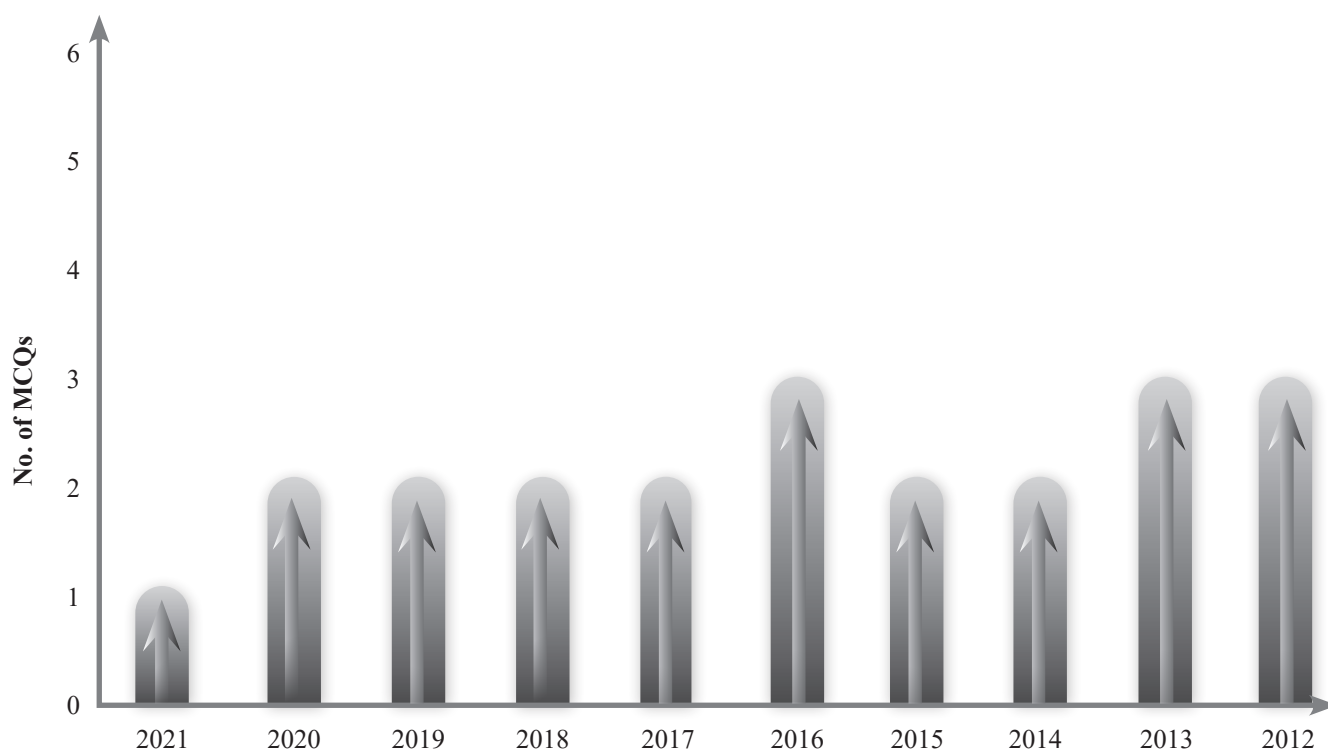


2

STRUCTURE OF ATOM

Past Years NEET Trend



Investigation Report

TARGET EXAM	PREDICTED NO. OF MCQs	CRITICAL CONCEPTS
NEET	1-2	Bohr's model for hydrogen atom, Calculation of E and r, Quantum numbers

Perfect Practice Plan

Topicwise Questions	Learning Plus	Multiconcept MCQs	NEET Past 10 Years Questions	Total MCQs
118	35	24	22	199

INTRODUCTION

The atomic theory of matter was first proposed by John Dalton, known as Daltons atomic theory.

Dalton regarded that atom is the ultimate particle of matter.

According to Modern atomic theory atoms can be further divided into subatomic particles i.e. electrons, protons and neutrons.

SUB-ATOMIC PARTICLES

Dalton's Theory is able to explain law of conservation of mass, law of constant composition and law of multiple proportions.

Same salient feature's of this theory are:

- Atoms of a specific element are like but it differ from atoms of other element
- Atom of each element is an ultimate particle and it has a characteristic mass but is structureless
- Atoms are indestructible, as they can neither be created nor be destroyed.

Fundamental Particles

	Fundamental Particle		
	Electron	Proton	Neutron
Charge	$-1.6022 \times 10^{-19} \text{ C}$	$+1.6022 \times 10^{-19} \text{ C}$	Neutral
Mass	$9.10939 \times 10^{-31} \text{ kg}$ 0.00054 a.m.u	$1.67262 \times 10^{-27} \text{ kg}$ 1.00727 a.m.u	$1.67493 \times 10^{-27} \text{ kg}$ 1.00867 a.m.u

Charge to Mass Ratio of Electron

The charge to mass ratio is known as specific charge. Larger the magnitude of the charge on the particle larger is the deflection when electric and magnetic field is applied.

Lighter the mass of the particle larger will be the deflection.

Thomson was able to find the value of charge to mass ratio as $1.758820 \times 10^{11} \text{ C kg}^{-1}$

As the velocity of the electron increases, the specific charge of the electron decreases due to the increase of relative mass of the electron.

The mass of a moving electron may be calculated by applying the formula

$$m = \frac{m_0}{\sqrt{1 - \left(\frac{v}{c}\right)^2}}$$

Where m_0 = Rest mass of electron
 v = Velocity of the electron
 c = Velocity of light

If $v = c$, mass of the moving electron becomes infinity.

Charge on the Electron

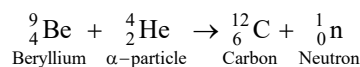
Mullikan determined the charge of the electron by an oil drop experiment. Millikan concluded that the magnitude of electrical charge, q , on the droplets is always an integral multiple of the electrical charge, e , that is $q = ne$, where $n = 1, 2, 3, \dots$

Charge on the oil drops was always an integral multiple of $1.60 \times 10^{-19} \text{ C}$.

$$m_e = \frac{e}{e/m_e} = \frac{1.60 \times 10^{-19} \text{ C}}{1.758820 \times 10^{11} \text{ C kg}^{-1}} = 9.1094 \times 10^{-31} \text{ kg}$$

Proton: The smallest and highest positive ion obtained from hydrogen.

Neutron: Neutron are the particles in an atom that have neutral charge



ATOMIC MODELS

Thomson Model

J.J. Thomson, in 1898, proposed that an atom possesses a spherical shape radius in which the positive charge is uniformly distributed. According to Thomson atom is like water melon and electron's are embedded like seeds in water melon.

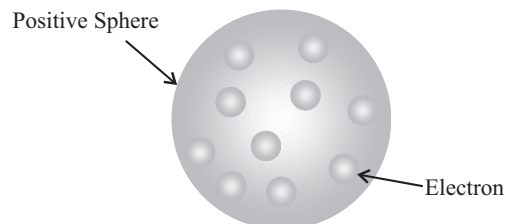


Fig: Thomson model of atom

An important feature of this model is that the mass of the atom is assumed to be uniformly distributed over the atom.

This model can not explain electrical neutrality of the atom.

This model also called **plum pudding**, **raisin pudding** or **watermelon model of atom**.

Rutherford's Model of Atom

Rutherford suggested atomic model based on α -ray scattering experiment.

Scattering of a narrow beam of α -particles as they passed from a thin gold foil and it is covered with fluorescent ZnS screen. When α -particles strike the screen then flash of light was produced at that point.

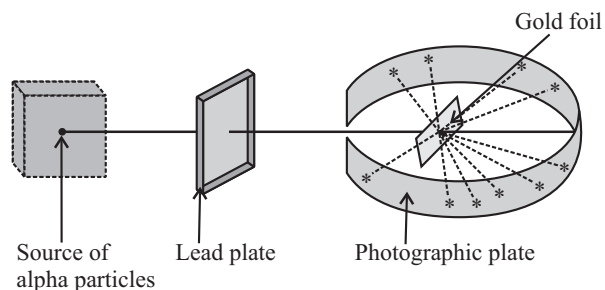


Fig.: Rutherford's scattering experiment

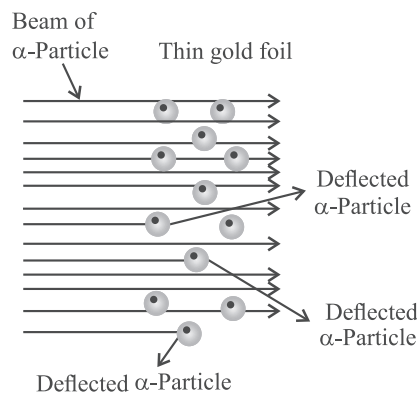


Fig.: Schematic molecular view of the gold foil

Observation

1. Most of the α -particles pass through the foil undeflected.
2. A small fraction of α -particles were deflected by small angles.
3. A very few α -particles bounced back were deflected by 180°

Conclusion

1. Most of the space in the atom is empty.
2. A few positively charged were deflected. The deflection must be due to enormous repulsive forces shows that the positive charge of the atom is not spread out the atom.
3. Volume occupied by the nucleus is very small as compare to total volume of atom

Assumption of this Model

- (i) All the positive charge and mass of the atom is present in a very small region at the centre of the atom. It is called nucleus.
- (ii) The nucleus is surrounded by electrons that move around the nucleus with a very high speed in circular paths called orbits.
- (iii) The centrifugal force is present due to fast moving electrons balances the coulombic force of attraction present between the nucleus and the electrons.
- (iv) Rutherford's atomic model is comparable with the solar system. So it is known as planetary model.

Drawback of Rutherford's Model

1. It fails to explain the atomic spectrum or line spectrum.
2. It fails to explain stability of atom.

Atomic Number and Mass number

- The number of electrons or protons present in an atom of an element is called its **atomic number**(Z).
- The sum of protons and neutrons in the atom of an element is called its **mass number**(A).
- Number of neutrons = $A - Z$.

Isotopes and Isobars

Atoms of the same element having same atomic number but different mass numbers are known as **isotopes**.

Example: (1) Isotopes of hydrogen:

Protium (${}_1\text{H}^1$), Deuterium (${}_1\text{H}^2$) or (${}_1\text{D}^2$) or Tritium ${}_1\text{T}^3$

(2) Isotopes of chlorine : (${}_{17}\text{Cl}^{35}$) and (${}_{17}\text{Cl}^{37}$)

Isobars

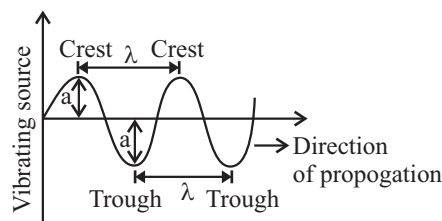
Atoms of different elements having same mass number but different atomic numbers are known as **isobars**.

Eg: ${}^{14}_6\text{C}$, ${}^{14}_7\text{N}$

WAVE NATURE OF ELECTROMAGNETIC RADIATION

- Electromagnetic radiation is the energy transmitted from one body to another in the form of waves and these waves travel in the space with the same speed as light (3×10^8 m/s) and these waves are called as Electromagnetic waves or radiant energy.

- Cosmic rays, γ -rays, X-rays, UV light, visible light, Infrared light, micro waves and radio waves are known electromagnetic radiation as they are made up of electric and magnetic fields that are radiates in perpendicular directions in one another.
- Electromagnetic radiations have wave characteristics and no medium is required for their propagation. They can travel through the vacuum.



The Electromagnetic Spectrum

In $\text{\AA} \times 10^{-4}$

0.01	0.1	150	3800	7600	6×10^6	3×10^9	3×10^{14}
Cosmic rays	γ -rays	X-rays	Ultra violet	Visible	Infra red	Micro wave	Radio waves



V	I	B	G	Y	O	R
Violet	Indigo	Blue	Green	Yellow	Orange	Red
3800	4300	4500	4900	5500	5900	6500
7600 In $\text{\AA}$						

A wave is characterized by following characteristics:

Wave Length (λ): The distance between two neighbouring troughs or crests in wave is known as wave length.

The units of wave length are m, cm, $\text{\AA}$, nm, μm or pm.

$$1\text{\AA} = 10^{-8} \text{ cm} = 10^{-10} \text{ m}$$

Frequency (ν): The number of waves which pass through a given point in one second is called frequency.

The units of frequency are sec^{-1} , **cycles per second (cps)** or Hertz (Hz).

$$1 \text{ cps} = 1 \text{ Hz} = \text{sec}^{-1}$$

The relation between frequency(ν) and wavelength (λ) is

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

Where c = Velocity of light

Wave Number ($\bar{\nu}$): The number of wave lengths per centimetre or the reciprocal wave length is called wave number.

The unit of wave number is cm^{-1} or m^{-1}

$$\text{Wave number } \bar{\nu} = \frac{1}{\lambda}$$

The relation between ν and $\bar{\nu}$ is $\nu = c\bar{\nu}$

Amplitude (A): The height of the crest or depth of the trough of a wave is called amplitude.

Amplitude is a measure of the intensity or brightness of a beam of light.

Velocity (C): The distance travelled by a wave in one second is called its velocity.

The units of velocity are **m/sec or cm/sec**.

Particle Nature of Electromagnetic Radiation

Some of the experimental phenomenon such as diffraction and interference can be explained by the wave nature of the electromagnetic radiation.

A body that is capable of absorbing all types of radiations and emits completely the absorbed radiations is called a black body.

When a black body is heated it emits thermal radiation of different wave lengths or frequencies.

At a given temperature the intensity of radiation increases with wavelength reaches a maximum and then decreases.

When solids are heated they emit radiation over a wide range of wavelength.

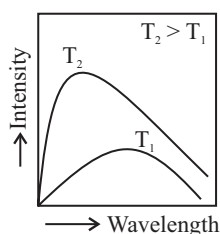


Fig.: Wavelength intensity relationship

Planck's Quantum Theory

- Substances that absorb or emit light discontinuously in the form of small packets or bundles of energy known as quanta.
- The radiation is propagated in the form of waves.
- The energy of a quanta is directly proportional to the frequency of the radiation.

$$E \propto \nu$$

$$E = h\nu$$

$$\therefore E = \frac{hc}{\lambda} = hc\bar{\nu}$$

Where E = Energy of radiation

h = Planck's constant

$$= 6.625 \times 10^{-27} \text{ erg} - \text{sec}$$

$$= 6.625 \times 10^{-34} \text{ Joule} - \text{sec}$$

- A body that can absorb or emit energy in whole number multiple of quantum.

$$E = nh\nu$$

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

- The frequency of emitted radiation goes from lower to higher as the temperature increases.

TRAIN YOUR BRAIN

Q. Calculate number of photon coming out per sec. from the bulb of 100 watt. If it is 50% efficient and wavelength coming out is 600 nm.

Ans. Energy = 100J

Energy of one photon

$$= \frac{hc}{\lambda} = \frac{6.625 \times 10^{-34} \times 3 \times 10^8}{600 \times 10^{-9}} = \frac{6.625}{2} \times 10^{-19}$$

$$\text{No. of photon} = \frac{100}{6.625} \times 10^{19} = 15.09 \times 10^{19}$$

Photo Electric Effect

In 1887, H. Hertz performed an experiment that is photoelectric effect.

When light is exposed to clean metallic surface, electrons are ejected from the surface. This phenomenon is called photo electric effect.

The Observation of Photoelectric Effect

- The electrons are ejected from the metal surface as soon as the beam of light strikes the surface, i.e., there is no time lag between the striking of light beam and the ejection of electrons from surface.
- Ejection of electrons from the surface of a metal by irradiating it with light of suitable frequency.
- A part of the energy of photon which is used to escape the electron from the attractive forces and the remaining energy is used to increase the kinetic energy of electron.

$$E = W + KE$$

$$h\nu = h\nu_0 + KE$$

Where W = Work function or Threshold energy

$$W = h\nu_0$$

Where ν_0 = Threshold frequency

- In photo electric effect the number of photo electrons that is emitted is proportional to intensity of incident light.

The minimum energy that is required for emission of photo electrons is called **threshold energy or work function**.

For each metal, there is a characteristic minimum frequency (also known as threshold frequency) below which photoelectric effect is not observed. At a frequency $\nu > \nu_0$ then photoelectric effect is observed.

Spectra

The spectra that is obtained by the emission of energy by the excited atoms are called **emission spectra**.

When white light is passed through a gas and the emergent beam of light that is allowed to fall on a photographic plate, the spectrum obtained is called **absorption spectrum**.

Hydrogen Spectrum

The source of radiation here is a hydrogen discharge tube.

The discharge tube that contains hydrogen gas at low pressure and high potential difference

The bright light emitted from the discharge tube is passed through a prism to cause dispersion.

The emergent beam of light falls on a photographic plate and is recorded as the **atomic spectrum of hydrogen**.

The wavelength or wave number of various lines in the visible region can be expressed by an equation. [Rydberg's equation]

$$\bar{\nu} = \frac{1}{\lambda} = R_H \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right]$$

where R_H = Rydberg's constant for H-atom

$$= 1,09,677$$

n_1 = Lower energy level

n_2 = Higher energy level

Rydberg constant value is not same for all the elements.

For hydrogen like species He^+ , Li^{2+} , Be^{3+} ,

$$R = 1,09,677 \times Z^2 \text{ cm}^{-1}$$

$$= R_H \times Z^2$$

Maximum no of spectral lines produced from n_2 to n_1 state of a

$$\text{simple atom} = \frac{n(n-1)}{2} \text{ where } n = n_2 - n_1$$

They can be classified into various series.

Series of Hydrogen of Spectrum

Name of the series	n_1	n_2	Region
Lyman series	1	2, 3, 4, 5..	Ultraviolet
Balmer series	2	3, 4, 5, 6..	Visible
Paschen series	3	4, 5, 6, 7	Near I.R
Brackett series	4	5, 6, 7, 8..	I.R
Pfund series	5	6, 7, 8, 9	Far I.R

BOHR'S MODEL

Postulates of Bohr's Atomic Model

The electrons in an atom that revolve round the nucleus in fixed circular orbits or shells or energy levels.

