement-2 : Magnetic quantum number is denoted by 'm'.

Answer:A

Solution:m determines the spatial orientation of an orbital,denoted by 'm'

COMPREHENSION TYPE

Comprehension-I

Quantum numbers are essential in describing the various properties and characteristics of atomic orbitals within an atom. These numbers arise from the solutions to the Schrödinger equation, which governs the behavior of electrons in atoms. There are four quantum numbers: principal quantum number (n), azimuthal quantum number (l), magnetic quantum number (m_l), and spin quantum number (m_s).

18. How many possible values can the spin quantum number (m_s) have?

a) One b) Two c) Three d) Four

Answer:B

Solution:The spin quantum number (m_l) describes the intrinsic spin of an electron and can have only two possible values +1/2 and -1/2

19. If the principal quantum number (n) is 4, what could be the maximum value of the magnetic quantum number (m_l) for an electron in that atom?

a) 3 b) 4 c) -4 d) -3

Answer:A

Solution:For n=4,l=0 to 3

ml=-3,-2,-1,0,1,2,3

maximum value of the magnetic quantum number (m_l) for an electron=3

Comprehension-II

To explain the fine spectrum each in an atom is assigned with a set of four quantum numbers.The number of electrons that can present in a subshell is equal to 2(2l+A).

S-subshell will have only one value '0' so contain only one orbital.P-subshell will have three orbitals having 'm' values -1,0,+1.d-subshell will have five orbitals having 'm' values -2,-1,0,+2,+1.f-subshell will have seven orbitals having 'm' values -3,-2,- 1,0,+1,+2,+3.The spin of an electron is either clock wise (+1/B) or anti clock wise

(-1/B).(n=A)=1,(n=B)=2 etc..

l values are depends on the values of 'n' and are equal to n-1, The values of 'm' depends on the 'l' and are equal to (2l+A).

20. Correct set of four quantum numbers of valency electron of rubidium (Z=37) is:
A) 5,0,0,+1/2 B) 5,1,0,+1/2 C) 5,1,1,+1/2 D) 6,0,0,+1/2

Answer:A

Solution:Rubidium (Rb):Valence electron = $5s^1$ →Quantum numbers: 5, 0, 0, +½.

21. The quantum number for the last electron present in the valence shell of an element are given below. n=2, l = 0, m = 0, s = +½. Three atoms is:
A) Li B) Be C) H D) B

Answer:A

Solution:Li Valence electron = $2s^1$ →Matches given quantum numbers.

INTEGER TYPE

22. What can be the maximum number of electrons that can have m_s= -1/2 in n=4?

Answer:16

Solution:Total electrons in n=4

$2n^2$=32

16 elecrons have +1/2 and 16 electrons have -1/2

23. Quantum numbers for the valence electron of cobalt is ....

Answer:n=3,l=2,m_l=2,m_s=+1/2 or -1/2

Solution:Co=[Ar]$3d^7$ $4s^2$

Principal (n): 3

Azimuthal (l): 2 (for d-orbital)

Magnetic (m_l): Can be -2,-1,0,+1,+2 (any one, depending on orbital).

Spin (m_s): +1/2 or -1/2

MATRIX MATCHING TYPE

24.

Column-I	**Column-II**
a) Principal Quantum Number	A) shape of orbitals
b) Azimuthal Quantum Number	B) $2n^2$
c) Magnetic Quantum Number	C) m - space orientations
d) Spin Quantum Number	D) spin of an electron

Answer:a-B,b-A,c-C,d-D

Solution:

a) Principal Quantum Number	B) $2n^2$
b) Azimuthal Quantum Number	A) shape of orbitals
c) Magnetic Quantum Number	C) m - space orientations
d) Spin Quantum Number	D) spin of an electron

LEARNERS TASK

CONCEPTUAL UNDERSTANDING QUESTIONS (CUQ's)

1. The quantum number which cannot say any thing about an orbital is
   A)n B)l C) m D) s

Answer:D

Solution:n, l, m describe orbital properties (size, shape, orientation).
s (spin quantum number) describes electron spin, not the orbital itself.

