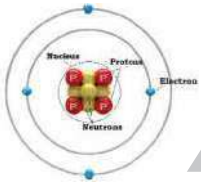


Chapter - 2

Structure of Atom

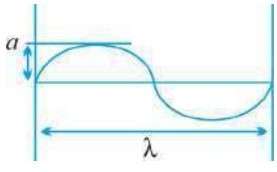
FAST TRACK : QUICK REVISION

- **Information about fundamental particles of atom**

Name of Constant	UNIT	Electron	Proton	Neutron
Mass	amu	0.000546	1.00728	1.008665
	kg	9.109×10^{-31}	1.673×10^{-27}	1.675×10^{-27}
Charge	Coloumbs	-1.602×10^{-19}	$+1.602 \times 10^{-19}$	Zero
	esu	-4.8×10^{-10}	$+4.8 \times 10^{-10}$	Zero
	Relative Charge	-1	$+1$	Zero

- **Electromagnetic radiations :** Energy emitted from any source (in forms of waves) in which electric and magnetic fields oscillated perpendicular to each other and travelling with a velocity of light is known as EM radiation.
- **Characteristics of waves :**

(a) Wavelength : The distance of one crest and one trough in a wave. Denoted by 'λ'.



(b) Frequency : Number of waves passing through a given point in one second.

Denoted by υ. $\left[\upsilon = \frac{1}{t} \Rightarrow \sec^{-1} \text{ or Hz}, \quad t = \text{Time period}\right]$

(c) Amplitude : The height of crest or depth of a trough denoted by '*a*'.

(d) Wave Number : Number of waves per unit length denoted by $\bar{\upsilon}$

$$\bar{\upsilon} = \frac{1}{\lambda} = \text{cm}^{-1} \text{ (or m}^{-1}\text{)}$$

(e) Velocity : Linear distance travelled by a wave in one second.

$$\text{velocity of light } c = \frac{\text{Distance}}{\text{Time}} = \lambda \times \frac{1}{t} = \upsilon\lambda$$

$$\therefore \quad \upsilon = \frac{c}{\lambda}$$

- **Energywise** order for EM radiation.

cosmic < γ rays < X rays < UV < VIBGYOR < IR < Microwaves < Radiowaves

λ (**Increases**) υ (**Decreases**) Energy (**Decreases**)

- **Photon :** A packet or particle of light energy is knows as **Photon.**
- **Planck's quantum theory :** The energy emitted or absorbed by a source is discontinuous in form of small packet of energy, called **quantum**. Quantum of light is called **photon.**

$E \alpha v$

$E = hv$ (h = Planck's constant)

$E = nhv$ ($h = 6.626 \times 10^{-34}$ J sec)

If 'n' photons are emitted $E = nh\upsilon$

- **Photo electric effect :** The phenomenon of ejection of electrons from a metal surface when a light of suitable frequency falls on metal surface.

$h\upsilon - h\upsilon_0 = \frac{1}{2} mv^2$

$h\upsilon \Rightarrow$ Energy of incident light on metal surface.

$h\upsilon_0 \Rightarrow$ Work function of metal.

$\frac{1}{2}mv^2 =$ Kinetic energy by which e^- is emitted from metal surface.

- **de Broglie equation :** All material particles in motion also exhibit wave like properties.

$$\lambda = \frac{h}{mv} = \frac{h}{p}$$

For microscopic particles mass is very less therefore Wavelength of wave associated with it can be detected.

For macroscopic particles mass is large, λ of wave associated with it can not be detected. Hence dominant wave character.

Hence microscopic bodies have dual nature, where as macroscopic bodies have particle nature.

Heisenberg's Uncertainty Principle

It is impossible to determine the exact position and velocity of a moving subatomic particle simultaneously with accuracy.

$$\Delta x \times m\Delta v \geq \frac{h}{4\pi}$$

Δx = uncertainty in position

Δv = uncertainty in velocity

Bohr's theory for H [H like one e^- systems He^+; Li^{2+}]

(1) e^- revolving round the nucleus in circular path [stationary state; SHELL] with a definite angular momentum $\frac{nh}{2\pi}$ [Here n = no. of shell of e^-] and with definite energy

$$E_n = \left[\frac{-2\pi^2 me^4 z^2}{n^2 h^2}\right] \Rightarrow -2.18 \times 10^{-18} \frac{Z^2}{n^2} \text{ J/Atom.}$$

(2) As n increases, Energy of e^- becomes less – ve [Due to less force of Proton attraction]

As n decreases, Energy of e^- becomes More – ve [Due to more force of attraction by protons]

(3) In infinity shell e^- has zero force of attraction therefore zero energy.

(4) Electron energy only changes by definite values $\Delta E = E_f - E_i$.

Hydrogen spectrum : When e^- in hydrogen atom is provided energy it gets excited to higher shell from ground state, it comes back to ground state by emitting energy in definite values.

Emission Spectrum : The emission of light energy is known as emission spectra. It corresponds to each atom depending upon which energy shell e^- is

excited. It is **discontinuous** spectra as 'λ' of light radiations do not merge with each other like in VIBGYOR (Continous Spectra).

When e^- falls from any excited state to

$$\frac{1}{\lambda} = 1{,}09{,}678\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]Z^2 \quad R = \text{Rydberg constant} = 109678\ cm^{-1}$$

$n_i = 1, n_f = 2, 3, 4, ...$ [Lyman series] (UV)

$n_i = 2, n_f = 3, 4, 5, ...$ [Balmer series] (VIBGYOR)

$n_i = 3, n_f = 4, 5, 6$ [Paschen series] IR.

$n_i = 4, n_f = 5, 6, 7$ [Bracket series] IR.

$n_i = 5, n_f = 6, 7, 8$ [Pfund series] IR.

Quantum numbers : The numbers which **completely** define the **state** of e^- in an atom.

(1) Principal Quantum No. : It describes the distance of e^- from **nucleus '*n*'** *i.e.*, defines the **shell** no. It is denoted by '*n*'.

n = 1, 2, 3, 4, 5, ...

