

EXERCISE

MULTIPLE CHOICE QUESTIONS

1. choose the correct answer (MCQs)

i. Wave mechanical model of the atom depends upon

- a) De-Broglie's concept of duality.
- b) Uncertainty Principle.
- c) Schrodinger's wave equation
- d) All of the above

ii. For which species Bohr's theory does not apply

- a) H
- b) He⁻
- c) Li²⁺
- d) Be

iii. From the discharge tube experiment, it is concluded that

- a) Mass of a proton is fraction.
- b) Matter contained electrons.
- c) Nucleus contains positive charge.
- d) Positive rays are heavier than protons.

iv. When an electron of charge 'e' and mass 'm' moves with velocity 'v' about the nuclear charge Ze in the circular orbit of radius 'r', the P.E of electron is given by

- a) Ze^2/r
- b) Ze^2/r

v. Which of following quantum numbers is not obtained from Schrodinger wave equation?

- a) Principal quantum number, n
- b) Azimuthal quantum number, l
- c) Magnetic quantum number, m
- d) Spin quantum number, s

vi. Electronic configuration of species M^{2+} is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^1$ and its atomic weight is 56 number of neutrons in the nucleuse of species M is

- a) 20
- b) 26
- c) 28
- d) 30

vii. The energy of an electromagnetic radiation is 3×10^{-12} ergs. What is its wave length in nanometers?

- a) 400
- b) 228.3
- c) 3000
- d) 662.5

viii. which of the following configuration is not according to hund's rule

(a)

↑↓
↑↓

 (b)

↑↓	↑	↑
↑↓	↑↓	

(c)

↑↓	↑	↑
↑↓	↑↓	

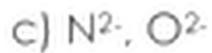
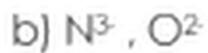
 (d)

↑↓	↑	↑
↑↓	↑	↑

ix. Which one of the following statements is not correct?

- a) Rydberg's constant and wave number have same unit.
- b) Lyman series of hydrogen spectrum occurs in the ultraviolet region.

x. Which one of the following is not isoelectronic pair?



xi. The third line in Balmer series corresponds to an electronic transfer between which Bohr's orbit in hydrogen



Answers:

i. d	ii. d	iii. b	v. d	vi. d
vii. d	viii. c	ix. d	x. a, c	

2. Short questions and answers:

i. How mass of electron can be calculated from e/m ratio charge

Ans: Determination of Mass of an Electron:

We calculate the mass of an electron by using e/m ratio.

We know that $e/m = 1.7588 \times 10^{11} \text{ Coulomb kg}^{-1}$

but $e = 1.6022 \times 10^{-19} \text{ Coulomb}$

$$\frac{1.60 \times 10^{-19} \text{ C}}{m} = \frac{1.7588 \times 10^{11} \text{ C kg}^{-1}}{1}$$

$$\text{or } m \times 1.7588 \times 10^{11} \text{ C kg}^{-1} = 1.60 \times 10^{-19} \text{ C}$$

$$m = \frac{1.60 \times 10^{-19} \text{ C}}{1.7588 \times 10^{11} \text{ C kg}^{-1}} = 9.1095 \times 10^{-31} \text{ kg}$$

Mass of electron compared with the mass of H atom is much less, which is

ii. How does Mosley's Law help in the production of X-rays?

Ans: A relationship between frequency (ν) and atomic number (Z) of the elements is given as:

$$\sqrt{\nu} = a (Z - b)$$

This is called Moseley Law. Where a and b are called constant quantities.

This law states that the frequency of a spectral line in x-ray spectrum varies as the square of atomic number of an element emitting it.

X-rays produce when an inner electron is removed and electrons from higher energy levels fill the vacancy. The X-ray series are labeled according to the level in which the original vacancy was created.

Mosley showed that the K-alpha x-rays followed a straight line when the atomic number Z versus the square root of frequency was plotted.

$$\sqrt{\nu} = a (z - b)$$

This law states that the frequency of a spectral line in x-ray spectrum varies as the square of atomic number of an element emitting it.

