CAREER POINT

PHYSICS

THEORY

EXAMPLES

EXERCISES

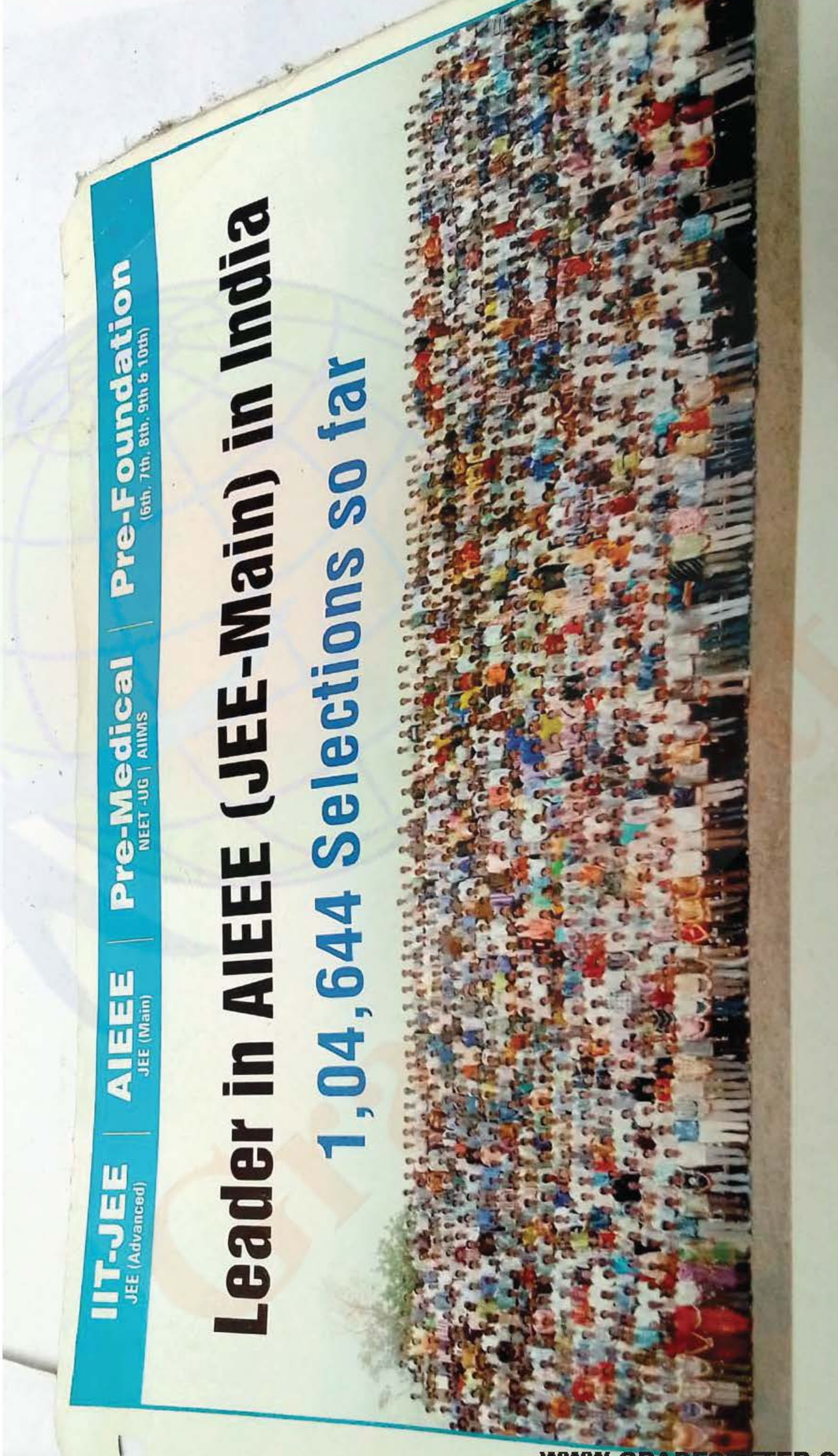
SOLUTION & TIPS

AIEEE

- ATOMIC STRUCTURE
- MATTER WAVE
- PHOTOELECTRIC EFFECT
- NUCLEAR PHYSICS & RADIOACTIVITY
- SEMICONDUCTOR DEVICES & TRANSISTORS
- COMMUNICATION SYSTEM
- X-RAYS