2. An impossible set of four quantum number of an electron is
   A) n = 4, l = 2, m = -2, s = + 1/2 B) n = 4,l = 0, m = 0, s = +1/2
   C) n = 3, l = 2, m = -3, s = + 1/2 D) n = 5, l = 3, m = 0, s = - 1/2

Answer:C

Solution:For l=2, m must be -2, -1, 0, +1, +2.
m=-3 violates $|m| \leq l$.

3. The direction of spin of an electron is represented by
   A) n B) l C) m D) s

Answer:D

Solution:Spin quantum number (s = ±½) indicates spin direction (up/down).

4. The electrons occupying the same orbital have the same values for all the quantum number except for
   A) n B) l C) m D) s

Answer:D

Solution:Paired electrons in an orbital share n, l, m but have opposite spins (s=+½ and s=-½).

5. The magnetic quantum number for the outermost electron in sodium atom is
   A) -2 B) 0 C) +1 D) -1

Answer:B

Solution:Sodium (Z=11): [Ne]$3s^1$
Outermost electron is in 3s orbital $\rightarrow$ l=0, m=0.

6. The azimuthal quantum number and the principal quantum number of the 17th electron are
   A) ℓ = 1, n = 3 B) ℓ = 3, n = 2 C) ℓ = 2, n = 3 D) ℓ = 2, n = 1

Answer:A

Solution:For the 17th electron (e.g., chlorine, Z=17): [Ne]$3s^2 3p^5$.
Last electron enters 3p $\rightarrow$ n=3, l=1.

7. The quantum numbers n = 3, l = 1, m = +1 and s = +1/2 represent the unpaired electron present in
   A) Sodium atom B) Aluminium atom C) Fluorine atom D) Potassium atom

Answer:B

Solution:Aluminium (Z=13): [Ne]$3s^2$ $3p^1$.
The unpaired electron is in 3p (n=3, l=1, m=+1).

8. In order to designate an orbital in an atom the no. of quantum no. required
   A) One B) Two C) Three D) Four

Answer:C

Solution:An orbital is defined by n, l, m (spin is for electrons, not orbitals).

9. A 3d electron having s = + 1/2 can have a magnetic quantum number
   A) + 2 B) + 3 C) - 3 D) - 4

Answer:A

Solution:For 3d, l=2 $\rightarrow$ m = -2, -1, 0, +1, +2.
s=+½ is independent of m.

10. The quantum number which determines the orientation of electron orbit is
    A) n B) l C) m D) s

Answer:C

Solution:Magnetic quantum number (m) specifies orbital orientation in space.

JEE MAINS LEVEL QUESTIONS

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1. Which of the following statements about the principal quantum number (n) is TRUE?
   a) It directly corresponds to the size of the atom.
   b) It determines the shape of the orbital.
   c) It can have negative values.
   d) It is independent of the energy of the electron.

Answer:A

Solution:n determines the energy level and size of the orbital (higher n = larger orbital).

2. How many different values can the azimuthal quantum number (l) have for an electron in an n = 3 shell?
   a) 1 b) 2 c) 3 d) 4

Answer:C

Solution:For n=3, l can be 0, 1, 2 (s, p, d orbitals).
Total possible values = 3.

3. An electron in an atom is described by the quantum numbers n = 4 and l = 2. How many different orbitals can this electron occupy?
   a) 1 b) 3 c) 5 d) 7

Answer:C

Solution:l=2 (d-orbital) $\rightarrow$ m_l can be -2, -1, 0, +1, +2.
Each m$\rightarrow$ value represents a distinct orbital $\rightarrow$ 5 orbitals.

4. Which of the following combinations of quantum numbers is not allowed for an electron in an atom?
   a) n = 3, l = 2 b) n = 4, l = 3 c) n = 2, l = 2 d) n = 1, l = 0

Answer:C

Solution:l must be = n-1. For n=2, max l=1 (p-orbital).
l=2 is invalid for n=2.

