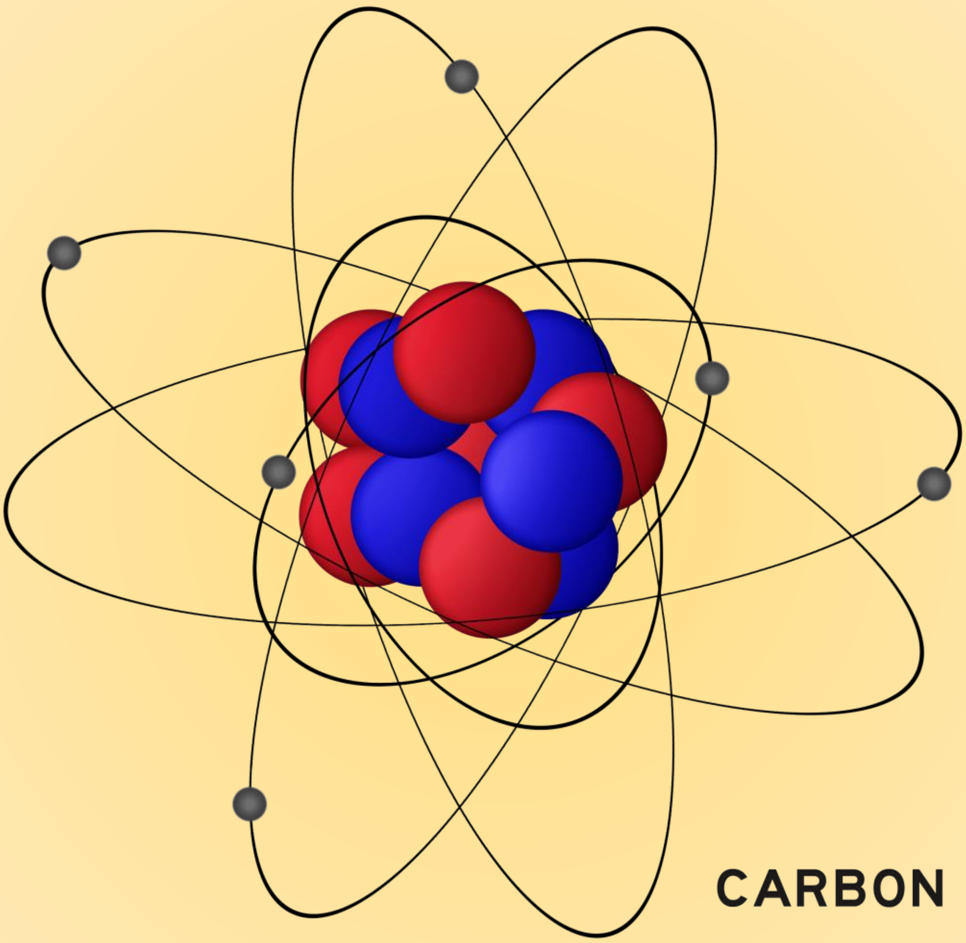
2. STRUCTURE OF ATOM



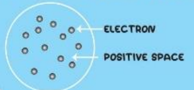
Chemistry Smart Booklet

Theory + NCERT MCQs + NEET PYQs

STRUCTURE OF ATOM

J.J. THOMSON

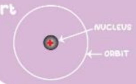
- Discovered electron(e^-)
- Proposed Plum Pudding Model



- e^-: Charge of an e^- = -1.6022×10^{-19} C; Mass of an e: 9.1×10^{-31} kg
- P^+: Charge of a proton P^+ = $+1.6 \times 10^{-19}$ C; Mass of an P: 1.6×10^{-27} kg
- Neutron: Discovered by James Chadwick. Charge on Neutron is 0; Mass of an Neutron is 1.6×10^{-27} kg

ERNEST RUTHERFORD

- Discovered proton (P^+)
- α-partical experiment
- Proposed Rutherford's model of an atom (1911)
- Atom consist of two parts nucleus and extra nucleus part



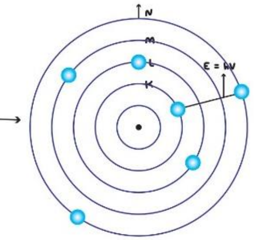
BOHR'S MODEL OF AN ATOM

- Electron in H atom can move around the nucleus in a circular path of fixed radius
- Each orbits has a definite energy known as energy level or stationary levels.
- When an electron jumps from a lower energy level to to higher one, energy is absorbed.
- Angular momentum of electron = $m_e v_r = n \frac{h}{2\pi}$ n = 1, 2, 3

Radius = r = $0.529 \times \frac{n^2}{z}$ Å Energy = E = $-1.36 \times 10^6 \times \frac{z^2}{n^2}$ J/mol

Velocity = v = $2.18 \times 10^8 \times \frac{z}{n}$ cm/sec

STATIONARY STATES



LIMITATION

- Applicable on only one e^- system eg: H, He^+
- If could not able to explain dual nature of n atom

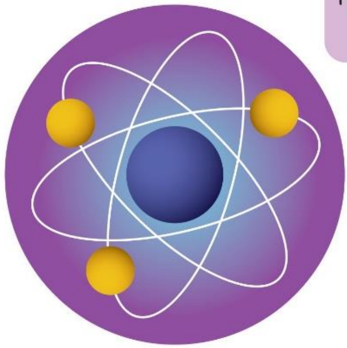
NODES

Space or region, wher finding the probability of e^- is zero

TYPES:-
- Radial node = (N – l –1)
- Angular node = l
- Total node = N – 1

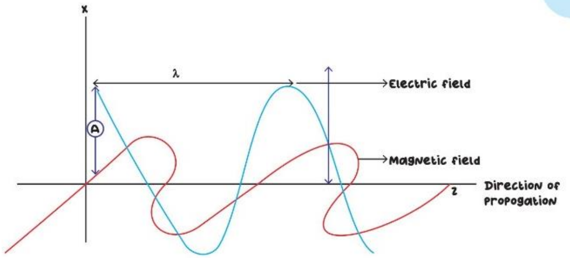
SERIES

Lyman: n_1 = 1, n_2 = 2, 3...
Balmer: n_1 = 2, n_2 = 3, 4...
Paschen: n_1 = 3, n_2 = 4, 5
Bracket: n_1 = 4, n_2 = 5, 6



ELECTRO-MAGNETIC WAVE THEORY

- Wavelength: Distance between successive crest or trough
- Frequency: Number of waves passed through a point in 1 sec.



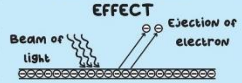
PLANK'S CONSTANT (H)

e = hν
h = 6.623×10^{-34} JS

Found by H. Hertz

PARTICLE NATURE OF ELECTRON MAGNETIC RADIATITION

PHOTOELECTRIC EFFECT



KINETIC ENERGY OF EJECTED e^-

$h\nu = h\nu_0 + \frac{1}{2} m_e v^2$

$E = h\nu_0$ + K.E.

BLACK BODY RADIATION

A PERFECT OBSORBER OR EMITTER OF LIGHT. I.E ABSORBER OR EMITS ALL TYPE OF FREQUENCY/ radiation

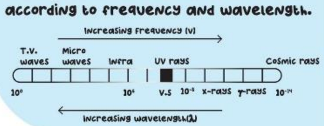
CHARACTERISITICS OF WAVE

(a) Wavelength (λ)
(b) Wave no. ($\bar{\nu}$)
(c) Frequency (v)
(d) Time Period (T)
(e) Velocity (c)
(f) Amplitude (a)

$\lambda = \frac{c}{v}$

ELECTRO-MAGNETIC SPECTRUM

Electromagnetic spectrum is a collection ofall electromagnetic waves arranged according to frequency and wavelength.



ATOMIC SPECTRA

Spectrum of the electromagnetic radiation emitted or absorbed by an electron during transition from one energy level to another

$\bar{v} = 109677 \left(\frac{1}{N_1^2} - \frac{1}{N_2^2}\right)$ cm^{-1}

EMISSION SPECTRA

Spectrum of tansition emitted by a substance that has absorbed energy

ABSORPTION SPECTRA

It is like photographic negative of an emission spectra

TOWARDS QUANTUM MECHANICAL MODEL

DUAL NATURE OF MATTER

- Every material particle in the motion has dual nature (wave and particle nature)
- de-Broglie's wavelength

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

HEISENBERG'S UNCERTAINITY PRINCIPLE

- Every material particle in the motion has dual nature (wave and particle nature)
- de-Broglie's wavelength

$\Delta x \cdot \Delta p \geq \frac{h}{4\pi}$

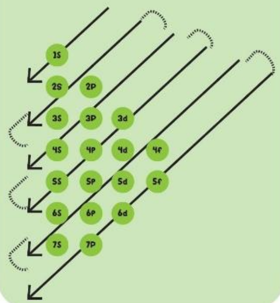
QUANTUM MECHANICS

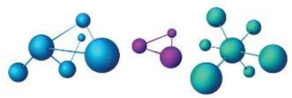
- Fundamental equation was developed by Schrodinger know as Schrodinger wave equation.

$$\left[\frac{d^2\psi}{dx^2} + \frac{d^2\psi}{dy^2} + \frac{d^2\psi}{dz^2} + \frac{8\pi^2 m}{h^2}(E - V)\psi = 0\right]$$

- The electrons in an atom have quantized values of energy.
- By evaluating ψ^2 at different points around the nucleus in a atom, we can predict the probability of finding the electron is maximum.

ENERGY LEVEL



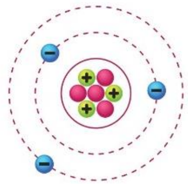


QUANTUM NUMBER

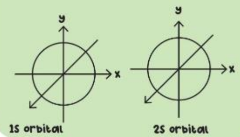
1. Principle quantum No.: n = 1, 2, 3, 4... Shell = K, L, M, N
2. Azimuthal Quantum No.: l = for given value of N, l = 0 to N – 1)
3. Magnetic quantum No.: m = for subshells with 'l' value. ml = 2l + 1
4. Spin quantum number = S = $+\frac{1}{2}$ (↑), $-\frac{1}{2}$ (↓)

RULES FOR ARRANGING ELECTRON

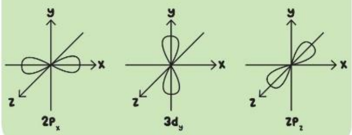
(a) Aufbau principle: Electron occupy lowest energy level available
(b) Pauli Exclusion principle: No two e^- can have same set of 4 quantum numbers.
(c) Hund's rule: If two or more orbitals of equal energy available, then electron will occupy them singly before filled in pairs.



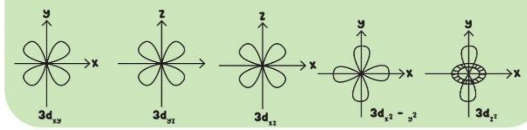
SHAPE OF ORBITALS



P ORBITAL (DUMBELL SHAPE)



D ORBITALS



STRUCTURE OF ATOM

Introduction:

The word "atom" has been derived from the Greek word 'atoms' which mans '**indivisible**'. These early ideas were mere speculation and there was no way to test them experimentally.

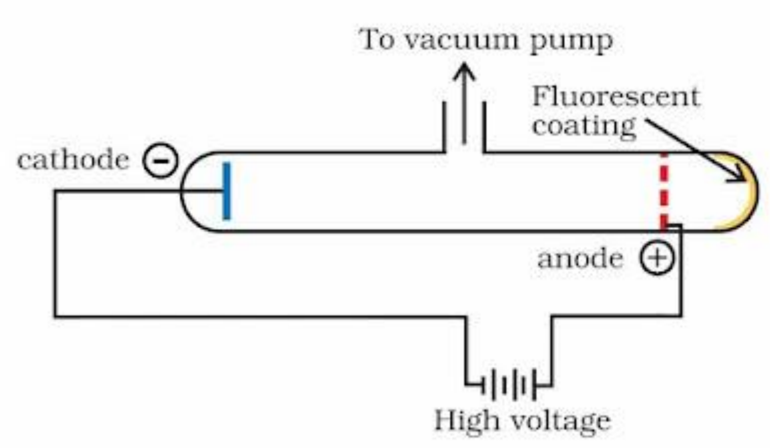
Atomic Structure:

Atom is made up of smaller units like proton, neutron and electron. Some other particles like positron, neutrino, antineutrino, π-meson, μ-meson, k meson etc are also present which are very short lived.

Particle	Mass	Charge	Special Remark
Electron	9.1×10^{-31} kg	-1.6×10^{-19} C	Discovered by J.J. Thomson
Proton	1.67×10^{-27} kg	$+1.6 \times 10^{-19}$ C	Discovered by Gold Stein
Neutron	1.67×10^{-27} kg		Discovered by Chadwick
Positron		$+1.6 \times 10^{-19}$	Anderson
π meson	π° - 264 Me π^{+} - 273 Me π– 273 Me		Yukawa

Discovery of Electron

In 1879, **William Crooks** studied the conduction of electricity through gases at low pressure. He performed the experiment in a discharge tube which is a cylindrical hard glass tube about 60 cm in length. It is sealed at both the ends and fitted with two metal electrodes. The electrical discharge through the gases could be observed only at very low pressures and at very high voltages.



J.J. Thomson took a discharge tube and applied a voltage of a 10000 volt potential difference across it at a pressure of 10–2 mm of Hg. He found some glowing behind anode. It means some invisible rays produced at cathode strike behind anode and produce fluorescence. He named them cathode rays.

Properties of Cathode Rays

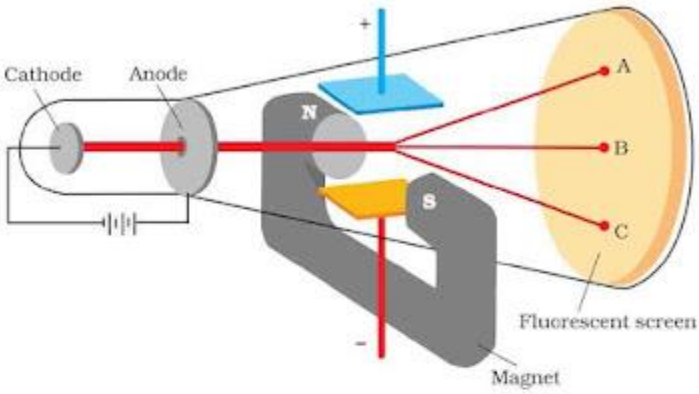
i. These rays have mechanical energy and travel in straight line.
ii. These rays are deflected towards positive plate of electric field. It means these are made up of negatively charged particle called **electron**.
iii. Colour observed is independent from nature of gas.
iv. Mulliken determined the charge on electron which is 1.602×10^{-19}C.
v. Specific charge on electron is calculated by J.J. Thomson.

Charge to mass ratio

J.J. Thomson for the first time experimentally determined charge/mass ratio called e/m ratio for the electrons. For this, he subjected the beam of electrons released in the discharge tube as cathode rays to influence the electric and magnetic fields. These were acting perpendicular to one another as well as to the path followed by **electrons**.