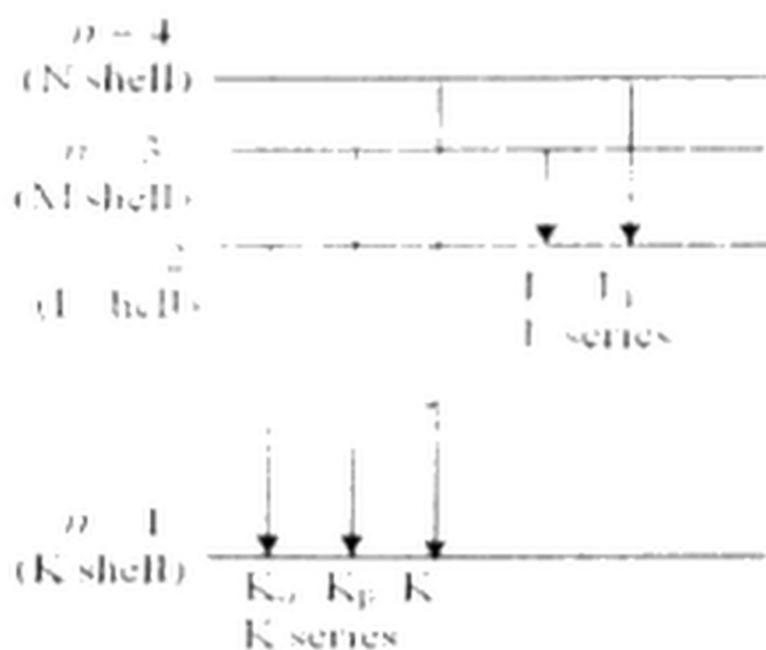


Fig: shows the K and L series.

iii. Which quantum number is also called sub-shell quantum number?

Ans: The Azimuthal Quantum Number (l) is called sub-shell quantum number.

Azimuthal Quantum Number (l) / Secondary Quantum Number:

and subshell are identical. When $n = 2$ there are two sets of sub shells; $l=1$ and $l=0$.

A number could be used to identify the subshell however to avoid confusion between the numerical values of n and those of l the l values are given a letter code.

Value of l	0	1	2	3	4
Letter designation	s	p	d	f	g

iv. What is the difference between orbit and orbital?

Ans: Difference between Orbit and Orbital:

Orbit	Orbital or Sub-shell
i. It is well-defined circular path followed by electron around nucleus.	i. It is a region of space around the nucleus where the probability of finding an electron is maximum.
ii. It represents two dimensional motion of electron around nucleus.	ii. It represents three-dimensional motion of electron around nucleus.
iii. The maximum number of electrons in an orbit is $2n^2$.	iii. The maximum number of electrons in an orbital is 2.
iv. Orbit is circular in shape.	iv. Orbitals have different shapes.
v. Orbit shows certainty about the position of an electron.	v. Orbital shows uncertainty about the position of an electron.
vi. Bohr provided this concept	vi. This concept was given by modern techniques (Schrodinger)
vii. They cannot be degenerate	vii. They can be degenerate e.g. P_x, P_y, P_z
viii. Explained by principle quantum number	viii. Explained by magnetic quantum number.

v. What is the relationship between?

a. energy and wavelength

b. frequency and wavelength

Ans: (a) Relation between energy and wavelength:

According to de Broglie equation.

Thus, greater the value of λ , smaller will be the energy.

Where E =Energy, c = Velocity of light, λ = wavelength

h = Planck's constant= $6.625 \times 10^{-34} \text{ Js}$

Thus, greater the value of A , smaller will be the frequency.

λ =wavelength, ν =frequency, c = speed of light

vi. What species are formed by the decay of neutron.

Ans. A free neutron decays into a proton with the emission of electron and neutrino.



Free neutron decays into a proton (${}_1P^1$) with the emission of an electron ${}_1e^0$ and a neutrino (${}_0n^0$).

vii. Hydrogen atom and He^+ are mono electronic system, but the size of He^+ is much smaller than H, why?

Ans: In hydrogen atom there are one electron and one proton whereas in He atom there are two electrons and two protons. In case of H^+ ion there is one proton but in He^+ , there are two protons and one electron. These two protons exert more force of attraction on one electron as a result electron comes closer to the nucleus so size of He^+ is decreases.

OR

H-atom and He^+ are monoelectronic: system. It means both H-atom and He^+ have one electron in the valence shell. H-atom has one proton in the nucleus whereas He^+ has two protons in the nucleus. So, the force of attraction between two protons and one electron is greater than one proton and one electron. Hence, the size of He^+ is much smaller than H-atom.

viii. How the wavelength of moving particles is related to the momentum of electron.