CAREER POINT

Where **Care** *leads to* **Career**


IIT-JEE
JEE (Advanced)
AIEEE
JEE (Main)
Pre-Medical
NEET-UG | AIIMS
Pre-Foundation
(6th, 7th, 8th, 9th & 10th)
Leader in AIEEE (JEE-Main) in India
1,04,644 Selections so far

Name :- Aniket Raj

CONTENTS

ATOMIC -STRUCTURE

MATTER WAVE

PHOTOELETRIC EFFECT

NUCLEAR PHYSICS & RADIO ACTIVITY

SEMICONDUCTOR ELECTRONICS

COMMUNICATION SYSTEM

X-RAY

— ATOMIC STRUCTURE —

AIEEE Syllabus

1. Introduction
2. Model
3. Some important Definitions & Their Meaning
4. Type of Line spectrum
5. Time Period and Frequency of Electron's Motion
6. Determination of No. of spectral lines (theoretical) in emission & in Absorption Transitions
7. Explanation of H-Spectrum & Spectral Line formula
8. General points For Spectral lines in every spectral Series
9. Concept of Reduced Mass & its Application in Bohr Theory
10. Concept of Recoiling of An Atom & Determination of Momentum & energy for Recoil Atoms
11. Shortcoming's of Bohr's Atomic model
12. Important Formulae

Total No. of questions in **Atomic Structure** are:

Solved examples..**11**

Level # 1 53

Level # 2 35

Level # 3 27

Level # 4 32

Total No. of questions.................158

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1. Students are advised to solve the questions of exercises (Levels # 1, 2, 3, 4) in the same sequence or as directed by the faculty members.
2. Level #3 is not for foundation course students, it will be discussed in fresher and target courses.

Index : Preparing your own list of Important/Difficult Questions

Instruction to fill

(A) Write down the Question Number you are unable to solve in **column A** below, by Pen.

(B) After discussing the Questions written in **column A** with faculties, strike off them in the manner so that you can see at the time of Revision also, to solve these questions again.

(C) Write down the Question Number you feel are important or good in the **column B**.

EXERCISE NO.	COLUMN :A Questions I am unable to solve in first attempt	COLUMN :B Good/Important questions
Level # 1		
Level # 2		
Level # 3		
Level # 4		

Advantages

1. It is advised to the students that they should prepare a question bank for the revision as it is very difficult to solve all the questions at the time of revision.
2. Using above index you can prepare and maintain the questions for your revision.

KEY CONCEPT

1. Introduction

Write from the beginning of civilisation, people were very curious to know that what from the substances are made up of but, first significant attempt in this direction was made by Dalton & from where Dalton's atomic model starts.

Before we go into detail of any model, here first we must understand the difference between a model & a theory.

2. Model

A model is simply a set of hypothesis based on logical & scientific facts.

Theory : When any model satisfies majority of scientific queries by experimental verification then it is termed as theory otherwise, model is simply not accepted.

In Nutshell we can say that every theory is a model but every model is not a theory. So, after more & more clarity about the substances, various new models like Dalton, Thomson, Rutherford, Bohr etc came into the pictures.

2.1 Dalton's atomic model -

(i) Every element is made up of tiny indivisible particles called atoms.

(ii) Atoms of same element are identical both in physical & chemical properties while atoms of different elements are different in their properties

(iii) All elements are made up of hydrogen atom. The mass of heaviest atom is about 250 times the mass of hydrogen atom while radius of heaviest atom is about 10 times the radius of hydrogen atom

(iv) Atom is stable & electrically neutral.