According to Thomson, the amount of deviation of the particles from their path in presence of electrical and magnetic field depends on,

1. Magnitude of the negative charge on particle
2. Mass of particle
3. Strength of magnetic field



When electric field is applied, deviation from path takes place. If only electric field is applied, cathode rays strike at A. If only magnetic field is applied, cathode rays strike at C. In absence of any field, cathode rays strike at B.

By carrying out accurate measurements on the amount of deflections observed by the electrons on the electric field strength or magnetic field strength, Thomson was able to determine the value of $e/m_e = 1.758820 \times 10^{11}$ C kg^{-1}

where me = Mass of the electron in kg

e = magnitude of charge on the electron in coulomb (C).

Discovery of anode rays

In 1886, Goldstein modified the discharge tube by using a perforated cathode. On reducing the pressure, he observed a new type of luminous rays passing through the holes or perforations of the cathode and moving in a direction opposite to the cathode rays. These rays were named as positive rays or anode rays or as canal rays. Anode rays are not emitted from the anode but from a space between anode and cathode.

Properties of anode rays

1. These rays deflect towards negative plate of applied electric field. It means these are made up of positively charged particle.
2. Property of anode rays depends on nature of gas.
3. These rays travel in straight line and have mechanical energy.

Discovery of Neutron

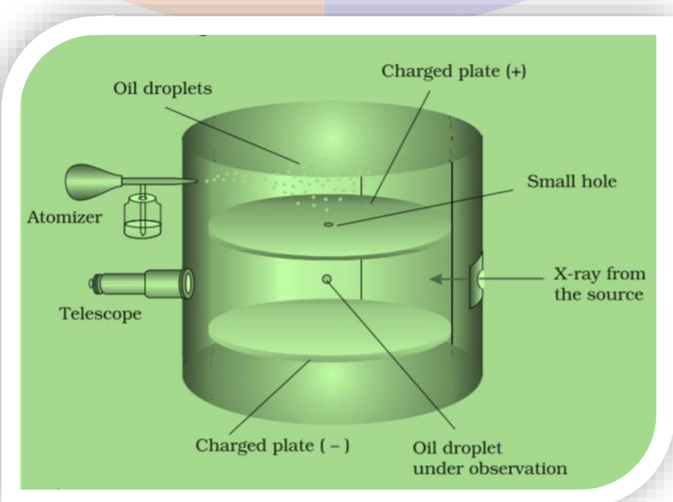
Chadwick in 1932 found the evidence for the production of neutron in given reaction.

$$_4Be^9 + {}_2He^4 \longrightarrow {}_6C^{12} + {}_0n^1$$

Neutron is chargeless particle and have mass equal to proton.

Millikan's Oil Drop Experiment

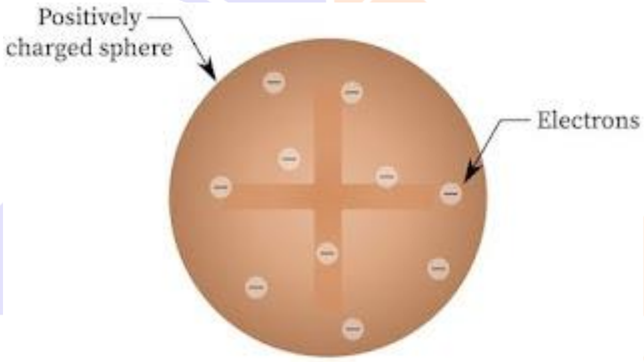
In this experiment, some fine oil droplets were allowed to enter through a tiny hole into the upper plate of electrical condenser. These oil droplets were produced by atomiser. The air in the chamber was subjected to the ionization by X-rays. The electrons produced by the ionization of air attach themselves to the oil drops.



Thus oil droplets acquire negative charge. When sufficient amount of electric field is applied, the motion of the droplets can be accelerated, retarded or made stationary. Millikan observed that the smallest charge found on them was –1.6 × 10–19 coulomb and the magnitude of electrical charge, q on the droplets is always an integral multiple of the electrical charge 'e' i.e., q = ne

Thomson's Model of Atom

J.J. Thomson in 1898, proposed a model of atom which looked more or less like plum pudding or raisin pudding. He assumed atom to be a spherical body in which electrons are unevenly distributed in a sphere having positive charge which balance the electron's charge. It is called Plum pudding model.

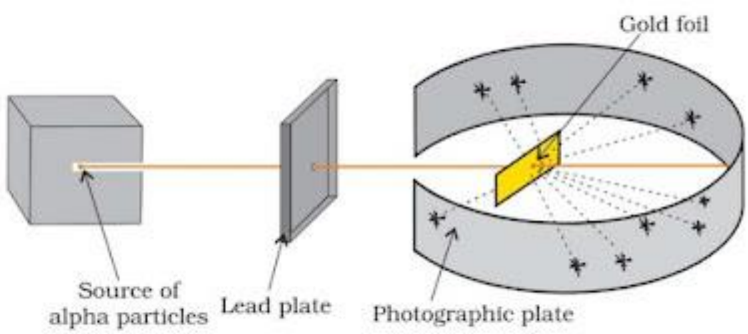


Important Feature of This Model: The mass of the atom is assumed to be uniformly distributed over whole atom.

Failure: This model was able to explain the overall neutrality of the atom, it could not satisfactorily, explain the results of scattering experiments carried out by Rutherford in 1911.

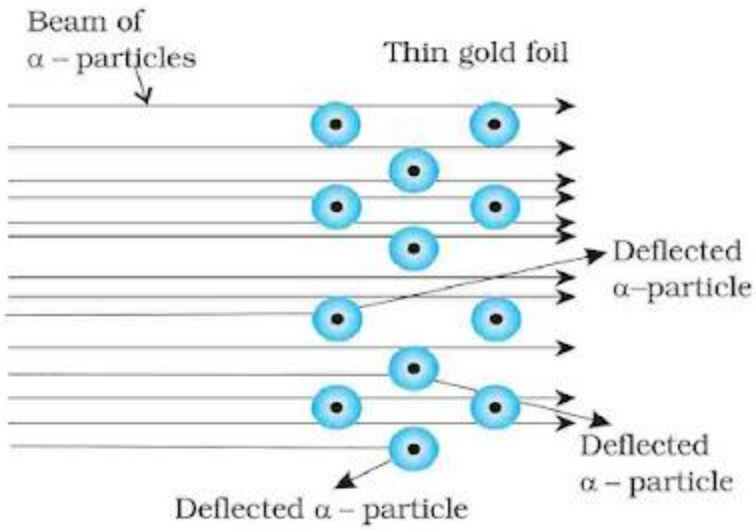
Rutherford's Model

Rutherford in 1911, performed some scattering experiments in which he bombarded thin foils of metals like gold, silver, platinum or copper with a beam of fast moving a-particles. The thin gold foil had a circular fluorescent zinc sulphide screen around it. Whenever a-particles struck the screen, a tiny flash of light was produced at that point.



From these experiments, he made the following observations:

1. Most of the α-particles pass without any deviation.
2. Few particles deviate with small angle.
3. Rare particles retrace its path or show deflection greater than 90°.



On the basis of these observation, he proposed a model.

1. Atom is of spherical shape having size of order 10–10 meters.
2. Whole mass is concentrated in centre called nucleus having size of order 10–15 meters.
3. Electron revolves around the nucleus in circular path like planets revolve around sun.

Limitation: This model could not explain stability of atom. According to Maxwell's classic theory, an accelerated charged particle liberates energy. So, during revolution, it must radiate energy and by following the spiral path it should comes on nucleus.

Atomic number

It is equal to the number of protons present in the nucleus of an atom. Atomic number is designated by the letter 'Z'. In case of neutral atom atomic number is equal to the number of protons and even equal to the number of electrons in atom.

Z = Number of protons (p) = Number of electrons (e)

Mass number

It is equal to the sum of the positively charged protons (p) and electrically neutral neutrons (n). Mass number of an atom is designated by the letter 'A'.

Mass number (A) = Number of protons (p or Z) + Number of neutrons (n)

Note: The atom of an element X having mass number (A) and atomic number (Z) may be represented by a symbol $_{Z}X^{A}$.

Isotopes

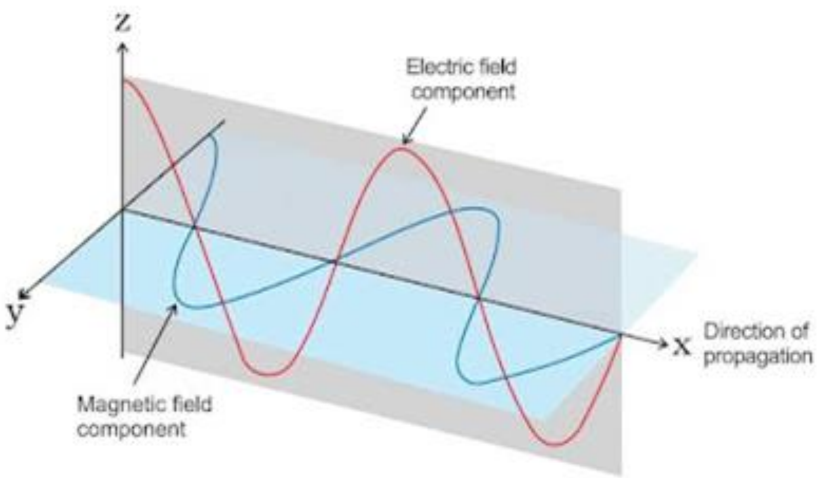
Atoms with identical atomic number but different atomic mass number are known as Isotopes. Isotopes of Hydrogen $_1H^1$, $_1H^2$ and $_1H^3$

Isobars

Isobars are the atom with the same mass number but different atomic number, for example $_6C^{14}$ and $_7N^{14}$

Electromagnetic Waves Theory

This theory was put forward by James Clark Maxwell in 1864. Electromagnetic Waves are the waves which are produced by varying electric field and magnetic field which are perpendicular to each other in the direction perpendicular to both of them.



The main points of this theory are as follows:

1. The energy is emitted from any source continuously in the form of radiations and is called the radiant energy.
2. The radiations consist of electric and magnetic fields oscillating perpendicular to each other and both perpendicular to the direction of propagation of the radiation.
3. The radiations possess wave character and travel with the velocity of light 3×10^8 m/sec.
4. These waves do not require any material medium for propagation. For example, rays from the sun reach us through space which is a non-material medium.

Characteristics of a Wave

Wavelength (λ): It is the distance between two consecutive crests or troughs and is denoted by λ.

Frequency (v): It is the number of waves passing through a given point in one second. The unit frequency is hertz or cycle per second.

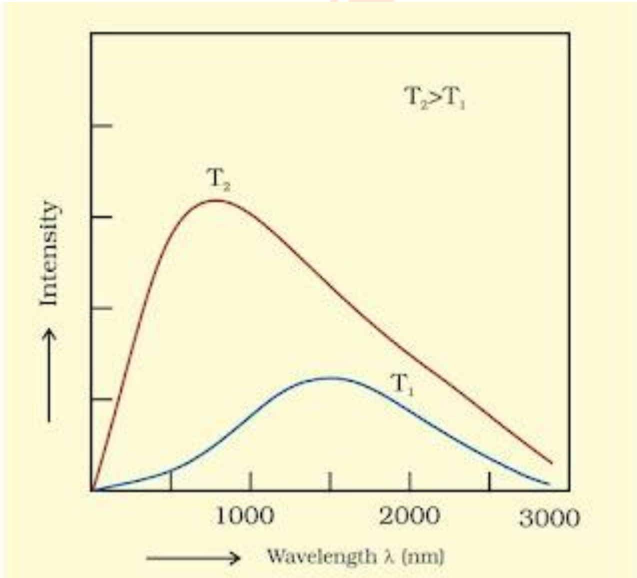
Wave number: It is the number of waves in a unit cycle. wave number =1λ=1λ

Velocity: Velocity of a wave is defined as the linear distance travelled by the wave in one second. It is represented by c and is expressed in m/sec.

Amplitude: Amplitude of a wave is the height of the crest or the depth of the through. It is represented by V and is expressed in the units of length.

Black Body Radiations

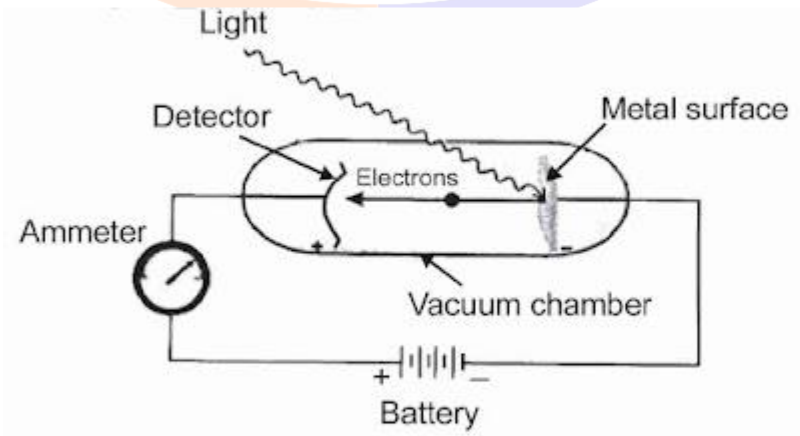
Black-body is an ideal body which emits and absorbs radiations of all frequencies. The radiation emitted by these bodies is called **black-body radiation**.



At a given temperature, the intensity and frequency of the emitted radiation depends is temperature. At a given temperature, the intensity of radiation emitted increases with decrease of wavelength.

Photoelectric Effect

When light of a suitable frequency is allowed to incident on a metal, ejection of electrons take place. This phenomenon is known as photo electric effect.



Observations in Photoelectric Effect

1. Only photons of light of certain minimum frequency called threshold frequency (v_0)

can cause the photoelectric effect. The value of v_0 is different for different metals.

2. The kinetic energy of the electrons which are emitted is directly proportional to the frequency of the striking photons and is quite independent of their intensity.
3. The number of electrons that are ejected per second from the metal surface depends upon the intensity of the striking photons or radiations and not upon their frequency.

Explanation of Photoelectric Effect

Einstein in (1905) was able to give an explanation of the different points of the photoelectric effect using Planck's quantum theory as under:

1. Photoelectrons are ejected only when the incident light has a certain minimum frequency (threshold frequency v_0).
2. If the frequency of the incident light (v) is more than the threshold frequency (v_0), the excess energy ($hv - hv_0$) is imparted to the electron as kinetic energy.
3. On increasing the intensity of light, more electrons are ejected but the energies of the electrons are not altered.

   K.E. of the ejected electron.

   $\frac{1}{2} mv^2 = hv - hv_0$

Planck's Theory

According to this theory, energy cannot be absorbed or released continuously but it is emitted or released in the form of small packets called quanta. In case of light this quanta is known as photon. This photon travels with speed of light. Energy of the photon is directly proportional to frequency.

$$E \propto v$$

$$E = hv$$

h is ***Planck's constant***, value is 6.62×10^{-34} Js

Bohr's Model

1. Niels Bohr in 1913, proposed a new model of atom on the basis of Planck's Quantum Theory. The main points of this model are as follows:
2. Atom is of spherical shape having size (of order 10^{-10} metre).
3. Whole mass is concentrated in centre called nucleus (having order of size 10^{-15} metre).
4. Electron revolves around nucleus only in limited circular path and he assumed that electron does not radiate energy during its revolution in permitted paths.
5. Only those orbits are allowed whose orbit angular momentum is integral multiple of h2πh2π.