Electrons that can revolve only in those stationary orbits in which their angular momentum is equal to integral multiple of $\frac{h}{2\pi}$.

$$\therefore mvr = \frac{nh}{2\pi}$$

where m = mass of electron

v = velocity of electron

r = radius of orbit

n = Principal quantum number

= 1, 2, 3, 4, ...

h = Planck's constant

KEY NOTE

Angular momentum is the product of moment of inertia(I) and angular velocity(ω).

When an electron drops from a higher state to a lower state, energy is released.

When an electron jumps from a lower state to a higher state, energy is absorbed.

The absorbed or evolved energy is equal to the difference in energies of two orbits, which is equal to quanta.

$$\Delta E = E_2 - E_1 = h\nu$$

where E_2 = Energy of higher state

E_1 = Energy of lower state

The frequency of radiation absorbed (or) emitted when transitions occurs between two stationary states that differ in energy by ΔE , is given by

$$\nu = \frac{\Delta E}{h} = \frac{E_2 - E_1}{h}$$

This expression is known Bohr's frequency

The line spectrum is obtained due to the electronic transition from one state to another state

KEY NOTE

♦ The force of attraction between the nucleus and then electron

$$= \frac{-Ze^2}{r^2}$$

♦ Radius of orbits in H atom like ions $r = \frac{0.529 \times n^2}{Z} \text{ \AA}$

♦ Kinetic energy of electron $= \frac{1}{2}mv^2 = \frac{Ze^2}{2r}$

♦ Potential energy of electron $= \frac{-Ze^2}{r}$

♦ As we go to higher orbits, kinetic energy decreases, potential energy increases and the total energy increases.

♦ Total energy of electron

$$E = KE + PE = \frac{Ze^2}{2r} - \frac{Ze^2}{r} = -\frac{Ze^2}{2r}$$

♦ Expression for the energy of Bohr's orbit

$$E = \frac{-2\pi^2 m Z^2 e^4}{n^2 h^2}$$

♦ Velocity of electron in bohr orbit

$$mvr = \frac{nh}{2\pi}$$

Energy of orbits in hydrogen atom ($Z = 1$)

$$E = \frac{-2.179 \times 10^{-11}}{n^2} \text{ ergs/atom}$$

$$= \frac{-2.179 \times 10^{-18}}{n^2} \text{ Joules/atom}$$

$$= \frac{-1312}{n^2} \text{ kJ/mole}$$

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

$$1 \text{ eV} = 1.602 \times 10^{-19} \text{ J}$$

The energy of the electron in a hydrogen atom has a negative sign for all possible otbitals because the energy of the electrons in the atom is lower than the energy of a free electron at rest.

For Hydrogen atom like ions.

$$E_n = \frac{Z^2}{n^2} \times E_1$$

where E_n = Energy of n^{th} orbit in other ions like H-atom

Z = Atomic number

E_1 = Energy of first orbit in hydrogen atom

Difference of energy between two Bohr orbits of hydrogen atom

$$R = \frac{2\pi^2 m Z^2 e^4}{h^3 C} = 1, 09, 680 \times Z^2 \text{ cm}^{-1}$$

$$\Delta E = Z^2 R_H \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right]$$

where Z = atomic number.

Velocity of electron in hydrogen atom

$$V = \frac{2\pi Z e^2}{nh} = 2.188 \times 10^8 \times \frac{Z}{n} \text{ cm/sec}$$

Magnitude of velocity of electron increases with increase of positive charge on the nucleus and decreases with increases of principle Quantum Number.

KEY NOTE

- Number of revolutions per second (or) orbital frequency by an electron in a shell

$$= \frac{\text{Velocity}}{\text{Circumference}} = \frac{v}{2\pi r} = 6.66 \times 10^{15} \times \frac{Z^2}{n^3}$$

- For hydrogen atom, ionization potential $= \frac{-E_1}{n^2}$.

- For H atom, like ions, Ionisation potential $= \frac{-E_1 \times Z^2}{n^2}$

- Ionisation potential of an atom or ion $= 13.6 \left[\frac{Z^2}{n^2} \right] \text{ eV}$

TRAIN YOUR BRAIN

- Q.** The ratio of $(E_2 - E_1)$ to $(E_4 - E_3)$ for He^+ ion is approximately equal to (where E_n is the energy of n^{th} orbit)

(a) 10 (b) 15 (c) 17 (d) 12

$$\text{Ans. (b)} \quad \frac{13.6(2)^2 \left[\frac{1}{(1)^2} - \frac{1}{(2)^2} \right]}{13.6(2)^2 \left[\frac{1}{(3)^2} - \frac{1}{(4)^2} \right]} = 15$$

- Q.** What is the orbit number of H atom if electron having energy is -3.4 eV ? Also report the angular momentum of electron.

Ans. E_1 for H $= -13.6 \text{ eV}$

$$\text{Now } E_n = \frac{E_1}{n^2} \quad \therefore -3.4 = \frac{-13.6}{n^2} \quad \therefore n = 2$$

Now, Angular momentum (mvr)

$$n \cdot \frac{h}{2\pi} = \frac{2 \times 6.626 \times 10^{-34}}{2 \times 3.14} = 2.1 \times 10^{-34} \text{ J-sec}^{-1}$$

- Q.** The ionization energy of a hydrogen like Bohr atom is 4 Rydberg. What is the radius of the first orbit of this atom? (Bohr radius of hydrogen $= 5 \times 10^{-11} \text{ m}$; 1 Rydberg $= 2.2 \times 10^{-18} \text{ J}$)

$$\text{Ans. } -13.6 \frac{Z^2}{n^2} = 4R = 4 \times 2.2 \times 10^{-18} \text{ J}$$

$$Z^2 = \frac{4 \times 2.2 \times 10^{-18} \text{ J}}{13.6 \times 1.6 \times 10^{-19}} = 4; \quad Z = 2$$

$$r = 0.529 \times 10^{-10} \times \frac{1}{2} = 2.645 \times 10^{-11} \text{ m.}$$

$$2.65 \times 10^{-11} \text{ m.}$$

- Q.** Which state of the triply ionized Beryllium (Be^{3+}) has the same orbit radius as that of the ground state of hydrogen atom?

Ans. Radius of ground state of hydrogen atom $= 0.529 \text{ \AA}$

$$0.529 = 0.529 \times \frac{n^2}{Z}$$

$$0.529 = 0.529 \times \frac{n^2}{4}$$

$$\therefore n = 2$$

Limitations of Bohr's Model

- It failed to explain the line spectra of atoms or ions having more than one electron.
- It fails to account the fine spectra details of the hydrogen atom.
- It fail to explain Zeeman's effect and stark effect.

KEY NOTE

- The splitting of spectral lines of an atom into a group of fine lines under the influence of a magnetic field is called **Zeeman effect**.
- The splitting of spectral lines of an atom into group of fine lines under the influence of an electric field is called **Stark effect**.

De Broglie's Wave Theory

The wave nature of electron was first proposed by de Broglie.

According to de Broglie theory all moving particles have wave properties.

Wave properties are important only for particles of small mass and high velocity.

$$\text{de Broglie's equation is } \lambda = \frac{h}{mv} = \frac{h}{p}$$

where λ = wave length

h = Planck's constant

v = Velocity of the particle

$mv = p$ = Momentum of the particle

According to de Broglie's theory, electrons revolve around the nucleus in atomic orbits with stationary waves.

Electrons revolves in those orbits, whose circumference must be equal to integral multiple of wave length.

$$\therefore 2\pi r = n\lambda$$

where r = radius of the orbit

$n = 1, 2, 3, 4 \dots$

HEISENBERG'S UNCERTAINTY PRINCIPLE

It is impossible to determine simultaneously, the exact position and exact momentum (or velocity) of an electron. It is called Heisenberg's uncertainty principle.

The uncertainty principle equation is

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

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

where Δx = uncertainty in position
 Δp = uncertainty in momentum
 Δv = uncertainty in velocity
 m = mass of the particle
 h = Planck's constant

If $\Delta x = 0$ i.e., the position of the electron determined accurately then $\Delta v = \infty$

If $\Delta v = 0$ i.e., the velocity of the electron determined accurately then $\Delta x = \infty$

TRAIN YOUR BRAIN

Q. Alveoli are the tiny sacs of air in the lungs whose average diameter is 50 pm. Consider an oxygen molecule trapped within a sac. Calculate uncertainty in the velocity of oxygen molecule?

- (a) $1.98 \times 10^{-2} \text{ ms}^{-1}$ (b) 19.8 ms^{-1}
 (c) $198 \times 10^{-4} \text{ ms}^{-1}$ (d) $19.8 \times 10^{-6} \text{ ms}^{-1}$

Ans. (b) $\Delta x = 50 \text{ pm}$

$$\Delta v = \frac{h}{4\pi m \Delta x} = \frac{6.625 \times 10^{-34} \times 6.022 \times 10^{23}}{4 \times 3.14 \times 32 \times 10^{-3} \times 50 \times 10^{-12}} \text{ m/sec}$$

$$= 0.0019853 \times 10^4 \text{ m/sec}$$

$$= 19.853 \text{ m/sec}$$

QUANTUM MECHANICAL MODEL OF ATOM & ITS IMPORTANT FEATURES

The branch of science that takes into account this dual behaviour of matter is called quantum mechanics.

The fundamental equation of quantum mechanics was developed by Schrodinger.

Schrodinger's wave equation is

$$\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} + \frac{\partial^2 \psi}{\partial z^2} + \frac{8\pi^2 m}{h^2} (E - V) \psi = 0$$

where ψ = Wave function

m = Mass of electron

h = Planck's constant

E = Total energy of the electron

V = Potential energy of electron

x, y, z are co-ordinates.

The solution of Schrodinger wave equation gives principal, azimuthal and magnetic quantum number but not the spin quantum number ψ indicates the amplitude of the wave.

For a system (such as an atom or a molecule whose energy does not change with time) the Schrodinger equation is written as $\hat{H}\psi = E\psi$ where $\hat{H}$ is a mathematical operator called Hamiltonian operator.

$$\hat{H} = V - \frac{h^2}{8\pi^2 m} \left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2} \right)$$

Important Features of Quantum Mechanical Model of Atom

The energy of electrons in atoms is quantized (i.e., can only have certain specific values), for example when electrons are bound to the nucleus in atoms.

Exact position and exact velocity of an electron in an atom cannot be determined simultaneously (Heisenberg uncertainty principle). the path of an electron in an atom thus, can never be determined or known accurately.

An atomic orbital is the wave function ψ for an electron in an atom.

The probability of finding an electron at a point within an atom is proportional to the square of the orbital wave function i.e., $|\psi|^2$ at that point. $|\psi|^2$ is known as probability density and is always positive.

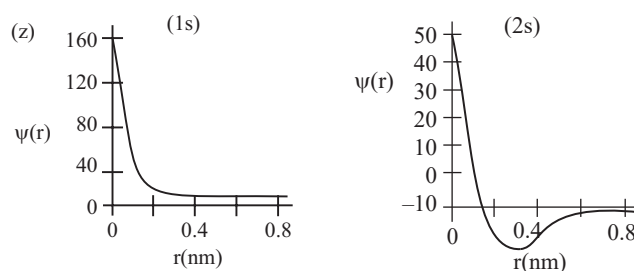
From the value of $|\psi|^2$ at different point within an atom, it is possible to predict the region around the nucleus where electron will most probability be found.

The probability of finding an electron at a certain distance from the nucleus is called **radial probability**.

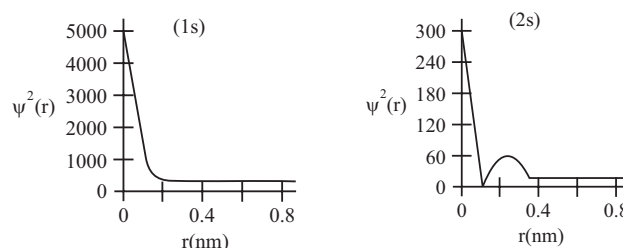
Shapes of Atomic Orbitals

The space around the nucleus of an atom in which there is a maximum probability of finding an electron is called an **orbital**.

The variation of $\psi(r)$ as function of r for 1s and 2s orbitals is given as follows



The variation of $\psi^2(r)$ as function of r for 1s and 2s orbitals is given as follows



The region where probability density (ψ^2) is zero called nodes (or) nodal surface.

s-orbital

For ns-orbital, (n-1) nodes are present.

Eg: For 2s-one, 3s-two

The shape of s orbital ($l = 0$) is spherical.

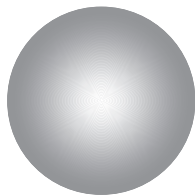


Fig: Shape of s-orbital

Size of s orbital increases with increase in n, that is $4s > 3s > 2s > 1s$.
s-orbital is a non directional orbital.

p-orbital

In a p-sub shell, the three orbitals are represented as p_x , p_y , and p_z .
These are degenerate orbitals.

The shape of a p-orbital ($l = 1$) is dumb bell.

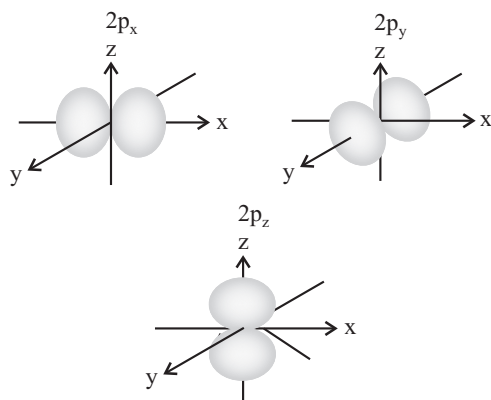


Fig: Shape of p-orbital

p-orbitals are oriented along the axes. So they are directional orbitals.

Orbital: P_x P_y P_z

m: ± 1 ± 1 0

With the increase of principle quantum number size, and energy of 'p' orbitals increases $4p > 3p > 2p$.

d-orbital

- In a d-sub shell, the five orbitals are represented as d_{xy} , d_{yz} , d_{zx} , $d_{x^2-y^2}$ and d_{z^2} .

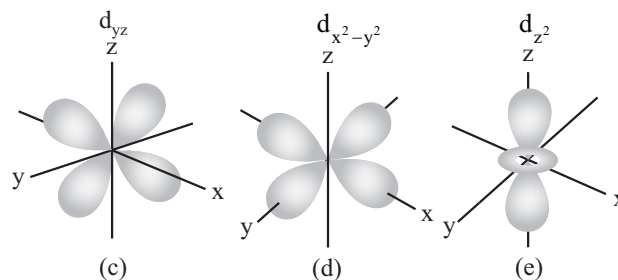
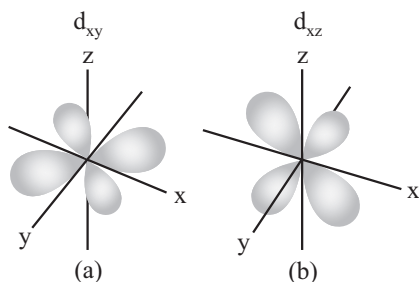


Fig: Shape of d-orbital

These are degenerate orbitals.

The shape of a d-orbital ($l = 2$) is double dumb bell.

d_{xy} , d_{yz} and d_{zx} orbitals are oriented in between the axes.

$d_{x^2-y^2}$ and d_{z^2} orbitals are oriented along the axes.

Orbital :	d_{xy}	d_{yz}	d_{zx}	$d_{x^2-y^2}$	d_{z^2}
m:	± 2	± 1	± 1	± 2	0

KEY NOTE

- Number of nodal planes (or) angular nodes for an orbital = l .
- When the number of nodal planes increases, the energy of the orbital increases. So the energy order of the orbitals is $s < p < d < f$.
- Number of radial nodes = $n - l - 1$
where n = principal quantum number
 l = Azimuthal quantum number
- Total numbers of nodes = $(n-1)$ i.e., sum of angular nodes and radial nodes.

Quantum Numbers

A set of numbers used to provide a complete description of an electron in an atom are called quantum numbers.

There are four quantum numbers required for a complete explanation of electrons in an atom.

The quantum numbers are

- Principal quantum number
- Azimuthal quantum number
- Magnetic quantum number
- Spin quantum number

Principal quantum number : Represented by "n"

It represents the name, size and energy of the shell to which electron belongs.

Greater the value of n greater is the distance from the nucleus.

Greater the value of n greater is the energy of shell

$$E_1 < E_2 < E_3 < E_4 \text{ -----}$$

The number of electrons in a particular shell is equal to $2n^2$

Azimuthal quantum number/Angular quantum number: Represented by "l"

- It represents the shape of the subshell and orbital.
- It is used for calculating orbital angular momentum.
- Value of l is between 0 to $(n-1)$

i.e. $l = 0, 1, 2 \text{ ----- } (n-1)$
 $l = 0$ (s Subshell)

$\ell = 1$ (p Subshell)

$\ell = 2$ (d Subshell)

$\ell = 3$ (f Subshell)

If the value of n is same then the order of energy of the various subshells will be $s < p < d < f$

If Value of ℓ is same but value of n is different then the order of energy will be. $1s < 2s < 3s < 4s < 5s < 6s$

The orbital angular momentum is equal to

$$\sqrt{l(l+1)} \frac{h}{2\pi} \text{ or } \sqrt{l(l+1)} \hbar \left\{ \because \hbar = \frac{h}{2\pi} \right\}$$

The number of electron in a particular subshell is equal to $2(2\ell + 1)$

Magnetic quantum number / Orientation quantum number (m)

- It represents the orientation of electron cloud (orbital) i.e. direction of electron density.
- Value of m = All integral values from $-\ell$ to $+\ell$, including zero.

Spin Quantum number (s)

- It represents the direction of electron spin around its own axis.