Ans: According to Louis de-Broglie an electron is a solid particle which

electron. Mathematically,

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

Where, λ = Wavelength, h = Plank's constant

m = mass of electron, v = velocity of electron

mv = momentum of electron

According to this relation, the wavelength (λ) of the moving particle or electron is inversely proportional to its momentum (p).

ix. State Heisenberg's uncertainty principle.

Ans: According to this principle position and momentum of an electron cannot be determined simultaneously in an atom if we use the photons of longer wavelength to avoid the change of momentum of electron the determination of position of electron is impossible.

Mathematical,

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

Where Δx = Uncertainty to measure the position of electron

Δp = uncertainty in the measurement of momentum of an electron

This relationship is called uncertainty principle.

x. Why is 4s orbital lower in energy than 3d orbital?

Ans. According to Wiesel's rule ($n + l$) For 3d, $n + l = 3 + 2 = 5$ and for 4s, $n + l = 4 + 0 = 4$. Therefore, 4s orbital lower in energy than 3d orbital.

xi. Write electronic configuration of ${}_{25}\text{Mn}^{+2}$, ${}_{30}\text{Zn}^{2+}$, ${}_{64}\text{Cd}^{3+}$ and ${}_{13}\text{Al}^{3+}$

Ans: ${}_{25}\text{Mn}^{+2} = 1s^2, 2s^2 2p^6, 3s^2 3p^6 4s^2 3d^3$



xii. What is (n + l) rule?

Ans: This rule says that sub-shells are arranged in the increasing order of (n + l) values and if any two sub-shells have the same (n + l) values, then the sub-shell is filled first whose n values is smaller.

This is also called Wis-Wesser's rule. According to this rule "when electrons are filled in different orbitals of an atom, the electrons go first in orbital having lower value of n + l. But when two orbitals have same value of n + l, the electrons will go

first in the orbital having lower value of n + l where n = number of shells

Example 1:	1s	2s
	1+0	2+0
	1	2

So, electrons will go first in 1s, then

Example 2:	3d	4p
	3+d	4+1
	5	5

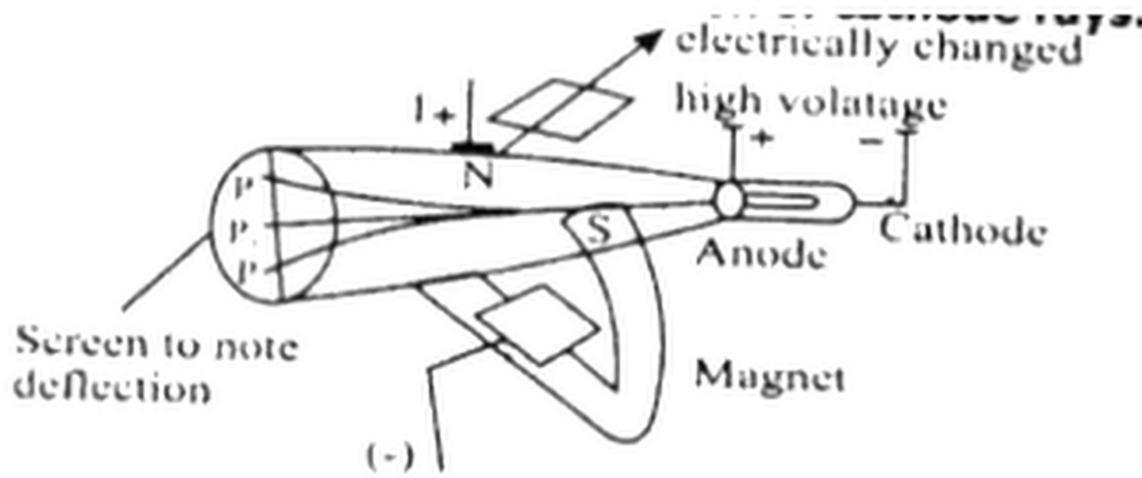
Here Values of n + l are same

but n value of 3d = 3

And n value of 4p = 4

So, Electrons will go first in 3d then in 4p.

xiii. The given diagram shows the deflection of cathode rays.



What do you understand when cathode rays strikes at?

a. A. at point P₃ (b) at point P₂ (c) at point P₁

Ans: (a) at point P₃

The electrons from cathode rays strike at point P₃ under the influence of electric field only

When cathode rays strike on point P₃ it means cathode rays which have negative charge have been attracted by positive plate of anode.