6. mvr = nh/2π, where n = 1, 2, 3, 4...
7. When electron absorbs energy, it jumps to higher orbit and when it comes back, it radiates energy. This postulate explain spectra.

Achievements of Bohr's Theory

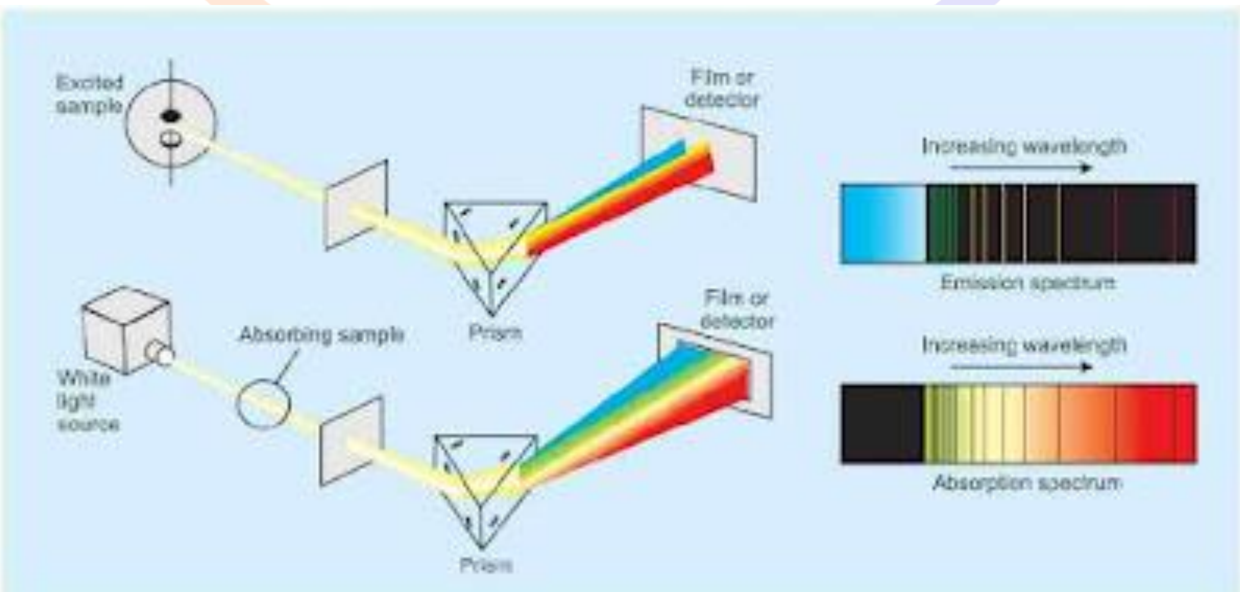
1. Bohr's theory has explained the stability of an atom.
2. Bohr's theory has helped in calculating the energy of electron in hydrogen atom and one electron species.
3. Bohr's theory has explained the atomic spectrum of hydrogen atom.

Limitations of Bohr's Model

1. The theory could not explain the atomic spectra of the atoms containing more than one electron or multielectron atoms.
2. Bohr's theory failed to explain the fine structure of the spectral lines.
3. Bohr's theory could not offer any satisfactory explanation of Zeeman effect and Stark effect.
4. Bohr's theory failed to explain the ability of atoms to form molecule formed by chemical bonds.
5. It was not in accordance with the Heisenberg's uncertainty principle.

Spectra

The most compelling evidence for the quantization of energy comes from spectroscopy. Spectrum word is taken from Latin word which means appearance. The record of the intensity transmitted or scattered by a molecule as a function of frequency or wavelength is called its spectrum.



Cosmic rays < gamma rays < x rays < ultraviolet rays < visible rays < infra red < micro waves < radio waves.

Line Spectrum of Hydrogen Atom

When electric discharge is passed through hydrogen gas enclosed in discharge tube under low pressure and the emitted light is analysed by a spectroscope, the spectrum consists of a large number of lines which are grouped into different series. The complete spectrum is known as hydrogen spectrum.

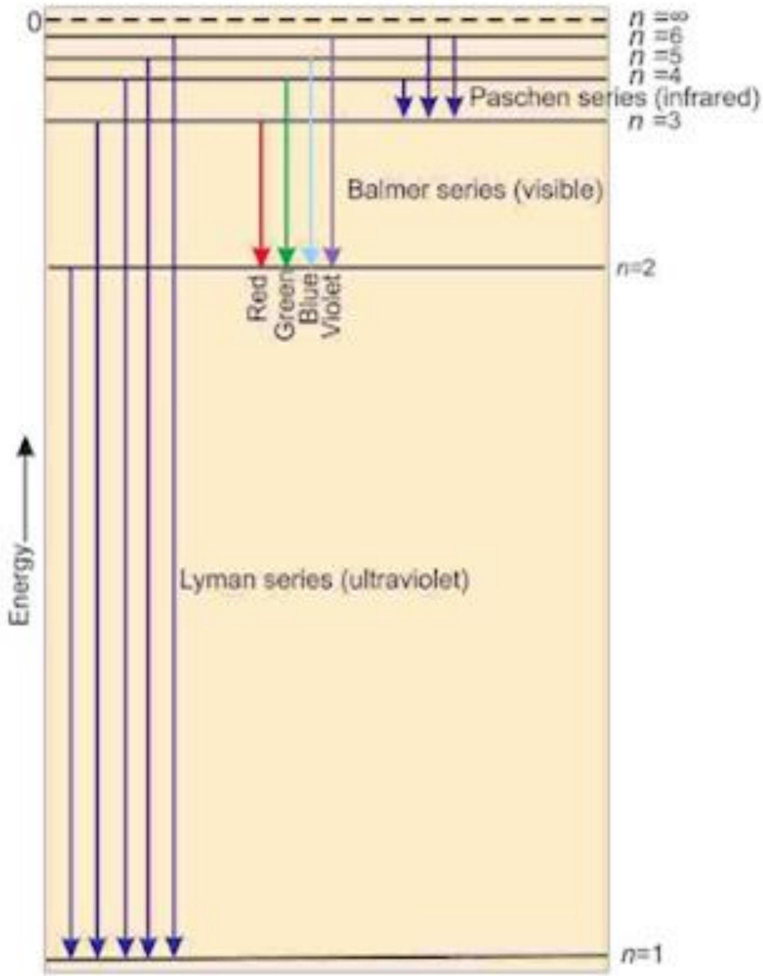
On the basis of experimental observations, Johannes Rydberg noted that all series of lines in the hydrogen spectrum could be described by the following expression:

wave number = 1λ = R(1n21 − 1n22)1λ = R(1n12 - 1n22)

R = Rydberg constant

R = 109678 cm^{-1}

Series	n_1	n_2	Spectral Region
Lyman	1	2,3....	Ultraviolet
Balmer	2	3,4....	Visible
Paschen	3	4,5....	Infrared
Brackett	4	5,6....	Infrared
Pfund	5	6,7....	Infrared



Zeeman Effect

When spectral line (source) is placed in magnetic field, spectral lines split up into sublines. This is known as zeeman effect.

Stark Effect

If splitting of spectral lines take place in electric field, then it is known as stark effect.

Dual Behaviour of Matter (de Broglie Equation)

De Broglie in 1924, proposed that matter, like radiation, should also exhibit dual behaviour i.e., both particle like and wave like properties. This means that like photons, electrons also have momentum as well as wavelength.

Assume light have wave nature, then its energy should be given by Planck's theory

$$E = h\nu E = h\nu \quad \ldots(i)$$

If it have particle nature, then its energy should be given by Einstein relation,

$$E = mc^2 \quad \ldots(ii)$$

On comparing equation (i) and (ii),

$$h\nu = mc^2$$

$$\lambda = hmc \text{ (for light)} \quad \ldots(iii)$$

For other matter,

$$\lambda = hmv \ldots(iv)$$

$$\lambda = hp \ldots(v)$$

where p = momentum

This equation is called de Broglie equation.

Heisenberg's Uncertainty Principle

It states that, "It is impossible to measure simultaneously the exact position and exact momentum of a microscopic particle".

If uncertainty in position = Δ × and

Uncertainty in momentum = ΔP

When both are measured simultaneously, According to this principle,

$$\Delta \times . \Delta P \geq h4\pi$$

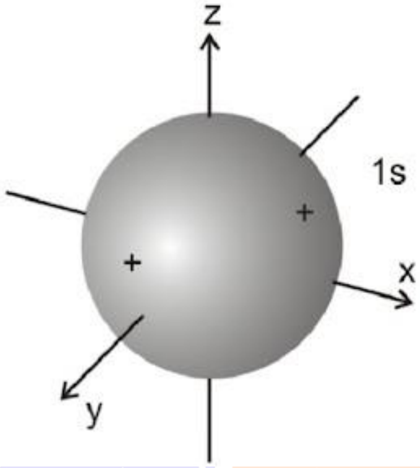
Quantum Numbers

There are a set of four quantum numbers which specify the energy, size, shape and orientation of an orbital. To specify an orbital only three quantum numbers are required while to specify an electron all four quantum numbers are required.

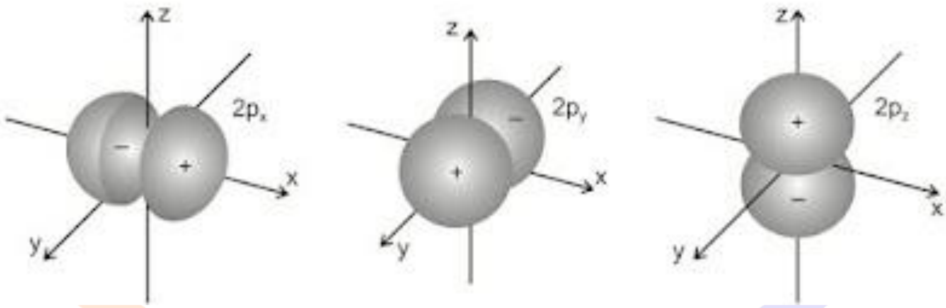
1. **Principal quantum number (n)**: It identifies shell, determines sizes and energy of orbitals. It is indicated by 'n' and its values are 1, 2, 3, 4...
2. **Azimuthal quantum number (l)**: Azimuthal quantum number. 'l' is also known as orbital angular momentum or subsidiary quantum number. l. It identifies sub-shell, determines the shape of orbitals, energy of orbitals in multi-electron atoms along with principal quantum number and orbital angular momentum, i.e., The number of orbitals in a sub shell = 2l + 1. For a given value of n, it can have n values ranging from 0 to n-1.
3. **Magnetic quantum number (ml)**: It gives information about the spatial orientation of the orbital with respect to standard set of co-ordinate axis.For any sub-shell (defined by 'l' value) 2l+1 values of ml are possible. For each value of l, ml = – l, – (l–1), – (l–2)... 0,1...(l–2), (l–1), l
4. **Electron spin quantum number (ms)**: It refers to orientation of the spin of the electron. It can have two values +1/2 and -1/2. +1/2 identifies the clockwise spin and -1/2 identifies the anti-clockwise spin.

Shape of Atomic Orbitals

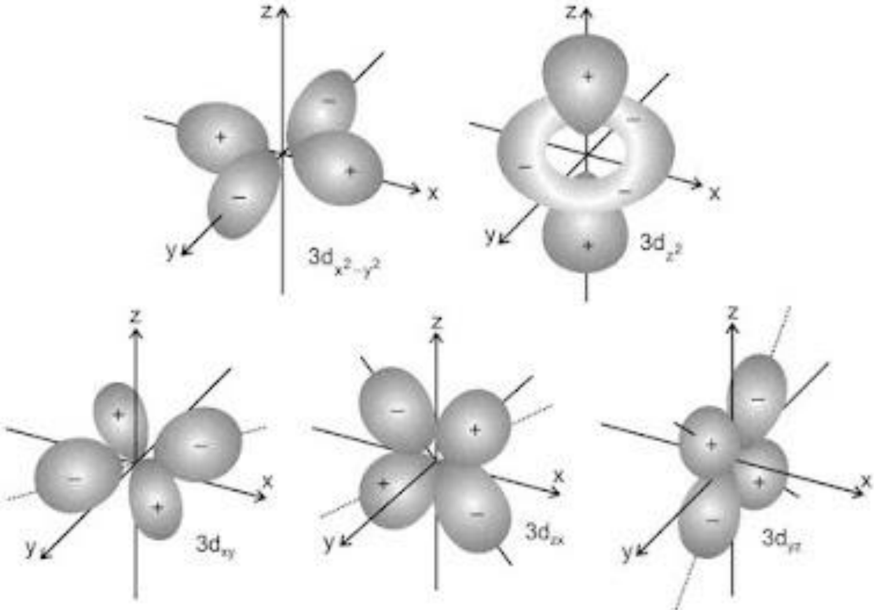
Shapes of s-orbitals: s-orbital is present in the s-sub shell. For this sub shell, l = 0 and ml = 0. Thus, s-orbital with only one orientation has a spherical shape with uniform electron density along all the three axes. The probability of Is electron is found to be maximum near the nucleus and decreases with the increase in the distance from the nucleus.



Shapes of p-orbitals: p-orbitals are present in the p-subshell for which l = 1 and ml can have three possible orientations –1, 0, +1. Thus, there are three orbitals in the p-subshell which are designated as px, py and pz orbitals depending upon the axis along which they are directed. The general shape of a p-orbital is dumb-bell consisting of two portions known as lobes.



Shapes of d-orbitals: d-orbitals are present in d-subshell for which l = 2 and ml = -2, -1, 0, +1 and +2. This means that there are five orientations leading to five different orbitals. d orbitals are of five types: d_{xy}, d_{yz}, d_{zx}, $d_{x^2-y^2}$, d_{z^2}

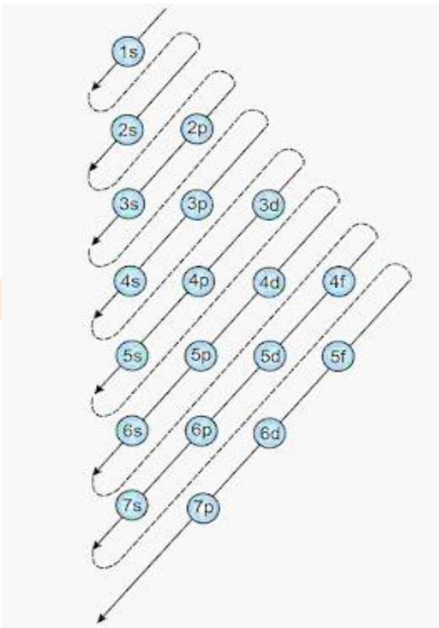


Electronic Configuration

Distribution of electron in various orbitals is known as electronic configuration. The electrons filled in orbitals must obey the following rules-

- Aufbau's principle
- Pauli's exclusion principle
- Hund's rule of maximum multiplicity

1. **Aufbau's principle:** According to this principle, orbitals with lowest energy are filled before the orbitals having higher energy.