5. Spin angular momentum for unpaired electron in sodium (Atomic No. = 1A) is
   A) $\frac{\sqrt{3}}{2}$ B) 0.866 h/2π C) $-\frac{\sqrt{3}}{2}\ \frac{h}{2\pi}$ D) None of these

Answer:B

Solution:Spin angular momentum=$\sqrt{s(s+1)}(\frac{h}{2\pi})$,s=1/2

$$S=\sqrt{s(s+1)}(\frac{h}{2\pi})=\sqrt{\frac{1}{2}(\frac{1}{2}+1)}(\frac{h}{2\pi})=0.8666\hbar$$

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

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

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

Answer:C

Solution:4f requires:n=4, l=3 (f-orbital), m_l = -3 to +3, s=±½.

7. Consider the ground state of Cr atom (Z = 24). The numbers of electrons with the azimuthal quantum numbers, l = 1 and 2 are, respectively

A) 12 and 4 B) 12 and 5 C) 16 and 4 D) 16 and 5

Answer:B

Solution:Cr configuration: $[Ar]3d^5 4s^1$.

l=1 (p): 12 electrons ($2p^6 + 3p^6$).

l=2 (d): 5 electrons ($3d^5$).

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]

(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

A) (iv) and (v) B) (iii) and (iv) C) (ii) and (iii) D) (i) and (ii)

Answer:A

Solution:Orbitals with the same n and l are degenerate (same energy).

(iv) n=3, l=2, m=1 and (v) n=3, l=2, m=0 are both 3d orbitals.

9. Which of the following set of quantum numbers represents the highest energy of an atom ? [AIEEE 2008]

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

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

Answer:C

Solution:Higher l values within the same n have higher energy (3d > 3p > 3s).

10. The electrons identified by quantum numbers n and ℓ : [AIEEE 2012]

A) n = 4, ℓ = 1 B) n = 4, ℓ = 0 C) n = 3, ℓ = 2 D) n = 3, ℓ = 1

can be placed in order of increasing energy as :

A) (C) < (D) < (B) < (A) B) (D) < (B) < (C) < (A)

C) (B) < (D) < (A) < (C) D) (A) < (C) < (B) < (D)

Answer:B

Solution:Energy order: n+l rule:

(D) n=3, l=1 (3p) $\rightarrow$ 3+1=4

(B) n=4, l=0 (4s) $\rightarrow$ 4+0=4

(C) n=3, l=2 (3d) $\rightarrow$ 3+2=5

(A) n=4, l=1 (4p) $\rightarrow$ 4+1=5

Final order: 3p < 4s < 3d < 4p.

11. The correct set of four quantum numbers for the valence elections of rubidium atom (Z = 37) is : [JEE MAIN 2014]

A) 5, 1, 1, + $\frac{1}{2}$ B) 5, 0, 1, + $\frac{1}{2}$ C) 5, 0, 0, + $\frac{1}{2}$ D) 5, 1, 0, + $\frac{1}{2}$

Answer:C

Solution:Rb: [Kr]$5s^1 \rightarrow$ Valence electron is $5s^1$.

n=5, l=0 (s), m=0, s=+½.

12. A principal quantum number of an atom is related to the
 A) size of the orbital B) spin angular momentum
 C) orbital angular momenum D) orietation of the orbital in space

Answer:A

Solution:n determines orbital size and energy level.

13. Which set of quantum number represents permissible values?
 A) n = 3, l = 1, m = 1, s = +1/2 B) n = 3, l = 1, m = 4, s = +1
 C) n = 3, l = 2, m = 4, s = +1/2 D) n = 1, l = –1, m = –1, s = –1/2

Answer:A

Solution:A) All values follow rules: $l<n$, $|m| \leq l$, s=±½.

14. A neutral atom of an element has two 'K' eight 'L' nine 'M' and two 'N' electrons. The total numbers of electrons present in the orbitals having I value 1 are
 A)6 B)8 C) 10 D) 12

Answer:D

Solution:Given configuration: 2(K), 8(L), 9(M), 2(N) $\rightarrow$ Total electrons = 21 (likely Sc, Z=21).

l=1 (p-orbitals):$2p^6$ (L-shell) + $3p^6$ (M-shell) $\rightarrow$ 12 electrons.