K, L, M, N, O .....

(2) Azimuthal (*l*) Quantum No. : It defines the path of e^- decided by angular momentum of e^-. Each angular momentum value corresponds to one subshell. The no. of subshells in a shell is 0 to $n - 1$.

n	l (0 to n-1)			
1	0	$l = 0$	'*s*'	subshell
2	0, 1	$l = 1$	'*p*'	subshell
3	0, 1, 2	$l = 2$	'*d*'	subshell
4	0, 1, 2, 3	$l = 3$	'*f*'	subshell

All subshells are wave functions for locating e^-.

In the same shell energy increase $s < p < d < f$.

(3) Magnetic Quantum No. : It gives the no. of magnetic orientations an e^- can have in a subshell. That is number of orbitals in a sub-shell. $m_s = -l.....o.....+ l = (2l + 1)$.

(4) Spin Quantum No. : An e^- is continuously spinning on its own axis.

The value of $s = \frac{1}{2}$ or $-\frac{1}{2}$

An orbital can have maximum two e^- one with clockwise and other with anticlockwise spin.

Aufbau principle

(a) Electrons are filled in increasing order of energy of sub-shell.

(b) As '$n + l$'value increases energy of e^- increases in that sub-shell.

(c) For two sub-shells with same '$n + l$' value, as 'n' value increases energy of e^- increases.

Pauli's principle

No two electrons can have same set of four quantum numbers in an atom.

Hund's rule of maximum multiplicity

The pairing of e^- in degenerate orbitals (different orbitals with same energy) will get paired only once they have been singly occupied with same spin.

IMPORTANT POINTS

The filling of e^- in subshells follows this order. (As per Aufbau principle)

(A) $1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p < 5s < 4d < 5p < 6s < 4f < 5d < 6p < 7s < 5f < 6d < 7p$

(B) Half filled and completely filled subshells have more **stability** than incompletely filled subshells.

Cr = [Ar] $4s^1\ 3d^5$

Cu = [Ar] $4s^1\ 3d^{10}$

(C) As the shell no. inc. size of subshell increases *e.g.*, size of $(2s > 1s)$; $(3p > 2p)$; $(4d > 3d)$

(D) The region in an orbital where probability of finding the e^- is zero is known as **Nodal plane** (or Node).

The no. of [radial nodes] = $n - l - 1$ and Angular Nodes = l,

Total nodes = n–1.

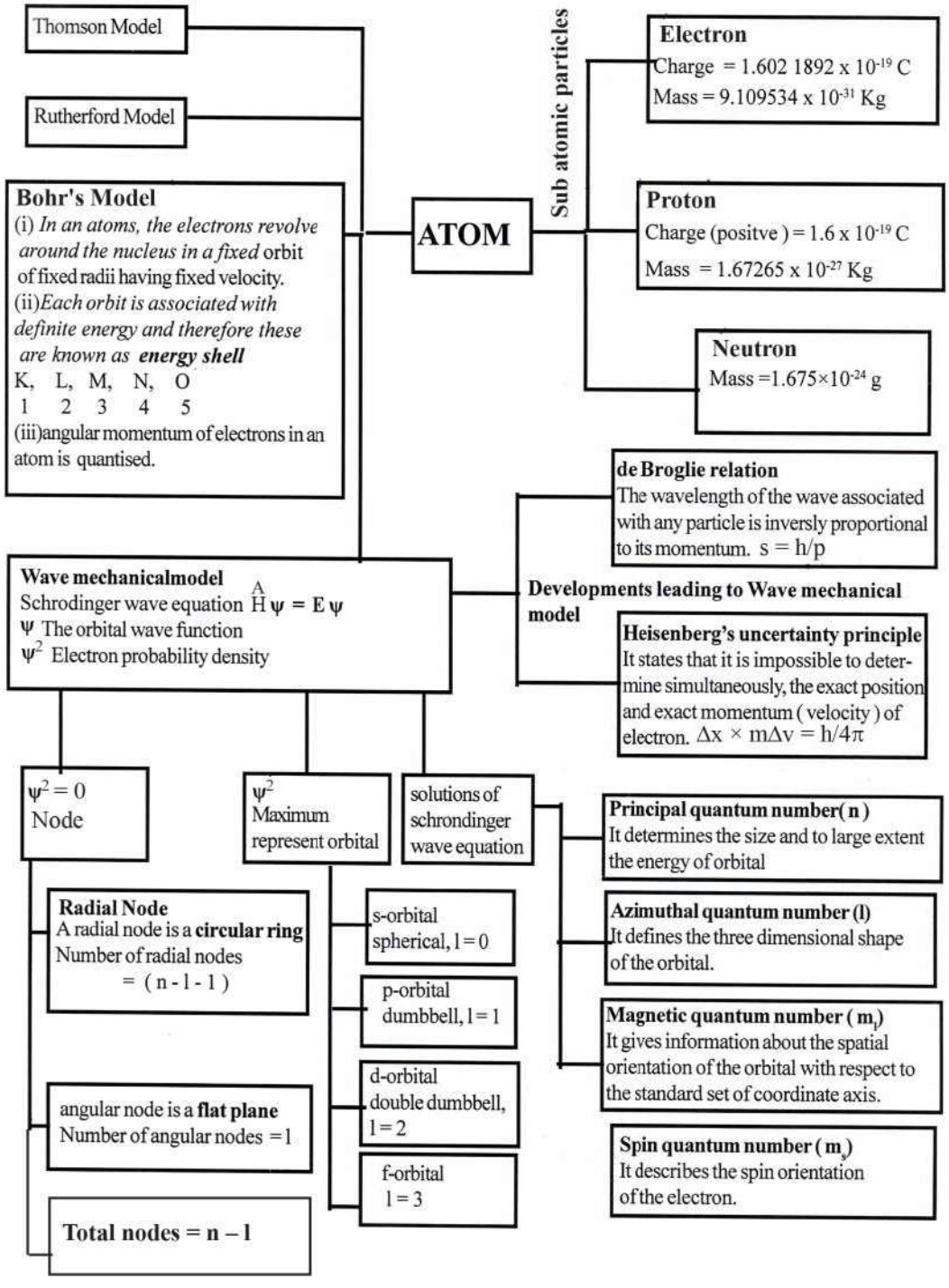
(E)