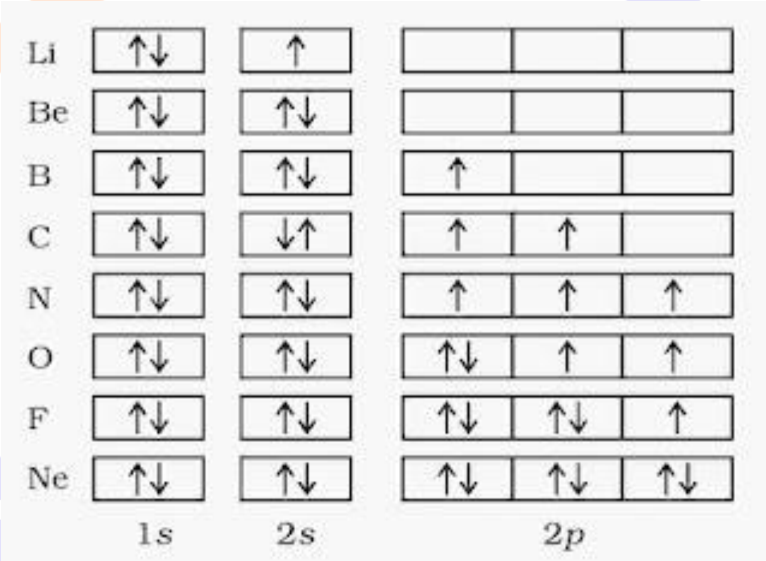


1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p < 5s < 4d < 5p < 6s < 4f < 5d < 6p < 7s < 5f < 6d < 7p

(n + l) rule (Bohr Bury's Rule)

According to this, The orbital which has lower value of (n + l) is lower in energy.

2. **Pauli's exclusion principle:** According to this principle, in an atom, no two electrons have same value of all the four quantum numbers. In the same orbital, electron always accommodate in opposite spins. An orbital can have a maximum of two electrons, with opposite spin.
3. **Hund's rule of maximum multiplicity:** According to this rule, electrons are distributed among the orbital of a subshell in such a way so as to give the maximum number of unpaired electrons with a parallel spin.



Summary-

1. **Atomic number**: It is equal to the number of protons in the nucleus of an atom.
2. **Mass number**: It is equal to the sum of the positively charged protons (p) and electrically neutral neutrons (n).
3. **Isotopes**: Isotopes are the atoms of the same element which have the same atomic number but different mass numbers.
4. **Isobars:** Isobars are the atoms of different elements having the same mass number but different atomic numbers.
5. **Isoelectronic species**: These are those species which have same number of electrons.
6. **Radiations**: These are defined as the emission or transmission of energy through space in the form of waves.
7. **Electromagnetic waves**: The waves which consist of oscillating electric and magnetic fields are called electromagnetic waves.
8. **Electromagnetic radiations**: Those radiations which are associated with electric and magnetic field are called electromagnetic radiations.

9. **Electromagnetic spectrum**: The arrangement of the various types of electromagnetic radiations in the order of increasing or decreasing wavelengths or frequencies is known as electromagnetic spectrum.
10. **Wavelength (λ)**: It is the distance between successive points of equal phase of a wave.
11. **Frequency (f)**: The number of waves that pass a given point in one second is known as the frequency.
12. **Time period (T)**: Time taken by the wave for one complete cycle or vibration is called time period.
13. **Velocity (v)**: It is the distance travelled by a wave in one second.
14. **Wave number**: It is defined as the number of wavelengths per unit length.
15. **Threshold frequency**: It is the minimum frequency of light needed to cause the photoelectric effect.
16. **Continuous spectrum**: The combination of light of different frequencies in continuous manner is called continuous spectrum.
17. **Line spectrum**: The spectrum of atoms consist of sharp well-defined lines corresponding to definite frequencies is called line spectrum.
18. **Spectroscopy**: The study of emission or absorption spectra is called spectroscopy.
19. **Quantization**: The restriction of a property to discrete values and not continuous values is called quantization.
20. **Quantum mechanics**: The branch of science that takes into account the dual behaviour of matter is called quantum mechanics.
21. **Atomic orbital**: It is the region of space where the probability of finding the electron is maximum.
22. **Quantum numbers**: may be defined as a set of four numbers with the help of which we can get complete information about electron in an atom.

NCERT LINE BY LINE QUESTIONS

(1.) The measurement of the electron position is associated with an uncertainty in momentum of 5×10^{-20} gcms^{-1}. The uncertainty in electron velocity is **[Page: 52]**

(a.) 5.6×10^{7} cm/s

(b.) 5.6×10^{7} m/s

(c.) 6.5×10^{7} cm/s

(d.) 6.5×10^{7} m/s

(2.) Match the following: **[NCERT Exemplar Modified, Page: 38]**

(i.)	X- Rays	(P.)	$\nu = 10^{10}$ Hz
(ii.)	Long radio waves	(Q.)	$\nu = 10^{22}$ Hz
(iii.)	Microwaves	(R.)	$\nu = 10^{0} - 10^{4}$ Hz
(iv.)	γ – Rays	(S.)	$\nu = 10^{18}$ Hz

(a.) (i)-S, (ii)-P, (iii)-R, (iv)-Q

(b.) (i)-R, (ii)-Q, (iii)-P, (iv)-S

(c.) (i)-S, (ii)- R, (iii)- P, (iv)-Q

(d.) (i)-S, (ii)- Q, (iii)- P, (iv)-R

(3.) For the electrons of oxygen atom, which of the following statements is incorrect? **[NCERT Exemplar Modified, Page: 6l]**

(a.) Zeff for an electron in a 2*s*-orbital is greater than the Zeff for an electron in a 2*p*-orbital.

(b.) An electron in the 2*s*-orbital has lesser energy as an electron in the 2*p*-orbital.

(c.) Zeff for an electron is ls-orbital is different from that of an electron in 2*s*-orbital.

(d.) The two electrons present in the 2*s*-orbital have different quantum number values with same sign.

(4.) Which of the following series of transitions in the spectrum of hydrogen atom falls in the visible region) **[NEET-2019, Page: 45]**

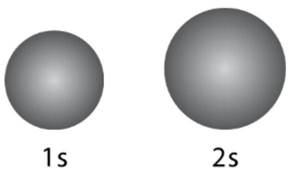
(a.) Lyman series

(b.) Balmer series

(c.) Paschen series

(d.) Brackett series

(5.) The probability density plots of ls and 2s orbitals are given in figure: **[NCERT Exemplar modified, Pages: 57-59]**



The density of dots in a region represents the probability density of finding electrons in the region. On the basis of above diagram which of the following statements is/are correct)

(i)ls and *2s* orbitals are spherical in shape.

(ii)The probability of finding the electron is minimum near the nucleus.

(iii)The probability of finding the electron at a given distance is equal in all directions.

(iv)The probability density of electrons for 2*s*-orbital decreases uniformly as distance from the nucleus increases.

(a.) (i) & (ii) only
(b.) (ii) a (iii) only
(c.) (i) & (iii) only
(d.) only (iv)

(6.) The energy of a mole of photons of radiation whose frequency is 5.5×10^{12} Hz is **[Page: 41]**

(a.) 2.18 J
(b.) 2.18kJ
(c.) 2.18 eV
(d.) 1.89kJ

(7.) The aim of Millikan's oil drop experiment is to determine **[Page: 32]**

(a.) mass of electron
(b.) velocity of electron
(c.) charge of electron
(d.) *elm* of an electron

(8.) The energy associated with the first orbit of Li^{2+} is **[Page: 48]**

(a.) -19.62×10^{17} J
(b.) -1.96×10^{17} J
(c.) -8.72×10^{18} J
(d.) -2.18×10^{18} J

(9.) The number of electrons and neutrons of an element is 18 and 20 respectively. Its mass number is f Page: 35]

(a.) 18
(b.) 38
(c.) 20
(d.) 37

(10.) Few sets of quantum numbers are given below. Which of the following sets are incorrect? **[NCERT Exemplar Modified, HOT, Page: 57]**

(I) $n=1, l=1, m_1=+2$

(II) $n=2, l=1, m_1=+1$

(III) $n=3, l=2, m_1=-2$

(IV) $n=3, l=4, m_1=-2$

(a.) (II) & (I1I) only
(b.) (I) and (IV) only
(c.) (I), (II) & (III) only
(d.) All of these

(11.) A ball has a mass of 20 g and a speed of 45 m/s. It speed can be measured within the accuracy of 0.5%. The uncertainty in its position will be **[Page: 5l]**

(a.) 1.49×10^{-32} m
(b.) 1.17×10^{-32} m
(c.) 2.82×10^{-33} m
(d.) 5.12×10^{-34} m

(12.) The energy of an electron in the 3^{rd} orbit of hydrogen atom is -E. The energy of an electron in the first orbit will be **[Page: 47]**

(a.) $-9E$
(b.) $-3E$

(c.) $-E/9$ (d.) $-E/3$

(13.) In a hydrogen spectrum if electron moves from 5^{th} to 2^{nd} by transition in multi-steps then find the number of lines in spectrum. **[Page: 45]**

(a.) 10 (b.) 6

(c.) 2 (d.) 8

(14.) The number of photons which will provide 2 J of energy and having wavelength 7500 A is approx. **[Page: 4l]**

(a.) 8×10^{18} (b.) 2×10^{19}

(c.) 9×10^{17} (d.) 8×10^{19}

(15.) **Assertion:** Greater the magnitude of the negative charge on the particle, greater is the interaction with electric or magnetic field and thus greater the deflection.
Reason: The deflection of electrons from its original path decreases with the increase in the voltage across the electrodes. **[Page: 3l]**

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

(b.) Both A and R are true but R is not the correct explanation of A.

(c.) A is true but R is false.

(d.) Both A and R are false.

(16.) Match the following species with their corresponding ground state electronic configuration. **[NCERT Exemplar Modified, Page: 63]**

	Atom / Ion		Electronic configuration
(i)	Cu	(P)	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$
(ii)	Cu^+	(Q)	$1s^2 2s^2 2p^6 3s^2 3p^6$
(iii)	Fe^{3+}	(R)	$1s^2 2s^2 2p^6 3s^2 3p^2 3d^{10} 4s^1$
(iv)	Sc^{3+}	(S)	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^9 4s^1$
		(T)	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$

(a.) (i)-R, (ii) - P, (iii)-T, (iv)-Q

(b.) (i)-R, (ii) - P, (iii) - S, (iv) -T

(c.) (i)-P, (ii)- R, (iii)- S, (iv)-T

(d.) (i)-P, (ii)-Q, (iii)- T, (iv)-S

(17.) Match the following: **[Page: 35]**

Column - 1	Column - 11
A. Isotope	(i) $^{86}_{36}Kr, ^{89}_{39}Y$
B. Isobar	(ii) $^{127}_{53}I$, $^{131}_{53}I$
C. Isotone	(iii) $_{21}Sc^{3+}$ $_{17}Cl^{-}$
D. Isoelectronic	(iv) $^{40}_{19}K, ^{40}_{16}S$

(a.) A-(iii), B-(iv), C-(ii), D-(i)

(b.) A-(ii), B-(iv), C-(i), D-(iii)

(c.) A- (ii), B-(i), C- (iv), D- (iii)

(d.) A- (iii), B- (ii), C-(i), D- (iv)

(18.) The specific charge for positive rays is X and that of cathodic rays is Y then **[Page: 31]**

(a.) $X > Y$

(b.) $Y > X$

(c.) $X = Y$

(d.) X can be greater or less than Y.

(19.) Write the complete symbol of an element with number of protons = 56 and mass number 138. **[Page: 35]**

(a.) $^{138}_{56}Ba$

(b.) $^{138}_{56}Fe$

(c.) $^{82}_{56}Ba$

(d.) $^{138}_{82}Fe$

(20.) Which of following is responsible to rule out the existence of definite paths or trajectories of electrons. **[NCERT Exemplar Modified, Page: 62]**

(a.) Zeeman effect

(b.) Heisenberg's uncertainty principle

(c.) Hund's rule of maximum multiplicity

(d.) None of these

(21.) Read the given statements and choose one which is incorrect. **[Page: 31]**

(a.) e/m ratio of β-particles is constant.

(b.) Cathode rays have constant e/m ratio.

(c.) e/m ratio of protons is not constant.

(d.) e/m ratio of anode rays is not constant.

(22.) The number of electrons, protons and neutrons in a species is 17, 14 and 14 respectively. The appropriate symbol for the species is **[Page: 35]**

(a.) $^{17}_{14}C^{3-}$

(b.) $^{28}_{14}N^{3-}$

(c.) $^{31}_{14}O^{2-}$

(d.) $^{31}_{14}N^{3-}$

(23.) The radius of the electron in the first Bohr orbit of H-atoms is 0.529 A^{o}. The radius of the electrons in third Bohr orbit of Li^{2+} is **[Page: 48]**

(a.) 1.587 A^{o}

(b.) 5.29 A^{o}

(c.) 15.87 A° (d.) 0.529 A°

(24.) **Assertion:** The energy of the electron in a hydrogen atom has a negative value.
Reason: The energy of the electron in the atom is lower than the energy of a free electron at rest. **[Page: 47]**

(a.) Both A and R are true and R is the correct explanation of A.
(b.) Both A and R are true but R is nor the correct explanation of A.
(c.) A is true but R is false.
(d.) Both A and R are false.

(25.) Out of the following pairs of electrons, identify the pairs of electrons present in degenerate orbitals **[NCERT Exemplar Modified, Page: 55]**

(I) (i) $n=3, l=2, m_l=-2, m_s=-1/2$
(ii) $n=3, l=2, m_l=-1, m_s=-1/2$
(II) (i) $n=3, l=1, m_l=-1, m_s=+1/2$
(ii) $n=3, l=2, m_l=1, m_s=+1/2$
(III) (i) $n=4, l=1, m_l=1, m_s=+1/2$
(ii) $n=3, l=2, m_l=1, m_s=+1/2$
(IV) (i) $n=3, l=2, m_l=+2, m_s=-1/2$
(ii) $n=3, l=2, m_l=+2, m_s=+1/2$

(a.) (I) & (IV)
(b.) (I) & (II)
(c.) (II) & (III)
(d.) (III) & (IV)

(26.) If uncertainty in position is twice the uncertainty of momentum, then uncertainty in velocity is **[Page: 5l]**

(a.) $\frac{1}{m}\sqrt{\frac{h}{\pi}}$
(b.) $\frac{1}{2m}\sqrt{\frac{h}{\pi}}$
(c.) $\frac{1}{2m}\sqrt{\frac{h}{2\pi}}$
(d.) $\frac{1}{4m}\sqrt{\frac{h}{\pi}}$

(27.) **Assertion:** The value of l for 3*p*-orbital is one. **Reason:** Value of l can be given by $(n-2)$. **[Page: 55]**

(a.) Both A and R are true and R is the correct explanation of A.
(b.) Both A and R are true but R is not the correct explanation of A.
(c.) A is true but R is false.
(d.) Both A and R are false.