- Value of $s = \pm \frac{1}{2}$

- Spin angular momentum of an

$$e^- = \sqrt{s(s+1)} \cdot \frac{h}{2\pi} \text{ or } \sqrt{s(s+1)} \hbar$$

- Total spin = no. of unpaired electron $\times \pm 1/2$

KEY NOTE

Magnetic moment (μ) is given by $\mu = \sqrt{n(n+2)}$
where n is number of unpaired electron

TRAIN YOUR BRAIN

Q. Calculate total spin, magnetic moment for the atoms having at. no. 7, 24 and 36.

Ans. The electronic configuration are

${}_7\text{N} : 1s^2, 2s^2, 2p^3$ unpaired electron = 3

${}_{24}\text{Cr} : 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^5, 4s^1$ unpaired electron = 6

${}_{36}\text{Kr} : 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^{10}, 4s^2, 4p^6$ unpaired electron = 0

$\therefore$ Total spin for an atom = $\pm 1/2 \times$ no. of unpaired electron

For ${}_7\text{N}$, it is $\pm 3/2$; For ${}_{24}\text{Cr}$, it is ± 3 ;

For ${}_{36}\text{Kr}$, it is = 0

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

For ${}_7\text{N}$, it is $\sqrt{15}$; For ${}_{24}\text{Cr}$, it is $\sqrt{48}$;

For ${}_{36}\text{Kr}$, it is $\sqrt{0}$

Energy of orbitals

The energy of an electron in a hydrogen atom is determined by the principal quantum number. Thus the energy of the orbitals increases as follows:

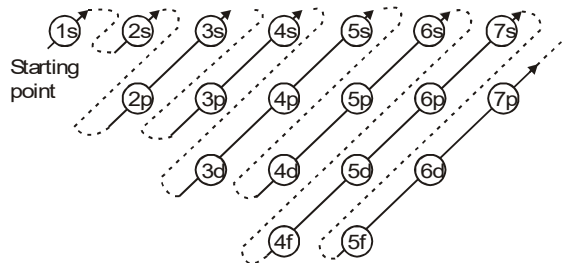
$$1s < 2s = 2p < 3s = 3p = 3d < 4s = 4p = 4d = 4f$$

RULES FOR FILLING OF ORBITALS

Aufbau Principle

Principle: The electrons are filled up in increasing order of the energy of the subshells. The subshell with minimum energy is filled up first and when this subshell obtains maximum quota of electrons then the next subshell of higher energy starts filling.

The sequence in which various subshell are filled is the following.



($n + \ell$) rule

Principle of ($n + \ell$) rule

The subshell with lowest ($n + \ell$) value is filled up first, but when two or more subshells have same ($n + \ell$) value then the subshell with lowest value of n is filled up first.

Subshell	n	ℓ	$n + \ell$
1s	1	0	1
2s	2	0	2
2p	2	1	3
3s	3	0	3
3p	3	1	4
4s	4	0	4
3d	3	2	5
4p	4	1	5
5s	5	0	5
4d	4	2	6
5p	5	1	6
6s	6	0	6

Pauli's Exclusion principle

In 1925, Pauli stated that no two electrons in an atom can have same values of all four quantum numbers.



An orbital can accommodate maximum 2 electrons and that too with opposite spin.

Hund's Rule of Maximum Multiplicity

According to Hund's rule electrons are distributed among the Orbitals of subshell in such a way as to give maximum number of unpaired electron with parallel spin. i.e. in a subshell pairing of electron will not start until and unless all the orbitals of that subshell will get one electron each with same spin.

Exceptions of Aufbau Principle

In some cases it is observed that the actual electronic configuration of an element is slightly different from the arrangement given by aufbau principle. A simple reason behind this is that the half filled and full filled subshell have got extra stability due to symmetry and exchange energy.

Stability of Completely Filled and Half Filled Subshells

The completely filled and exactly half filled sub shells are stable due to the following reason.

- 1. Symmetrical Distribution of electrons:** It is that symmetry leads to stability, the completely filled or half filled subshells have symmetrical distribution of electrons in them and they are therefore more stable.
- 2. Exchange Energy:** The number of exchanges which can take place is maximum when the subshell is either half filled or completely filled. As a result the exchange energy is maximum and so is the stability.

Topicwise Questions

SUB-ATOMIC PARTICLES

- The charge of an electron was discovered by:
(a) J.J. Thomson (b) Neil Bohr
(c) Chadwick (d) Millikan
- Which has highest specific charge?
(a) Na^+ ($A = 23$) (b) Mg^{2+} ($A = 24$)
(c) Al^{3+} ($A = 27$) (d) Si^{4+} ($A = 28$)
- Which of the following properties of atom could be explained correctly by Thomson model of atom?
(a) Overall neutrality of atom
(b) Spectra of hydrogen atom
(c) Position of electrons, protons and neutrons in atom.
(d) Stability of atom

ATOMIC MODELS

- The ratio of charge and mass would be greater for:
(a) Proton (b) Electron
(c) Neutron (d) α -particle
- $({}_{32}\text{Ge}^{76}, {}_{34}\text{Se}^{76})$ and $({}_{14}\text{Si}^{30}, {}_{16}\text{S}^{32})$ are the examples of
(a) Isotopes and isobars
(b) Isobars and isotones
(c) Isotones and isotopes
(d) Isobars and isotopes
- The lightest particle is:
(a) α -particle (b) Positron (c) Proton (d) Neutron

DEVELOPMENTS LEADING TO THE BOHR'S MODEL OF ATOM

- Which pair is of isoelectronic species?
(a) K^+ , Cl^- , Na^+ (b) K^+ , Cl^- , Ca^{2+}
(c) Fe^- , Al^{3+} , K^+ (d) Fe^{2+} , Cu^{2+} , V^{3+}
- The Wavelength (in Å) of an emission line obtained for Li^{2+} during a electronic transition from $n_2 = 2$ to $n_1 = 1$ is: ($R = \text{Rydberg constant}$)
(a) $3R/4$ (b) $27R/4$ (c) $4/3R$ (d) $4/27R$
- Splitting of spectral lines under the influence of magnetic field is called:
(a) Zeeman effect (b) Stark effect
(c) Photoelectric effect (d) None of these
- A metal surface is exposed to solar radiations
(a) The emitted electrons have energy less than a maximum value of energy depending upon the frequency of the incident radiation.
(b) The emitted electrons have energy less than the maximum value of energy depending upon intensity of incident radiations.

- The emitted electrons have zero energy.
- The emitted electrons have energy equal to energy of photons of incident light.
- In photoelectric effect, the kinetic energy of photoelectrons increases linearly with
(a) Wavelength of incident light
(b) Frequency of incident light
(c) Velocity of incident light
(d) Atomic mass of the element
- The value of Rydberg constant is:
(a) $109,677 \text{ cm}^{-1}$ (b) 19876 cm^{-1}
(c) 108769 cm^{-1} (d) 108976 cm^{-1}
- What is the lowest energy of the spectral line emitted by the hydrogen atom in the Lyman series?
(a) $\frac{5hR_Hc}{36}$ (b) $\frac{4hR_Hc}{3}$ (c) $\frac{3hR_Hc}{4}$ (d) $\frac{7hR_Hc}{144}$
- The scientist who proposed the atomic model based on the quantisation of energy for the first time is:
(a) Max Planck (b) Neil Bohr
(c) De-Broglie (d) Heisenberg
- The kinetic energy of electron is $3.0 \times 10^{-25} \text{ J}$. The wave length of the electron is
(a) 7965 Å (b) 4625 Å (c) 91 Å (d) 8967 Å
- A 100 watt bulb emits monochromatic light of wavelength 400 nm . Calculate the number of photons emitted per second by the bulb.
(a) $20.12 \times 10^{20} \text{ s}^{-1}$ (b) $2.012 \times 10^{20} \text{ s}^{-1}$
(c) $4.969 \times 10^{-19} \text{ s}^{-1}$ (d) $49.69 \times 10^{-19} \text{ s}^{-1}$

BOHR'S MODEL FOR HYDROGEN ATOM

- The wave number for the longest wavelength transition in the Balmer series of atomic hydrogen is
(a) $15.2 \times 10^6 \text{ m}^{-1}$ (b) $13.6 \times 10^6 \text{ m}^{-1}$
(c) $1.5 \times 10^6 \text{ m}^{-1}$ (d) $1.3 \times 10^6 \text{ m}^{-1}$
- The ratio of the energies of two different radiations whose frequencies are $3 \times 10^{14} \text{ Hz}$ and $5 \times 10^{14} \text{ Hz}$ is
(a) 3 : 5 (b) 5 : 3 (c) 3 : 1 (d) 5 : 1
- If the wavelength of green light is about 5000 Å , then the frequency of its wave is
(a) $16 \times 10^{14} \text{ sec}^{-1}$ (b) $16 \times 10^{-14} \text{ sec}^{-1}$
(c) $6 \times 10^{14} \text{ sec}^{-1}$ (d) $6 \times 10^{-14} \text{ sec}^{-1}$
- What is the energy of photons that corresponds to a wave number of $2.5 \times 10^{-5} \text{ cm}^{-1}$
(a) $2.5 \times 10^{-20} \text{ erg}$
(b) $5.1 \times 10^{-23} \text{ erg}$
(c) $4.96 \times 10^{-21} \text{ erg}$
(d) $8.5 \times 10^{-2} \text{ erg}$

21. The frequency of a wave light is $1.0 \times 10^6 \text{ sec}^{-1}$. The wave length for this wave is
 (a) $3 \times 10^4 \text{ cm}$ (b) $3 \times 10^{-4} \text{ cm}$
 (c) $6 \times 10^4 \text{ cm}$ (d) $6 \times 10^6 \text{ cm}$
22. Suppose 10^{-17} J of energy is needed by the interior of human eye to see an object. How many photons of green light ($\lambda = 550 \text{ nm}$) are needed to generate this minimum amount of energy?
 (a) 14 (b) 28 (c) 39 (d) 42
23. The wavelength of a spectral line emitted by hydrogen atom in the Lyman Series is $\frac{16}{15R} \text{ cm}$. What is the value of n^2 ?
 (R = Rydberg constant)
 (a) 2 (b) 3 (c) 4 (d) 1
24. The energy of an electron present in Bohr's second orbit of hydrogen atom is _____
 (a) $-1312 \text{ J atom}^{-1}$ (b) -328 kJ mol^{-1}
 (c) -328 J mol^{-1} (d) -164 J mol^{-1}
25. The emission spectrum of hydrogen discovered first and the region of the electromagnetic spectrum to which it belongs, respectively are-
 (a) Lyman, Ultraviolet (b) Lyman, Visible
 (c) Balmer, Ultraviolet (d) Balmer, Visible
26. The velocity of electron in second shell of hydrogen atom is:
 (a) $10.94 \times 10^6 \text{ m/sec}$ (b) $18.88 \times 10^6 \text{ m/sec}$
 (c) $1.88 \times 10^6 \text{ m/sec}$ (d) $1.094 \times 10^6 \text{ m/sec}$
27. For which of the following species, Bohr's theory is not applicable?
 (a) Be^{3+} (b) Li^{2+} (c) He^{2+} (d) H
28. If the first ionisation energy of H atom is 13.6 eV , then the second ionisation energy of He^+ atom is:
 (a) 27.2 eV (b) 40.8 eV
 (c) 54.4 eV (d) 108.8 eV
29. When the electrons of hydrogen atom return to L-shell from shell of higher energy, we get a series of lines in the spectrum. This series is called:
 (a) Balmer series
 (b) Lyman series
 (c) Brackett series
 (d) Pascher series
30. The nitride ion in lithium nitride is composed of:
 (a) 7-protons + 10 electrons
 (b) 10-protons + 10 electrons
 (c) 7-protons + 7 electrons
 (d) 10-protons + 7 electrons
31. In which one of the following pairs, the two species are both isoelectronic and isotopic? (Atomic number: Cr = 24, Ar = 18, K = 19, Mg = 12, Fe = 26, Na = 11)
 (a) $^{24}\text{Mg}^{2+}$ and ^{40}Ar (b) $^{39}\text{K}^+$ and $^{40}\text{K}^+$
 (c) $^{24}\text{Mg}^{2+}$ and ^{25}Mg (d) ^{23}Na and $^{24}\text{Na}^+$
32. A species having only one electron has ionization energy of $11810 \text{ kJ mol}^{-1}$. The number of protons in its nucleus will be:
 (a) 1 (b) 2 (c) 3 (d) 4
33. When the electron of a hydrogen atom jump from $n = 4$ to $n = 1$ state, the number of different spectral line emitted are:
 (a) 15 (b) 9 (c) 6 (d) 3
34. The wave number of the spectral line in the emission spectrum of hydrogen will be equal to $8/9$ times the rydberg constant if the electron jumps from:
 (a) $n = 3$ to $n = 1$ (b) $n = 10$ to $n = 1$
 (c) $n = 9$ to $n = 1$ (d) $n = 2$ to $n = 1$
35. The radius of the first Bohr orbit of the H-atom is r . Then, the radius of the first orbit of Li^{2+} will be:
 (a) $r/9$ (b) $r/3$
 (c) $3r$ (d) $9r$
36. In which one of the following, the number of protons is greater than the number of neutrons but number of protons is less than the number of electrons?
 (a) D_3O^+ (b) SO_2
 (c) H_2O (d) OH^-
37. The energy ratio of a photon of wavelength $3000 \text{ \AA}$ and $6000 \text{ \AA}$ is:
 (a) 1 : 1 (b) 2 : 1 (c) 1 : 2 (d) 1 : 4
38. Bohr's model can explain:
 (a) The solar spectrum
 (b) Spectrum of hydrogen molecule
 (c) Spectrum of any atom or ion containing one electron only
 (d) Spectrum of hydrogen atom only
39. The first line emission of hydrogen atom spectrum in the Balmer species appears at:
 (a) $5R/36 \text{ cm}^{-1}$ (b) $3R/4 \text{ cm}^{-1}$
 (c) $7R/144 \text{ cm}^{-1}$ (d) $9R/400 \text{ cm}^{-1}$
40. The radius of 2nd Bohr's orbit of hydrogen atom is:
 (a) 0.053 nm (b) 0.106 nm
 (c) 0.2116 nm (d) 0.4256 nm
41. The maximum energy possessed by an electron in when it is present:
 (a) In nucleus
 (b) In ground energy state
 (c) In 1st excited state
 (d) At infinite distance from the nucleus
42. Which one of the following transition have minimum wavelength?
 (a) $n_4 \rightarrow n_1$ (b) $n_2 \rightarrow n_1$
 (c) $n_4 \rightarrow n_2$ (d) $n_3 \rightarrow n_1$
43. Select the pair where both species have same radius?
 (a) $r_4\text{He}^+$ and $r_1\text{H}$ (b) $r_2\text{Be}^{3+}$ and $r_1\text{H}$
 (c) $r_2\text{He}$ and $r_1\text{H}$ (d) $r_3\text{Li}^{2+}$ and $r_1\text{H}$

44. The radius of the first orbit of hydrogen atom is 0.52×10^{-8} cm. The radius of the first orbit of He^+ ion is
 (a) 0.26×10^{-8} cm (b) 0.52×10^{-8} cm
 (c) 1.04×10^{-8} cm (d) 2.08×10^{-8} cm
45. The ratio of ionization energy of H and Be^{+3} is
 (a) 1 : 1 (b) 1 : 3 (c) 1 : 9 (d) 1 : 16
46. As we move away from nucleus, the energy of orbit
 (a) Decreases (b) Increases
 (c) Remains unchanged (d) None of these
47. In hydrogen atom, energy of first excited state is -3.4 eV. Then find out KE of same orbit of hydrogen atom
 (a) $+3.4$ eV (b) $+6.8$ eV
 (c) -13.6 eV (d) $+13.6$ eV
48. The ratio of the velocity of the electron in the third and fifth shell for He^+ would be :
 (a) 5 : 3 (b) 1 : 2 (c) 3 : 5 (d) 3 : 4
49. The wavelength of the electron emitted when in a hydrogen atom, electron falls from infinity to stationary state would be (Rydberg constant = $1.097 \times 10^7 \text{ m}^{-1}$)
 (a) 91 nm (b) 192 nm
 (c) 406 nm (d) 9.1×10^{-8} nm
50. In two H atoms A and B the electrons move around the nucleus in circular orbits of radius r and $4r$ respectively. The ratio of the times taken by them to complete one revolution is:
 (a) 1 : 4 (b) 1 : 2 (c) 1 : 8 (d) 2 : 1
51. The equation corresponding to the wave number of spectral line in the Bracket series
 (a) $R[(1/2^2) - (1/4^2)]$ (b) $R[(1/4^2) - (1/5^2)]$
 (c) $R[(1/3^2) - (1/5^2)]$ (d) $R[(1/6^2) - (1/4^2)]$
52. The ratio of highest possible wavelength to lowest possible wavelength of Lyman series is
 (a) $4/3$ (b) $9/8$ (c) $27/5$ (d) $16/5$
53. Which of the following lines will have a wave no. equal in magnitude to the value of R in the H - Spectral series
 (a) Limiting line of Balmer series
 (b) Limiting line of Lyman series
 (c) First line of Lyman series
 (d) First line of Balmer series
54. If the wave number of the first line in the Balmer series of hydrogen atom is 15000 cm^{-1} , the wave number of the first line of the Balmer series of Li^{2+} is
 (a) $1.43 \times 10^4 \text{ cm}^{-1}$ (b) $1.66 \times 10^9 \text{ cm}^{-1}$
 (c) $13.5 \times 10^5 \text{ cm}^{-1}$ (d) $1.35 \times 10^5 \text{ cm}^{-1}$
55. The ionisation energy for the Hydrogen atom in the ground state is $2.18 \times 10^{-18} \text{ J atom}^{-1}$. The energy required for the following process
 $\text{He}^+ (\text{g}) \rightarrow \text{He}^{2+} (\text{g}) + \text{e}^-$ is
 (a) $8.72 \times 10^{-18} \text{ J atom}^{-1}$
 (b) $8.72 \times 10^{-19} \text{ J atom}^{-1}$
 (c) $4.35 \times 10^{-18} \text{ J atom}^{-1}$
 (d) $2.62 \times 10^{-19} \text{ J atom}^{-1}$