ψ(psi)	**ψ^2(psi square)**
A wave function for locating an electron	The square of wave function where the probability of finding the e^- is maximum. [Each value of ψ^2 is a region and **defines** one orbital]

(F)

Orbit	**Orbital**
(1) A definite distance from the nucleus for finding the e^- [e^- as a particle].	(1) A probability region for locating the e^- around the nucleus. It is a wave function [e^- as a wave]
(1) It has definite size and e^- in this orbit has definite energy.	(2) It does not define definite size. But only a boundary region diagram of a wave for locating the e^-.

MIND MAP - STRUCTURE OF ATOM



CASE BASED QUESTIONS

1. **Read the passage given below and answer the following questions:**

The capacities of shells with a given principal quantum number are fixed by (1) the rules governing the permitted values of the quantum numbers and (2) the Pauli Exclusion Principle. The permitted values of the quantum numbers are :

Principal quantum number	n	1 to ∞
Azimuthal quantum number	l	0 to n–1 (n values)
Magnetic quantum number	m_l	$-l$ to $+l$, ($2l$ +1 values)
Spin quantum number	m_s	– ½ or + ½ (2 values)

The Pauli Exclusion Principle states that no two electrons in the same atom may have the same values of all four quantum numbers. It follows that, for a given value of n, there are $2n^2$ different sets of values for the quantum numbers, because l may have the values O, 1, . . ., n–1, and for each value of l there are $2l$ +1 values of m_l and for each set of values of l and m there are just two choices for m_s.

(Reference : Thomas H. Hazlehurst, J. Chem. Educ. 1941, 18, 12, 580 Publication Date: December 1, 1941, Journal of American Chemical Society).

The following questions are multiple choice questions. Choose the most appropriate answer:

(i) Based on the concept of quantum numbers mentioned in the study, which of the following value sets of quantum numbers are not possible?

(a) n=0, l=0, m_l= 0, m_s= -1/2

(b) n=5, l=3, m_l= -4, m_s= +1/2

(c) n=3, l=1, m_l= -1, m_s= -1/2

(d) n=6, l=1, m_l= 0, m_s= +1/2

(ii) What will be the maximum possible number of electrons having m_s = -1/2 for n=5?

(a) 50 (b) 25

(c) 32 (d) 72

(iii) Which of the following quantum numbers can distinguish between two electrons present in the same orbital?

(a) Azimuthal quantum number

(b) Principal quantum number

(c) Magnetic quantum number

(d) Spin quantum number

(iv) Maximum number of electrons having n = 3 and l = 1 is-

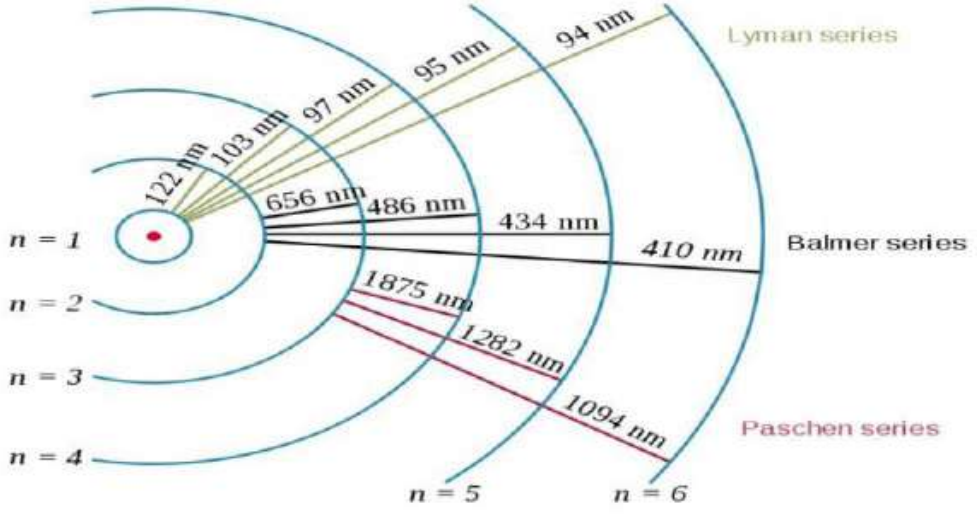
(a) 14 (b) 6

(c) 10 (d) 2

ANS: I-B, II-B, III-D, IV-B

2. Read the passage given below and answer the following questions:

A hydrogen atom consists of an electron orbiting its nucleus. The electromagnetic force between the electron and the nuclear proton leads to a set of quantum states for the electron, each with its own energy. These states were visualized by the Bohr model of the hydrogen atom as being distinct orbits around the nucleus. Each energy state, or orbit, is designated by an integer, *n* as shown in the figure. The Bohr model was later replaced by quantum mechanics in which the electron occupies an atomic orbital rather than an orbit, but the allowed energy levels of the hydrogen atom remained the same as in the earlier theory.



Spectral emission occurs when an electron transitions, or jumps, from a higher energy state to a lower energy state. To distinguish the two states, the lower energy state is commonly designated as n', and the higher energy state is designated as n. The energy of an emitted photon corresponds to the energy difference between the two states. Because the energy of each state is fixed, the energy difference between them is fixed, and the transition will always produce a photon with the same energy.

(Reference : Andrew, A. V. (2006). "2. Schrödinger equation". Atomic spectroscopy Introduction of theory to Hyperfine Structure p. 274 ISBN 978-0-387-255736. https://en.wikipedia.org/wiki/Hydrogen_spectral_series).

In these questions (Q. No. (i) to (iv) , a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices :

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement

i. ASSERTION: The energy states of H-atom are independent of azimuthal quantum number.