B. at point P₂

The electrons from cathode-ray strike at point P₂ under the influence of magnetic field only.

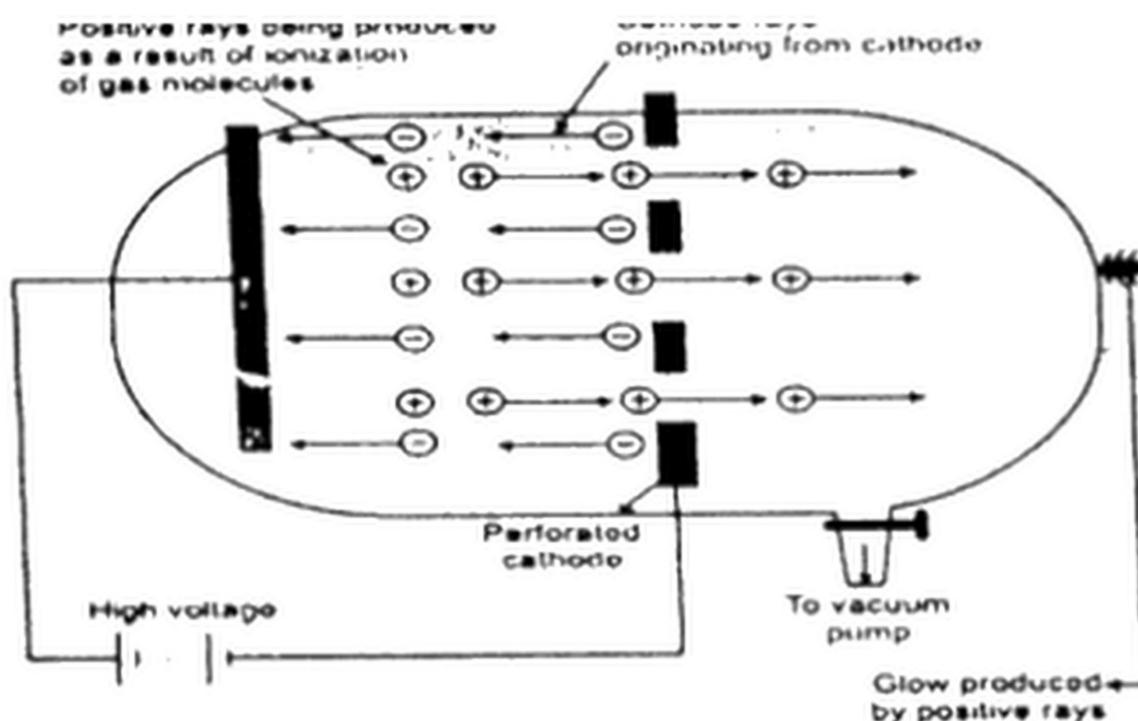
When cathode rays strike at point P₂ this indicates that cathode rays having negative charge are repelled.

C. at point P₁

The electrons from cathode rays strike at point P₁ under two conditions:

- i. In the absence of any electric and magnetic field.
- ii. When both electric and magnetic field are adjusted (balanced) and applied.

xiv. Diagram shows the canal rays passing through perforated cathode



- Name of apparatus and its use
- How much voltage is required to follow current through the gas?
- What is the function of vacuum pump?

Ans: (a) Name of the apparatus:

Discharge tube.

Use of Discharge tube:

It is used to study ionization of gases at high pressure and high temperature.

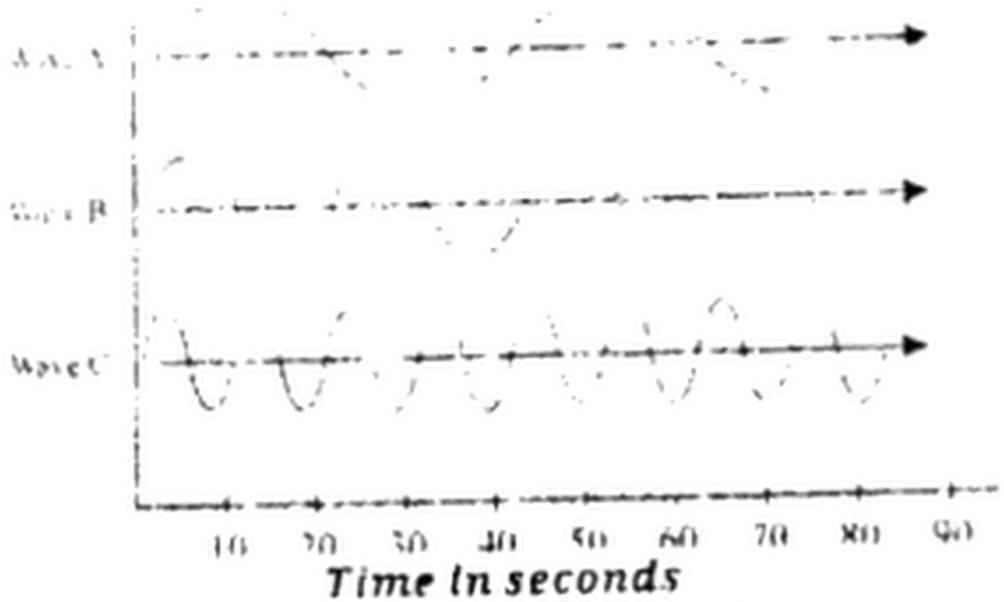
This discharge tube is used to generate cathode and anode rays.