DE BROGLIE RELATION AND HEISENBERG'S UNCERTAINTY PRINCIPLE

56. The velocities of two particles A and B are 0.05 and 0.02 ms^{-1} respectively. The mass of B is five times the mass of A. The ratio of their de-Broglie's wavelength is
 (a) 2 : 1 (b) 1 : 4
 (c) 1 : 1 (d) 4 : 1
57. The energy absorbed by each molecule (A_2) of a substance is $4.4 \times 10^{-19} \text{ J}$ and bond energy per molecule is $4.0 \times 10^{-19} \text{ J}$. The kinetic energy of the molecule per atom will be:
 (a) $2.2 \times 10^{-19} \text{ J}$ (b) $2.0 \times 10^{-19} \text{ J}$
 (c) $4.0 \times 10^{-20} \text{ J}$ (d) $2.0 \times 10^{-20} \text{ J}$
58. The uncertainty in the velocity of particle of mass $6.626 \times 10^{-28} \text{ Kg}$ is 10^{-6} m/sec . What is the uncertainty in its position in nm?
 (a) $\frac{1}{2\pi}$ (b) $\frac{2.5}{\pi}$
 (c) $\frac{4}{\pi}$ (d) $\frac{1}{4\pi}$
59. The ratio of de-broglie wavelength of a deuterium atom to that of α -particle when the velocity of former is five times greater than that of latter is:
 (a) 4 (b) 10.2 (c) 2 (d) 0.4
60. The mass of the electrons 9.1×10^{-28} gram and uncertainty in the velocity equal to $2 \times 10^{-3} \text{ cm/sec}$. The uncertainty in the position of an electron is ($h = 6.62 \times 10^{-27} \text{ erg sec}$)
 (a) $2.9 \times 10^{+2} \text{ cm}$ (b) $2.9 \times 10^{-2} \text{ cm}$
 (c) $2.9 \times 10^{-12} \text{ cm}^{-1}$ (d) $2.9 \times 10^{+12} \text{ cm}^{-1}$
61. The uncertainty in the positions of an electron and proton is equal, the ratio of the uncertainties in the velocity of an electron and proton is
 (a) $10^3 : 1$ (b) 1 : 1838
 (c) 3672 : 1 (d) 1838 : 1
62. The de-Broglie wavelength for a proton with a velocity 15% of the speed of light is:
 (a) $8.8 \times 10^{-12} \text{ m}$ (b) $8.8 \times 10^{-15} \text{ cm}$
 (c) $8.8 \times 10^{-15} \text{ m}$ (d) $4.4 \times 10^{-15} \text{ cm}$
63. de-Broglie wave length associated with a material particle is
 (a) Inversely proportional to momentum
 (b) Inversely proportional to its energy
 (c) Directly proportional to momentum
 (d) Directly proportional to its energy
64. A microscope using suitable photons is employed to locate an electron in an atom within a distance of $0.1 \text{ \AA}$. What is the uncertainty involved in the measurement of its velocity?
 (a) $2.69 \times 10^6 \text{ ms}^{-1}$ (b) $5.79 \times 10^5 \text{ ms}^{-1}$
 (c) $5.79 \times 10^6 \text{ ms}^{-1}$ (d) $4.62 \times 10^6 \text{ ms}^{-1}$
65. A cricket ball of 0.5 Kg is moving with a velocity of 100m per sec. the wavelength associated with its motion is
 (a) $1/100 \text{ m}$ (b) $6.6 \times 10^{-34} \text{ m}$
 (c) $1.32 \times 10^{-35} \text{ m}$ (d) $6.6 \times 10^{-28} \text{ m}$

66. As per de-broglie formula a microscopic particle of mass 100 g and moving at a velocity of 100 cm/sec will have a wavelength of:
 (a) 6.6×10^{-29} cm/s (b) 6.6×10^{-30} cm/s
 (c) 6.6×10^{-31} cm/s (d) 6.6×10^{-32} cm/s
67. The wavelengths of electron waves in two orbits is 3 : 5. The ratio of kinetic energy of electron
 (a) 25 : 9 (b) 5 : 3
 (c) 9 : 25 (d) 3 : 5
68. If E_e , E_α , and E_p represents the kinetic energy of an electron, α -particle and proton respectively each moving with same de-broglie wavelength then:
 (a) $E_e = E_\alpha = E_p$ (b) $E_e > E_\alpha > E_p$
 (c) $E_\alpha > E_p > E_e$ (d) $E_e > E_p > E_\alpha$
69. In sommerfeld's modification of Bohr's theory the trajectory of an electron of hydrogen atom is:
 (a) A perfect ellipse
 (b) A close ellipse like curve, narrower at the perihelion position and flatter at the aphelion position
 (c) A close loop on spherical surface
 (d) Rosette
70. A particle having a mass of 1 mg has a velocity 1 Km/sec. Calculate the wavelength of the particle:
 (a) 6.626×10^{-28} cm (b) 6.626×10^{-29} cm
 (c) 6.626×10^{-30} cm (d) 6.626×10^{-31} cm
71. The uncertainty in the position of an electron moving with a velocity of 3×10^4 cm/sec accurate upto 0.011% will be:
 (a) 1.92 cm (b) 7.66 cm
 (c) 0.175 cm (d) 3.84 cm
72. If uncertainty in position and velocity are equal, then uncertainty in momentum will be:
 (a) $\frac{1}{2} \sqrt{\frac{mh}{\pi}}$ (b) $\frac{1}{2} \sqrt{\frac{h}{\pi m}}$
 (c) $\frac{h}{4\pi m}$ (d) $\frac{mh}{4\pi}$
73. The velocity of particle "A" is 0.1m/sec and that of particle "B" is 0.05m/sec. If the mass of particle B is 5 times that of particle A, then the ratio of de-broglie wavelength associated with particle A and B:
 (a) 2:5 (b) 3:4 (c) 6:4 (d) 5:2
74. If de-broglie wavelength of mass 'm' is 100 times of its velocity then its value in term of its mass 'm' and planck's constant "h" is:
 (a) $\frac{1}{10} \times \sqrt{\frac{m}{h}}$ (b) $10 \sqrt{\frac{h}{m}}$
 (c) $\frac{1}{10} \sqrt{\frac{h}{m}}$ (d) $10 \sqrt{\frac{m}{h}}$
75. The wavelength of electron waves in two orbit is in ratio 3:5. The ratio of K.E. of electrons will be:
 (a) 25:9 (b) 15:3 (c) 9:25 (d) 3:5

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

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

77. The de-broglie wavelength associated with a mass of 1kg having K.E. 0.5J is:

(a) 6.626×10^{-34} m (b) 13.20×10^{-34} m
 (c) 10.38×10^{-31} m (d) 6.626×10^{-34} Å

78. The velocity of an electron with de Broglie wavelength of 1.0×10^2 nm is:

(a) 7.2×10^5 cm/sec
 (b) 72×10^5 cm/sec
 (c) 7.2×10^4 cm/sec
 (d) 3.6×10^5 cm/sec

QUANTUM MECHANICAL MODEL OF ATOM

79. The number of waves made by an electron moving in an orbit having maximum magnetic quantum number + 3 is -

(a) 4 (b) 3 (c) 5 (d) 6

80. Which have the same number of s-electrons as the d-electrons in Fe^{2+} ?

(a) Li (b) Na (c) N (d) P

81. The set of quantum no. not applicable for an electron -

(a) $2, 0, 0, -\frac{1}{2}$
 (b) $3, 1, -2, +\frac{1}{2}$
 (c) $4, 2, -2, -\frac{1}{2}$
 (d) $6, 0, 0, +\frac{1}{2}$

82. Which of the following pair of ions have same paramagnetic moment ?

(a) Cu^{+2} , Ti^{+3} (b) Mn^{+2} , Cu^{+2}
 (c) Ti^{+4} , Cu^{+2} (d) Ti^{+3} , Ni^{+2}

83. The atomic number of an element 'M' is 26. How many electrons are present in the M-shell of the element in its M^{3+} state?

(a) 11 (b) 15 (c) 14 (d) 13

84. The minimum angular momentum of an electron with the magnetic quantum numbers $-1, 0, +1$

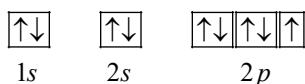
(a) $\sqrt{\frac{3h}{2\pi}}$ (b) $\frac{h}{\pi}$ (c) $\frac{2h}{\pi}$ (d) $\frac{3h}{2\pi}$

85. The values of four quantum numbers of valence electron of an element X is $n = 4, l = 0, m = 0, s = \frac{1}{2}$. The element is

(a) K (b) Ti (c) Na (d) Sc

86. Which of the following elements has least number of electrons in its M shell?
 (a) K (b) Mn (c) Ni (d) Sc
87. Which one of the following set of quantum numbers is not possible for a 4p electron?
 (a) $n = 4, l = 1, m = +1, m_s = +\frac{1}{2}$
 (b) $n = 4, l = 1, m = 0, m_s = +\frac{1}{2}$
 (c) $n = 4, l = 1, m = 2, m_s = +\frac{1}{2}$
 (d) $n = 4, l = 1, m = -1, m_s = +\frac{1}{2}$
88. The maximum number of electrons with spin value $+1/2$ in the orbital with azimuthal quantum number value $l = 2$ and magnetic quantum number $m = +2$ is
 (a) 5 (b) 6 (c) 3 (d) 1
89. The correct set of n, l, m , quantum numbers for the unpaired electron of chlorine atom is -
 (a) 2, 1, 0 (b) 2, 1, 1
 (c) 3, 1, 1, (d) 3, 0, 0
90. Which quantum number is not related with Schrodinger equation?
 (a) Principal (b) Azimuthal
 (c) Magnetic (d) Spin
91. Which of the following set of quantum numbers is correct for valence electron of potassium?
 (a) $n = 4, l = 0, m = 0, s = -1/2$
 (b) $n = 3, l = 0, m = 0, s = -1/2$
 (c) $n = 4, l = 1, m = 0, s = -1/2$
 (d) $n = 3, l = 1, m = -1, s = -1/2$
92. Given K L M N
 2 8 11 2
 The number of electrons present in $l = 2$ is
 (a) 3 (b) 6 (c) 5 (d) 4
93. In which transition, one quantum of energy is emitted?
 (a) $n_2 = 4 \rightarrow n_1 = 2$ (b) $n_2 = 3 \rightarrow n_1 = 1$
 (c) $n_2 = 2 \rightarrow n_1 = 1$ (d) All of these
94. Which of the following statement concerning the four quantum number is incorrect?
 (a) n gives the size of an orbital
 (b) l gives the shape of an orbital
 (c) m gives the energy of the electron in orbital
 (d) Both (a) and (b)
95. Consider the ground state of Cr atom ($Z = 24$). The number of electrons with the azimuthal quantum numbers $l = 1$ and 2 are respectively.
 (a) 12 and 4 (b) 16 and 5
 (c) 16 and 4 (d) 12 and 5
96. Two particles A and B are in motion. If the wavelength associated with the particle A is $5.0 \times 10^{-8} \text{ m}$, the wavelength of particle B having momentum half of A is:
 (a) $2.5 \times 10^{-8} \text{ m}$ (b) $1.254 \times 10^{-8} \text{ m}$
 (c) $1.0 \times 10^{-7} \text{ m}$ (d) $1.0 \times 10^{-8} \text{ m}$
97. Which one of the following expressions represent the electron probability function (D)?
 (a) $4\pi r dr \psi^2$ (b) $4\pi r^2 dr \psi$
 (c) $4\pi r^2 dr \psi^2$ (d) $4\pi r dr \psi$
98. The quantum of light energy is called:
 (a) Photon (b) Neutron
 (c) Electron (d) Proton
99. What is the orbital angular momentum of an electron in f-orbital?
 (a) $\frac{1.5h}{\pi}$ (b) $\frac{\sqrt{6}h}{\pi}$
 (c) $\frac{\sqrt{3}h}{\pi}$ (d) $\frac{\sqrt{3}h}{\pi}$
100. The magnetic moment of Ni^{2+} ion in BM unit is:
 (a) 1.73 (b) 4.81
 (c) 5.96 (d) 2.83
101. The angular momentum of an electron present in the excited state of Hydrogen is $\frac{1.5h}{\pi}$. The electron present in
 (a) Third orbit (b) Second orbit
 (c) Fourth orbit (d) Fifth orbit
102. The maximum number of electrons which can be held by subshell with azimuthal quantum number " l " in an atom is given by:
 (a) $2l + 1$ (b) $2l + 2$
 (c) $2(2l + 1)$ (d) $2(2l + 2)$
103. How many 'd' electrons are present in Cr^{2+} ion?
 (a) 4 (b) 5
 (c) 6 (d) 3
104. The atomic numbers of elements X, Y and Z are 19, 21 and 25 respectively. The number of electrons present in the M shells of these elements follow the order.
 (a) $Z > X > Y$ (b) $X > Y > Z$
 (c) $Z > Y > X$ (d) $Y > Z > X$
105. How many electrons are present in the M-shell of an atom of the element with atomic number $Z = 24$?
 (a) 5 (b) 6
 (c) 12 (d) 13
106. A transition metal 'X' has a configuration $[\text{Ar}] 3d^4$ in its +3 oxidation state, its atomic Number is
 (a) 25 (b) 26
 (c) 22 (d) 19
107. An element has 2 electrons in K shell, 8 electrons in L shell, 13 electrons in M shell and one electron in N shell. The element is
 (a) Cr (b) Fe
 (c) V (d) Ti

108. This electronic configuration shows element of:



- (a) Oxygen (b) Neon
(c) Fluorine (d) Nitrogen

109. Sum of electronic spins of all electrons with the configuration $3d^7$ is

- (a) $+3/2$ (b) $+5/2$
(c) $+7/2$ (d) $9/2$

110. The quantum number “m” of a free gaseous atom is associated with:

- (a) Effect volume of orbital
(b) Shape of orbital
(c) Spatial orientation of orbital
(d) Energy of orbital in the absence of magnetic field

111. The atomic number of element is 17. The number of orbital containing electron pair in its valence shell is:

- (a) 3 (b) 4
(c) 6 (d) 8

112. The total number of electrons present in all the p-orbital of bromine are (Given: Atomic no. of Br = 35)

- (a) 5 (b) 15
(c) 17 (d) 35

113. The number of unpaired electron in Fe^{3+} ($Z = 26$) are:

- (a) 5 (b) 6
(c) 3 (d) 4

114. Which of the following statement in relation to the hydrogen atom is correct:

- (a) 3s, 3p and 3d orbital all have the same energy
(b) 3s and 3p orbital are of lower energy than 3d orbital
(c) Both of these
(d) None of these

115. According to Bohr's theory, the angular momentum of an electron in the 4th orbit is:

- (a) $\frac{h}{2\pi}$ (b) $\frac{2h}{\pi}$
(c) $\frac{3h}{2\pi}$ (d) $\frac{3h}{\pi}$

116. The total number of orbitals in a shell with principle quantum number n is:

- (a) 2n (b) $2n^2$ (c) n^2 (d) $n + 1$

117. If the radius of 1st Bohr orbit be a_0 , then radius of 3rd Bohr orbit would be:

- (a) $3a_0$ (b) $6a_0$ (c) $9a_0$ (d) $\frac{1}{9}a_0$

118. Which of the following is not possible?

- (a) $n = 3, \ell = 0, m = 0$ (b) $n = 3, \ell = 1, m = -1$
(c) $n = 2, \ell = 0, m = -1$ (d) $n = 2, \ell = 1, m = -1$

Learning Plus

1. Which of the following conclusions could not be derived from Rutherford's α -particle scattering experiment?

- (a) Most of the space in the atom is empty
(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

2. How much energy is required to ionise a H-atom if the electron occupies $n = 5$ orbit?

- (a) 5.44 eV (b) 10.8 eV
(c) 0.544 eV (d) 1.08 eV

3. The hydride ion is isoelectronic with

- (a) H^+ (b) He^+
(c) He (d) Be

4. The momentum of radiation of wavelength 0.33 nm is $kg\ m\ sec^{-1}$

- (a) 2×10^{-24} (b) 2×10^{-12} (c) 2×10^{-6} (d) 2×10^{-48}

5. Which of the following options does not represent ground state electronic configuration of an atom?

- (a) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$ (b) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^9 4s^2$
(c) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$ (d) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$

6. Nitrogen laser produces a radiation at a wavelength of 337.1 nm. If the number of photons emitted is 5.6×10^{24} . Calculate the power of this laser.

- (a) 3.33×10^6 J (b) 3.33×10^5 J
(c) 1.56×10^6 J (d) 15.6×10^8 J

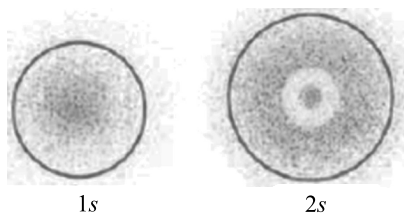
7. Which of the following does not characterise X-rays?

- (a) The radiation can ionise the gas
(b) It causes ZnS to fluorescence
(c) Deflected by electric and magnetic fields
(d) Have wavelength shorter than ultra-violet rays

8. In a photoelectric effect, the energy of the photon striking a metallic surface is 5.6×10^{-19} J. The kinetic energy of the ejected electrons is 12.0×10^{-20} J. The work function is :

- (a) 6.4×10^{-19} J (b) 6.8×10^{-19} J
(c) 4.4×10^{-19} J (d) 6.4×10^{-20} J

9. The probability density plots of 1s and 2s orbitals are given in figure:



1s

2s

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 incorrect?