JEE ADVANCED LEVEL QUESTIONS

MULTI CORRECT ANSWERS :

1. Considering the principal quantum number (n), which of the following statements are true regarding the maximum number of electrons that can occupy a given energy level? Select all that apply.
 a) For n = 2, the maximum number of electrons is 8.
 b) For n = 3, the maximum number of electrons is 18.
 c) For n = 4, the maximum number of electrons is 32.
 d) For n = 5, the maximum number of electrons is 25.

Answer:A,B,C

Solution:The maximum number of electrons in an energy level is given by $2n^2$:

n=2: =$2(2)^2$=8 (a is correct).

n=3: $2(3)^2$=18 (b is correct).

n=4: $2(4)^2$=32 (c is correct).

n=5: $2(5)^2$=50, not 25 (d is false).

2. Which of the following quantum numbers depend on the principal quantum number (n) in an atom? Select all that apply.
 a) Azimuthal quantum number (l) b) Magnetic quantum number (m_l)
 c) Spin quantum number (m_s) d) None of the above

Answer:A,B

Solution:a) Azimuthal quantum number (l): Ranges from 0 to n-1.
b) Magnetic quantum number (m?): Depends on l (which depends on n).
c) Spin quantum number (m?): Independent of n (always $\pm$ 1/2)

3. Which of the following sets of quantum number is/are correct ?

A) $n = 3, l = 3, m = 0, s = \frac{1}{2}$ B) $n = 3, l = 2, m = 2, s = -\frac{1}{2}$

C) $n = 3, l = 1, m = 2, s = -\frac{1}{2}$ D) $n = 3, l = 0, m = 0, s = +\frac{1}{2}$

Answer:B,D

Solution:A) n=3, l=3: Invalid (l must be 1 $\leq$n-1, so max l=2).
B) n=3, l=2, m=2, s=-½: Valid (for d-orbital, m can be -2 to +2).
C) n=3, l=1, m=2: Invalid (|m| $\leq$l, so max m=1).

D) n=3, l=0, m=0, s=+½: Valid (s-orbital).

4. For an electron in an f orbital, which of the following magnetic quantum number values are possible?

a) m_l = -3 b) m_l = 1 c) m_l = 4 d) m_l = 0

Answer:A,B,D

Solution:

4. Which of the given 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 must 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

Answer:A

Solution:Because inert gases have a stable electronic structure, they have an extremely high ionization enthalpy. They therefore don't tend to lose electrons. Inert gases hence have zero valency.

REASON AND ASSERTION TYPE

A) Both (A) and (R) are true and (R) is the correct explanation of(A)

B) Both (A) and (R) are ture and (R) is not the correct explanation of (A)

C) (A) is true but (R) is false D) (A) is false but (R) is true

5. Assertion: As the principal quantum number increases, the energy of the electron decreases.

Reason: The principal quantum number (n) determines the energy level of an electron in an atom.

Answer:D

Solution:Assertion (A): False.
As n increases, the electron's energy increases (becomes less negative).

Reason (R): True.
n does determine the energy level, but the assertion incorrectly states the trend.

6. Assertion: The number of subshells within an energy level is equal to the principal quantum number (n).
   Reason: The principal quantum number (n) is directly related to the number of subshells within an energy level.

Answer:A

Solution:Assertion (A): True.
For a given n, there are n subshells (l = 0 to n-1).
Reason (R): True.
n directly defines the number of subshells (l values).

7. Assertion: An electron cannot exist in an orbital with quantum numbers n = 3 and l = 3.
   Reason: The maximum value of the azimuthal quantum number (l) for a given principal quantum number (n) is (n - 1).

Answer:A

Solution:Assertion (A): True.
l cannot equal n (max l = n-1).
Reason (R): True.
l ranges from 0 to n-1.