(28.) For a prescribed wavelength a black body radiates how much energy at the temperature of body **[Page: 4l]**

(a.) Maximum
(b.) Minimum
(c.) 50%
(d.) 20%

(29.) In hydrogen spectrum, a series limit is found at $6854.8\,cm^{-1}$. Then it belongs to

[Page: 45]

(a.) Hyman series
(b.) Brackett series
(c.) Balmer series
(d.) Paschen series

(30.) The number of angular nodes for 3*p*-orbital is **[NCERT Exemplar Modified, Page: 57]**

(a.) 3
(b.) 4
(c.) 2
(d.) 1

(31.) The longest wavelength line in Balmer series of spectrum is **[Page: 45]**

(a.) 6.56 nm
(b.) 6560 nm
(c.) 656 nm
(d.) 65.6 nm

(32.) Which of the following conclusions could not be derived from Rutherford's α-particle scattering experiment) **[NCERT Exemplar Modified, Page: 34]**

(a.) The positive charge and most of the mass of the atom was densely concentrated in small region.
(b.) The radius of the atom is about 10^{10} m while that of nucleus is 10^{15}m.
(c.) Electrons move in a circular path of fixed energy called orbits.
(d.) Electrons and the nucleus are held together by electrostatic forces of attraction.

(33.) Angular momentum of an electron revolving around a nucleus is an integral multiple of **[Page: 47]**

(a.) $h/4\pi$
(b.) $h/2\pi$
(c.) h/π
(d.) $2h/\pi$

(34.) The ionisation potential for hydrogen atom is 13.6 eV, the ionisation potential for the He^{+} is **[Page: 47]**

(a.) 6.8 eV
(b.) 13.6 eV
(c.) 54.4 eV
(d.) 27.2 eV

(35.) Thomson model was first model for an atom. But Thomson model was able to explain any one of these given properties. That property is **[QR code, NCERT Exemplar Modified, Page: 33]**

(a.) overall neutrality of atom
(b.) spectra of hydrogen atom
(c.) position of electrons, protons and neutrons in atom
(d.) stability of atom.

(36.) Arrange these radiations in increasing order of energies: **[Page: 4l]**

$\lambda(A) = 300nm$	$\lambda(B) = 300\mu m$	$\lambda(C) = 3nm$	$\lambda(D) = 30Å$

(a.) $A = B = C = D$
(b.) $A = B > C > D$
(c.) $C = D > A > B$
(d.) $B > A > C = D$

(37.) Which of following options correctly represents the ground state electronic configuration of an atom ? **[Page: 63]**

(I) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$

(II) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^9 4s^2$

(III) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$

(IV) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$

(a.) I a II
(b.) II & IV
(c.) I & III
(d.) I , III & IV

(38.) According to Heisenberg's uncertainly principle **[Page: 50]**

(a.) all the four quantum number for an electron cannot be same.
(b.) for microscopic substances it's not possible to determine both position and momentum accurately.
(c.) electron can move only in those orbits in which its angular momentum is integral multiple of $h/2\pi$.
(d.) all of these.

(39.) The wavelength of a light wave whose period is 3.5×10^{-9}s is **[Page: 38]**

(a.) 1.05×10^2m
(b.) 1.05m
(c.) 3.1×10^{10}m
(d.) 3.1×10^8m

(40.) Two electrons occupying the same orbital are distinguished by **[NEET-2016, Phase-I, Page: 55]**

(a.) Principal quantum number
(b.) Magnetic quantum number
(c.) Azimuthal quantum number
(d.) Spin quantum number

(41.) **Assertion:** During Rutherford's scattering experiment few positively charged α-particles were deflected.

Reason: The positive charge of the atom is spread throughout the atom. **[Page: 34]**

(a.) Both A and R are true and R is the correct explanation of A.
(b.) Both A and R are true but R is not the correct explanation of A.
(c.) A is true but R is false.
(d.) Both A and R are false.

(42.) The wave number of line associated with the transition in Balmer series when the electron moves to n = 4 orbit is **[Page: 45]**

(a.) $2\times10^4 cm^{-1}$
(b.) $3\times10^4 cm^{-1}$
(c.) $1.09\times10^4 cm^{-1}$
(d.) $5.12\times10^4 cm^{-1}$

(43.) Which one is a wrong statement. **[NEET-2018, Page: 55]**

(a.) The electronic configuration of N atom is

$1s^2$	$2s^2$	$2p_x^1$	$2p_y^1$	$2p_z^1$
↑↓	↑↓	↑	↑	↓

(b.) An orbital is designated by three quantum numbers while an electron in an atom is designated by four quantum numbers.

(c.) Total orbital angular momentum of electrons in an orbital is equal ro zero.

(d.) The value of m for d_{z^2} is zero

(44.) Time taken for an electron to complete one revolution in the Bohr orbit for hydrogen atom is **[Page: 47]**

(a.) $\frac{nh}{2\pi mr}$

(b.) $\frac{2\pi mr^2}{nh}$

(c.) $\frac{4\pi^2 mr^2}{nh}$

(d.) $\frac{4\pi^2 mr^2}{n^2h^2}$

(45.) Consider the following elements: **[Page: 35]**

(I) $8p + 8n$ (II) $8p + 9n$

(III) $18p + 22n$ (IV) $20p + 20n$

Which is correct for these ?

(a.) I & II are isobars.

(b.) I & 11 are isotopes.

(c.) III & IV are isotopes.

(d.) Both a and c

(46.) In Balmer series of H atom which electronic transition represents 4^{rh} line? **[Page: 45]**

(a.) 3^{rd} to 2^{nd}

(b.) 4^{ch} to 2^{nd}

(c.) 6^{rh} to 2^{nd}

(d.) 5^{ch} to 2^{nd}

(47.) The representation of the ground state configuration of N is ↑↓ ↑↓ ↑↑ ↑ ↑ wrong as it violates

(a.) Heisenberg uncertainty principle

(b.) Aufbau principle

(c.) Pauli's exclusion principle

(d.) Hund's rule

(48.) Which of the following phenomena cannot be explained on the basis of wave nature of electromagnetic radiation **[Page: 39]**

(I)Black body radiation

(II)Interference

(III)Photoelectric effect

(IV)Variation of heat capacity of solids with temperature

(a.) I & II only

(b.) I, II and IV only

(c.) I a III only

(d.) I, III and IV only

(49.) The radius of Bohr's third orbit of hydrogen atom is **[Page: 48]**

(a.) 5.29 Å

(b.) 4.76 Å

(c.) 2.71 Å

(d.) 1.59 Å

(50.) Who first calculated the charge of electron. **[Page: 32]**

(a.) J. J. Thomson (b.) R. A. Millikan

(c.) Chadwick (d.) Michael Faraday

TOPIC WISE PRACTICE QUESTIONS

TOPIC 1: Discovery of Subatomic Particles, Atomic and Isoelectronic Species

1. The number of neutrons in dipositive zinc ion with mass number 70 is
(1) 34 (2) 36 (3) 38 (4) 40

2. Which of the following pairs are isosters?
(1) CO_2 and N_2O (2) CaO and KF (3) OF_2 and HClO (4) All of these

3. What is the optimum conditions required to study the conduction of electricity through gases?
(1) High pressure and low voltage (2) High pressure and high voltage
(3) Low pressure and high voltage (4) Low pressure and low voltage

4. In discharge tube experiment stream of negatively charged particles travel from
(1) anode to cathode (2) cathode to anode (3) Both (1) and (2) (4) Electrons does not travel

5. Which one of the following sets of ions represents the collection of isoelectronic species?
(1) K^+, Cl^-, Mg^{2+}, Sc^{3+} (2) Na^+, Ca^{2+}, Sc^{3+}, F^- (3) K^+, Ca^{2+}, Sc^{3+}, Cl^- (4) Na^+, Mg^{2+}, Al^{3+}, Cl^-
(Atomic numbers : F = 9, Cl = 17, Na = 11, Mg = 12, Al = 13, K = 19, Ca = 20, Sc = 21)

6. Which is correct statement about proton?
(1) Proton is nucleus of deuterium (2) Proton is a-particle
(3) Proton is ionized hydrogen molecule (4) Proton is ionized hydrogen atom

7. Which of the following pairs of nucleides are isodiaphers?
(1) ${}^{13}_{6}C$ and ${}^{16}_{8}O$ (2) ${}^{1}_{1}H$ and ${}^{2}_{1}H$ (3) ${}^{3}_{1}H$ and ${}^{4}_{2}He$ (4) ${}^{55}_{25}Mn$ and ${}^{65}_{30}Zn$

8. What is the ratio of mass of an electron to the mass of a proton?
(1) 1 : 2 (2) 1 : 1 (3) 1 : 1837 (4) 1 : 3

9. Of the following sets which one does NOT contain isoelectronic species?
(1) $BO_3^{3-}, CO_3^{2-}, NO_3^-$ (2) $SO_3^{2-}, CO_3^{2-}, NO_3^-$ (3) CN^-, N_2, C_2^{2-} (4) $PO_4^{3-}, SO_4^{2-}, ClO_4^-$

10. In which of the following the amount of deviation from their path in the presence of electric and magnetic field will be maximum?
(1) N^{2-} (2) N^{3-} (3) N^- (4) N

TOPIC 2: Atomic Models, Emission and Absorption Spectrum

11. The energy of an electron in the n[th] Bohr's orbit of hydrogen atom is
(1) $-\frac{13.6}{n^4}$ eV (2) $-\frac{13.6}{n^3}$ eV (3) $-\frac{13.6}{n^2}$ eV (4) $-\frac{13.6}{n}$ eV

12. Which of the following does not contain number of neutrons equal to that of ${}^{40}_{18}Ar$?
(1) ${}^{41}_{19}K$ (2) ${}^{43}_{21}Sc$ (3) ${}^{40}_{21}Sc$ (4) ${}^{42}_{20}Ca$

13. When an electron of charge e and mass m moves with a velocity v towards the nuclear charge Ze in circular orbit of radius r, the potential energy of the electrons is given by
(1) Ze^2 / r (2) $-Ze^2 / r$ (3) Ze^2 / r (4) mv^2 / r

14. The Bohr's orbit radius for the hydrogen atom (n = 1) is approximately 0.530 Å. The radius for the first excited state (n = 2) orbit is (in Å)
(1) 0.13 (2) 1.06 (3) 4.77 (4) 2.12

15. According to Bohr's theory, the angular momentum of an electron in 5th orbit is
(1) $10\ h / \pi$ (2) $2.5\ h / \pi$ (3) $25\ h / \pi$ (4) $1.0\ h / \pi$

16. An electron from one Bohr stationary orbit can go to next higher orbit
(1) by emission of electromagnetic radiation.
(2) by absorption of any electromagnetic radiation.

(3) by absorption of electromagnetic radiation of particular frequency.
(4) without emission or absorption of electromagnetic radiation.

17. The potential energy of electron present in ground state of Li^{2+} ion is represented by:
(1) $\frac{+3e^2}{4\pi\varepsilon_0 r}$ (2) $\frac{-3e}{4\pi\varepsilon_0 r}$ (3) $\frac{-3e^2}{4\pi\varepsilon_0 r^2}$ (4) $\frac{-3e^2}{4\pi\varepsilon_0 r}$

18. The angular speed of the electron in nth orbit of Bohr hydrogen atom is
(1) directly proportional to n
(2) inversely proportional of $\sqrt{n}$
(3) inversely proportional to n^2
(4) inversely proportional to n^3

19. The radius of 1st Bohr's orbit for hydrogen atom is 'r'. The radius of second Bohr's orbit is
(1) 4r (2) r^3 (3) $4r^2$ (4) $r^{1/3}$

20. Which of the following pairs will have same chemical properties?
(1) ${}^{14}_{6}C$ and ${}^{15}_{7}N$ (2) O^{2-} and F^- (3) ${}^{40}_{18}Ar$ and ${}^{40}_{19}K$ (4) ${}^{35}_{17}Cl$ and ${}^{37}_{17}Cl$

21. If m and e are the mass and charge of the revolving electron in the orbit of radius r for hydrogen atom, the total energy of the revolving electron will be:
(1) $\frac{1}{2}\frac{e^2}{r}$ (2) $-\frac{e^2}{r}$ (3) $\frac{me^2}{r}$ (4) $-\frac{1}{2}\frac{e^2}{r}$

22. Energy of an electron in a one-electron system can be calculated as

$$E_n = \frac{-2.18\times10^{-18} Z^2}{n^2}$$

Which of the following correctly states the relationship between the n = 2 level of He+ atom ($Z = 2$) and n = 2 level of Li^{2+} ion ($Z = 3$)?
(1) $E_{He^+} = \frac{9}{4}E_{Li^{2+}}$ (2) $E_{He^+} = \frac{4}{9}E_{Li^{2+}}$ (3) $E_{He^+} = \frac{9}{2}E_{Li^{2+}}$ (4) $E_{He^+} = \frac{2}{9}E_{Li^{2+}}$

23. What is the difference between two species if one has atomic mass = 14 and atomic number = 7 whereas the other has atomic mass = 14 and atomic number = 6?
(1) Neutrons (2) Protons (3) Electrons (4) All of these

24. The velocity of an electron in excited state of H-atom is 1.093×10^6 m/s. What is the circumference of this orbit?
(1) 3.32×10^{-10} m (2) 6.64×10^{-10} m (3) 13.30×10^{-10} m (4) 13.28×10^{-8} m

25. Monochromatic radiation of specific wavelength is incident on H-atoms in ground state. H-atoms absorb energy and emit subsequently radiations of six different wavelength. Find wavelength of incident radiations:
(1) 9.75 nm (2) 50 nm (3) 85.8 nm (4) 97.25 nm

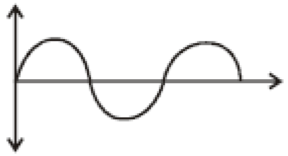
26. If I excitation energy for the H-like (hypothetical) sample is 24 eV, then binding energy in III excited state is:
(1) 2 eV (2) 3 eV (3) 4 eV (4) 5 eV

27. The energy of separation of an electron in a hydrogen like atom in excited state is 3.4 eV. The de-Broglie wave length (in Å) associated with the electron is: (Given radius of first orbit of H-atom is 0.53 Å)
(1) 3.33 (2) 6.66 (3) 13.31 (4) None of these

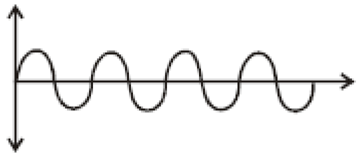
28. If an electron undergoes transition from n = 2 to n = 1 in Li^{2+} ion, the energy of photon radiated will be best given by
(1) $h\nu$ (2) $h\nu_1 + h\nu_2$ (3) $h\nu_1 + h\nu_2 + h\nu_3$ (4) All of these

29. The photoelectric current decreases if
(1) the intensity of the source of light is decreased.
(2) the frequency of incident radiation decreases below threshold frequency.
(3) the exposure time decreases.
(4) none of these.