- 1s and 2s orbitals are spherical in shape
 - The probability of finding the electron is maximum near the nucleus
 - The probability of finding the electron at a given distance is equal in all directions
 - The probability density of electrons for 2s orbital decreases uniformly as distance from the nucleus increases
10. The work function of a photoelectric material is 3.3 eV. Its threshold frequency will be
- 7.96×10^{14} Hz
 - 7.96×10^{10} Hz
 - 5×10^{33} Hz
 - 4×10^{11} Hz
11. Which of the following statement is not correct about the characteristics of cathode rays?
- They start from the cathode and move towards the anode
 - They travel in straight line in the absence of an external electrical or magnetic field
 - Characteristics of cathode rays do not depend upon the material of electrodes in cathode ray tube
 - Characteristics of cathode rays depend upon the nature of gas present in the cathode ray tube
12. A gas of mono atomic hydrogen is excited by an energy of 12.75 eV/atom. Which spectral lines of the following are formed in Lyman, Balmer and Paschen series respectively.
- 3, 2, 1
 - 2, 3, 1
 - 1, 3, 2
 - 1, 2, 3
13. The number of radial nodes for 3p orbital is:
- 3
 - 4
 - 2
 - 1
14. Number of angular nodes for 4d orbital:
- 4
 - 3
 - 2
 - 1
15. Which of the following is responsible to rule out the existence of definite paths or trajectories of electrons?
- Pauli's exclusion principle
 - Heisenberg's uncertainty principle
 - Hund's rule of maximum multiplicity
 - Aufbau principle
16. Total number of orbitals associated with third shell will be:
- 2
 - 4
 - 9
 - 3

17. Orbital angular momentum depends on:

(a) l (b) n and l (c) n and m (d) m and s

18. Chlorine exists in two isotopic forms. Cl-37 and Cl-35 but its atomic mass is 35.5. This indicates the ratio of Cl-37 and Cl-35 is approximately:

(a) 1 : 2 (b) 1 : 1 (c) 1 : 3 (d) 3 : 1

19. The pair of ions having same electronic configuration is:

(a) Cr^{3+} , Fe^{3+} (b) Fe^{3+} , Mn^{2+}
(c) Fe^{3+} , Co^{3+} (d) Sc^{3+} , Cr^{3+}

20. For the electrons of oxygen atom, which of the following statements is correct?

(a) Z_{eff} for an electron in a 2s orbital is the same as Z_{eff} for an electron in a 2p orbital
(b) An electron in the 2s orbital has the same energy as an electron in the 2p orbital
(c) Z_{eff} for an electron in 1s orbital is the same as Z_{eff} for an electron in a 2s orbital
(d) The two electrons present in the 2s orbital have spin quantum numbers m_s but of opposite sign

21. A ball of mass 200 gm is moving with velocity of 10 m.s^{-1} . If the error in measurement of velocity is 0.1%, the uncertainty in its position is:

(a) $3.3 \times 10^{-31} \text{ m}$ (b) $3.3 \times 10^{-27} \text{ m}$
(c) $5.3 \times 10^{-25} \text{ m}$ (d) $2.64 \times 10^{-32} \text{ m}$

22. If waves travelling at same speeds, which of the following matter waves have the shortest wavelength?

(a) Electron (b) Alpha particle (He^{2+})
(c) Neutron (d) Proton

23. An ion with mass number 56 contains 3 units of positive charge and 30.4% more neutrons than electrons. Assign the symbol to this ion

(a) ${}^{55}_{26}\text{Fe}^{3+}$ (b) ${}^{57}_{26}\text{Fe}^{3+}$ (c) ${}^{59}_{26}\text{Fe}^{3+}$ (d) ${}^{56}_{26}\text{Fe}^{3+}$

24. A quantum of light having energy E has wavelength equal to $7200 \text{ \AA}$. The frequency of light which corresponds to energy equal to $3E$, is

(a) $1.25 \times 10^{14} \text{ s}^{-1}$ (b) $1.25 \times 10^{15} \text{ s}^{-1}$
(c) $1.25 \times 10^{13} \text{ s}^{-1}$ (d) $1.25 \times 10^{14} \text{ s}^{-1}$

25. Bond dissociation energy of AB molecules is 300 kJ/mole. The number of moles of photons of wavelength $6625 \text{ \AA}$ requires to dissociate 3 moles of AB molecules is

(a) 1 (b) 2 (c) 4 (d) 5

26. Ultraviolet light of 6.2 eV falls on Cesium surface (work function = 1.2 eV). The kinetic energy (in electron volts) of the fastest electron emitted is approximately

(a) 5 eV (b) 4 eV
(c) 3 eV (d) 2 eV

27. The ionization potential of hydrogen atom is 13.6 eV. The wavelength of the energy radiation required for the ionization of H-atom

(a) 1911 nm (b) 912 nm
(c) 68 nm (d) 91.2 nm

28. Each hydrogen atom is excited by giving 10.2 eV. The maximum number of spectral lines in the emission is equal to
(a) 1 (b) 2 (c) 3 (d) 4
29. The ratio of the difference in energy between the first and the second Bohr orbit to that between the second and the third Bohr orbit is
(a) 1/2 (b) 34/19 (c) 102/121 (d) 27/5
30. Uncertainty in position of a particle of 25 gram in space is 10^{-5} m. Hence uncertainty in velocity (m/sec) is ($h = 6.6 \times 10^{-34}$ J-sec)
(a) 2.1×10^{-28} (b) 2.1×10^{-34}
(c) 0.5×10^{-34} (d) 5×10^{-24}
31. An electron of a velocity 'x' is found to have a certain wavelength. The velocity to be possessed by the neutron to have half the de-Broglie wavelength possessed by electron is:
(a) $x/1840$ (b) $x/920$
(c) $3680x$ (d) $x/3680$
32. Which set of quantum numbers is possible for the last electron of Mg^+ ion -
(a) $n = 3, l = 2, m = 0, s = +1/2$
(b) $n = 2, l = 3, m = 0, s = +1/2$
(c) $n = 1, l = 0, m = 0, s = +1/2$
(d) $n = 3, l = 0, m = 0, s = +1/2$
33. The number of radial nodes, nodal planes for an orbital with $n = 4, l = 1$ is
(a) 3, 1 (b) 2, 1 (c) 2, 0 (d) 4, 0
34. A single electron in an ion has ionization energy equal to 217.6 eV. What is the total number of neutrons present in one ion of it?
(a) 2 (b) 4 (c) 5 (d) 9
35. Which one of the following transitions of an electron in hydrogen atom emits radiation of the lowest wavelength?
(a) $n_2 = \infty$ to $n_1 = 2$
(b) $n_2 = 4$ to $n_1 = 3$
(c) $n_2 = 2$ to $n_1 = 1$
(d) $n_2 = 5$ to $n_1 = 3$

Multiconcept MCQs

1. An electronic transition in hydrogen atom results in the formation of the H_α spectral line in Lyman series of hydrogen atomic spectrum is formed due to an electronic transition in hydrogen atom. The energies associated with the electron in each of the orbits involved in the transition (in kcal mol^{-1}) are:
(a) -313.6, -34.84 (b) -313.6, -78.4
(c) -78.4, -34.84 (d) -78.4, -19.6
2. In an atom, an electron is moving with a speed of 600 m/s with an accuracy upto 0.005%. What is the uncertainty in position?
(a) 1.52×10^{-4} m (b) 5.10×10^{-3} m
(c) 1.92×10^{-3} m (d) 3.84×10^{-3} m
3. Photon having wavelength 310 nm is used to break the bond of A_2 molecule having bond energy 288 kJ/mol, then the percentage of energy of photon converted to KE is ($1 \text{ eV} = 96 \text{ kJ/mol}$):
(a) 25 (b) 50 (c) 75 (d) 80
4. O_2 undergoes photochemical dissociation into one normal oxygen and one excited oxygen atom, 1.967 eV more energetic than normal. The dissociation of O_2 into two normal atoms of oxygen atoms requires 498 kJ mole^{-1} . What is the maximum wavelength effective for photochemical dissociation of O_2 ?
(a) 1645.3 Å (b) 1741.5 Å
(c) 1545.2 Å (d) 1942.3 Å
5. Which of the following statements is false?
(a) The energy of red photon is more than the energy of violet photon
(b) The momentum of photon is inversely proportional to its wave length
(c) The energy of a photon is inversely proportional to its wave length
(d) The particle nature of electromagnetic radiations is able to explain the photoelectric effect
6. Photons of frequency 3.2×10^{16} Hz is used to irradiate a metal surface, the maximum kinetic energy of the emitted photo-electron is $\frac{3}{4}$ of the energy of the irradiating photon? What is the threshold frequency of the metal?
(a) 2.4×10^{25} Hz (b) 2.4×10^{16} Hz
(c) 1.6×10^{15} Hz (d) 8×10^{15} Hz
7. For the energy levels in an atom which one of the following statements is correct:
(a) The 4s sub-energy level is at a higher energy than the 3d sub-energy level
(b) The second principal energy level can have four orbitals and contain a maximum of 8 electrons
(c) The M-energy level can have maximum of 32 electrons
(d) None of these

8. If an electron travels with a velocity of $\frac{1}{100}$ th speed of light in Bohr's first orbit, what is its velocity (relative to the speed of light) in the 5th Bohr orbit?
 (a) 0.002 (b) 0.1
 (c) 0.5 (d) 0.7

9. According to Bohr's theory, E_n = Total energy, K_n = Kinetic energy, V_n = Potential energy, r_n = Radius of nth orbit

Match the following:

	Column I		Column I
A	$V_N / K_N = ?$	(i)	0
B	If radius of nth orbit $\propto E_n^x$, $x = ?$	(ii)	-1
C	Angular momentum in lowest orbital	(iii)	-2
D	$\frac{1}{r_n} \propto Z^y, y = ?$	(iv)	1

(a)	A-(iii)	B-(ii)	C-(i)	D-(iv)
(b)	A-(iv)	B-(ii)	C-(iii)	D-(i)
(c)	A-(i)	B-(iv)	C-(iii)	D-(ii)
(d)	A-(i)	B-(iii)	C-(iv)	D-(ii)

10. In a multi-electron atom, which of the following orbitals described by the three quantum numbers will have the same energy in the absence of magnetic and electric fields?

- A. $n = 1, l = 0, m = 0$ B. $n = 2, l = 0, m = 0$
 C. $n = 2, l = 1, m = 1$ D. $n = 3, l = 2, m = 1$
 E. $n = 3, l = 2, m = 0$

- (a) A and B (b) B and C
 (c) C and D (d) D and E

11. The frequency of light emitted for the transition $n = 4$ to $n = 2$ of He^+ is equal to the transition in H atom corresponding to which of the following?

- (a) $n = 2$ to $n = 1$ (b) $n = 3$ to $n = 2$
 (c) $n = 4$ to $n = 3$ (d) $n = 3$ to $n = 1$

12. For a hydrogen atom in an $n = 4$ state, the maximum possible z-component of orbital angular momentum is

- (a) $2\hbar$ (b) $3\hbar$
 (c) $\sqrt{12}\hbar$ (d) $\sqrt{6}\hbar$

13. Last line of Lyman series for H-atom has wavelength λ_1 Å. The 2nd line of Balmer series has wavelength λ_2 Å, then:

- (a) $\frac{16}{\lambda_1} = \frac{9}{\lambda_2}$ (b) $\frac{16}{\lambda_2} = \frac{3}{\lambda_1}$
 (c) $\frac{4}{\lambda_1} = \frac{1}{\lambda_2}$ (d) $\frac{16}{\lambda_1} = \frac{3}{\lambda_2}$

14. Match the following

A	Energy of ground state of He^+	(i)	+ 6.04 eV
B	Potential energy of I orbit of H-atom	(ii)	-27.2 eV
C	Kinetic energy of II excited state of He^+	(iii)	54.4 eV
D	Ionisation potential of He^+	(iv)	- 54.4 eV

(a)	A-(i)	B-(ii)	C-(iii)	D-(iv)
(b)	A-(iv)	B-(iii)	C-(ii)	D-(i)
(c)	A-(iv)	B-(ii)	C-(i)	D-(iii)
(d)	A-(ii)	B-(iii)	C-(i)	D-(iv)

15. Photoelectric emission is observed from a metal surface with incident frequencies ν_1 & ν_2 where $\nu_1 > \nu_2$. If the kinetic energies of the photoelectrons emitted in the two cases are in the ratio 2:1, then the threshold frequency ν_0 of the metal is-

- (a) $2\nu_2 - \nu_1$ (b) $2\nu_1 - \nu_2$
 (c) $\frac{\nu_1 - \nu_2}{2}$ (d) $\nu_2 - \nu_1$

16. Consider the following sets of quantum number

	n	l	m	s
(i)	3	0	0	+1/2
(ii)	2	2	1	+1/2
(iii)	4	3	-2	-1/2
(iv)	1	0	-1	-1/2
(v)	3	2	3	+1/2

Which of the following sets of quantum number is not possible?

- (a) (i), (ii), (iii) and (iv) (b) (ii), (iv) and (v)
 (c) (i) and (iii) (d) (ii), (iii) and (iv)

17. The dissociation energy of H_2 is 430.53 kJ mol⁻¹. If H_2 is dissociated by illumination with radiation of wavelength 253.7 nm. The fraction of the radiant energy which will be converted into kinetic energy is given by:

- (a) 8.86% (b) 2.33%
 (c) 1.3% (d) 90%

18. Light of wavelength λ shines on a metal surface with intensity x and the metal emits Y electrons per second of average energy, Z. What will happen to Y and Z if x is doubled?

- (a) Y will be double and Z will become half
 (b) Y will remain same and Z will be doubled
 (c) Both Y and Z will be doubled
 (d) Y will be doubled but Z will remain same

19. Arrange the electrons represented by the following set of quantum numbers in the decreasing order of energy

(i) $n = 4, l = 0, m = 0, s = +1/2$

(ii) $n = 3, l = 1, m = 1, s = -1/2$

(iii) $n = 3, l = 2, m = 0, s = +1/2$

(iv) $n = 3, l = 0, m = 0, s = -1/2$

(a) $(i) > (ii) > (iii) > (iv)$ (b) $(iv) > (iii) > (ii) > (i)$

(c) $(iii) > (i) > (ii) > (iv)$ (d) $(i) > (iii) > (ii) > (iv)$

20. Select the correct statement(s):

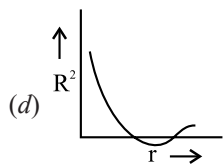
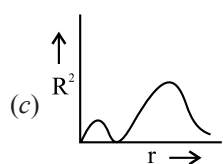
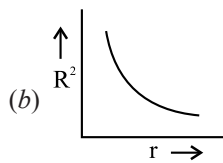
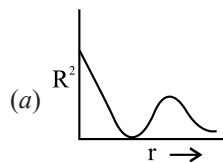
(a) The value of spin only magnetic moment of Co^{3+} ion (in BM) = $\sqrt{24}$

(b) The number of radial nodes in a 3p-orbital = 1

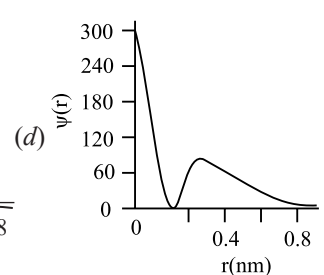
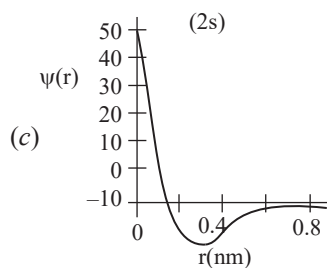
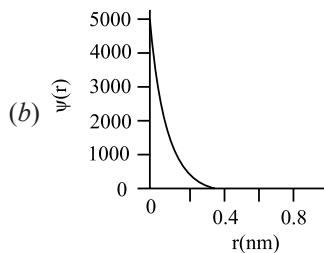
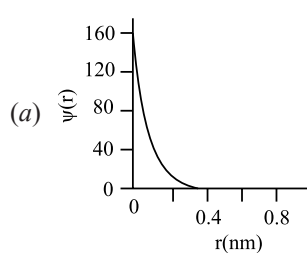
(c) The number of electrons with $(m = 0)$ in Mn^{2+} ion = 11

(d) All are correct

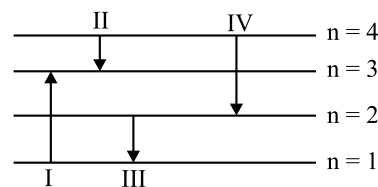
21. The probability density curve for 2s electron appears like



22. The plot of orbital wave function $\psi(r)$ as a function of distance r of the electron from the nucleus for 2s orbital is.



23. The diagram shows the energy levels for an electron in certain atom. Which transition shown represents the emission of a photon with the most energy?



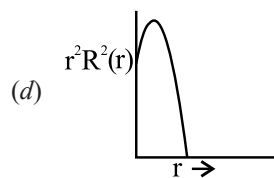
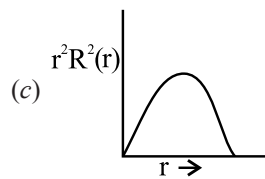
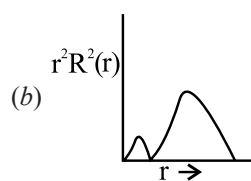
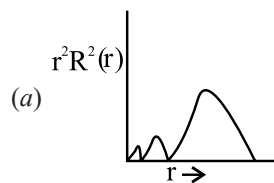
(a) II

(b) I

(c) IV

(d) III

24. Which of the following radial distribution graphs corresponds to $l = 2$ for H atom for the least value of n for which $l = 2$ is allowed?