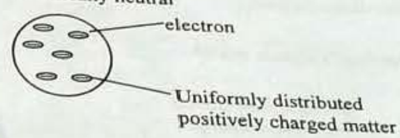
Reason of Failure of model -

After the discovery of electron by J.J.Thomson (1897), it was established that atom can also be divide. Hence the model was not accepted.

2.2 Thomson's atomic model (or Plum-pudding model)

(i) Atom is a positively charged solid sphere of radius of the order of 10^{-10}m in which electrons are embedded as seeds in a watermelon

(ii) Total charge in a atom is zero & so, atom is electrically neutral



Achievements of model -

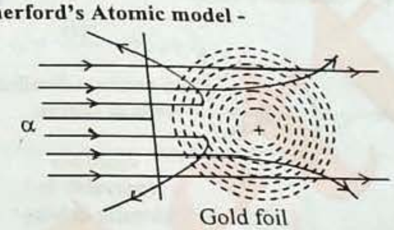
Explained successfully the phenomenon of thermionic emission, photoelectric emission & ionization

Failure of the model -

(i) It could not explain the line spectrum of H-atom

(ii) If could not explain the Rutherford's α-particle scattering experiment.

2.3 Rutherford's Atomic model -

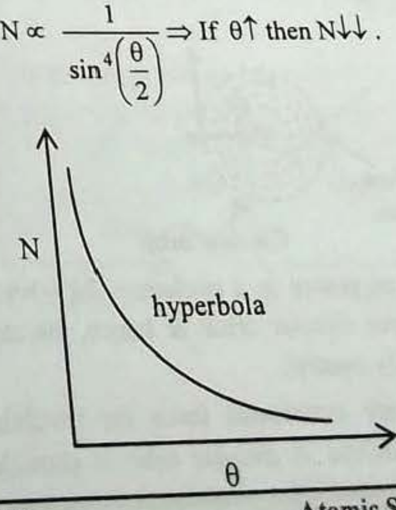


Result of the experiment :

(1) Majority of α-particles passes undeviated through gold foil that is possible when most part of the atom remains hollow.

(2) Few of α-particles (< 1 in 8000) deflects at an angle larger than 90° & even some at 180° which is possible only in that case when there exists a solid positive mass confining in a very narrow space.

(3) $N \propto \dfrac{1}{\sin^4\left(\dfrac{\theta}{2}\right)} \Rightarrow$ If $\theta\uparrow$ then $N\downarrow\downarrow$.



Equation indicates that at larger deflection (scattering) angle , no. of particles deflected are very-very less

Graph for N & θ show that coulomb's law holds for atomic distances also

Rutherford's atomic model -

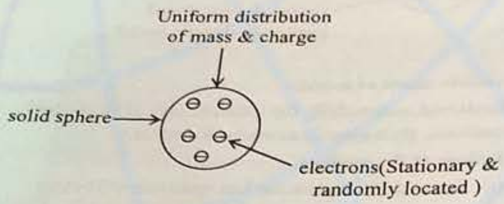


Fig : Thomson's model

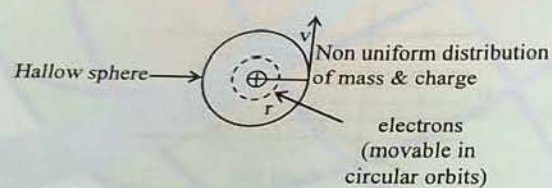
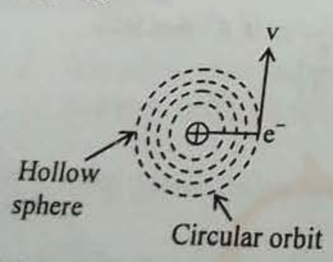


Fig : Rutherford's model

(1) The whole positive charge & almost whole mass of an atom (leaving aside the mass of revolving e^- in various circular orbits) remains concentrated in a nucleus of radius of the order of 10^{-15}m.