8. Assertion: The azimuthal quantum number (l) determines the number of possible orientations of an atomic orbital in space.
   Reason: The number of orientations is given by the formula 2l + 1.

Answer:D

Solution:Assertion (A): False.
l determines orbital shape, not orientation (which is determined by m_l).
Reason (R): True.
2l + 1 gives the number of possible m_l values (orientations)

9. Assertion: The magnetic quantum number (m_l) specifies the orientation of an atomic orbital in space.
   Reason: The magnetic quantum number can take on integer values ranging from -l to +l, where l is the azimuthal quantum number.

Answer:A

Solution:Assertion (A): True.
m_l specifies orbital orientation (e.g., p?, p?, p_z).
Reason (R): True.
m_l ranges from -l to +l, defining orientations.

10. Assertion: An electron with m_l = 0 can be found in any orientation around the nucleus.
    Reason: The magnetic quantum number (ml) determines the shape of the orbital, not its orientation.

Answer:E

Solution:Assertion (A): False.
m_l=0 corresponds to a specific orientation (e.g., p_z orbital).
Reason (R): False.

m_l determines orientation, not shape.

11. Assertion: For a given value of the principal quantum number (n), the maximum number of possible values for m_l is equal to n.
Reason: The magnetic quantum number (ml) can take on integer values ranging from -l to +l, where l is the azimuthal quantum number, and for a given n, l can range from 0 to (n - 1).

Answer:D

Solution:Assertion (A): False.

Max m_l values = 2l + 1, where max l = n-1 $\rightarrow$Total m_l values = n^2, not n.

Reason (R): True.

Correctly describes the range of m_l for each l.

STATEMENT TYPE

A) Both the statements ar TRUE B) Both the statements are FALSE
C) Statement -I is TRUE and Statement -II is FALSE
D) Statement -Iis FALSE and Statement -II is TRUE

12. **Statement-1 :** Magnetic quantum number gives the orientation of the orbital.
Statement-2 : Magnetic quantum number is denoted by 'm'.

Answer:A

Solution:Statement-I: Correct. The magnetic quantum number (m_l) specifies the spatial orientation of an orbital (e.g., p_x,p_y,p_z).

Statement-II: Correct. The standard notation for the magnetic quantum number is m_l or simply m

13. **Statement-1 :** Magnetic quamtum number was proposed by Zeeman.
Statement-2 : The number of degenerate orbitals of s - subshell = 0

Answer:C

Solution:Statement-I: True. The magnetic quantum number arose from the Zeeman effect (splitting of spectral lines in a magnetic field), discovered by Pieter Zeeman.

Statement-II: False. The s-subshell has 1 orbital (l=0, m_l =0), which is non-degenerate in isolation but is still a single orbital. Degeneracy refers to orbitals with the same energy, and for s-subshells, there is only one orbital (not zero).

COMPREHENSION TYPE

Following table gives the information about the quantum numbers and it values.

Number of sub level	*l* - value	No. of orientation in space (2*l* + 1)	m - value
s – sub level	*l* = 0	2 × 0 + 1 = 1	0
p – sub level	*l* = 1	2 × 1 + 1 = 3	-1, 0, +1
d – sub level	*l* = 2	2 × 2 + 1 = 5	-2, -1, 0, +1, +2
f – sub level	*l* = 3	2 × 3 + 1 = 7	-3, -2, -1, 0, +1, +2, +3

14. Beryllium fourth electron will have the four quantum numbers

S.No	n	l	m	s
1)	1	0	0	0.5
2)	1	1	1	0.5
3)	2	1	0	0.5
4)	2	0	0	–1/2

Answer:4

Solution:Be=$1s^2 2s^2$

n=2,l=0,m=0,s=-1/2

15. Which of the following represents the correct set of four quantum number of a 4d electron?

A) 4, 3, 2 +1/2 B) 4, 2, 1, 0 C) 4, 3, –2, + 1/2 D) 4, 2, 1,+1/2

Answer:D

Solution:For 4d

n=4,l=2,m=-2,-1,0,1,2,S=$\pm$ 1/2

INTEGER TYPE :

16. Azimuthal quantum number of the 16th Electron is

Answer:1

Solution:16th Electron Location:

Occupies the 3p subshell (specifically, one of the 3p orbitals).