NEET Past 10 Years Questions

- 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, $c = 3.0 \times 10^8 \text{ ms}^{-1}$] (2021)
 - 219.2 m
 - 2192 m
 - 21.92 cm
 - 219.3 m
- The number of protons, neutrons and electrons in $^{175}_{71}\text{Lu}$, respectively, are : (2020)
 - 104, 71 and 71
 - 71, 71 and 104
 - 175, 104 and 71
 - 71, 104 and 71
- The number of angular nodes and radial nodes in 3s orbital are (2020 Covid Re-NEET)
 - 1 and 0, respectively
 - 3 and 0, respectively
 - 0 and 1, respectively
 - 0 and 2, respectively
- 4d, 5p, 5f and 6p orbitals are arranged in the order of decreasing energy. The correct option is (2019)
 - $5f > 6p > 5p > 4d$
 - $6p > 5f > 5p > 4d$
 - $6p > 5f > 4d > 5p$
 - $5f > 6p > 4d > 5p$
- Which of the following series of transitions in the spectrum of hydrogen atom fall in visible region? (2019)
 - Lyman series
 - Balmer series
 - Paschen series
 - Brackett series
- Magnesium reacts with an element (X) to form an ionic compound. If the ground state electronic configuration of (X) is $1s^2 2s^2 2p^3$, the simplest formula for this compound is (2018)
 - Mg_2X_3
 - MgX_2
 - Mg_3X_2
 - Mg_2X
- Which one is a wrong statement? (2018)
 - Total orbital angular momentum of electron in 's' orbital is equal to zero
 - An orbital is designated by three quantum numbers while an electron in an atom is designated by four quantum numbers
 - The value of m for d_z^2 is zero
 - The electronic configuration of N atom is

$$\begin{array}{|c|c|c|c|c|} \hline 1s^2 & 2s^2 & 2p_x^1 & 2p_y^1 & 2p_z^1 \\ \hline \uparrow\downarrow & \uparrow\downarrow & \uparrow & \uparrow & \downarrow \end{array}$$
- Which one is the wrong statement? (2017-Delhi)
 - The energy of 2s orbital is less than the energy of 2p orbital in case of hydrogen like atoms
 - de-Broglie's wavelength is given by $\lambda = \frac{h}{mv}$, where m = mass of the particle, v = group velocity of the particle
 - The uncertainty principle is $\Delta E \times \Delta t \geq \frac{h}{4\pi}$
 - Half-filled and fully filled orbitals have greater stability due to greater exchange energy, greater symmetry and more balanced arrangement
- The total number of orbitals present for principal quantum number, $n = 4$ is: (2017-Gujarat)
 - 30
 - 12
 - 15
 - 16
- Which of the following pairs of d-orbitals will have electron density along the axes? (2016 - II)
 - $d_{z^2}, d_{x^2-y^2}$
 - $d_{xy}, d_{x^2-y^2}$
 - d_{z^2}, d_{xz}
 - d_{xz}, d_{yz}
- How many electrons can fit in the orbital for which: $n = 3$ and $l = 1$? (2016 - II)
 - 10
 - 14
 - 2
 - 6
- Two electrons occupying the same orbital are distinguished by: (2016 - I)
 - Spin quantum number
 - Principal quantum number
 - Magnetic quantum number
 - Azimuthal quantum number
- Which is the correct order of increasing energy of the listed orbitals in the atom of titanium? (Atomic number $Z = 22$): (2015 Re)
 - 3s 3p 4s 3d
 - 3s 4s 3p 3d
 - 4s 3s 3p 3d
 - 3s 3p 3d 4s
- The angular momentum of electron in 'd' orbital is equal to: (2015)
 - $2\sqrt{3}\hbar$
 - $0\hbar$
 - $\sqrt{6}\hbar$
 - $\sqrt{2}\hbar$
- What is the maximum number of orbitals that can be identified with the following quantum numbers: $n = 3, l = 1, m_l = 0$? (2014)
 - 2
 - 3
 - 4
 - 1
- Calculate the energy in joule corresponding to light of wavelength 45 nm (Planck's constant $h = 6.63 \times 10^{-34} \text{ Js}$; speed of light $c = 3 \times 10^8 \text{ ms}^{-1}$) (2014)
 - 6.67×10^{11}
 - 4.42×10^{-15}
 - 4.42×10^{-18}
 - 6.67×10^{15}
- What is the maximum number of electrons that can be associated with the following set of quantum numbers? (2013) $n = 3, \ell = 1$ and $m = -1$.
 - 10
 - 6
 - 4
 - 2

18. The value of Planck's constant is 6.63×10^{-34} Js. The speed of light is 3×10^8 ms⁻¹. Which value is closest to the wavelength in nanometer of a quantum of light with frequency of 6×10^{15} s⁻¹? (2013)

- (a) 10 nm (b) 25 nm
(c) 50 nm (d) 75 nm

19. Based on equation, $E = -2.178 \times 10^{-18} \text{ J} \left(\frac{Z^2}{n^2} \right)$ certain

conclusions are written. Which of them is not correct? (2013)

- (a) The negative sign in equation simply means that the energy of electron bound to the nucleus is lower than it would be if the electrons were at the infinite distance from the nucleus.
(b) Larger the value of n, the larger is the orbit radius.
(c) Equation can be used to calculate the change in energy when the electron changes orbit.

(d) For $n = 1$, the electron has a more negative energy than it does for $n = 6$ which means that the electron is more loosely bound in the smallest allowed orbit.

20. Maximum number of electrons in a subshell with $l = 3$ and $n = 4$ is: (2012 Pre)

- (a) 14 (b) 16
(c) 10 (d) 12

21. The correct set of four quantum numbers for the valence electron of rubidium atom ($Z = 37$) is: (2012 Pre)

- (a) 5, 1, 1, +1/2 (b) 6, 0, 0, +1/2
(c) 5, 0, 0, +1/2 (d) 5, 1, 0, +1/2

22. The orbital angular momentum of a p -electron is given as: (2012 Mains)

- (a) $\sqrt{\frac{3}{2}} \frac{h}{\pi}$ (b) $\sqrt{6} \frac{h}{2\pi}$
(c) $\frac{h}{\sqrt{2}\pi}$ (d) $\sqrt{3} \frac{h}{2\pi}$

ANSWER KEY

Topicwise Questions

1. (d)	2. (d)	3. (a)	4. (b)	5. (b)	6. (b)	7. (b)	8. (d)	9. (a)	10. (a)
11. (b)	12. (a)	13. (c)	14. (b)	15. (d)	16. (b)	17. (c)	18. (a)	19. (c)	20. (c)
21. (a)	22. (b)	23. (c)	24. (b)	25. (d)	26. (d)	27. (c)	28. (c)	29. (a)	30. (a)
31. (b)	32. (c)	33. (c)	34. (a)	35. (b)	36. (d)	37. (b)	38. (c)	39. (a)	40. (c)
41. (d)	42. (a)	43. (b)	44. (a)	45. (d)	46. (b)	47. (a)	48. (a)	49. (a)	50. (c)
51. (b)	52. (a)	53. (b)	54. (d)	55. (a)	56. (a)	57. (d)	58. (d)	59. (d)	60. (a)
61. (d)	62. (c)	63. (a)	64. (c)	65. (c)	66. (c)	67. (a)	68. (d)	69. (d)	70. (b)
71. (c)	72. (a)	73. (d)	74. (b)	75. (a)	76. (a)	77. (a)	78. (a)	79. (a)	80. (d)
81. (b)	82. (a)	83. (d)	84. (b)	85. (a)	86. (a)	87. (c)	88. (d)	89. (c)	90. (d)
91. (a)	92. (a)	93. (d)	94. (c)	95. (d)	96. (c)	97. (c)	98. (a)	99. (d)	100. (d)
101. (a)	102. (c)	103. (a)	104. (c)	105. (d)	106. (a)	107. (a)	108. (c)	109. (a)	110. (c)
111. (a)	112. (c)	113. (a)	114. (a)	115. (b)	116. (c)	117. (c)	118. (c)		

Learning Plus

1. (c)	2. (c)	3. (c)	4. (a)	5. (c)	6. (a)	7. (c)	8. (c)	9. (d)	10. (a)
11. (d)	12. (a)	13. (d)	14. (c)	15. (b)	16. (c)	17. (a)	18. (c)	19. (b)	20. (d)
21. (d)	22. (b)	23. (d)	24. (b)	25. (d)	26. (a)	27. (d)	28. (a)	29. (d)	30. (a)
31. (b)	32. (d)	33. (b)	34. (c)	35. (a)					

Multiconcept MCQs

1. (b)	2. (c)	3. (a)	4. (b)	5. (a)	6. (d)	7. (b)	8. (a)	9. (a)	10. (d)
11. (a)	12. (b)	13. (b)	14. (c)	15. (a)	16. (b)	17. (a)	18. (d)	19. (c)	20. (d)
21. (a)	22. (d)	23. (d)	24. (c)						

NEET Past 10 Years Questions

1. (d)	2. (d)	3. (d)	4. (a)	5. (b)	6. (c)	7. (d)	8. (a)	9. (d)	10. (a)
11. (c)	12. (a)	13. (a)	14. (c)	15. (d)	16. (c)	17. (d)	18. (c)	19. (d)	20. (a)
21. (c)	22. (c)								

Solution

Topicwise Questions

1. (d) It was determined by Millikan's with a help of oil drop experiment.
2. (d) $S.C = e/m = \frac{4 \times e}{28}$
3. (a) Neutrality of atom.
4. (b) The ratio of charge and mass would be greater for electron as the mass of electron is least among the species.
5. (b) Number of neutrons = $M - A$
 Number of neutrons in ${}_{14}\text{Si}^{30} = 30 - 14 = 16$
 Number of neutrons in ${}_{16}\text{S}^{32} = 32 - 16 = 16$
 Because of the presence of same number of neutrons, ${}_{14}\text{Si}^{30}$ and ${}_{16}\text{S}^{32}$ are called isotones.
 Hence; ${}_{32}\text{Ge}^{76}$, ${}_{34}\text{Se}^{76}$ and ${}_{14}\text{Si}^{30}$ and ${}_{16}\text{S}^{32}$ are the isobars and isotones respectively.
6. (b) Positron is lightest.
7. (b) Isoelectronic species have same number of electrons.
 ${}_{19}\text{K}^+$: Number of electrons = $19 - 1 = 18$
 ${}_{17}\text{Cl}^-$: Number of electrons = $17 + 1 = 18$
 ${}_{20}\text{Ca}^{2+}$: Number of electrons = $20 - 2 = 18$
 hence, K^+ , Cl^- and Ca^{2+} are isoelectronic species.
8. (d) $\frac{1}{\lambda} = R_H (Z)^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$
 where, $R_H = R$, $Z = 3$ (for Li^{2+} , atomic no. 3)
 $n_2 = 2$, $n_1 = 1$

$$\frac{1}{\lambda} = R(3)^2 \left(\frac{1}{(1)^2} - \frac{1}{(2)^2} \right) = \frac{R \times 9 \times 3}{4} \Rightarrow \lambda = \frac{4}{27R}$$
9. (a) Zeeman effect is the splitting of spectral line emitted by an excited electron under the influence of magnetic field.
10. (a) Energy of emitted electrons = $h\nu - h\nu_0$.
11. (b) KE of photoelectrons increases linearly with frequency of incident light ($h\nu = h\nu_0 + \text{KE}$ or $\text{KE} = h\nu - h\nu_0$)
12. (a) $109,677 \text{ cm}^{-1}$.
13. (c) We know that $\Delta E = hc R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$
 For the lowest energy of spectral line in the lyman series.
 $n_1 = 1$, $n_2 = 2$
 Hence, $\Delta E = hc R_H \left(\frac{1}{(1)^2} - \frac{1}{(2)^2} \right) = hc R_H \left(\frac{1}{1} - \frac{1}{4} \right)$

$$= \frac{3hcR_H}{4}$$
14. (b) Neil Bohr utilised the concept of quantisation of energy (proposed by max planck) first time to give a new model of an atom.
15. (d) $\lambda = \frac{h}{\sqrt{2m K.E}}$
16. (b) $E = n \frac{hc}{\lambda} \Rightarrow n = \frac{E\lambda}{hc}$
17. (c) For Balmer series, transition from $n = 2$ to $n = 3$

$$\bar{\nu} = (1.097 \times 10^7) \left[\frac{1}{2^2} - \frac{1}{3^2} \right]$$
18. (a) $\frac{E_1}{E_2} = \frac{\nu_2}{\nu_1}$
19. (c) $\nu = \frac{c}{\lambda} = \frac{3 \times 10^{10} \text{ cm/sec}}{500 \times 10^{-8} \text{ cm}} = 6 \times 10^{14} \text{ sec}^{-1}$
20. (c) $E = hc\bar{\nu}$

$$= 6.625 \times 10^{-27} \text{ erg sec} \times 3 \times 10^{10} \text{ cm sec}^{-1} \times 2.5 \times 10^{-5} \text{ cm}^{-1}$$

$$= 4.96 \times 10^{-21} \text{ ergs}$$

$$21. (a) \lambda = \frac{c}{\nu} = \frac{3 \times 10^{10} \text{ cm/s}}{1 \times 10^6} = 3 \times 10^4 \text{ cm}$$

$$22. (b) E = \frac{n \times h \times c}{\lambda}$$

$$n = \frac{E\lambda}{hc} = \frac{10^{-17} \text{ J} \times 550 \times 10^{-9} \text{ m}}{6.625 \times 10^{-34} \times 3 \times 10^8} \\ = 27.6 \approx 28$$

23. (c) Equation for Lyman series

$$\bar{\nu} = \frac{1}{\lambda} = R \left[\frac{1}{1^2} - \frac{1}{n_2^2} \right]$$

$$\frac{15R}{16} = R \left[\frac{1}{1^2} - \frac{1}{n_2^2} \right]$$

$$\frac{1}{n_2^2} = 1 \left(\frac{15}{16} \right) = \frac{1}{16}$$

$$n_2 = 4$$

$$24. (b) E_n = \frac{-1312}{n^2} \text{ kJ mole}^{-1}$$

$$E_2 = \frac{-1312}{4} = -328 \text{ kJ mole}^{-1}$$

25. (d) In 1885, Balmer for the first time showed that the wave numbers of spectral lines present in the visible region in hydrogen spectrum are given by:

$$\bar{\nu} (\text{cm}^{-1}) = 109677 \left(\frac{1}{(2)^2} - \frac{1}{n_2^2} \right)$$

Hence; $n_2 = 3, 4, 5, \dots$

Hence; the Balmer spectrum of hydrogen was discovered first and it lies in visible region.

26. (d) According to Bohr, velocity of an electron (v)

$$= 2.188 \times 10^6 \frac{Z}{n} \text{ m/sec}$$

for H ; $Z = 1$ $n = 2$ (given)

$$\therefore V = \frac{2.188 \times 10^6 \times 1}{2} = 1.094 \times 10^6 \text{ m/sec}$$

27. (c) Bohr model of an atom is applicable for those species which have only 1 electron but He^{2+} do not have any electron. Therefore, this model is not applicable to He^{2+}

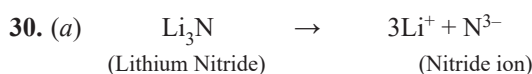
28. (c) Ionisation energy of an atom of atomic number, Z is given by

$$\text{I.E.} = \frac{(\text{I.E.})_{\text{H}} \times Z^2}{n^2} = 13.6 \times \frac{Z^2}{n^2} \text{ eV}$$

Thus, second ionisation energy for He-atom is given by

$$\text{I.E.} = \frac{13.6 \times (2)^2}{(1)^2} \text{ eV} = 54.4 \text{ eV}$$

29. (a) The lines are called Balmer series.



Number of protons = 7

Number of electrons = $7 + 3 = 10$

Therefore, nitride ions contain 7-protons + 10 electrons.

31. (b) $^{39}\text{K}^+$ and $^{40}\text{K}^+$ both contain 18 electrons; i.e., they are isoelectronic and isotopic as they have same atomic number.

$$32. (c) \text{ I.E.} = \frac{1312}{n^2} \times Z^2 \text{ kJ mol}^{-1}$$

For one electron species in the ground state, $n = 1$

$$\therefore 1312 \times Z^2 = 11810 \text{ or } Z^2 = 9 \text{ or } Z = 3$$

$$33. (c) \text{ The number of spectral lines} = \frac{n(n-1)}{2}$$

$\therefore$ When an electrons jump from $n = 4$ level, number of

$$\text{spectral line:} = \frac{(4)(4-1)}{2} \Rightarrow \frac{4 \times 3}{2} = \frac{12}{2} = 6$$

34. (a) Wave number of spectral lines in emission series of hydrogen,

$$\bar{\nu} = R_{\text{H}} \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right) \quad \dots(i)$$

$$\text{Given; } \bar{\nu} = \frac{8}{9} (R_{\text{H}})$$

On putting the value of $\bar{\nu}$ in equation (i), we get

$$\frac{8}{9} R_{\text{H}} = R_{\text{H}} \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$$

$$\frac{8}{9} = \frac{1}{(1)^2} - \frac{1}{n_2^2}$$

$$1 - \frac{8}{9} = \frac{1}{n_2^2} \Rightarrow \frac{1}{9} = \frac{1}{n_2^2}$$

$$n_2 = 3$$

$\therefore$ electrons jumps from $n_2 = 3$ to $n_1 = 1$

35. (b) Radius of H-like species,

$$\text{As } r_n = \frac{0.529 \times n^2}{Z} \text{ is radius for first Bohr orbit of H-atom}$$

which is equal to r (given).

So, radius of first orbit of Li^{2+} .

($n = 1$, $Z = 3$, for Li^{2+}) is $r/3$

36. (d) In OH^- , number of protons = $8 + 1 = 9$

number of neutrons = $8 + 0 = 8$

number of electrons = $8 + 1 + 1 = 10$

Hence, in OH^- the number of protons is greater than the number of neutrons but number of protons is less than the number of electrons.

37. (b) $\lambda_1 = 3000 \text{ \AA}$, $\lambda_2 = 6000 \text{ \AA}$

$$E_1 = \frac{hc}{\lambda_1} = \frac{hc}{3000}, \quad E_2 = \frac{hc}{\lambda_2} = \frac{hc}{6000}$$

$$\frac{E_1}{E_2} = \frac{hc}{3000} \times \frac{6000}{hc} = 2:1$$

38. (c) As the Bohr's model applicable only to H-atom and H-like species containing one electron system.

39. (a) Rydberg equation; $\bar{\nu} = R \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right]$

for Balmer series; $n_1 = 2, n_2 = 3$

$$\bar{\nu} = R \left[\frac{9-4}{36} \right] = \frac{5R}{36} \text{ cm}^{-1}$$

40. (c) Second Bohr orbit of hydrogen atom, i.e., $n = 2$.
Atomic number of hydrogen (z) = 1

$$\text{by using } r = \frac{0.529n^2}{z} = \frac{0.529 \times (2)^2}{1}$$

$$= 2.116 \text{ \AA} = 0.2116 \text{ nm}$$

41. (d) As $E_n = -21.8 \times 10^{-19} \times \frac{z^2}{n^2}$

Thus; $E_n \propto \left(\frac{-1}{n^2} \right)$ where n is the number of orbit. Hence;

as the value of "n" increases, energy of the electron also increases; due to this reason; maximum energy is possessed by an electron when it is present at infinite distance from the nucleus.

42. (a) $\therefore E = \frac{hc}{\lambda}$

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

$\therefore$ Decrease in wavelength, increases the energy.

Energy difference in $n_4 \rightarrow n_1$ transition is maximum.

$\therefore n_4 \rightarrow n_1$, transition has minimum wavelength

43. (b) $r_2 \text{Be}^{3+} = \frac{r_2 \text{H}}{4} = \frac{r_1 \text{H} \times 2^2}{4} = r_1 \text{H}$

44. (a) $r_n = 0.529 \times \frac{n^2}{Z} \text{ \AA}$

$$= \left(0.529 \times \frac{1^2}{2} \right) \text{ \AA} \quad \left(\because n=1 \text{ \& } z=2 \right)$$

$$\left(\text{for He} \right)$$

$$= 0.26 \text{ \AA} = 0.26 \times 10^{-8} \text{ cm}$$

45. (d) Ionisation energy of H = 13.6 eV
Ionisation energy of Be^{+3} (H-like atom)

$$= 13.6 \times \frac{z^2}{n^2} \text{ eV} = 13.6 \times \frac{4^2}{1^2} = 13.6 \times 16$$

$$\therefore \text{ratio (required)} = \frac{13.6}{13.6 \times 16} = 1:16$$

46. (b) Orbitals away from nucleus have higher energy due to:

- (i) The inner electrons which repel them, results in increases their energy.
- (ii) Shielding effect or screening effect i.e., the electrons away from nucleus get less attracted by nucleus.