(2) Σq (+)ve on proton in a nucleus = Σq (-)ve on e^- in various circular orbits & hence, the atom is electrically neutral.

(3) The necessary centripetal force for revolving round the nucleus in circular orbit is provided by coulomb's electrostatic force of attraction.

$$\frac{mv^2}{r} = \frac{k(ze)(e)}{r^2}$$

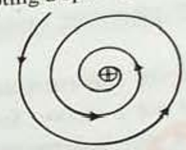
Reason of failure of model -

(1) It could not explain the line spectrum of H-atom.

Justification : According to Maxwell's electromagnetic theory every accelerated moving charged particle radiates energy in the form of electromagnetic waves & therefore during revolution of e^- in circular orbit its frequency will continuously vary (i.e. decrease) which will result in the continuous emission of lines & therefore spectrum of atom must be continuous but in reality, one obtains line spectrum for atoms.

(2) It could not explain the stability of atoms.

Justification - Since revolving electron will continuously radiates energy & therefore radii of circular path will continuously decrease & in a time of about 10^{-8} sec revolving electron must fall down in a nucleus by adopting a spiral path



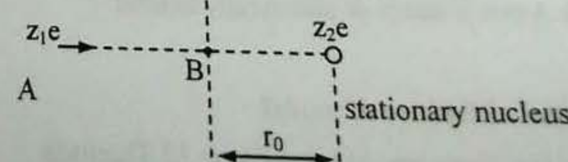
2.3.1 Application of rutherford's model

Determination of distance of closest approach :

When a positively charged particle approaches towards stationary nucleus then due to repulsion between the two, the kinetic energy of positively charged particle gradually decreases and a stage comes when its kinetic energy becomes zero & from where it again starts retracing its original path.

Definition : The distance of closest approach is the minimum distance of a stationary nucleus with a positively charged particle making head on collision from a point where its kinetic energy becomes zero.

Suppose a positively charged particle A of charge q_1 ($=z_1e$) approaches from infinity towards a stationary nucleus of charge z_2e then,



Let at point B, kinetic energy of particle A becomes zero then by the law of conservation of energy at point A & B,

$TE_A = TE_B$

$KE_A + PE_A = KE_B + PE_B$

$E + 0 = 0 + \frac{k(z_1 e)(z_2 e)}{r_0}$ (in joule)

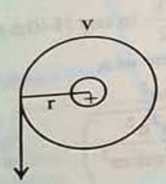
$\therefore \; r_0 = \frac{k(z_1 e)(z_2 e)}{E}$ m

2.4 Bohr's Atomic model

Bohr proposed his model for H or H-like atoms by mixing the concepts of classical physics with quantum mechanics. This model is based on law of conservation of angular momentum.

(1) **(a) Concept of stable, stationary, quantized, fixed allowed radii orbit, or maxwell's licensed orbits -**

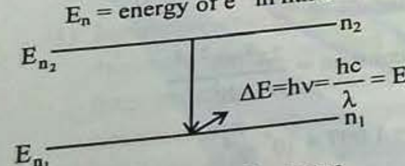
According to Bohr, if an electron revolve in these orbits then electron neither radiate nor absorb any energy.



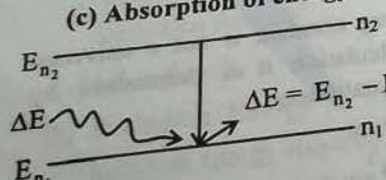
(b) Emission of energy

Where n = principle quantum no.