30. What will be the difference between electromagnetic radiation shown in A and B respectively?



(A)



(B)

(i) Velocity (ii) Wavelength (iii) Frequency (iv) Energy
(1) (ii) only (2) (ii) and (iv) (3) (ii), (iii) and (iv) (4) (iv) only

31. The work function of a photoelectric material is 3.3 eV, its threshold frequency will be
(1) 8×10^{14} Hz (2) 5×10^{33} Hz (3) 8×10^{10} Hz (4) 4×10^{11} Hz

32. Arrange the electromagnetic radiations a, b, c, d and e in increasing order of energy. Frequencies of a, b and c are 10^{15}, 10^{14} and 10^{17} respectively whereas wavelength of (d) and (e) are 350 nm and 100 nm respectively?
(1) a, b, c, d, e (2) a, b, d, e, c (3) a, d, b, e, c (4) b, d, a, e, c

33. For any H like system, the ratio of velocities of electron in I, II and III orbit i.e., $v_1 : v_2 : v_3$ will be :
(1) 1 : 2 : 3 (2) 1 : 1/2 : 1/3 (3) 3 : 2 : 1 (4) 1 : 1 : 1

34. In which of the following Bohr's stationary state, the electron will be at maximum distance from the nucleus?
(1) IInd (2) Ist (3) Vth (4) IIIrd

35. What is the potential energy of an electron present in N-shell of the Be ion?
(1) –3.4 eV (2) –6.8 eV (3) –13.6 eV (4) –27.2 eV

36. Which of the following transitions of electrons in the hydrogen atom will emit maximum energy?
(1) $n_5 \rightarrow n_4$ (2) $n_4 \rightarrow n_3$ (3) $n_3 \rightarrow n_2$ (4) all will emit same energy

37. What is the ratio of time periods (T_1 / T_2) in second orbit of hydrogen atom to third orbit of He^+ ion?
(1) 8/27 (2) 32/27 (3) 27/32 (4) None of these

38. Bohr's model is not able to account for which of the following.
(1) Stability of atom. (2) Spectrum of neutral helium atom.
(3) Energy of free electron at rest. (4) Calculation of radii of the stationary states.

TOPIC 3: Planck's Quantum Theory, Heisenberg's Uncertainty Principle and Schrodinger's Wave Equation:

39. If the energy of a photon is 3.03×10^{-19} J then, the wavelength (λ) of the photon is :
(1) 6.56 nm (2) 65.6 nm (3) 656 nm (4) 0.656 nm

40. The value of Planck's constant is 6.63×10^{-34} Js. The velocity of light is 3.0×10^{8} ms^{-1}. Which value is closest to the wavelength in nanometers of a quantum of light with frequency of 8×10^{15} s^{-1}?
(1) 3×10^{7} (2) 2×10^{-25} (3) 5×10^{-18} (4) 4×10^{1}

41. The de Broglie wavelength of a tennis ball of mass 60 g moving with a velocity of 10 metres per second is approximately Planck's constant, h = 6.63×10^{-34} Js
(1) 10^{-31} metres (2) 10^{-16} metres (3) 10^{-25} metres (4) 10^{-33} metres

42. Wavelength associated with electron motion
(1) increases with increase in speed of electron.
(2) remains same irrespective of speed of electron.
(3) decreases with increase of speed of e^- (electron).
(4) is zero.

43. The Heisenberg uncertainty principle will be most significant for which of the following object?
(1) Object A of mass 9.11×10^{-30} kg (2) Object B of mass 9.11×10^{-28} g
(3) Object C of mass 9.11×10^{-24} mg (4) Object D of mass 9.11×10^{-28} kg

44. The momentum (in kg-m/s) of photon having 6 MeV energy is :
(1) 3.2×10^{-21} (2) 2.0 (3) 1.6×10^{-21} (4) None of these

45. When electronic transition occurs from higher energy state to lower energy state with energy difference equal to ΔE electron volts, the wavelength of the line emitted is approximately equal to

(1) $\frac{12395}{\Delta E}\times10^{-10}\,m$ (2) $\frac{12395}{\Delta E}\times10^{10}\,m$ (3) $\frac{12395}{\Delta E}\times10^{-10}\,cm$ (4) $\frac{12395}{\Delta E}\times10^{10}\,cm$

46. Which of the following statement concerning probability density (ψ^2) and radial distribution function ($4\pi r^2\psi^2$) for a *s*-orbital of H-like species is correct?

(1) ψ^2 is minimum at nucleus but $4\pi r^2\psi^2$ is maximum at nucleus.

(2) ψ^2 is maximum at nucleus but $4\pi r^2\psi^2$ is minimum at nucleus.

(3) Both ψ^2 and $4\pi r^2\psi^2$ are maximum at nucleus. (4) Both ψ^2 and $4\pi r^2\psi^2$ are minimum at nucleus.

47. The angular momentum of *d* electron is

(1) $\frac{h}{2\pi}\sqrt{6}$ (2) $\frac{h}{\pi}\sqrt{6}$ (3) $\frac{h}{2\pi}\sqrt{2}$ (4) $\frac{h}{\pi}\sqrt{2}$

48. If E_1, E_2, and E_3 represent respectively the kinetic energies of an electron and an alpha particle and a proton each having same de-Broglie wavelength then

(1) $E_1 > E_3 > E_2$ (2) $E_2 > E_3 > E_1$ (3) $E_1 > E_2 > E_3$ (4) $E_1 = E_2 = E_3$

49. If uncertainty in position and momentum are equal, then uncertainty in velocity is :

(1) $\frac{1}{2m}\sqrt{\frac{h}{\pi}}$ (2) $\sqrt{\frac{h}{2\pi}}$ (3) $\frac{1}{m}\sqrt{\frac{h}{\pi}}$ (4) $\sqrt{\frac{h}{\pi}}$

50. Which of the following statement is wrong about photon ?

(1) Photon's energy is $h\nu$. (2) Photon's rest mass is zero.

(3) Momentum of photon is $\frac{h\nu}{c}$ (4) Photon exerts no pressure.

51. Excited hydrogen atom emits light in the ultraviolet region at 2.47×10^{15} Hz. With this frequency, the energy of a single photon is: ($h = 6.63 \times 10^{-34}$ Js)

(1) 8.041×10^{-40} J (2) 2.680×10^{-19} J (3) 1.640×10^{-18} J (4) 6.111×10^{-17} J

52. Ionization energy of gaseous Na atoms is 495.5 kJ mol^{-1}. The lowest possible frequency of light that ionizes a sodium atom is ($h = 6.626 \times 10^{-34}$ Js, $N_A = 6.022 \times 10^{23}$ mol^{-1})

(1) 7.50×10^4 s^{-1} (2) 4.76×10^{14} s^{-1} (3) 3.15×10^{15} s^{-1} (4) 1.24×10^{15} s^{-1}

TOPIC 4: Quantum Numbers, Electronic Configuration and Shape of Orbitals

53. Which one of the following set of quantum numbers is not possible for 4p electron?

(1) $n = 4, \ell = 1, m = -1, m_s = +\frac{1}{2}$ (2) $n = 4, \ell = 1, m = 0, m_s = +\frac{1}{2}$

(3) $n = 4, \ell = 1, m = 2, m_s = +\frac{1}{2}$ (4) $n = 4, \ell = 1, m = -1, m_s = -\frac{1}{2}$

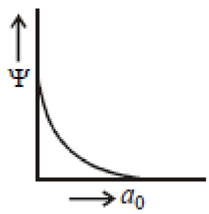
54. What is the correct orbital designation of an electron with the quantum number, $n = 4$, $l = 3$, $m = -2$, $s = 1/2$?

(1) 3*s* (2) 4 *f* (3) 5*p* (4) 6*s*

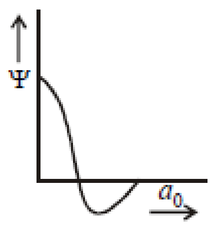
55. Which orbital of the following is lower in energy in a many electron atom?

(1) 2 *s* (2) 3 *d* (3) 4 *s* (4) 5 *f*

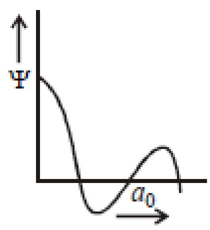
56. Which of the following graph correspond to one node



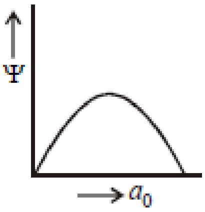
(1)



(2)



(3)



(4)

57. The total number of electrons that can be accommodated in all orbitals having principal quantum number 2 and azimuthal quantum number 1 is

(1) 2 (2) 4 (3) 6 (4) 8

58. What can be the representation of the orbital having 3 angular nodes and $n = 5$.

(1) 5 *d* (2) 5 *f* (3) 5 *p* (4) 5 *s*

59. The five d-orbitals are designated as $d_{xy}, d_{yz}, d_{xz}, d_{x^2-y^2}$ and d_{z^2}. Choose the correct statement.
(1) The shapes of the first three orbitals are similar but that of the fourth and fifth orbitals are different.
(2) The shapes of all five d-orbitals are similar.
(3) The shapes of the first four orbitals are similar but that of the fifth orbital is different.
(4) The shapes of all five d-orbitals are different.

60. Maximum number of electrons in a subshell of an atom is determined by the following:
(1) $2l + 1$ (2) $4l - 2$ (3) $2n^2$ (4) $4l + 2$

61. An e– has magnetic quantum number as –3, what is its principal quantum number?
(1) 1 (2) 2 (3) 3 (4) 4

62. For a, *f*-orbital, the values of m are
(1) –2, –1, 0, +1, +2 (2) –3, –2, –1, 0, +1, +2,+ 3
(3) –1, 0, +1 (4) 0, +1, +2, +3

63. A 5*f* orbital has
(1) one node (2) two nodes (3) three nodes (4) four nodes.

64. If electron has spin quantum number + 1/2 and a magnetic quantum number – 1, it cannot be present in
(1) *d*-orbital (2) *f*-orbital (3) *p*-orbital (4) *s*-orbital.

65. The orbital angular momentum for an electron revolving in an orbit is given by $\sqrt{l(l+1)}.\frac{h}{2\pi}$. This momentum for an *s*-electron will be given by
(1) zero (2) $\frac{h}{2\pi}$ (3) $\sqrt{2}.\frac{h}{2\pi}$ (4) $+\frac{1}{2}.\frac{h}{2\pi}$

66. The energy of the electron in Be^{3+} ion depends on
(1) the principal quantum number only.
(2) the principal and azimuthal quantum numbers only.
(3) the principal, azimuthal and magnetic quantum numbers only.
(4) the principal, azimuthal, magnetic and spin quantum numbers.

67. What are the component values (in terms of $h/2\pi$) of the orbital angular momentum along the Z-direction for a 2*p* electron?
(1) $+\frac{1}{2}, -\frac{1}{2}$ (2) $+\frac{3}{2}, +\frac{1}{2}, -\frac{1}{2}, -\frac{3}{2}$ (3) +2, +1, 0, –1, –2 (4) +1, 0, –1

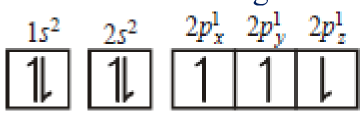
68. The total number of orbitals associated with the principal quantum number 5 is :
(1) 20 (2) 25 (3) 10 (4) 5

69. The total spin and magnetic moment for the atom with atomic number 24 are:
(1) $\pm 3, \sqrt{48}$ BM (2) $\pm 3, \sqrt{35}$ BM (3) $\pm\frac{3}{2}, \sqrt{48}$ BM (4) $\pm\frac{3}{2}, \sqrt{35}$ BM

70. A principal shell having the highest energy subshell to be '*g*' can accomodate electrons to a maximum of
(1) 18 (2) 32 (3) 25 (4) 50

NEET PREVIOUS YEARS QUESTIONS

1. Which one is a wrong statement? **[2018]**



(1) Total orbital angular momentum of electron in '*s*' orbital is equal to zero.
(2) An orbital is designated by three quantum numbers while an electron in an atom is designated by four quantum numbers.
(3) The value of *m* for d_{z^2} is zero.
(4) The electronic configuration of N atom is

2. Which one is the wrong statement? **[2017]**

(1) The uncertainty principle is
$\Delta E \times \Delta t \geq h/4\pi$
(2) Half-filled and fully filled orbitals have greater stability due to greater exchange energy, greater symmetry and more balanced arrangement.
(3) The energy of 2*s* orbital is less than the energy of 2*p* orbital in case of Hydrogen like atoms
(4) de-Broglie's wavelength is given by $\lambda = \frac{h}{m\nu}$, where m = mass of the particle, ν = group velocity of the particle.

3. Two electrons occupying the same orbital are distinguished by **[2016]**
(1) Principal quantum number
(2) Magnetic quantum number
(3) Azimuthal quantum number
(4) Spin quantum number

4. Which is the correct order of increasing energy of the listed orbitals in the atom of titanium? **[2015]**
(1) 3*s* 4*s* 3*p* 3*d* (2) 4*s* 3*s* 3*p* 3*d* (3) 3*s* 3*p* 3*d* 4*s* (4) 3*s* 3*p* 4*s* 3*d*

5. The number of *d*-electrons in Fe^{2+} (Z = 26) is not equal to the number of electrons in which one of the following? **[2015]**
(1) *p*-electrons in Cl (Z = 17) (2) *d*-electrons in Fe (Z = 26)
(3) *p*-electrons in Ne (Z = 10) (4) *s*-electrons in Mg (Z = 12)

6. The angular momentum of electron in '*d*' orbital is equal to: **[2015]**
(1) $\sqrt{2}\,\hbar$ (2) $2\sqrt{3}\,\hbar$ (3) $0\,\hbar$ (4) $\sqrt{6}\,\hbar$

7. What is the maximum number of orbitals that can be identified with the following quantum numbers?
$n = 3,\ \ell = 1,\ m_\ell = 0$ **[2014]**
(1) 1 (2) 2 (3) 3 (4) 4

8. Calculate the energy in joule corresponding to light of wavelength 45 nm :
(Planck's constant h = 6.63×10^{-34} Js; speed of light c = 3 × 108 ms^{-1}) **[2014]**
(1) 6.67×10^{15} (2) 6.67×10^{11} (3) 4.42×10^{-15} (4) 4.42×10^{-18}

9. Be^{2+} is isoelectronic with which of the following ions? **[2014]**
(1) H^+ (2) Li^+ (3) Na^+ (4) Mg^{2+}

10. 4d, 5p, 5f and 6p orbitals are arranged in the order of decreasing energy. The correct option is :- **[NEET-2019]**
(1) 5f > 6p > 5p > 4d (2) 6p > 5f > 5p > 4d (3) 6p > 5f > 4d > 5p (4) 5f > 6p > 4d > 5p

11. Which of the following series of transitions in the spectrum of hydrogen atom falls in visible region? **[NEET-2019]**
(1) Lyman series (2) Balmer series (3) Paschen series (4) Brackett series

12. Orbital having 3 angular nodes and 3 total nodes is :- **[NEET-2019(ODISSA)]**
(1) 5 p (2) 3 d (3) 4 f (4) 6 d

13. In hydrogen atom, the de Broglie wavelength of an electron in the second Bohr orbit is :-
[Given that Bohr radius, a0 = 52.9 pm] **[NEET-2019(ODISSA)]**
(1) 211.6 pm (2) 211.6 p pm (3) 52.9 p pm (4) 105.8 pm

14. The number of angular nodes and radial nodes in3s orbital are **[NEET-2020(COVID-19)]**
(1) 0 and 2, respectively (2) 1 and 0, respectively
(3) 3 and 0, respectively (4) 0 and 1, respectively

15. The calculated spin only magnetic moment of Cr^{2+} ion is : **[NEET-2020]**
1) 2.84 BM 2) 3.87 BM 3) 4.90 BM 4) 5.92 BM

16. A particular station of All India Radio, New Delhi, broadcasts on a frequency of 1,368 kHz(kilohertz). The wavelength of the electromagnetic radiation emitted by the transmitter is : [speed of light, $c = 3.0 \times 10^8\,ms^{-1}$] **[NEET-2021]**
1) 219.2 m 2) 2192 m 3) 21.92 cm 4) 219.3 m

17. Which amongst the following is incorrect statement? **[NEET-2022]**
1) The bond orders of O_2^+, O_2, O_2^- *and* O_2^{2-} are 2.5,2,1.5 and 1, respectively
2) C_2 molecule has four electrons in its two degenerate π molecular orbitals

3) H_2^+ ion has one electron

4) O_2^+ ion is diamagnetic

18. Identify the incorrect statement from the following **[NEET-2022]**

1) All the five 5d orbitals are different in size when compared to the respective 4d orbitals

2) All the five 4d orbitals have shapes similar to the respective 3d orbitals

3) In an atom, all the five 3d orbitals are equal in energy in free state

4) The shapes of d_{xy}, d_{yz} and d_{zx} orbitals are similar to each other; and $d_{x^2-y^2}$ and d_{z^2} are similar to each other.