REASON: H-atom does not have any inter-electronic repulsion as it has only 1 e^-.

ii. ASSERTION: A spectral line will be seen for a $2p_x - 2p_y$ transition.

REASON: Energy is released when electron drops to lower stationary state.

iii. ASSERTION: For Balmer series of hydrogen spectrum, the value $n_1 = 2$ and $n_2 = 3, 4, 5...$.

REASON: The value of n_2 for a line in Balmer series of hydrogen spectrum having the highest wavelength is 6.

iv. ASSERTION: Electromagnetic radiations of fixed wavelengths are absorbed by the H-atom.

REASON: Radiations corresponding to the energy difference between the two stationary states are absorbed.

ANS:- I-A, II-D, III-C, IV-A

MULTIPLE CHOICE QUESTIONS (MCQ)

1. Packet of energy is called

   (a) Electron (b) Photon

   (c) Position (d) Proton

2. Orbital which is not possible

   (a) 2p (b) 3d

   (c) 3s (d) 3f

3. the magnetic quantum number of an atom is related to the

   (a) size of the orbital (b) spin angular momentum

   (c) orbital angular momentum (d) orientation of the orbital in space

4. The principal quantum number of an atom is related to the

   (a) size of the orbital (b) spin angular momentum

   (c) orbital angular momentum (d) orientation of the orbital in space

5. The designation of an orbital with $n = 4$ and $1 = 3$

   (a) 4s (b) 4p

   (c) 4d (d) 4f

6. What transition in the hydrogen spectrum would have the same wavelength as the Balmer transition n = 4 to n = 2 in the He^+ spectrum?

   (a) n = 4 to n =1 (b) n = 3 to n = 2

   (c) n = 3 to n = 1 (d) n = 2 to n = 1

7. The wave number of first line of Balmer series of hydrogen in 15200 cm-1. The wave number of the first Balmer line of Li^{2+} ion is

   (a) 15200 cm^{-1} (b) 60800 cm^{-1}

   (c) 76000 cm^{-1} (d) 136,800 cm^{-1}

8. An electron is moving in Bohr's orbit. Its de Broglie wavelength is λ. What is the circumference of the forth orbit?

   (a) 2/λ (b) 2λ

   (c) 3λ (d) 3/λ

9. Which of the following statements in relation to the hydrogen atom is correct?

(a) 3s-orbital is lower in energy than 3p-orbital

(b) 3p-orbital is lower in energy than 3-d-orbital

(c) 3s and 3p orbitals all have the same energy.

(d) 3s, 3p and 3d orbitals all have the same energy.

10. For principle quantum number, n = 4, the total number of orbitals having 1 = 3 is

(a) 3 (b) 7

(c) 5 (d) 9

11. The number of d-electrons retained in Fe^{2+} (At. no. of Fe = 26) ion is

(a) 3 (b) 4

(c) 5 (d) 6

12. Pauli exclusion principle helps to calculate the maximum number of electrons that can be accommodated in any

(a) orbital (b) subsell

(c) shell (d) All of these

Ans. 1. (b), 2. (d), 3. (d), 4. (a), 5. (d), 6. (d), 7. (d), 8. (c), 9. (d), 10. (b), 11. (d), 12. (a)

FILL IN THE BLANK

1. Bohr's theory is based on _____ of radiation.
2. The angular momentum of the electron in the 4th energy shell in the hydrogen atom is _____.
3. Lines of Balmer series appear in _____ region.
4. The maximum number of electrons in Fe^{3+} (At. No. 26) is _____.
5. Li^{2+} and He^{+} ions have spectrum similar to _____ atom.
6. Bohr's atomic theory is not able to explain the atomic spectra of atoms containing _____ electron.
7. An electron in the first shell will have _____ stability and _____ energy than an electron in the third shell.

8. The space or three-dimensional region round the nucleus where there is maximum probability of finding an electron of specific energy is called an____

9. According to ____ no two electrons in an atom will have all the four quantum numbers ____

10. When there are two electrons in the same orbital they have ____ spins.

11. The s-subhells have ____ shape and the p-subshells have____

12. The maximum number of electrons on a subshell is equal to _____ where l = _____

Ans. 1. Planck's theory 2. $\frac{2h}{\pi}$

3. Visible 4. 23

5. H-atom 6. more than 1

7. Larger, lower 8. orbital

9. Pauli exclusion principle; similar

10. Opposite

11 Spherical, dumb bell shape.

12. 2l + 1; azimuthal quantum numbers

TRUE AND FALSE TYPE QUESTIONS

Write true or false for the following statements

1. Bohr's theory cannot explain the spectra of multi-electron atoms.
2. Bohr's theory based on the Planck's quantum theory.
3. Size of orbital is determined by principal quantum number.
4. Fe^{2+} ion has more number of unpaired electrons than Fe^{3+}.
5. The outer electronic configuration of chromium atom is $3d^4 4s^2$.
6. The designation of an orbital n=4 and l=0 is 4s.
7. All photons of light have same energy.
8. Fe^{3+} has $3d^5$ configuration.

9. The number of subshells is always equal to the order of the orbit.
10. Two electrons in the same orbital has antiparallel spin.
11. The second orbit in He^+ ion has radius as the first orbit in hydrogen atom.
12. Heisenberg principle is applicable to microscopic particles.
13. 3s orbital has 2 radial nodes.