E_n = energy of e^- in nth orbit



(c) Absorption of energy



(2) Electron revolve only in those orbits in which its angular momentum is integer multiple of $\frac{h}{2\pi}$

$$mvr = I\omega = n\frac{h}{2\pi}$$

(3) $\frac{mv^2}{r} = \frac{KZe^2}{r^2}$

2.4.1 Determination of radius, velocity & energy of e^- in Bohr's orbit

(A) Determination of radius of circular path (orbit)

$\because \; mvr = \frac{nh}{2\pi}$ .....(1)

$\therefore \; v = \frac{nh}{2\pi mr}$ ......(2)

& $\frac{mv^2}{r} = \frac{kze^2}{r^2}$

$\therefore m\left(\frac{nh}{2\pi mr}\right) = \frac{kze^2}{r}$; $r_n = v\left(\frac{n^2h^2}{4\pi^2 mkze}\right)$

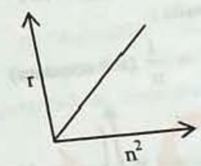
$r_n = \frac{n^2}{z} \times \frac{h^2}{4\pi^2 mke^2}$;

$r_n = \frac{n^2}{z} \times 0.529$ Å ..... (3)

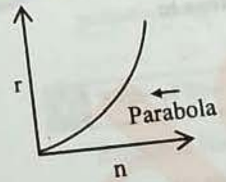
Results :

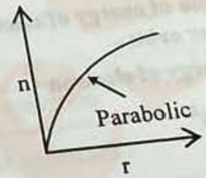
(i) $\because \; r_1 = \frac{(1)^2}{z} \times 0.529$ Å

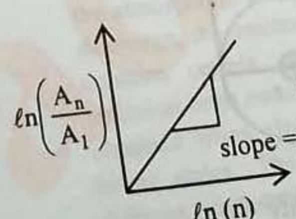
$\therefore \; r_n = n^2 r_1$.

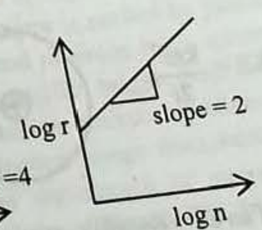


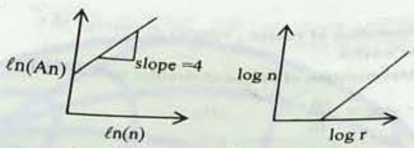
(ii) $\therefore \; r \propto n^2$











where A_n = Area of n^{th} circular orbit

(B) Determination of velocity of electron in Circular orbit →

$$\therefore mvr = \frac{nh}{2\pi} \quad .....(1)$$

$$r = \frac{nh}{2\pi mv}$$

$$\Rightarrow \frac{mv^2}{r} = \frac{kze^2}{r^2} \Rightarrow v = \frac{2\pi kze^2}{nh}$$

$$\Rightarrow v = \frac{z}{n} \times \frac{2\pi ke^2}{h} \quad \Rightarrow v = 2.18 \times 10^6 \frac{z}{n} \text{ m/s}$$

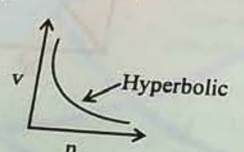
$$v = \frac{c}{137}\frac{z}{n} \text{ m/s}$$

where c = velocity of light in vacuum

$= 3 \times 10^8$ m/s

Results :

(i) $v \propto \frac{1}{n}$ (z = constant)

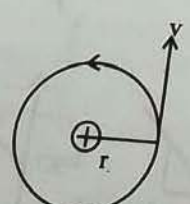


2.4.2 Determination of energy of electron in Bohr's circular orbit -

(1) Kinetic energy of electron

$$KE = \frac{1}{2}mv^2$$

$$KE = \frac{kze^2}{2r}$$



Results :

(i) KE of an e^- = positive quantity

(ii) r↑ , KE↓

(iii) of $r = \infty$, KE = 0

(2) Potential energy of an electron

$$PE = \frac{K(+ze)(-e)}{r}$$

$$PE = -\frac{Kze^2}{r}$$

Results :

(i) PE of an e^- = negative quantity (ii) r↑ , PE↑

(iii) If $r = \infty$, PE = 0

(3) Total energy of an electron : Total energy of an electron in any orbit is sum of its kinetic & potential energy in that orbit.