19. If radius of second Bohr orbit of the He^+ ion is 105.8 pm, what is the radius of third Bohr orbit of Li^{2+} ion ? **[NEET-2022]**

1) 158.7 pm 2) 15.87 pm 3) 1.587 pm 4) 158.7 $\overset{0}{A}$

NCERT LINE BY LINE QUESTIONS – ANSWERS

(1.)	a	(2.)	c	(3.)	d	(4.)	b	(5.)	c
(6.)	b	(7.)	c	(8.)	b	(9.)	b	(10.)	b
(11.)	b	(12.)	a	(13.)	b	(14.)	a	(15.)	c
(16.)	a	(17.)	b	(18.)	b	(19.)	a	(20.)	b
(21.)	c	(22.)	b	(23.)	a	(24.)	a	(25.)	a
(26.)	c	(27.)	c	(28.)	a	(29.)	b	(30.)	d
(31.)	c	(32.)	c	(33.)	b	(34.)	c	(35.)	a
(36.)	c	(37.)	d	(38.)	b	(39.)	b	(40.)	d
(41.)	c	(42.)	a	(43.)	a	(44.)	c	(45.)	b
(46.)	c	(47.)	c	(48.)	c	(49.)	b	(50.)	b

TOPIC WISE PRACTICE QUESTIONS-ANSWERS

1)	4	2)	4	3)	3	4)	2	5)	3	6)	4	7)	4	8)	3	9)	2	10)	2
11)	3	12)	3	13)	2	14)	4	15)	2	16)	3	17)	4	18)	4	19)	1	20)	4
21)	4	22)	2	23)	4	24)	3	25)	4	26)	1	27)	2	28)	1	29)	1	30)	3
31)	1	32)	4	33)	2	34)	3	35)	4	36)	3	37)	2	38)	2	39)	3	40)	4
41)	4	42)	3	43)	2	44)	1	45)	1	46)	2	47)	2	48)	1	49)	1	50)	4
51)	3	52)	4	53)	3	54)	2	55)	1	56)	2	57)	3	58)	2	59)	3	60)	4
61)	4	62)	2	63)	1	64)	4	65)	1	66)	1	67)	4	68)	2	69)	1	70)	4

NEET PREVIOUS YEARS QUESTIONS-ANSWERS

1)	4	2)	3	3)	4	4)	4	5)	1	6)	4	7)	1	8)	4	9)	2	10)	1
11)	2	12)	3	13)	2	14)	1	15)	3	16)	4	17)	4	18)	4	19)	1		

NCERT LINE BY LINE QUESTIONS-EXPLANATIONS

(1.) (a)Uncertainty in momentum

$$m\Delta v = 5\times10^{-20}\,gcms^{-1}$$

$$\Delta\nu = \frac{5\times10^{-20}\,g}{9.1\times10^{-28}\,g}\,cms^{-1} = 5.6\times10^{7}\,cm/s$$

(2.) (c)

	Frequency	Wavelength
X - Rays	10^{18} Hz	10^{-10} m
Long radio waves	$10^{0}-10^{4}$ Hz	10^{4} m
Microwaves	10^{10} Hz	10^{-2} m
γ - Rays	10^{22} Hz	10^{-12} m

(3.) (d) The two electrons present in the $2s$-orbital have same spin quantum numbers value but of opposite sign.

(4.) (b)Lyman series-UV Region

Balmer series-Visible Region
Paschen series-IR region
Brackett series-IR region

(5.) (c)The probability of finding the electron is maximum near the nucleus and the probability density of electron for 2s-orbital first increases then decreases and after that it begins to increase again,

(6.) (b) $E = hv = 6.6\times10^{-34}\times5.5\times10^{12}$

Energy of 1 mol photon

$=6.6\times10^{-34}\times5.5\times10^{12}\times6.023\times10^{23}$

$=2.18\times10^{3}J$ or 2.18 kJ

(7.) (c)R. A. Millikan devised a method to determine the charge of the electron.

(8.) (b) $E_n = \frac{-2.18\times10^{-18}J\times Z^2}{n^2}$ atom^{-1}

$=\frac{-2.18\times10^{-18}\times3^2}{1^2}=-19.62\times10^{-18}=-1.96\times10^{-17}J$

(9.) (b)Mass number = Number of electrons + Number of neutrons

= 18 + 20 = 38

(10.) (b)I and IV are incorrect as l cannot be equal to or greater than n.

(11.) (b)The uncertainty in the speed is 0.5%

i.e. $45\times\frac{0.5}{100}=0.225m/s$

according to Heisenberg uncertainty principle

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

$=\frac{6.626\times10^{-34}}{4\times3.14\times20\times10^{-3}\times0.225}=1.17\times10^{-32}m$

(12.) (a) $E_n = E_1/n^2$

$E_3 = E_1/3^2 = -E \Rightarrow E_1 = -9E$

(13.) (b)Total number of lines =

$\frac{(n_2-n_1)[(n_2-n_1)+1]}{2}=\frac{(5-2)[(5-2)+1]}{2}=\frac{3\times4}{2}=6$

(14.) (a) $E=\frac{nhc}{\lambda}\Rightarrow n=\frac{E\lambda}{hc}=\frac{2\times7500\times10^{-10}}{6.6\times10^{-34}\times3\times10^{8}}$

$=7.57\times10^{18}$ Photon

(15.) (c)The deflection of electrons from its original path increases with the increase in the voltage across the electrodes.

(16.) (a)

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

Cu^+ : $[Ar]3d^{10}$

Fe^{3+} : $3d^5$

Sc^{3+} : $3d^0$

(17.) (b)Isotopes: Elements with same number of protons but different mass number, *e.g.* $^{127}_{53}I$, $^{131}_{53}I$

Isobars: Elements with same mass number but different atomic number, *e.g.* ${}^{40}_{19}K$ & ${}^{40}_{16}S$

Isotones: Elements with same number of neutrons

${}^{86}_{36}Kr$ (Neurons $= 86 - 36 = 50$)

${}^{89}_{39}Y$ (Neurons $= 89 - 39 = 50$)

Isoelectronic: Species that have same number of electrons.

(18.) (b) $X = \frac{e}{M}$ $Y = \frac{e}{m}$

as, $M > m$ so $Y > X$

(19.) (a)Atomic number = 56 and element with 56 atomic number is Ba. Element can be represented as

$${}^{\text{Mass Number}}_{\text{Atomic Number}}X$$

(20.) (b)According to Heisenberg's uncertainty principle the position and velocity of an electron cannot be determined simultaneously with accuracy which rules out the existence of fixed paths.

(21.) (c)Por protons e/m is constant.

(22.) (b)Number of protons = 14

Number of electrons = 17

Thus, charge = 17- 14 = -3

Mass number = 14 + 14 = 28

Thus, the given ion is ${}^{28}_{14}N^{3-}$

(23.) (a) $r_n = \frac{n^2}{Z} \times 0.529 A^\circ$

$$r_3 \text{ for } Li^{2+} = \frac{3 \times 3}{3} \times 0.529 \quad = 1.587 A^o$$

(24.) (a)The given reason is correct for the assertion.

(25.) (a)The orbitals having same energy are called degenerate orbitals.

(26.) (c)According to Heisenberg's uncertainty principle

$$\Delta x \cdot \Delta p \geq \frac{h}{4\pi}$$

$$\Delta x \times m\Delta\nu \geq \frac{h}{4\pi} \text{ (as } \Delta x = 2\Delta P\text{)}$$

so $\Delta x = 2(m\Delta\nu)$

$$2(m\Delta\nu)^2 \geq \frac{h}{4\pi}$$

$$(\Delta\nu)^2 \geq \frac{1}{2m^2}\frac{h}{4\pi}$$

$$\Delta v = \frac{1}{2m}\sqrt{\frac{h}{2\pi}}$$

(27.) (c)Possible value of l are $(n-1)$. Thus, 2 values of orbital 3 are possible

$l = 0,1$

0 for 3s and 1 for 3p

(28.) (a)A black body neither reflects nor transmits any amount of incident radiation.

(29.) (b)Series limit is the last line of the series, i.e. $n_2 = \infty$

$$\bar{v} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] = R\left[\frac{1}{n_1^2} - \frac{1}{\infty}\right]$$

$$\bar{v} = \frac{R}{n_1^2} \Rightarrow 6854.8 = \frac{109677}{n_1^2}$$

$$n_1^2 = \frac{109677}{6854.8} = 16$$

Thus, $n_1 = 4$ means Brackett series.

(30.) (d)Angular nodes $= l = 1$ (for orbital)

(31.) (c) $\frac{1}{\lambda} = R_H\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

For longest wavelength $n_1 = 2$ $n_2 = 3$ (Balmer series)

$$\frac{1}{\lambda} = R_H\left[\frac{1}{4} - \frac{1}{9}\right] = \frac{5}{36}R_H = 15233$$

$$\lambda = \frac{1}{15233} = 6.56\times10^5 \text{cm} = 656\text{nm}$$

Assertion-Reason Type questions

(32.) (c)

(33.) (b) $mvr = \frac{nh}{2\pi}$

(34.) (c) $E_n = \frac{-13.6}{n^2}Z^2 eV$

$$(\text{I.E.})_H = E_\infty - E_1 = 13.6\text{eV}$$

$$(\text{I.E.})_{He^+} = Z^2 \times (\text{I.E.})_H$$

$$= 2^2 \times 13.6 = 54.4\text{eV}$$

(35.) (a)Thomson model was able to explain the overall neutrality of the atom.

(36.) (c) $\lambda(A) = 3\times10^{-7}$m

$$\lambda(B) = 3\times10^{-4}\text{m}$$

$$\lambda(C) = 3\times10^{-9}\text{m}$$

$$\lambda(D) = 3\times10^{-9}\text{m}$$

$$E \propto \frac{1}{\lambda}$$

Thus, increasing order of energy =

$C = D > A > B$

(37.) (d)II is not correct.

(38.) (b) Heisenberg uncertainty principle states that it is impossible to determine simultaneously the exact position and exact momentum (or velocity) of an electron.

(39.) (b) frequency $= \frac{1}{\text{time period}} = \frac{1}{3.5\times10^{-9}}$

$v = \frac{c}{\lambda} \Rightarrow \lambda = \frac{c}{v}$

$\lambda = \frac{3\times10^{8}}{1}\times3.5\times10^{-9} = 10.5\times10^{-1} = 1.05\text{m}$

(40.) (d)Two electrons, which are present in the same orbital, must have different spins. Thus, they can be distinguished by spin quantum number.

(41.) (c)A few positively charged α -particles were deflected. The deflection was due to enormous repulsive force as the positive charge is concentrated in a very smaller volume called nucleus.

(42.) (a)wave number $= \frac{1}{\bar{\lambda}} = RZ^2\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)$

$= R\left(\frac{1}{2^2}-\frac{1}{4^2}\right) = R\left(\frac{1}{4}-\frac{1}{16}\right) = \frac{3}{16}\times R = \frac{3}{16}\times109700 = 20568.75 = 2.06\times10^4\text{cm}^{-1}$

(43.) (a)According to Hund's rule of maximum multiplicity the electronic configuration of N -atom is

$1s^2$	$2s^2$	$3p^3$		
↓↑	↓↑	↑	↑	↑

(44.) (c) $mur = \frac{nh}{2\pi}$ $v = \frac{nh}{2\pi mr}$

$\text{Time} = \frac{\text{distance}}{\text{velocity}} = \frac{2\pi r}{nh/2\pi mr} = \frac{4\pi^2 mr^2}{nh}$

(45.) (b)1 & 1I are isotopes while III & IV are isobars.

(46.) (c) 3^{rd} to 2^{nd} → first line

4^{rh} to2^{nd} →second line

5^{th} to2^{nd} →third line

6^{rh} to2^{nd} →fourth line

(47.) (c)According to Pauli's exclusion principle two electrons of same orbital should have different spins.

(48.) (c)Interference and diffraction can be explained on the basis of wave nature of the electromagnetic radiation.