Azimuthal Quantum Number (l):

For p-orbitals, l=1.

17. Anti clock wise spin is represented by

Answer:+1/2

Solution:

Spin Quantum Number (m_s):

- $+\frac{1}{2}$: Represents anticlockwise (spin-up).
- $-\frac{1}{2}$: Represents clockwise (spin-down).

MATRIX MATCHING TYPE

	List-I		List-II
18.	A) n = 4, $\ell = 2$, m = 0	( )	A) $4dz^2$
	B) n = 3, $\ell = 1, m = \pm 1$	( )	B) $3p_x$(or) 3py
	C) n = 4, $\ell = 0$, m = 0	( )	C) 4s
	D) n = 3, $\ell = 2, m = \pm 2$	( )	D) $3d_{xy}$

Answer:A-A,B-B,C-C,D-D

Solution:Option A (n=4, l=2, m=0):

l=2 $\rightarrow$ d-orbital.

m=0 $\rightarrow 4dz^2$ orbital (unique shape aligned along z-axis).

Option B (n=3, l=1, m=±1):
l=1 $\rightarrow$ p-orbital.
m=±1 $\rightarrow 3p_x$(or) 3py(orientations along x/y axes).
Option C (n=4, l=0, m=0):
l=0 $\rightarrow$ s-orbital.
Only one orientation: spherical 4s.
Option D (n=3, l=2, m=±2):
l=2 $\rightarrow$ d-orbital.
m=±2 $\rightarrow 3d_{xy}$(cloverleaf shapes in xy-plane).

	List-I	List-II	
19.	**(A)** Number of value of l for an energy level(n)	(A)	0, 1, 2, ... (n - A)
	(B) Values of l for a particular type of orbit	(B)	+l to –l through zero
	(C) Number of value of m for ℓ = 2	(C)	5
	(D) Values of 'm' for a particular type of orbital	(D)	n

Answer:A-D,B-A,C-C,D-B

Solution:

(A) Number of value of l for an energy level(n)	(D)	n
(B) Values of l for a particular type of orbit	(A)	0, 1, 2, ... (n - A)
(C) Number of value of m for ℓ = 2	(C)	5
(D) Values of 'm' for a particular type of orbital	(B)	+l to –l through zero

KEY

			TEACHING TASK						
			JEE MAIN LEVEL QUESTIONS						
1	2	3	4	5	6	6	7	8	9
C	B	B	B,D	C	C	D	B	A,B,C	D
10	11	12	13	14	15	16	17		
B,D	B	D	A,C	C	A	A	B		
			JEE ADVANCED LEVEL QUESTIONS						
1	2	3	4	5	6	7	8	9	10
A,B,C	A,B,C	A,B,C	A,B,C	D	A	A	A	A	A
11	12	13	14	15	16	17	18	19	20
C	D	D	A	A	A	A	B	A	A
21	22	23			24				
A	16	n=3,l=2,ml=2,ms=+1/2 or -1/2			a-B,b-A,c-C,d-D				
			LEARNERS TASK						
			CUQ'S						
1	2	3	4	5	6	7	8	9	10
D	C	D	D	B	A	B	C	A	C
			JEE MAINS LEVEL QUESTIONS						
1	2	3	4	5	6	7	8	9	10
A	C	C	C	B	C	B	A	C	B
11	12	13	14						
C	A	A	D						
			JEE ADVANCED LEVEL QUESTIONS						
1	2	3	4	4	5	6	7	8	9
A,B,C	A,B	B,D	A,B,D	A	D	A	A	D	A
10	11	12	13	14	15	16	17	18	
E	D	A	C	4	D	1	1-Feb	A-A,B-B,C-C,D-D	
19-A-D,B-A,C-C,D-B									