$$TE = KE + PE = \frac{Kze^2}{2r} - \frac{Kze^2}{r} \quad ; \quad TE = -\frac{Kze^2}{2r}$$

Results :

(i) TE of an electron in an atom = (–)ve quantity. (–)ve sign indicates that electron is in bound state

(ii) If r↑ , TE↑

(iii) if $r = \infty$, TE = 0

(iv) TE = - KE = $\frac{PE}{2}$ in any H-like atom

Total energy in term of n

$$TE = -\frac{kze^2}{2\times\left(\frac{n^2h^2}{4\pi^2 mkze^2}\right)}$$

$$\Rightarrow TE = -\frac{2\pi^2 mk^2z^2e^4}{n^2h^2} \Rightarrow TE = -Rch\frac{z^2}{n^2} \text{ joule}$$

$$\Rightarrow TE = -13.6\frac{z^2}{n^2} \text{ eV}$$

where R = Rydberg constant = $\frac{2\pi^2 mk^2e^4}{ch^3}$

$$= \frac{me^4}{8\epsilon_0^2 ch^3} = 1.097 \times 10^7 \text{ m}^{-1}$$

* Remember that Rydberg constant is not a universal constant. In Bohr calculation it is determined by assuming nucleus to be stationary

For Bohr Rydberg constant

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

If nucleus is not assumed stationary then

$$R = \frac{R_\infty}{1+\left(\frac{m_e}{m_N}\right)}, \ m_N = \text{mass of nucleus}$$

2.4.3 Results based on total energy equation

(i) With the increase in principal quantum number, both total energy & potential energy of an electron increases. While kinetic energy decreases

(ii) With the increase in principal quantum number, the difference between any two consecutive energy level decreases.

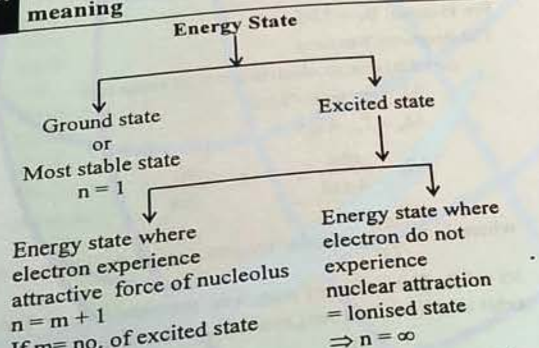
(iii) Total energy of an electron in any orbit in H-like atom = (Total energy of an electron in that orbit in H-atom) × z^2

(iv) PE of an electron in any orbit in H-like atom = (PE of an electron in that orbit in H-atom) × z^2

(v) KE of an electron in any orbit in H-like atom = (KE of an electron in that orbit in H-atom) z^2

(vi) $\Delta E_{n_1 n_2}$ in any H-like atom = ($\Delta E_{n_1 n_2}$ in H-atom) × z^2

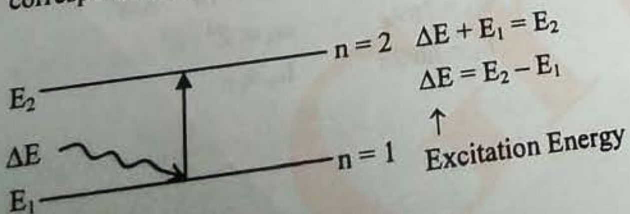
3. Some important definitions & their meaning