Ans. 1. (T) 2. (T) 3. (T) 4. (F) 5. (F) 6. (T) 7. (F)
8. (T) 9. (F) 10. (T) 11. (T) 12. (T), 13. (T)

MATCH THE COLUMNS

1. Match the following

	List-I		List-II
a.	Lyman series	p.	Visible region
b.	Balmer series	q.	Infrared region
c.	Paschen series	r.	Absorption spectrum
d.	Brackett series	s.	Ultraviolet region

2. Match the following

	List-I		List-II		List-III
a.	Principal quantum number	p.	Spin of electrons	i.	$-l$ to $+l$
b.	Azimuthal quantum number	q.	Size of orbital	ii.	0 to ∞
c.	Magnetic quantum number	r.	Orientation of the orbital	iii.	$\pm$ ½
d.	Spin quantum number	s.	Shape of the orbital	iv.	0 to (n–1)

3. Match the following

	List-I		List-II		List-III
a.	2s	p.	DOUGHNUT shape	i.	along z-axis
b.	$2p_x$	q.	Spherical	ii.	In between x & y-axis
c.	$3d_{xy}$	r.	Dumb bell	iii.	non-directional
d.	$3d_{z^2}$	s.	Double dumb bell	iv.	along x-axis

4. Match the following

List-I	List-II
a. 2s	p. Two nodal planes
b. ψ^2	q. One radial node
c. Heisenberg's uncertainty	r. Electron probability density principle
d. $3d_{yz}$	s. Microscopic particles

Ans.: 1. a. (s), b. (p), c. (q), d. (q)

2. a. (q). (ii), b. (s). (iv), c. (r). (i), d. (p). (iii)

3. a. (q). (iii), b. (r). (iv), c. (s). (ii), d. (p).(i)

4. a. (q), b. (r), c. (s), d. (p)

ASSERTION AND REASON TYPE QUESTIONS

Directions: (Questions 1 to 10)

A. Both Assertion & Reason are true and the reason is the correct explanation of the assertion.

B. Both Assertion & Reason are true but the reason is not the correct explanation of the assertion.

C. Assertion is true statement but Reason is false.

D. Assertion is false but Reason is true.

1. **Assertion :** Number of orbitals in 3rd shell is 9.
   Reason : Number of orbitals for a particular value of $n = n^2$.

2. **Assertion :** Two nodal planes are present in $3d_{xy}$.
   Reason : Number of nodal planes = 1

3. **Assertion :** The energy of an electron is largely determined by its principal quantum number.
   Reason : The principal quantum number is a measure of the most probable distance of finding the electrons around the nucleus.

4. **Assertion :** An orbital cannot have more than two electrons, moreover, if an orbital has two electrons they must have opposite spins.

   Reason : No two electrons in an atom can have same set of all the four quantum numbers.

5. Assertion: Black body is an ideal body that emits and absorbs radiations of all frequencies.

   Reason: The frequency of radiation emitted by a body goes from a lower frequency to higher frequency with an increase in temperature.

6. Assertion: 2p orbitals do not have any radial nodes.

   Reason: The number of radial nodes in p-orbitals is given by (n-2) where n is the principal quantum number.

7. Assertion: The opposite lobes of a p-orbital have opposite sign whereas opposite lobes of d-orbital have the same sign.

   Reason: The opposite lobes of a p-orbital have opposite charge whereas the opposite lobes of d-orbital have the same charge.

8. Assertion: Electronic configurations of Cr^{3+} (containing 21 electrons) is same as that of Sc(Z=21) i.e., isoelectronic species have the same electronic configuration.

   Reason: Orbitals of atoms are filled in order of increasing energy following aufbau principle.

9. Assertion: Hydrogen has one electron in its orbit but it produces several spectral lines.

   Reason: There are many excited energy levels available.

10. Assertion: The free gaseous Cr atom has six unpaired electrons.

    Reason: Half-filled d-orbitals have greater stability.

Ans. 1. A 2. A 3. A 4. A 5. B 6. D 7. C 8. D 9. A 10. A

ONE WORD ANSWER TYPE QUESTIONS

1. Write the name of the theory which explain the wave nature of light.
2 Write the name of the theory which explain the Black body radiations and photo electric effect
3 If the length of the crest of a wave is 4 pm. Write the wavelength of this wave. [Ans.8 pm]
4. A radiation emitted from a hot iron is photon or quantum ?
5. Out of the d orbitals which does not have four lobes ?
6. What is the lowest value of n that allows g orbitals to exist ?
7. Which quantum number is not obtained from solution of Schrödinger wave equation ?
8. Which of the following orbitals are possible ?

   1p, 2s, 2p and 3f
9. Write the name of non-directional subshell.
10. Write the name of quantum number which determines the orientation of orbitals ?
11. Write the name of quantum number which determines the shape of orbitals.
12. How many orbitals are present in 'g' subshell ?

1-MARK QUESTIONS

1 Write the relation between frequency and wave number.
2 Cs shows maximum photoelectric effect, why ?
3 Distinguish between a photon and a quantum.
4 The line spectrum of an element is known as fingerprints of its atom. Comment.
5 What is the value of the Bohr's radius for the third orbit of hydrogen atom?
6 What type of metals are used in photoelectric cell ? Give one example.
[**Ans.** With large size, less work function.]
7 Which series of lines of the hydrogen spectrum lie in the visible region'?

8. What is uncertain in uncertainty principle ?
9. Can a moving cricket ball have a wave character ? Justify your answer.
10. Heisenberg uncertainty principle has no significance in our everyday life. Explain.
11. Why uncertainty in position is more when uncertainty in velocity is less for an electron ?
12. What are the four quantum numbers of 19th electron of copper ?

    (Given : Atomic number of copper = 29)
13. How many electrons will be present in the sub-shells having ms, value of – 1/2 for n = 4 ?
14. Write the electronic configuration of Ni^{3+}. (At. No. of Ni = 28)
15. How many radial and angular nodes are present in 2p orbital.
16. Mention the physical significance of Ψ and Ψ^2.

[**Ans.** Radial nodes = 0, Angular nodes = 1]

2-MARKS QUESTIONS

Q. 1. Define black body and black body radiations.

Q. 2. Give the essential postulates of Bohr's model of an atom. How did it explain ?

(i) the stability of the atom ?

(ii) origin of the spectral lines in H-atom ?

Q. 3. What is quantisation ? How quantisation of energy was introduced in Bohr's model ?

Q. 4. What transition in the hydrogen spectrum would have the same wavelength as the Balmer transition $n = 4$ to $n = 2$ of He^+spectrum?