47. (a) $\frac{\text{KE}}{E_{\text{Total}}} = -1$

Total energy = -3.4 eV (Given)

$$\therefore \text{KE} = -(-3.4 \text{ eV}) = +3.4 \text{ eV}$$

48. (a) $V_n = \frac{V_0 Z}{n} \Rightarrow \frac{V_3}{V_5} = \frac{5}{3}$

49. (a) $\bar{\nu} = \frac{1}{\lambda} R \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$

$$= 1.097 \times 10^7 \text{ m}^{-1} \left(\frac{1}{1^2} - \frac{1}{\infty^2} \right)$$

$$= 1.097 \times 10^7 \text{ m}^{-1}$$

$$\text{or } \lambda = \frac{1}{1.097 \times 10^7} \text{ m}$$

$$= 0.91 \times 10^{-7} \text{ m} = 91 \text{ nm}$$

50. (c) $v \propto \frac{1}{\sqrt{r}}, v_A \propto \frac{1}{\sqrt{r}}, v_B \propto \frac{1}{\sqrt{4r}}$

$$\therefore \frac{v_A}{v_B} = 2$$

$$\frac{t_A}{t_B} = \frac{2\pi r / v_A}{2\pi (4r) / v_B} = \frac{1}{4} \frac{v_A}{v_B}$$

$$= \frac{1}{4} \times \frac{1}{2} = \frac{1}{8} = 1:8$$

51. (b) For Bracket series $n_1 = 4$

$$n_2 = 5, 6, 7, \dots$$

52. (a) $\frac{1}{\lambda_1} = R \left[\frac{1}{1} - \frac{1}{\infty} \right] = R$

$$\frac{1}{\lambda_2} = R \left[\frac{1}{1} - \frac{1}{4} \right] = \frac{3R}{4}$$

$$\frac{\lambda_1}{\lambda_2} = \frac{4}{3}$$

53. (b) $\bar{\nu} = R \left[\frac{1}{1} - \frac{1}{\infty} \right]$

$$\bar{\nu} = R$$

54. (d) $\bar{\nu} = z^2 \bar{\nu}_H$

$$\bar{\nu} = 3^2 \times 1500 \text{ cm}^{-1}$$

$$= 135000 \text{ cm}^{-1}$$

$$= 1.35 \times 10^5 \text{ cm}^{-1}$$

$$55. (a) [IE]_z = [IE]_h \frac{Z^2}{n^2} = E_n = \frac{(-2.18 \times 10^{-18}) \times 2^2}{1^2}$$

$$56. (a) \lambda = \frac{h}{mv}$$

$$\lambda_A = \frac{h}{m \times 0.05}; \lambda_B = \frac{h}{5m \times 0.02}$$

$$\frac{\lambda_A}{\lambda_B} = \frac{5m \times 0.02}{m \times 0.05} = 2:1$$

$$57. (d) \text{K.E. per atom}$$

$$= \frac{(4.4 \times 10^{-19}) - (4.0 \times 10^{-19})}{2} \text{ J}$$

$$= \frac{0.4 \times 10^{-19}}{2} \text{ J} = 2.0 \times 10^{-20} \text{ J}$$

$$58. (d) \text{According to Heisenberg's uncertainty principle}$$

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

$$m = 6.626 \times 10^{-28} \text{ kg}$$

$$\Delta v = 10^{-6} \text{ m/sec}$$

$$h = 6.626 \times 10^{-34} \text{ Js}$$

$$6.626 \times 10^{-28} \times 10^{-6} \times \Delta x = \frac{6.626 \times 10^{-34}}{4\pi}$$

$$\Delta x = \frac{6.626 \times 10^{-34}}{4\pi \times 6.626 \times 10^{-34}} = \frac{1}{4\pi}$$

$$59. (d) \lambda = \frac{h}{mv}$$

$$\text{mass of } \alpha\text{-particle} = 4u, \text{ mass of deuterium} = 2u$$

$$V_D = 5V_\alpha$$

$$\lambda_D = \frac{1}{2 \times V_D}, \lambda_\alpha = \frac{1}{4V_\alpha}$$

$$\frac{\lambda_D}{\lambda_\alpha} = \frac{4V_\alpha}{2V_D} = \frac{4}{2 \times 5} = \frac{4}{10} = 0.4$$

$$60. (a) \Delta x \cdot m \cdot \Delta v = \frac{h}{4\pi}$$

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

$$61. (d) \frac{\Delta x_e \cdot m_e \cdot \Delta v_e}{\Delta x_p \cdot m_p \cdot \Delta v_p} = 1$$

$$\frac{\Delta v_e}{\Delta v_p} = \frac{m_p}{m_e}$$

$$62. (c) \lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34}}{1.67 \times 10^{-27} \times 0.15 \times 3 \times 10^8}$$

$$63. (a) \lambda = \frac{h}{mv}$$

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

$$64. (c) \Delta v = \frac{h}{4\pi m \Delta x}$$

$$65. (c) \lambda = \frac{h}{mv} = \frac{6.625 \times 10^{-34}}{0.5 \times 100} = 1.32 \times 10^{-35} \text{ m}$$

$$66. (c) \text{According to de-Broglie equation;}$$

$$\text{Wavelength } (\lambda) = \frac{h}{mv}$$

$$\text{Given; } m = 100g, v = 100 \text{ cm/sec}$$

$$h = 6.6 \times 10^{-34} \text{ Js} = 6.6 \times 10^{-27} \text{ erg-s}$$

on substituting values, we get

$$\lambda = \frac{6.6 \times 10^{-27}}{100 \times 100} = \frac{6.6 \times 10^{-27}}{10^4} = 6.6 \times 10^{-31} \text{ cm/s}$$

$$67. (a) \text{According to de-Broglie equation}$$

$$\lambda = \frac{h}{mv} \text{ But } \lambda_1 : \lambda_2 = 3 : 5$$

$$\therefore v_1 : v_2 = 5 : 3$$

$$KE = \frac{1}{2}mv^2 \quad KE_1 : KE_2$$

$$= 5^2 : 3^2 = 25 : 9$$

$$68. (d) \text{de-Broglie equation}$$

$$\lambda = \frac{h}{mv} \Rightarrow v = \frac{h}{m\lambda} \quad \dots(1)$$

$$K.E. = \frac{1}{2}mv^2 \quad \dots(2)$$

on putting the value of v in e. (2) we get

$$K.E. = \frac{1}{2}m \left(\frac{h}{m\lambda} \right)^2 = \frac{1}{2} \left(\frac{h^2}{m\lambda^2} \right)$$

Hence, K.E. $\propto 1/m$ (if λ is same) and order of mass is as

$$m_e < m_p < m_\alpha$$

Thus; the order of K.E. is

$$E_e > E_p > E_\alpha$$

$$69. (d)$$

$$70. (b) \lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-27}}{10^{-3} \times 10^5} \Rightarrow \frac{6.626 \times 10^{-27}}{10^2} = 6.626 \times 10^{-29} \text{ cm}$$

$$71. (c) \text{According to Heisenberg principle}$$

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

$$\Delta x = \frac{6.6 \times 10^{-27} \times 100}{4 \times 3.14 \times 9.1 \times 10^{-28} \times 3 \times 10^4 \times 0.011}$$

$$\Delta x = 0.175 \text{ cm}$$

72. (a) Here; $\Delta x = \Delta v$

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

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

$$(\Delta v)^2 = \frac{h}{4\pi m}$$

$$(\because \Delta x = \Delta v)$$

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

$$\Delta p = m \cdot \Delta v$$

$$\Delta p = m \sqrt{\frac{h}{4\pi m}} = \sqrt{\frac{mh}{4\pi}}$$

$$\Delta p = \frac{1}{2} \sqrt{\frac{mh}{\pi}}$$

73. (d) $\lambda = \frac{h}{mv}$

$$\lambda_A = \frac{h}{m_A \times 0.1}, \quad \lambda_B = \frac{h}{5 \times m_A \times 0.05}$$

$$\frac{\lambda_A}{\lambda_B} = \frac{m_A \times 0.05 \times 5}{m_A \times 0.1} = \frac{5}{2}$$

74. (b) Let, the wavelength of particle be x ,

Thus; $x = 100 \times \text{velocity}$

$$\text{velocity (v)} = \frac{x}{100}, \quad \lambda = \frac{h}{mv}$$

$$x = \frac{h \times 100}{m \times x}$$

$$x^2 = 100 \times \frac{h}{m} \Rightarrow x = 10 \sqrt{\frac{h}{m}}$$

75. (a) de-broglie equation is $\lambda = \frac{h}{mv}$

$$\text{K.E.} = \frac{1}{2}mv^2 \quad \text{or} \quad v = \sqrt{\frac{2\text{K.E.}}{m}}$$

$$\lambda = \frac{h}{\sqrt{2m \text{K.E.}}}$$

$$\frac{\text{K.E.}_1}{\text{K.E.}_2} = \frac{\lambda_2^2}{\lambda_1^2} = \left(\frac{5}{3}\right)^2 = \frac{25}{9}$$

76. (a) According to Heisenberg's uncertainty principle

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

Here $\Delta x = \Delta p$ and $\Delta p = m \cdot \Delta v$

$$\therefore (\Delta v^2) = \frac{h}{m^2 4\pi} \quad \text{or} \quad \Delta v = \frac{1}{2m} \sqrt{\frac{h}{\pi}}$$

$$\begin{aligned} 77. (a) \lambda &= \frac{h}{\sqrt{2mE}} = \frac{6.626 \times 10^{-34}}{\sqrt{2 \times 1 \times 0.5}} \\ &= 6.626 \times 10^{-34} \text{ m.} \end{aligned}$$

$$78. (a) \lambda = \frac{h}{mv}$$

79. (a) If $m = +3$ (maximum), then $\ell = 3$ and n can have maximum value of four. Also no. of waves in an orbit = no. of orbit.

80. (d) $P(1s^2, 2s^2 2p^6, 3s^2 3p^3)$ has 6 electrons in s-subshells as in d-shell of Fe^{2+} .

81. (b) for any value of ℓ the possible value of $m = -\ell$ to $+\ell$

$$\ell = 1, m = -1, 0, +1$$

82. (a) $\text{Cu}^{2+} (3d^9)$ and $\text{Ti}^{3+} (3d^1)$ have one unpaired electron each
So they have same paramagnetic moment

83. (d) $Z = 26 = \text{Fe} = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$

$$\text{Fe}^{3+} = \frac{1s^2}{K} \frac{2s^2 2p^6}{L} \frac{3s^2 3p^6 3d^5}{M}$$

$\therefore$ Electron in M shell = 13

84. (b) $l = 1$

$\therefore$ minimum value of $n = 2$

$$mvr = \frac{nh}{2\pi} = \frac{h}{\pi}$$

85. (a) Valence electron is $4s^1$

86. (a) $K = 19 = 1s^2 2s^2 2p^6 \underbrace{3s^2 3p^6}_M 4s^1$ K has only 8 electron in M shell

87. (c) For a p electron l value must be one and m values are $-1, 0, +1$.

88. (d) An orbital can accommodate one electron with $s = +\frac{1}{2}$

89. (c) $3p^5$: $\uparrow\downarrow \uparrow\downarrow \uparrow$

$$n = 3, l = 1, m = 1$$

90. (d) Spin quantum number is not related with Schrodinger wave equation.

91. (a) Electronic configuration of K = $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$
For valence electron ($4s^1$)

92. (a) Electronic configuration is

$$1s^2 2s^2 2p^6 3s^2 3p^6 \underline{3d^3} 4s^2$$

93. (d) (Fact Based) All transition emit one quantum of energy but the energy of each quantum differs.

94. (c) m = represents the orientation of orbital in magnetic field.
 m = orbitals

95. (d) Configuration of Cr ($Z = 24$) is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$
 $l = 1$ denotes p -electrons ($2p^6, 3p^6$) $l = 2$, denotes d -electrons ($3d^5$)

$$96. (c) \lambda = \frac{h}{p} \quad \therefore \frac{\lambda_A}{\lambda_B} = \frac{p_B}{p_A} = \frac{1}{2}$$

$$\text{or } \lambda_B = 2 \times \lambda_A = 2 \times 5 \times 10^{-8} \text{ m} = 10^{-7} \text{ m}$$

97. (c) D functions is $= 4\pi r^2 \cdot dr \psi^2 = \text{probability function}$

98. (a) The quantum of light energy is called photon.

$$99. (d) \text{Orbital angular momentum} = \frac{h}{2\pi} \sqrt{\ell(\ell+1)}$$

For f-orbital, $\ell = 3$

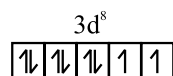
$$\therefore \text{orbital angular momentum} = \frac{h}{2\pi} \sqrt{3(3+1)} = \frac{h\sqrt{3(4)}}{2\pi}$$

$$= \frac{2h\sqrt{3}}{2\pi} = \frac{h\sqrt{3}}{\pi} = \frac{\sqrt{3}h}{\pi}$$

100. (d) Electronic configuration of

Ni-28 is [Ar] $3d^8, 4s^2$

Thus, outer orbital diagram for Ni^{2+} is



$$\Rightarrow n = 2$$

$$\mu = \sqrt{n(n+2)} \text{ B.M.}$$

$$\mu = \sqrt{2(2+2)} \text{ B.M.}$$

$$\mu = \sqrt{8}$$

$$\mu = 2.83 \text{ B.M.}$$

$$101. (a) \text{Angular momentum} = \frac{nh}{2\pi} = \frac{1.5h}{\pi}$$

$$n = 3$$

102. (c) The maximum number of electrons which can be held by electron with Azimuthal quantum number " ℓ " in an atom is given by $2(2\ell + 1)$.

$$103. (a) 1s^2 2s^2 2p^6 3s^2 3p^6 3d^4$$

$$104. (c) {}_{19}\text{X} \rightarrow 1s^2 2s^2 2p^6 \underline{3s^2 3p^6 4s^1}$$

$${}_{21}\text{Y} \rightarrow 1s^2 2s^2 2p^6 \underline{3s^2 3p^6 4s^2 3d^1}$$

$${}_{25}\text{Z} \rightarrow 1s^2 2s^2 2p^6 \underline{3s^2 3p^6 4s^2 3d^5}$$

$$Z > Y > X$$

$$105. (d) E.C. \text{ of Cr} = 1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$$

106. (a) Element is 'Mn'

$$107. (a) 2 \text{ K} \quad 8 \text{ L} \quad 13 \text{ M} \quad 1 \text{ N}$$

$$1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$$

108. (c) This electronic configuration shows atomic number '9'.
So that element is fluorine.



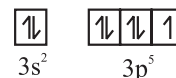
$$\text{Sum of spin Q. No.} = 5 \times \frac{1}{2} + 2 \times \frac{-1}{2}$$

$$= \frac{5}{2} - 1 = \frac{3}{2}$$

110. (c) Azimuthal quantum number determines shape of the, orbital magnetic quantum number, m is associated with spatial orientation of the orbital. Principal quantum number (n) determines energy of the electron & size (volume) of the atom.

111. (a) Atomic number 17, $1s^2 2s^2 2p^6 3s^2 3p^5$

Valence shell has $3s^2 3p^5$ orbit.



Valence shell has 3 orbitals with paired electrons.

112. (c) Electronic configuration of bromine is

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

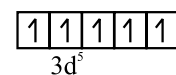
Then; the total no. of p-electron in bromine is 17.

113. (a) Electronic configuration of ${}_{26}\text{Fe}$ is

$$1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$$

$$\text{Fe}^{3+} = 1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$$

$\therefore$ Outer orbital diagram of Fe^{3+} is



$\therefore$ the no. unpaired electrons are 5.

114. (a) The hydrogen atom has configuration $1s^1$.