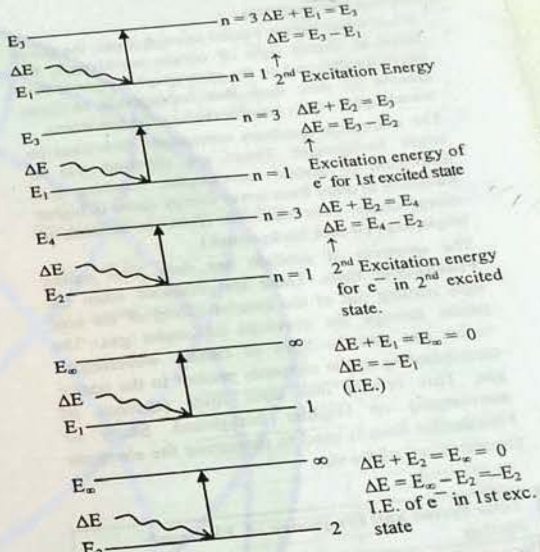


(1) Ionization energy & ionization potential - The minimum energy required to remove an electron from hydrogen or hydrogen like atom is called its ionization energy & corresponding potential through which an electron is accelerated for this is called ionization potential

$I.E. = E_\infty - E_1 = -E_1$ = Binding energy of e^-

(2) Excitation Energy & excitation potential - The minimun energy required to excite an atom is called excitation energy of the particular excited state & corresponding potential is called excitation potential.





If excitation energy & ionisation energy are represented in ev then corresponding value in volt is termed as excitation potential & ionisation potential respectively.

For example : Excitation energy & Ionisation energy for H-atom are 10.2 eV & 13.6 eV respectively & there fore 10.2V & 13.6V are excitation & ionisation potential respectively.

4. Type of line spectrum

Emission line spectrum :

When an atomic gas or vapour at a pressure less than the atmospheric pressure is excited by passing electric discharge, the emitted radiation has a spectrum which contains certain specific bright lines only. These emission lines constitute emission spectrum. These are obtained when electron jumps from excited states to lower states. The wavelength of emission lines of different elements are different. For one element the emission spectrum is unique. It is used for the determination of composition of an unknown substance.

Absorption line spectrum :

When white light is passed through a gas, the gas is found to absorb light of certain wavelength. the bright background on the photographic plate is then crossed by dark lines that corresponds to those wavelengths which are absorbed by the gas atoms.

The absorption spectrum consists of dark lines on bright background. These are obtained due to absorption of certain wavelengths, resulting into transition of atom from lower energy states to higher energy states. (The emission spectrum consists of bright lines on dark background.)

The spectrum of sunlight has dark lines called **Fraunhoffer lines**. These are produced when the light coming out of the interior (core) of the sun, passes through the envelope of cooler gas. The cooler gas absorbs light of certain wavelengths corresponding to the elements present in the cooler gas. This results into dark lines (absence of wavelength) on brighter backgound. Study of Fraunhoffer lines is used to determine the elements (composition) of the star.

5. Time Period and Frequency of Electron's Motion

Time period of revolution of an electron in the n^{th} Bohr orbit is

$$T_n = \frac{2\pi r_n}{v_n}$$

$$= \frac{n^3}{Z^2}\frac{h^3}{4\pi^2 m k^2 e^4}$$

For H-atom, $Z = 1$; then for $n = 1$,

$$T_1 = 1.5 \times 10^{-16} \text{ sec}$$

$$T_1 : T_2 : T_3 = 1 : 8 : 27$$

Frequency of revolution

$$\nu_n = \frac{1}{T_n}$$

$$\nu_n \propto \frac{Z^2}{n^3}$$

For H-atom $\nu_1 = 6.6 \times 10^{15}$ Hz,

$$\nu_1 : \nu_2 : \nu_3 = 1 : \frac{1}{8} : \frac{1}{27}$$

Current and Magnetic field Due to Electron's Motion

The motion of electron in circular orbit, give rise to some equivalent current in the orbit, it is equal to (in the n^{th} orbit).