[**Ans.** $n_1 = 1$ and $n_2 = 2$]

Q. 5. What transition of Li^{2+} spectrum will have the same wavelength as that of the second line of Balmer series in He^+spectrum ?

[**Ans.** $n_2 = 6$ to $n_1 = 3$]

Q. 6. Calculate the energy required for the process

$$He^+(g) \longrightarrow He^{2+}(g) + e^-$$

The ionization energy for the H atom in the ground state is 2.18×10^{-18} J atom^{-1}] [**Ans.** 8.72×10^{-18} J]

Q. 7. Calculate the wave number for the longest wavelength transition in the Balmer series of atomic hydrogen. [**Ans.** 1.523×10^{6} m^{-1}]

Q. 8. To which orbit the electron in H atom will jump on absorbing 12.1 eV energy ? [**Ans.** 3rd orbit]

Q. 9. Calculate the energy associated with the first orbit of He^{+}. What is the radius of this orbit? [**Ans.** – 54.38 eV, 0.2645 Å]

Q. 10. What is the distance of separation between 3rd and 4th orbit of H-atom ? [**Ans.** 3.703 Å]

Q. 11. The energy of electron in the first Bohr's orbit is – 13.6 eV. Calculate the energy of electron in the first excited state. [**Ans.** – 3.4 eV]

Q. 12. Calculate the number of protons emitted in 10 hours by a 60 W sodium lamp emitting radiations of wavelength 6000 Å.

Q. 13. Which one has a higher energy, a photon of violet light with wavelength 4000 Å or a proton of red light with wavelength 7000 Å ?

[Given. $h = 6.62 \times 10^{-34}$ J sec.]

Q. 14. A 100 watt bulb emits monochromatic light of wavelength 400 nm. Calculate the number of protons emitted per second by the bulb.

[**Ans.** 2.012×10^{20} s^{-1}]

Q. 15. What are the maximum number of emission lines when the excited electron of a H atom in $n = 4$ drops to the ground state ? [**Ans.** 6]

Q. 16. Which has more energy, light radiation of wavelength 400 pm or light radiation of frequency 10^{15} Hz ?

Q. 17. Find the energy of electron in 4th shell of Li^{2+} ion.

Q. 18. What is the wave number of an electron with shortest wavelength radiation in Lyman spectrum of He^{+} ion?

Q. 19. Write short note on :

(a) Continuous and discontinuous spectrum.

(b) Absorbtion and emission spectrum.

Q. 20. Calculate the mass of the photon with wavelength of 3.6 Å.

[**Ans.** 6.135×10^{-29} kg]

Q. 21. Calculate the mass of the photon with wavelength of 5 pm.

Q. 22. On the basis of uncertainty principle show that an electron cannot exist with in atomic nucleus. *(Given : Nuclear radius = 10^{-15} m)*

[***Hint :*** *Taking 10^{-15} m as Δx, the Δv comes much higher than the velocity of light and hence is not possible*]

Q. 23. Explain why the uncertainty principle is significant only from the motion of subatomic particles and is negligible for macroscopic particles?

Q. 24. List two differences between orbit and orbital .

Q. 25. Show that the circumference of the Bohr orbit for the hydrogen atom is an integral multiple of the de Broglie wavelength associated with the electron revolving around the orbit

Q. 26. Comment on "Bohr's model is against the Heisenberg uncertainty principle".

Q. 27. What are the similarities and difference in 2*s* and $2p_x$ orbitals and 1s and 2*s* orbitals ?

Q. 28. Draw shape of $d_{x^2-y^2}$ orbital.

Q. 29. On the basis of Pauli's exclusion principle show that the maximum number of electrons in the M -shell ($n = 3$) of any individual atom is 18.

Q. 30. Designate each subshell with $n = 4$.

Q. 31. List the possible values for all the quantum numbers for the following subshell.

(a) 2*p* (b) 4*f*

Q. 32. Write down the electronic configuration of Fe^{3+} and Ni^{2+}. How many unpaired electrons are present? (Given Atomic number, Fe = 26, Ni = 28).

Q. 33. Out of principal, angular, magnetic and spin quantum number, which quantum number determines the ?

(a) Shape of the orbital
(b) Number of orbitals in an orbit
(c) Size of the orbital
(d) Spin orientation of the electron.

Q. 34. What is the Hund's rule of maximum multiplicity ? Explain with suitable example.

Q. 35. Explain why :

(a) The three electrons present in 2p subshell of nitrogen remain unpaired.

(b) Cr has configuration $3d^5\,4s^1$ and not $3d^4\,4s^2$.

Q. 36. (a) What is difference between '*l*' and 'L'?

(b) Nitrogen has 7 proton, 7 electron and 7 neutrons. Calculate the number of electron, protons and neutrons in N^{3-} ion.

Q. 37. Which one is having higher energy?

(a) Last electron of Cl^- or last electron of O^{2-}.

(b) $n = 4, l = 3$ or $n = 5, l = 2$.

3-MARKS QUESTIONS

Q. 1.(i) The energy associated with the first orbit in the hydrogen atom is -2.18×10^{-18} J atom^{-1}. What is the energy associated with the fourth orbit ?

(ii) Calculate the radius of Bohr's third orbit for hydrogen atom.

[**Ans.–** 1.36×10^{-19} J atom^{-1} .4.761 nm]

Q. 2. A bulb emits light of wave length 4500Å. The bulb is rated as 150 watt and 8% of the energy is emitted as light. How many photons are emitted by the bulb per second ? [**Ans.** $n = 27.2 \times 10^{18}$]

Q. 3. When light with a wavelength of 400 nm falls on the surface of sodium, electrons with a kinetic energy of 1.05×10^5 J mol^{-1} are emitted.

(a) What is the minimum energy needed to remove an electron from sodium ?

(b) What is the maximum wavelength of light that will cause a photoelectron to be emitted ?