(b) 5,000 - 10,000 volts

(c) Function of vacuum pump:

The function of vacuum pump is to reduced or change the pressure inside the tube. Function of vacuum pump is to decrease pressure in discharge tube by removing the gas. As a result, a uniform glow inside the tube appears. When the pressure is reduced to about 0.01 torr the original glow disappears.

xv. In fig. Below, the gives A, B and C has shown.



- a. Which wave has higher frequency?
- b. Which wave has longest wave length.
- c. Define the following term.

i. frequency ii. Wavelength

a. What is the frequency of wave B as compared to wave C?

Ans: a. Wave C has the highest frequency because it has shortest Wave-

length $v \propto \frac{1}{\lambda}$

(b) Wave A has largest wavelength because its frequency is Lowest $v \propto \frac{1}{\lambda}$

(c) (i) Frequency:

The number of waves passing through a point per second is called its frequency. Its symbol is v . Its units are herlz, cycle/sec, rev/sec.

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

Wavelength:

The distance between the adjacent crests or troughs is called wavelength.

Its units are \AA , nm or pm. Its symbol is lambda. (λ)

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

(d) Frequency of wave B is half than that of C because wavelength of B is

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

xvi. Point out the defects of Bohr's Model. How these defects are partially covered by dual nature of electron and Heisenberg' uncertainty principle.

Ans: Defects of Bohr's Atomic Model:

Spectrum of multi electrons or poly-electron system:

Bohr's theory cannot explain the origin of the spectrum of multi electron, or Poly-electron system like He, U, Be etc.

Motion of electron:

Bohr suggested circular orbits of electrons around the nucleus. But it is proved that motion of electron is not in a single plane but takes place in three-dimensional space.

Zeeman Effect:

When the excited atom of hydrogen giving atomic emission, spectrum is placed in a magnetic field, its spectral lines further split up into closely spaced lines. This type of splitting up of spectral lines is called Zeeman Effect.

Stark's effect:

Similarly, when the excited hydrogen atom is placed in a strong electrical field, then similar more splitting of spectral lines takes place which is called "Stark Effect".

Bohr's theory does not explain either Zeeman or Stark's effect.

Motion of electrons:

When a spectrum of Hydrogen gas is seen through a powerful spectrometer, the original spectral lines are replaced by several very fine lines. i.e. original lines are divided into other fine lines. Bohr suggested circular orbits of electrons around the nucleus of H-atom. But it is proved that the motion of electron is not in a single plane, but takes place in three-dimensional space.

Following the Heisenberg's uncertainty Principle, Bohr's picture of an atom is not satisfactory. In Bohr's atom, the electrons are moving in orbits with specific velocities in specific radii. But according to uncertainty principle, both of these quantities cannot be measured experimentally.

Schrodinger wave equation:

In order to solve this difficulty, Schrodinger gave a wave equation for hydrogen atom. According to him, although the position of an electron cannot be found exactly, the probability of finding an electron can be ascertained. The maximum probability is at a distance of 0.053 nm.

xvii. calculate the energy of electron of a hydrogen atom in the orbit for which the value of n=3.