So; 3s, 3p & 3d orbital will have the same energy with respect to 1s orbital.

$$115. (b) L = \frac{nh}{2\pi}$$

$$n = 4$$

$$\therefore L = \frac{4h}{2\pi} = \frac{2h}{\pi}$$

116. (c) Total no. of orbital in a shell is n^2 .

$$117. (c) \text{Radius of Bohr's orbit} = \frac{n^2 \times a_0}{Z}$$

$$= \frac{(3)^2 \times a_0}{1} = 9a_0$$

118. (c) $\therefore \ell = 0$

$$\therefore m = -\ell \text{ to } +\ell = 0$$

But m (given) = -1, so (c) is incorrect

Learning Plus

1. (c) Bohr put forward concept of electrons move in a circular path of fixed energy called orbits but not derived from Rutherford's scattering experiment.
2. (c) $E = \frac{13.6}{n^2} = \frac{13.6}{25} = 0.544 \text{ eV}$
3. (c) Hydride ion is H^- that is isoelectronic with He.
4. (a) $P = \frac{h}{\lambda}$
5. (c) Correct configuration should be $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$ for the copper which has atomic number 29 ($_{29}\text{Cu}$). Due to extra stability of full filled orbital of d-subshell, the last electron enter into d-orbital instead of s-orbital.
6. (a) $E = \frac{nhc}{\lambda}$
7. (c) X-rays not deflected by electric and magnetic field.
8. (c) $E = w + K.E$
9. (d) The probability density of electrons first increases then decreases and after that it begins to increase again as distance increases from nucleus.
10. (a) Work function
 $W = h\nu_0$
11. (d) It does not depend upon nature of gas. Negatively charged material particles are present in cathode rays
12. (a) Lyman n_1 to $n = 1$ $n_1 = 3$
Balmer n_2 to $n = 2$ $n_2 = 2$
Paschen n_3 to $n = 3$ $n_3 = 1$
13. (d) Number of radial nodes = $n - l - 1$
For 3p orbital = $3 - 1 - 1 = 1$
No of radial nodes = 1
14. (c) Number of angular node = l
For 4th orbital ($n = 4$) and $l = 2$ for d-orbital
Number of angular nodes = 2
15. (b) A German physicist Werner Heisenberg in 1927, stated uncertainty principle which states that it is not possible to determine simultaneously, the exact position and exact momentum of an electron.
Mathematically, $\Delta x \times \Delta p \geq \frac{h}{4\pi}$
The important implications of the Heisenberg uncertainty principle is that it rules out existence of definite paths or trajectories of electrons and other similar particles.
16. (c) Total number of orbitals associated with n^{th} shell = n^2
 $\therefore$ Total number of orbitals associated with third shell $(3)^2 = 9$
17. (a) Orbital angular momentum = $\sqrt{l(l+1)} \frac{h}{2\pi}$
So it depend upon only ' l '
18. (c) The fractional atomic mass (35.5) of chlorine is due to the fact that in ordinary chlorine atom. Cl-37 and Cl-35 are present in the ratio of 1 : 3.
 $\therefore$ Average atomic mass of
$$\text{Cl} = \frac{3 \times 35 + 1 \times 37}{4} = \frac{105 + 37}{4} = 35.5 \text{ amu}$$
19. (b) $_{24}\text{Cr} = [\text{Ar}]3d^5, 4s^1$ $_{24}\text{Cr}^{3+} = [\text{Ar}]3d^3$
 $_{26}\text{Fe} = [\text{Ar}]3d^6, 4s^2$ $_{26}\text{Fe}^{3+} = [\text{Ar}]3d^5$
 $_{25}\text{Mn} = [\text{Ar}]3d^5, 4s^2$ $_{25}\text{Mn}^{2+} = [\text{Ar}]3d^5$
 $_{27}\text{Co} = [\text{Ar}]3d^7, 4s^2$ $_{27}\text{Co}^{3+} = [\text{Ar}]3d^6$
 $_{21}\text{Sc} = [\text{Ar}]3d^1, 4s^2$ $_{21}\text{Sc}^{3+} = [\text{Ar}]$
Thus, Fe^{3+} and Mn^{2+} have the same electronic configuration
20. (d) (a) Electrons in 2s and 2p orbitals have different screen effect. Hence, their Z_{eff} is different. Z_{eff} of 2s orbital > Z_{eff} of 2p orbital.
Therefore, it is not correct.
(b) Energy of 2s orbital < energy of 2p orbital.
Hence, it is not correct.
(c) Z_{eff} of 1s orbital $\neq$ Z_{eff} of 2s orbital
Hence, it is incorrect.
(d) For the two electrons of 2s orbital, the value of m_s is $+\frac{1}{2}$ and $-\frac{1}{2}$.
21. (d) $\Delta x = \frac{h}{4\pi m \Delta v}$
22. (b) From De-Broglie equation, wavelength, $\lambda = \frac{h}{mv}$
For same speed of different particles, i.e., electron, proton, neutron and α -particle,
$$\lambda \propto \frac{1}{m}$$

As h is constant. Greater the mass of matter waves, lesser is wavelength and vice-versa. In these matter waves, alpha particle (He^{2+}) has higher mass, therefore, shortest wavelength.
23. (d) Let the no. of electrons in $\text{A}^{3+} = x$
 $56 = x + 3 + 1.304x$
 $x = 23$
24. (b) $\frac{E_1}{E_2} = \frac{v_1}{v_2}$
25. (d) $E = \frac{Nhc}{\lambda}$

26. (a) $KE = E - W$

27. (d) $E = \frac{hc}{\lambda}$

28. (a) Electron excited to 2nd orbit

$$\text{No. of spectral lines} = \frac{n(n-1)}{2}$$

29. (d) $\frac{E_2 - E_1}{E_3 - E_2} = \frac{-13.6\left(\frac{1}{4} - \frac{1}{1}\right)}{-13.6\left(\frac{1}{9} - \frac{1}{4}\right)}$

$$= \frac{-3}{4} = \frac{3}{4} \times \frac{36}{5} = \frac{27}{5} = 5.4$$

30. (a) $\Delta V = \frac{h}{4\pi m \Delta x} = \frac{6.626 \times 10^{-34}}{4 \times 3.14 \times 25 \times 10^{-3} \times 10^{-5}}$
 $= 2.1 \times 10^{-28} \text{ m/sec}$

31. (b) $\frac{\lambda_e}{\lambda_h} = \frac{\frac{h}{m_e v_e}}{\frac{h}{m_n v_n}}$

$$\frac{1}{2} = \frac{m_n v_n}{m_e v_e}$$

$$V_n = \frac{2 \times m_e \times v_e}{m_n} = \frac{x}{920}$$

32. (d) Electronic configuration : $1s^2 2s^2 2p^6 3s^1$
 For 3s orbital $n = 3$, $l = 0$, $m = 0$, $s = +1/2$

33. (b) No. of radial nodes = $n - l - 1$
 Nodel planes = l

34. (c) Ionization energy $-217.6 = -13.6 \times \frac{Z^2}{1^2}$
 $z = 4$

So, it is ${}^9_4\text{Be}^{3+}$; no. of neutrons $9 - 4 = 5$

35. (a)

Multiconcept MCQs

1. (b) Energy of a quantum level or orbit in hydrogen atom in $\text{kcal mol}^{-1} = -313.6/n^2$
 H_α line in Lyman series of hydrogen atomic spectrum corresponds to $n_1 = 1$ to $n_2 = 2$. It is the first line in Lyman series.

Energy of $n = 1$ level = $-313.6/1^2 = -313.6 \text{ kcal mol}^{-1}$

Energy of $n = 2$ level = $-313.6/2^2 = -78.4 \text{ kcal mol}^{-1}$

2. (c) For numerical purposes,

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

$$\Delta v = \frac{0.005}{100} \times 600 = 3 \times 10^{-2} \text{ ms}^{-1}$$

$$\Delta x = \frac{h}{4\pi m \Delta v} = \frac{6.626 \times 10^{-34}}{4 \times 3.14 \times 9.1 \times 10^{-31} \times 3 \times 10^{-2}}$$

$$\Delta x = 1.92 \times 10^{-3} \text{ m}$$

3. (a) $E = hv$

$$E = \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{310 \times 10^{-9}} \text{ J}$$

$$E = 0.0641 \times 10^{-26} \times 10^9 \text{ J}$$

$$E = 0.0641 \times 10^{-17} \text{ J}$$

This is the energy of one photon required to break one A_2 molecule.

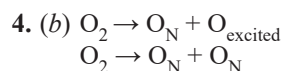
To break 1 mole of A_2 , Energy of photons required =

$$6.02 \times 10^{23} \times 0.0641 \times 10^{-17} = 0.386 \times 10^6 = 386 \text{ kJ/mole}$$

$$\text{K.E} = 386 \text{ kJ/mole} - 288 \text{ kJ/mole} = 98 \text{ kJ/mole}$$

Percentage of total energy that got converted into

$$\text{KE} = \frac{98}{386} \times 100 = 25\%$$



$$E = 498 \times 10^3 \text{ J/mole}$$

$$= 498 \times 10^3 / 6.023 \times 10^{23} \text{ per molecule} = 8.268 \times 10^{-19} \text{ J}$$

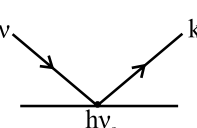
$$\text{Energy required for excitation} = 1.967 \text{ eV} = 3.146 \times 10^{-19} \text{ J}$$

$$\text{Total energy required for photochemical dissociation of } O_2 = 8.268 \times 10^{-19} + 3.146 \times 10^{-19} = 11.414 \times 10^{-19} \text{ J}$$

$$hc/\lambda = 11.414 \times 10^{-19} \text{ J}$$

$$\lambda = 6.626 \times 10^{-34} \times 3 \times 10^8 / 11.414 \times 10^{-19} = 1.7415 \times 10^{-7} \text{ m} = 1741.5 \text{ \AA}$$

5. (a) Energy of red photon is less than violet photon.

6. (d) 

Apply, $hv - hv_o = KE$

Apply, $hv - hv_o = \frac{3}{4} hv \Rightarrow hv - \frac{3}{4} hv = hv_o$

$$\frac{h\nu}{4} = h\nu_o \Rightarrow \frac{\nu}{4} = \nu_o$$

$$\frac{3.2 \times 10^{16}}{4} = \nu_o = 8 \times 10^{15} \text{ Hz}$$

7. (b) Option b is correct as second energy level have 8 electron in 4 orbital.

$$8. (a) V_n = 2.18 \times 10^6 \times \frac{Z}{n} \text{ ms}^{-1}$$

$$V_n = V_o \times \frac{Z}{n} \text{ ms}^{-1}$$

$$V_o = \frac{1}{100} \times 3 \times 10^8 = 3 \times 10^6 \text{ ms}^{-1}$$

$$V_n = 3 \times 10^6 \times \frac{Z}{n} \text{ ms}^{-1}$$

Velocity in 5th Bohr orbit

$$V_{5^{\text{th}}} = 3 \times 10^6 \times \frac{1}{5} \text{ ms}^{-1} = 0.6 \times 10^6 \text{ ms}^{-1}$$

Velocity relative to speed of light

$$\frac{0.6 \times 10^6}{3 \times 10^8} = 0.2 \times 10^{-2} = 2 \times 10^{-3} = 0.002$$

9. (a) [A — (iii)]; [B — (ii)]; [C — (i)]; [D — (iv)].

10. (d) Orbital having (n + l) same have same energy in absence of magnetic field n is same and orbital is 3d.

11. (a) The frequencies and the wave numbers of transitions in H atom and He⁺ ion are equal.

$$\text{i.e., } \bar{\nu}_H = \bar{\nu}_{He^+}$$

$$\text{or } R(Z_H)^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right] = R(Z_{He^+})^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right]$$

$$\left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right] = (2)^2 \left[\frac{1}{2^2} - \frac{1}{4^2} \right] = \left[\frac{1}{1} - \frac{1}{4} \right]$$

By comparing above terms:

$$n_1 = 1 \text{ and } n_2 = 2.$$

12. (b) For n = 4, the possible 'l' values are 0, 1, 2 & 3.

The z-component of L is given by,

$$L_z = m_l \frac{h}{2\pi} = m_l \hbar$$

For maximum possible 'l' value i.e., 3 and for this m_l can have values -3, -2, -1, 0, +1, +2, +3.

so. ans is 3ħ

13. (b) Last line of lyman series refers to transition ∞ → 1

$$\frac{1}{\lambda_1} = R \left(\frac{1}{1^2} - \frac{1}{\infty^2} \right)$$

$$\frac{1}{\lambda_1} = R \quad \dots(1)$$

2nd line of Balmer series refers to transition 4 → 2.

$$\frac{1}{\lambda_2} = R \left(\frac{1}{2^2} - \frac{1}{4^2} \right)$$

$$\frac{1}{\lambda_2} = R \left(\frac{1}{4} - \frac{1}{16} \right)$$

$$\frac{1}{\lambda_2} = R \times \frac{3}{16} \quad \dots(2)$$

Divide equation (1) and (2)

$$\frac{\frac{1}{\lambda_1}}{\frac{1}{\lambda_2}} = \frac{R}{\frac{3R}{16}} = \frac{R}{1} \times \frac{16}{3R}$$

$$= \frac{\lambda_2}{\lambda_1} = \frac{16}{3}$$

14. (c) A — (iv); B — (ii); C — (i); D — (iii)

$$15. (a) h\nu_1 - h\nu_o = KE_1 \quad \dots(1)$$

$$h\nu_2 - h\nu_o = KE_2 \quad \dots(2)$$

$$\frac{h(\nu_1 - \nu_o)}{h(\nu_2 - \nu_o)} = \frac{2}{1}$$

$$\nu_1 - \nu_o = 2\nu_2 - 2\nu_o \Rightarrow \nu_o = 2\nu_2 - \nu_1$$

16. (b) (ii), (iv), and (v) are not possible

(ii)	n = 2	l = 2	m = 1	s = +1/2	l not equal to n not possible
(iv)	n = 1	l = 0	m = -1	s = -1/2	Not possible because m = -1 where l = 0
(v)	n = 3	l = 2	m = 3	s = +1/2	Not possible because m = 3 is not for l = 2

$$17. (a) \frac{hc}{\lambda} = \frac{430.53 \times 10^3}{6.023 \times 10^{23}} + \text{K.E.}$$

$$\text{K.E.} = \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{253.7 \times 10^{-9}} - \frac{430.53 \times 10^3}{6.023 \times 10^{23}} = 6.9 \times 10^{-20}$$

$$\therefore \text{Fraction} = \frac{6.9 \times 10^{-20}}{7.83 \times 10^{-19}} = 0.088 = 8.86\%$$

18. (d) When intensity is doubled, number of electrons emitted per second is also doubled but average energy of photoelectrons emitted remains the same.

19. (c) The orbitals described by these sets of quantum numbers are :

(i) 4s (ii) 3p (iii) 3d (iv) 3s

The energy of these orbitals follows the order :

$$3d > 4s > 3p > 3s$$

(iii) (i) (ii) (iv)

20. (d) (a) $\text{Co}^{3+} : 1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$ $\therefore$ 4 unpaired electrons

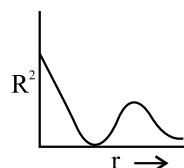
$$\therefore \mu = \sqrt{4(4+2)} = \sqrt{24} = 4.9 \text{ BM}$$

(b) Number of radial = $n - \ell - 1$

Number of radial nodes in 3p orbital = $3 - 1 - 1 = 1$

(c) Number of electrons with ($m = 0$) in Mn^{2+} ($1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$) ion = 1 s (2) + 2s(2) + 2p(2) + 3s(2) + 3p(2) + 3d(1) = 11

21. (a) Correct graph will be



22. (d)

23. (d) $\Delta E = RhcZ^2 \left(\frac{1}{n_i^2} - \frac{1}{n_f^2} \right)$ as highest energy difference between $n = 1$ and $n = 3$

24. (c)

NEET Past 10 Years Questions

1. (d) $\lambda = \frac{c}{\nu}$

$$\lambda = \frac{3 \times 10^8}{1368 \times 10^3} = 219.298 \text{ m} = 219.3 \text{ m}$$

2. (d) ${}_{71}^{175}\text{Lu}$

Z = atomic number

Z = No. of Protons = 71 = No. of Electrons

No. of Neutrons = Mass no. – No. of Protons
= 175 – 71
= 104

3. (d) Number of radial nodes = $n - \ell - 1$

Number of angular nodes = ℓ

For 3s orbital,

$$\ell = 0$$

• Number of radial nodes = $3 - 0 - 1 = 2$

• Number of angular nodes = 0

4. (a) $n \quad l$

($n + 1$) value for, 4d = $4 + 2 = 6$

$$5p = 5 + 1 = 6$$

$$5f = 5 + 3 = 8$$

$$6p = 6 + 1 = 7$$

Lower value of ($n + l$) signifies lower energy

In case of 4d and 5p, lower value of n in 4d has compare to 5p.

So, 4d has less energy in comparison to 5p.

$\therefore$ Correct order of energy will be $5f > 6p > 5p > 4d$

5. (b) In visible region Balmer series transitions fall in H-spectrum.

6. (c) Element (X) electronic configuration

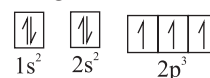
$$1s^2 2s^2 2p^3$$

So, valency of X will be 3.

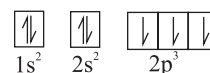
Valency of Mg is 2.

Formula of compound formed by Mg and X will be Mg_3X_2 .

7. (d) According to Hund's Rule of maximum multiplicity, the correct electronic configuration of N-atom is



OR



$\therefore$ Option (d) violates Hund's Rule.

8. (a) The energy of 2s orbital is less than the energy of 2p orbital in case of hydrogen like atoms is a wrong statement because:

$$1s > 2s = 2p > 3s = 3p = 3d \dots \text{etc.}$$

9. (d) The total number of orbital present in $n = 4$ is n^2 .
= $(4)^2 = 16$

Shell	No. of orbital
s	1
p	3
d	5
f	7

10. (a) Among d-orbitals d_{z^2} & $d_{x^2-y^2}$ have their electron densities orientated towards axes.

11. (c) When $n = 3$ and $l = 1$ orbital is 3p, so total number of electron that can be filled are 6 but in any orbital only 2 electron can accumulate.

12. (a) 2 electron occupying the same orbital can be distinguished using their spin quantum number (m_s) where one is clockwise ($\uparrow$) and other is anti-clockwise ($\downarrow$). In such case, the value of spin quantum number changes rest all quantum number remains the same.

13. (a) According to Aufbau's rule of increasing order of energy for filling up of electron.
 $3s < 3p < 4s < 3d$

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

For d orbital $\ell = 2$

So, angular momentum = $\sqrt{2(2+1)} \frac{h}{2\pi} = \sqrt{6} \frac{h}{2\pi}$

$\frac{h}{2\pi} = \hbar \rightarrow$ called as Planck's reducing constant or Dirac constant.

15. (d) $n = 3 \quad l = 1 \quad m_l = 0$
 $l = p \quad 3p = 1$ orbital as $m_l = 0$ so $3p_z$.

-1	0	1
$\uparrow\downarrow$	$\uparrow\downarrow$	$\uparrow\downarrow$
p_x	p_z	p_y

Thus, maximum no. of orbitals identified in $3p_z$ is 1.

16. (c) $E = \frac{hc}{\lambda}$

$E = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{45 \times 10^{-9}} = 4.42 \times 10^{-18} \text{ J}$

17. (d) $n = 3 \quad l = 1 \quad m_l = -1$

for p orbital $l = 1$

So orbital must be $3p_x$ or $3p_y$, where number of electron in each orbital will be 2.

18. (c) According to formula:

$E = \frac{hc}{\lambda}$ or $h\nu$

Where, $\frac{c}{\lambda} = \nu \Rightarrow \lambda = \frac{3 \times 10^8}{6 \times 10^{15}} = 50 \text{ nm}$

19. (d) The orbitals which are closer to nucleus are more strongly affected by the positive charged field of protons in nucleus. Whereas when we move away from nucleus & n (principal quantum number) increases, the effective influence of positive charged field decreases & electron in later (n) orbitals become loosely bounded.

20. (a) $n = 4$ and $\ell = 3$, this represent = 4f

Total number of electron in a sub shell = $2(2\ell + 1)$
 $= 2(2 \times 3 + 1)$
 $= 14$

21. (c) ${}_{37}\text{Rb} \rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^1$

from here we can say

for $5s \rightarrow n = 5$

$\ell = 0, \quad m = 0$

$s = \pm \frac{1}{2}$

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

For p-orbital $\ell = 1$

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

$m = \sqrt{1(1+1)} \frac{h}{2\pi} \rightarrow m = \sqrt{2} \frac{h}{2\pi} \Rightarrow m = \frac{h}{\sqrt{2}\pi}$