[**Ans.** $a = 3.2255 \times 10^{19}$ J, $b = 616$ nm]

Q. 4. Compare the frequency of light radiations emitted when electron falls from 5th shell to the 2nd shell in Li^{2+} ion and electron falls from 4th shell to the 1st shell in He^+ ion.

Q. 5. Calculate the number of waves made by Bohr electron in one complete revolution in its third orbit. [**Ans.** 3]

Q. 6. What should be the ratio of velocities of CH_4 and O_2 molecules so that they are associated with de Broglie waves of equal wavelength ? [**Ans.** 2]

Q. 7. Calculate the wavelength of an electron that has been accelerated in a particle accelerator through a potential difference of 1 kv.

[Given 1eV = 1.6 × 10^{-19} J] [**Ans.** 3.87 × 10^{-11} m]

Q. 8. (i) Discuss the similarities and differences between a 1s and 2s orbital.

(ii) Draw the shape of d_{z^2} .

Q. 9. Calculate the wavelength of a tennis ball of mass 60 gm moving with a velocity of 10 m per second. *(h = 6.626 × 10^{-34} kg m^2 s^{-1})*

[**Ans.** 10^{-3} metre]

Q. 10. Calculate the wavelength of 1000 kg rocket moving with a velocity of 3000 km/hr. *(h = 6.626 × 10^{-34} kg m^2 s^{-1})*

[**Ans.** 7.9512 × 10^{-40} m]

Q. 11. Calculate the uncertain it in the velocity of a cricket ball of mass 150 g, if uncertainity in its position is of the order of 1 Å.

[**Ans.** 3.5 × 10^{-24} m s^1]

Q. 12. (a) What is de-Broglie wavelength for an electron moving with velocity of light?

(b) What is the angular momentum of electron in 5th shell?

Q. 13. Two particles A and B have wavelength $\lambda_A = 5 \times 10^{-10}$ m and $\lambda_B = 10 \times 10^{10}$ m. Find their frequency, wave number and energies. Which has more penetrating power and why ?

Q. 14. (a) Which has max. uncertainty regarding position and why ?

Electron, proton and neutron.

(b) Find the number of waves associated with a light radiation of time period 5 ns.

Q. 15. If an electron in He^+ has angular momentum of $5h/2\pi$. Find its energy and wavelength associated with it. Find the kinetic energy of this electron.

Q. 16 .(i) An atomic orbital has $n = 2$. What are the possible values of l and m_l ?

(ii) List the quantum numbers (m_1 and l) of electrons for 3*d* orbital.

(iii) Which of the following orbitals are possible ?

2*d*, 1*s*, 2*p* and 3*f*.

Q. 17. (a) Write the maximum number of electron in a subshell with $l = 3$ and $n = 4$.

(b) Write the maximum number of electron that can be associated with the following set of quantum numbers ?

$n = 3$, $l = 1$ and $m_l = -1$

(c) Write the maximum number of electron that can be accomodated in an atom in which the highest principal quantum number value is 4.

Q. 18. (i) Write the electronic configurations of the following ions :

(a) H^- (b)Na^+ (c)O^{2-} (d) F^-

(ii) What are the atomic numbers of elements whose outermost electrons are represented by (a) $3s^1$(b) $2p^3$ and (c) $3p^5$?

(iii) Which atoms are indicated by the following configurations ?

(a) [He] $2s^1$ (b) [Ne] $3s^2\ 3p^3$ (c) [Ar] $4s^2\ 3d^1$.

Q. 19. Calculate:

(a) Total number of spherical nodes in 3*p* orbital.

(b) Total number of nodal planes in 3*p* orbital.

(c) Nodal planes in 3*d* orbital.

5-MARKS QUESTIONS

Q. 1.(a) Define Photoelectric effect ? Mention its one practical application in daily life.

(b) Electrons are emitted with zero velocity from a metal surface when it is exposed to radiation of wavelength 6800 Å. Calculate threshold frequency (ν_o) and work function (W_o) of the metal.

[**Ans.** $\nu_o = 4.41 \times 10^{14}\ s^{-1}$ $W_o = 2.92 \times 10^{-19}$ J]

Q. 2.(a) The electronic energy in Bohr's orbit is negative .How will you account for it?

(b) The ionisation energy of hydrogen atom is 13.6 eV. What will be the energy of the first orbit of He^+ and Li^{2+} ions ?

[**Ans.** E_1 of $He^+ = -54.4$ eV, E_1 of $Li^{2+} = -122.4$ eV]

Q. 3.(a) Define the following terms :

(i) Threshold frequency (ii) Work function.

(b) The work function for C*s* atom is 1 .9 eV. Find threshold wavelength (λ_0)and threshold frequency (ν_0) of this light radiation. If C*s* metal is irradiated with a radiation of wavelength 500 nm find kinetic energy and velocity of emitted electron.

Q. 4.(a) State de Broglie equation. Write its significance.

(b) A beam of helium atoms moves with a velocity of 2.0×10^3 m s^{-1}. Find the wavelength of the particle constituting the beam

($h = 6.626 \times 10^{-34}$ J s) [**Ans.** 49.9 pm]

Q. 5.(a) State Heisenbergs uncertainty principle. Give its mathematical expression. Also give its significance.

(b) Calculate the uncertainity in the position of a dust particle with mass equal to 1 mg if the uncertainity in its velocity is $5.5 \times 10^{-20} ms^{-1}$.

[**Ans.** 9.55×10^{10} m]

Q. 6.(a) Cricket ball, a tennis ball and a proton which has more uncertainity in velocity and which follows Heisenberg uncertainity principle maximum.

(b) What is the similarity in de-Broglie and Heisenberg principle? Which is different from Bohr theory for structure of atom?

(c) Why energy in a given subshell is negative?

Q. 7.(a) Write short notes on:

(i) Aufbau principle (ii) Pauli's principle (iii) Hund's rule.