Ans. $E_3 = -145.92 \text{ kJmol}^{-1}$

Solution:

$$E_n = \frac{1313.315}{n^2} \text{ kJmol}^{-1}$$

For 3rd orbit, n = 3. Putting the value of 'n' in above equation, we have:

$$E_3 = \frac{1313.315}{3^2} \text{ kJmol}^{-1} = 145.92 \text{ kJmol}^{-1}$$

OR (Second Method)

Energy of an electron can be determined using the following relation

$$E_n = -k \left(\frac{Z^2}{n^2} \right) \text{ joules}$$

$$E_n = -2.18 \times 10^{-18} \times \frac{Z^2}{n^2} \text{ Joules}$$

Where z= atomic number, n= number of shells

Here Z=1, n=3

$$E_3 = -2.18 \times 10^{-18} \times \frac{1^2}{3^2} \text{ Joules} = -0.242 \times 10^{-18} \text{ Joules}$$

$$E_3 = -2.42 \times 10^{-19} \text{ Joules}$$

xviii. A photon of light with energy 10^{-16} J is emitted by a light.

a. Convert this energy into the wave length, frequency and wave number of the photon in terms of meters, hertz and m^{-1} respectively.

b. Convert this energy of the photons into ergs and calculate the wave length in cm, frequency in Hz and wave number in cm^{-1}

Solution:

$$(a) \quad E = 10^{-16} \text{ J}$$

$$h = 6.625 \times 10^{-34} \text{ Js}$$

$$c = 3 \times 10^8 \text{ m/s}$$

$$V = ?$$

Since $E = hv$

$$v = \frac{E}{h} = \frac{10^{-16}}{6.625 \times 10^{-34}} = 1.509 \times 10^{18} \text{ s}^{-1}$$

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

$$\lambda = \frac{c}{v} = \frac{3 \times 10^8}{1.509 \times 10^{18}} = 1.988 \times 10^{-10} \text{ m}$$

$$\text{since } c = v\lambda$$

$$v = \frac{1}{\lambda} = \frac{1}{1.988 \times 10^{-10}} = 5.030 \times 10^9 \text{ m}^{-1}$$

(b) Convert this energy of the photons into ergs and calculate the Wavelength in cm, frequency in Hz and wavenumber in cm^{-1}

$$h = 6.625 \times 10^{-34} \text{ Js}$$

$$c = 3 \times 10^8 \text{ m/s}$$

$$E = 10^{-16} \text{ J} = 10^{-16} \times 10^7 = 10^{-9} \text{ erg} \quad (1 \text{ J} = 10^7 \text{ erg})$$

$$h = 6.625 \times 10^{-34} \text{ Js} = 6.625 \times 10^{-34} \times 10^7 = 6.625 \times 10^{-27} \text{ erg}$$

$$1 \text{ m} = 100 \text{ cm}$$

$$V = ?, \lambda = ? \quad V = ?$$

$$v = \frac{E}{h} = \frac{10^{-12}}{6.625 \times 10^{-34}} = 1.509 \times 10^{14} \text{ s}^{-1}$$

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

$$\lambda = \frac{c}{v} = \frac{3 \times 10^8}{1.509 \times 10^{14}} = 1.988 \times 10^{-4} \text{ cm}$$

$$\sin \theta = \frac{1}{\lambda}$$

$$v = \frac{1}{\lambda} = \frac{1}{1.988 \times 10^{-4}} = 5.030 \times 10^3 \text{ cm}^{-1}$$

xix. Bohr's equation for then radius of nth orbit of electron in the hydrogen atom

$$r_n = \frac{\epsilon_0 h^2 n^2}{\pi e^2 m}$$

a. When the electron moves from $n = 1$ to $n = 2$, how much does the radius change?

b. What is the distance travelled by the electron when It goes from (I) $n=8$ to $n =3$?

Solution a. $r_n = \frac{\epsilon_0 h^2 n^2}{\pi e^2 m}$

Since $\frac{\epsilon_0 h^2 n^2}{\pi e^2 m} = 0.529 \text{ \AA}$

Therefore (i) becomes,

$$r_n = 0.529 \text{ \AA} (n^2)$$

$$r_1 = 0.529 \text{ \AA} (1^2) = 0.529 \text{ \AA}$$

$$r_2 = 0.529 \times (2)^2 = 2.1164 \text{ \AA}$$

$$\text{increase in radius} = r_2 - r_1 = 2.116 - 0.529 = 1.587 \text{ \AA}$$

(b) $r_8 = 0.529 \times (8)^2 = 33.856 \text{ \AA}$

$$\text{Increase in radius} = r_8 - r_3 = 33.856 - 4.734 = 29.122 \text{ \AA}$$