(49.) (b) $r_n = \frac{0.529n^2}{Z}\text{A}^\circ$

For third Bohr's orbit $n=3$

$r_3 = \frac{0.529\times9}{1} = 4.76\text{A}^\circ$

(50.) (b)R. A. Millikan devised a method known as oil drop experiment to determine the charge of electron,

TOPIC WISE PRACTICE QUESTIONS-EXPLANATIONS

1. 4) Number of neutrons = Mass number – Atomic number = 70 – 30 = 40.
2. (4)

(a) CO2 : Atoms = 1 + 2 = 3; Electrons = 6 + 8 × 2 = 22 e^-

N2O : Atoms = 1 + 2 = 3; Electrons = 7 × 2 + 8 = 22 e^-

(b) CaO : Atoms = 2; Electrons = 20 + 8 = 28 e^-

KF : Atoms = 2; Electrons = 19 + 9 = 28 e^-

(c) OF2 : Atoms = 3; Electrons = 8 + 18 = 26 e^-

HClO : Atoms = 3; Electrons = 1 + 17 + 8 = 26 e^-

3. (3) The electrical discharge through the gases could be observed only at low pressure and high voltage.
4. (2) The cathode rays (negatively charged particles stream) originates from cathode and move towards anode.
5. 3)

	A.No.		Total electrons	
K^+	19	→	18	iso electronic species
Ca^{2+}	20	→	18	
Sc^{3+}	21	→	18	
Cl^-	17	→	18	

6. 4) Proton is the nucleus of H-atom (H-atom devoid of its electron)
7. 4) Isodiaphers have same difference of number of neutrons and protons or (A – 2Z) must be same.
8. 3)
9. 2)
10. 2) N^{3-} ,the amount of deviation depends upon the magnitude of negative charge on the particle.
11. 3) Energy of an electron in Bohr's orbit is given by the relationship.

$$E_n = \frac{13.6}{n^2} eV$$

12. 3) $_{18}Ar^{40}$ contains 22 neutrons and $_{21}Sc^{40}$ contains 19 neutrons. The number of neutrons = (A – Z)
13. 2) P.E. = work done $= \int_{\infty}^{r} -\frac{ze^2}{r^2} dr = -\frac{ze^2}{r}$
14. 4) Given : Radius of hydrogen atom = 0.530 Å, Number of excited state (n) = 2 and atomic number of hydrogen atom (Z) = 1. We know that the Bohr radius.

$$(r) = \frac{n^2}{Z} \times \text{Radius of atom} = \frac{(2)^2}{1} \times 0.530 = 4 \times 0.530 = 2.12 \overset{0}{A}$$

15. 2)
16. 3)
17. 4) In S.I units the P.E. $= \frac{-Ze^2}{4\pi\varepsilon_0 r}$. For Li^{2+}, Z = 3.

$$\therefore P.E. = \frac{-3e^2}{4\pi\varepsilon_0 r}$$

18. 4) $r \propto n^2; v \propto \frac{1}{n}$

$$\omega = \left(\frac{v}{r}\right) \propto \frac{1}{n^3}$$

19. 1) $r_n = r_1 \times n^2$ (for hydrogen atom)

$r_n = r \times n^2$

As $r_1 = r(\text{given})$

$r_2 = r \times 2^2 (2, \text{ for second Bohr's orbit}) = 4r$

20. 4) $_{17}Cl^{35}$ and $_{17}Cl^{37}$ are isotopes, so they will have same chemical properties.
21. 4) Total energy of a revolving electron is the sum of its kinetic and potential energy.

Total energy = K.E. + P. E.

$$= \frac{e^2}{2r} + \left(-\frac{e^2}{r}\right) = \frac{e^2 - 2e^2}{2r} = \frac{e^2}{2r}$$

22. 2) $E_{He+} = \frac{K(2)^2}{(2)^2} = K,$

$E_{Li^{2+}} = \frac{K(3)^2}{(2)^2} = \frac{9}{4}K$

$\Rightarrow E_{He^+} = \frac{4}{9}E_{Li^{2+}}$

23. 4) Atomic number is equal to number of protons or number of electrons. Thus if two species have different atomic number they must contain different number of protons and electrons. Number of neutrons = Atomic mass – Atomic number. Therefore due to difference of atomic numbers two species also have different number of neutrons.

24. 3) $v_n = 2.186\times10^6 \Rightarrow 1.093\times10^6 = 2.186\times10^6\times\frac{1}{n}; n = 2$

from Bohr theory we know $2\pi r = n\lambda = 2\lambda$, where $\lambda = \frac{h}{mv}$ or $r = 0.529\frac{n^2}{Z} \Rightarrow 0.529\times4\overset{0}{A}$

Circumference of the orbit $\Rightarrow 2\times0.529\times4\times10^{-10} \Rightarrow 13.30\times10^{-10}\,m$

28. 4) $\frac{n(n-1)}{2} = 6; n = 4$

$n = 4, E_4 = -0.85eV$

$n = 1, E_1 = -13.6eV$

$\therefore \Delta E = 12.75eV$

$12.75eV = \frac{1240eV - nm}{\lambda}$

$\lambda = 97.25nm$

26. 1) $\frac{\Delta E}{E_{4th}} = \frac{24}{E_{4th}} = \frac{\left[\frac{1}{1}-\frac{1}{4}\right]}{\left[\frac{1}{16}\right]} = \frac{3/4}{1/16}$

$E_{4th} = 2eV$

27. 2) $2\pi\rho_v = v\lambda \Rightarrow 2\pi\times0.53\frac{n}{z} = v\lambda$

$\lambda = 2\pi\times0.53\times\frac{n}{z}$............(i)

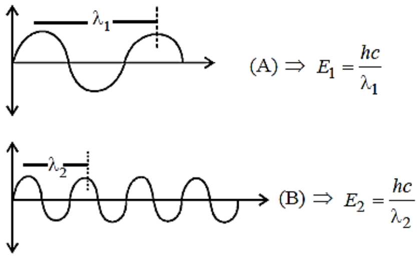
$E_{\sigma\varepsilon\pi} = 3.4 = 13.6\frac{z^2}{n^2} \Rightarrow \frac{n}{z} = 2$

$\lambda = 23.14\times0.53\times2 = 6.66\overset{0}{A}$

28. 1) There is only one type of transition from n = 2 to n = 1 and hence emitted radiation will constitute only one frequency

29. 1) When the intensity of the incident radiation is increased, the number of photoelectrons emitted does increase. Thus, the rate of flow of electrons increases and hence the photoelectronic current decreases with the decrease in intensity of the source of light.

30. 3) e/m waves shown in figure A has higher wavelength in comparison to e/m waves shown in figure B. Thus these waves also differ in frequency and energy $v = \frac{c}{\lambda}$



$\lambda_1 > \lambda_2 \Rightarrow E_1 < E_2$

31. 1) Threshold frequency $(v_0) = \frac{\text{work function}}{h} = \frac{3.3 \times 1.6 \times 10^{-19}\,J}{6.6 \times 10^{-34}\,Js} = 8 \times 10^{14}\,s^{-1}$

32. 4) $E = hv$ and $v = \left(\frac{c}{\lambda}\right)$

$v_a = 10^{15}, v_b = 10^{14}, v_c = 10^{17}, v_d = 0.85 \times 10^{15}$ and $v_e = 10 \times 10^{15}$

33. 2) $v \propto \frac{Z}{n}$

34. 3) Vth stationary state, as radii of stationary state is given as $r_n = n^2 \times a_0 \Rightarrow n = 5$

35. 4) Energy of N-shell $= \frac{-13.6 \times (4)^2}{(4)^2} = -13.6\text{eV}$

$\therefore$ P.E $= 2 \times E \Rightarrow 2 \times -13.6 = -27.2\text{eV}$

36. 3) ΔE for two energy levels $= 21.79\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ J / atom

37. 2) $T \propto \frac{n^3}{Z^2}; \frac{T_1}{T_2} = \frac{n_1^3}{Z_1^2} \times \frac{Z_2^2}{n_2^3} = \frac{Z^3}{1} \times \frac{2^2}{3^3} = \frac{32}{27}$

38. 2) Bohr model can only explain one electron system

39. 3) The energy of photon, $E = \frac{hc}{\lambda} = 3.03 \times 10^{-19}$ or $\lambda = \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{3.03 \times 10^{-19}}$

or $\lambda = \frac{19.878}{3.03} \times 10^{-7} = 6.56 \times 10^{-7}\,m = 656m$

40. 4)

41. 4) $\lambda = \frac{h}{mv} = \frac{6.6 \times 10^{-34}}{60 \times 10^{-3} \times 10} = 10^{-33}\,m$

42. 3) $\lambda = \frac{h}{mv}; \therefore \lambda \propto \frac{1}{v}$

43. 2) $\Delta x.\Delta v$ value will be large for object of smallest mass and is therefore the most significant for calculating uncertainty.

44. 1) $E = (mc).c$ or $P = \frac{E}{c} = \frac{6 \times 10^6 \times 1.6 \times 10^{-19}}{3 \times 10^8} = 3.2 \times 10^{-21}$ kgm / s

45. 1) $\lambda = \frac{hc}{\Delta E} = \frac{6.62 \times 10^{-34}\,Js \times 3 \times 10^8\,ms^{-1}}{E \times 1.602 \times 10^{-19}\,J} = \frac{12395}{E} \times 10^{-10}\,m$

46. 2) $\psi = \frac{1}{\sqrt{\pi}}\left(\frac{1}{a_0}\right)^{3/2} = e^{\left(-\frac{r}{a_0}\right)}$ Hence, ψ^2 is maximum at $r = 0$, but $4\pi\rho^2\psi^2$ is minimum at $r = 0$

47. 2)
48. 1)
49. 1)
50. 4) Photon exerts pressure as it has momentum and energy
51. 3) $E = hv = 6.63 \times 10^{-34} \times 2.47 \times 10^{15} = 1.640 \times 10^{-18}\,J$

52. 4) Energy = $N_A hv$

$$495.5 = 6.023\times10^{23}\times6.6\times10^{-34}\times v$$

$$v = \frac{495.5\times10^{3}J}{6.023\times10^{23}\times6.6\times10^{-34}} = 12.4\times10^{14} = 1.24\times10^{15}s^{-1}$$

53. 3)

54. 2) n = 4 represents 4^{th} orbit

$\ell = 3$ represents *f* subshell

s = 1/2 represents direction of spin of electron.

∴ The orbital is 4*f*.

55. 1) According to (n + ℓ) rule

For 2s, n = 2, ℓ = 0

$\therefore n+\ell = 2$

Similarly for $3d = (n+\ell) = 5$

$4s = (4+0) = 4$

$5f \rightarrow 5f = (5+3) = 8$

∴ 2s is lower in enery

56. 2)

57. 3) n = 2, ℓ = 1 means 2*p*–orbital. Electrons that can be accommodated = 6 as *p* sub-shell has 3 orbital and each orbital contains 2 electrons.

58. 2) According to given information *n* = 5 and ℓ = 3.

59. 3) First four orbitals contain four lobes, while fifth orbital consists of only two lobes. The lobes of *d*xy orbital lie between x and y axis. Similarly in the case of *d*yz and *d*zx. their lobes lie between yz and zx axis respectively. Four lobes of $d_{x^2-y^2}$ orbital are lying along x and y axis while two lobes of d_{z^2} orbital are lying along z-axis.

60. 4) The number of sub shell is (2 ℓ + 1). The maximum number of electrons in the sub shell is 2 (2 ℓ + 1) = (4 ℓ + 2).

61. 4) When m = – 3, ℓ = 3, ∴ n = 4.

62. 2) For *f*-orbital, the values of m are –3, –2, –1, 0, +1, +2, +3.

63. 1) Angular nodes = ℓ , spherical nodes (n – ℓ – 1); Total (n – 1). Hence spherical nodes for 5*f* orbits. = (5 – 3 –1) = 1

64. 4) As m = (2 ℓ + 1), hence m = – 1 means,

–1 = 2 ℓ + 1. ℓ = 1 (magnitude)

i.e least value of ℓ = 1. So it cannot be present in *s*-orbital. Because for *s* orbital ℓ = 0.

65. 1) For *s*-electron, ℓ = 0

$$\therefore \text{Orbital angular momentum} = \sqrt{0(0+1)}\,\frac{h}{2\pi} = 0$$

66. 1) Be^{3+} is hydrogenic ion, i.e. consists of one extra-nuclear electron.

67. 4) The component values of orbital angular momentum in z-direction = $m_\ell \times \frac{h}{2\pi}$

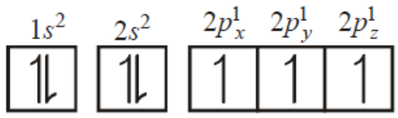
68. 2) Number of orbitals in a shell = $= n^2 = (5)^2 = 25$

69. 1)

70. 4) For ‘*g*’ subshell, $\ell = 4$. The minimum value of principal quantum number *n* = 5. No. of orbitals in 5th shell $5^2 = 25$, No. of electrons 2 n^2 = 2 x 25 = 50

NEET PREVIOUS YEARS QUESTIONS-EXPLANATIONS

1) 4) The correct configuration of 'N' is



2) 3) For hydrogen like atoms energy of 2*s*-orbital and 2*p*-orbital is equal.

3. 4) Two electrons occupying the same orbital should have opposite spins i.e. they differ in spin quantum number.

4. 4) (n + l) rule can be used. Titanium is a multi-electron system

$$(n+l)\quad 3s < 3p < 4s < 3d$$
$$3s \rightarrow (3+0) = 3,\quad 3p \rightarrow (3+1) = 4,\quad 4s \rightarrow (4+0) = 4,\quad 3d \rightarrow (3+2) = 5$$

5. 1) $Fe^{2+} = 3d^6$ (number of 'd' electrons = 6)

In Cl = $1s^2 2s^2 2p^6 3s^2 3p^5$ total *p* electrons = 11, which are not equal to number of 'd' electrons in Fe^{+2}

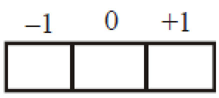
s – electrons in Mg = $1s^2 2s^2 2p^6 3s^2 = 6$

6. 4) Orbital angular momentum = $\sqrt{\ell(\ell+1)}.h$

For d-orbital $\ell = 2$

Angular momentum = $\sqrt{2(2+1)}h = \sqrt{6}h$

7. 1) Given: n = 3, *l* = 1, m = 0
Hence orbital is 3*p*



hence the number of orbital identified by m = 0 can be one only.

8. 4) $E = \frac{hc}{\lambda} = \frac{6.63\times10^{-34}\times3\times10^{8}}{45\times10^{-9}} = 4.42\times10^{-18}\,J$

9. 2) $Be^{2+} = (4-2) = 2$
is isoelectronic with Li^+ (3 – 1 = 2) Since both have same number of electrons in their outermost shell.

10. 1)According to (n+l) rule, correct order of energy is
5f > 6p > 5p > 4d

11. 2)In spectrum of hydrogen atom, spectral lines of Balmer series lie in visible region.

12. 3)

Orbital having angular node (ℓ) = 3

Total node = Radial node + angular node

$= n - \ell - 1 + \ell$

$3 = n - 1$

$n = 4$

Subshell "nℓ" = **4f**

13. 2)

$n\lambda = 2\pi r$

$n\lambda = 2\pi \frac{n^2}{z} a_0$

$n\lambda = 2\pi \times \frac{n^2}{Z} \times 52.9 \text{ pm}$

$\lambda = 2\pi \times 52.9 \times 2 \text{ pm}$

$= \mathbf{211.6\ \pi\ pm}$

14. 1)No. of angular nodes = ℓ
No. of Radial nodes = $n-\ell-1$
For 3s ; n = 3 and l = 0
$\therefore$ No. of angular nodes = 0
$\therefore$ No. of radial nodes = 2

15. 3) $Cr^{2+} - [Ar]3d^4 4s^0 \left[3d^4 \boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\uparrow}\boxed{\ }\right]$

Number of unpaired electrons = 4

Magnetic moment $\mu = \sqrt{n(n+2)}$; $BM = \sqrt{4(4+2)} = \sqrt{24} = 4.9BM$

16. 4) $C = \upsilon\lambda$; $\lambda = \frac{3\times10^8}{1368\times10^3} = 219.3m$

17. O_2^+ has one unpaired electron

18 $d_{x^2-y^2}$ *and* d_{z^2} has clove leaf and Taurus shape respectively

19 Red of sec bohr's orbit of He^+ is 105.8pm radius of third Bohr orbit of Li^{2+} = $105.8\times10^{-12} = \frac{x\times4}{2}$

$x = \frac{105.8}{2} = 52.6\times10^{-12} m$

$x = \frac{52.6\times10^{-12}\times n}{3} = 157.8\times10^{-12}$