(b) Write the electronic configuration of the following ions :

(i) Fe^{3+} (ii) Cu^{+} [Given Atomic number of Fe and Cu are 26 & 29]

Q. 8.(a) Draw the shapes of the following orbitals.

(i) $3d_{xy}$ (ii) d_{z^2}

(b) What is the total number of orbitals associated with the principal quantum number $n = 3$?

(c) Using s, p, d, f notations, describe the orbital with the following quantum numbers:-

(a) $n = 3$, $l = 0$, (b) $n = 4$, $l = 2$, (c) $n = 5$, $l = 3$, (d) $n = 1$, $l = 0$

Q .9. Explain the following :

(i) Energy of electron is not decided by : n, l ,m and s.

(ii) Maximum number of electron with – 1/2 spin for $n = 3$ is 6,9,12 or none.

(iii) Maximum number of electron can be present for $n + l = 4$.

(iv) $3f$ subshell is not possible.

(v) Maximum number of electrons in a subshell is :

$(2l + 1)$ or $(4l + 1)$ or n^2

Q. 10.(a) A neutral atom has 2K, 8L and 15 M electrons. Find the total numbers of electrons in s, p, d and f subshell.

(b) How many unpaired electrons are present in the following ions :

Al^{+}, Cr^{2+}, Co^{3+} and Mn^{2+}

(Given Atomic number : Al=13, Cr = 24, Co = 27 & Mn = 25)

(c) One electron is present in 4f subshell. What is the sum of $n + l + m_1 + m_s$ values assuming 'f' subshell follows – 3 to + 3 order of filling electron.

Q. 11. Answer the following :

(a) $n + l$ value for 14^{th} electron in an atom.

(b) Increasing order of filling electron in $4f$, $5p$ and $6d$ subshells.

(c) 'm' and 'l' value for last electron of Mg atom.

(Given atomic number of Mg is 12)

(d) Subshell in which last electron is present in Ga.

(Given Atomic number of Ga is 31)

(e) Sum of spin of all the electron in element having atomic number 14.

UNIT TEST-I

Time allowed : 1 Hour **Maximum Marks : 20**

General instructions :

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

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1. Designation for an orbital with $n = 4$ and $l = 3$ is (1)

   (a) 4s (b) 4p (c) 4d (d) 4f

2. Maximum number of unpaired electrons in chromium is (1)
   (Given: Atomic number of Cr = 24)

   (a) 4 (b) 5 (c) 6 (d) 7

3. Which series of lines of the hydrogen spectrum lie in the visible region'? (1)

4. Why de-Broglie's wavelength is not significant for macroscopic objects.(1)

5. Which of the following is not possible ?

   (a) 2p (b) 3d (c) 3f (d) 4p (1)

6. Write two difference between orbit and orbital. (2)

7. Calculate the wave number for the longest wavelength transition in the paschen series of atomic hydrogen. (2)

8. (a) How many orbitals are associated with $n = 4$? (3)

   (b) How many electrons will be present in the sub-shells having ms value of $-1/2$ for $n = 3$?

   (c) Draw the shape of d_z^2.

9. Calculate the uncertainty in the position of a dust particle with mass equal to 1 mg if the uncertainty in its velocity is 5.5×10^{-20} ms^{-1}. (3)

10. (i) The energy associated with the first orbit in the hydrogen atom is -2.18×10^{-18} J $atom^{-1}$. What is the energy associated with the fifth orbit?

    (ii) Calculate the radius of Bohr's fifth orbit for hydrogen atom.

    (iii) Calculate the radial and angular nodes in 2p orbital.

    (iv) Define the black body and black body radiations. (5)

UNIT TEST-II

Time allowed : 1 Hour **Maximum Marks : 20**

General instructions :

(i) All questions are compulsory.

(ii) Maximum marks carried by each question are indicated against it.

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1. The de-Broglie wavelength associated with a ball of mass 1 kg having kinetic energy 0.5 J is (1)

   (a) 6.626×10^{-34} m (b) 13.20×10^{-34} m

   (c) 10.38×10^{-21} m (d) 6.626×10^{-34} Å

2. The radius of which of the following orbit is same as that of first orbit of hydrogen atom? (1)

   (a) He^{+} (n = 2) (b) Li^{2+} (n = 2) (c) Li^{2+} (n = 3) (d) Be^{3+} (n = 2)

3. Which series of hydrogen spectrum lies in the UV region'? (1)

   In following questions a statement of Assertion followed by a statement of Reason is given. Choose the correct answer out of the following choices.

   (a) Assertion and Reason are true and Reason is the correct explanation of Assertion.

   (b) Assertion and Reason are true but Reason is not the correct explanation of Assertion.

   (c) Assertion is true but Reason is false.

   (d) Both Assertion and Reason are false.

4. **Assertion :** It is impossible to determine the exact position and exact momentum of an electron simultaneously.

   Reason : The path of an electron in an atom is clearly defined. (1)

5. **Assertion :** All isotopes of a given element show the same type of chemical behaviour.

   Reason : The chemical properties of an atom are controlled by the number of electrons in the atom. (1)

6. Calculate the number of angular nodes and radial nodes in 3p orbital. (2)

7. Calculate the mass of photon with wavelength 3.6A°. (2)

8. What transition in the hydrogen spectrum would have the same wavelength as the Balmer transition n = 4 to n = 2 of He^+ spectrum? (3)

9. (a) The energy associated with Bohr's first orbit is -2.18×10^{-18} J $atom^{-1}$. What is the energy associated with fifth orbit?

   (b) The work function for Caesium atom is 1.9eV. Calculate the threshold wavelength.

   [Given : lev = 1.6×10^{-19} J]

   (c) How many sub-shells are associated with n = 4? (1×3=3)

10. (i) How many electrons will present in sub-shell having spin quantum number value of –½ for n = 4?

   (ii) Which of the following transition will have minimum wavelength and why?

   $n_4 \rightarrow n_1$, $n_4 \rightarrow n_2$, $n_2 \rightarrow n_1$

   (iii) Give the number of radial nodes for 3s and 2p orbitals. (5)

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