$$I_n = e\nu_n$$

$$= \frac{Z^2}{n^3}\left(\frac{4\pi^2 m k^2 e^5}{h^3}\right)$$

$$I_n \propto \frac{Z^2}{n^3}$$

For H-atom, $I_1 = 1$ mA

The magnetic field at the centre of the orbit, (at nucleus) is

$$B_n = \frac{\mu_o I}{2a_o}$$

$$= \left(\frac{\mu_o 8\pi^4 m^2 k^3 e^7}{h^5}\right)$$

$$b_n \propto Z^3/n^5$$

For H-atom, $B_1 = 12.5$ tesla

The magnetic moment (orbital) due to electrons orbital motion is

$$M = \text{current} \times \text{area}$$

$$M_n = I_n \cdot \pi r_n^2$$

$$M_n = \frac{nhe}{4\pi m} \quad ; \quad M_n = \frac{eL}{2m}$$

where $L = \frac{nh}{2\pi}$, angular momentum of the electron in its orbit. The value of magnetic moment in first Bohr orbit is called Bohr magneton (μ_B). Its value is

$$\mu_B = \frac{eh}{4\pi m} = 9.27 \times 10^{-24} \text{ Am}^2.$$

Commeat In my view, you should not try to cram the formulas for T_n, ν_n, I_n, B_n. Usually no one is going to ask the full form. What you must memorise is their dependence on Z and n and order of magnitudes in first Bohr orbit.

$T_n \propto n^3/Z^2$; $T_1 \approx 1.5 \times 10^{-16}$ sec

$\nu_n \propto Z^2/n^3$; $\nu_1 \approx 6.6 \times 10^{15}$ Hz

$I_n \propto Z^2/n^3$; $I_1 \approx 1$ mA

$B_n \propto Z^3/n^5$; $B_1 \approx 12.5$ T

$M_n \propto n$; $M_1 = \mu_B \approx 9.27 \times 10^{-24}$ Am^2

$\omega_n = 2\pi\nu_n$; $\omega_n \propto Z^2/n^3$

$L_n = nh/2\pi$; $L_n \propto n$

6. Determination of no. of spectral lines (theoretical) in emission & in absorption transitions

6.1 **No. of emission spectral lines** - If the electron is excited to state with principal quantum number n then from the n^{th} state, the electron may go to (n – 1)th state , ..., 2^{nd} state or 1st state. So there are (n – 1) possible transitions starting from the nth state. The electron reaching (n - 1)th state may make (n - 2) different transitions. Similarly for other lower states. The total no. of possible transitions is (n-1)+(n-2)+(n-3) + ... 2 + 1 = $\frac{n(n-1)}{2}$

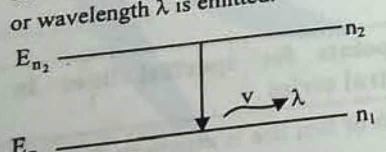
6.2 **No. of absorption spectral lines** - Since at ordinary temperatures, almost all the atoms remain in their lowest energy level (n = 1) & so absorption transition can start only from n = 1 level (not from n = 2 , 3 , 4, ... levels). Hence , only Lyman seires is found in teh absorption spectrum of hydrogen atom (which as in the emission spectrum , all the series are found)

No. of absorption spectral lines = (n – 1)

Remember : The absorption spectrum of sun has Balmer series also besides the Lyman series. Many H-atoms remain in n = 2 also due to very high temperature.

7. Explanation of H-spectrum & spectral line formula

In a hydrogen like atom, when an electron makes transition from any higher energy state n_2 to any lower energy state n_1 then a photon of frequency ν or wavelength λ is emitted.



Then $\Delta E = h\nu = \frac{hc}{\lambda} = En_2 - En_1$

$\because E = -Rch\frac{z^2}{n^2}$ J $= -13.6\frac{z^2}{n^2}$ eV

$\therefore \Delta E = -\frac{Rchz^2}{n_2^2} - \left(\frac{Rchz^2}{n_1^2}\right)$

$$\Delta E = Rch\,z^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$\therefore h\nu = = Rchz^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

$$\bar{\nu} = \frac{1}{\lambda} = Rz^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$\bar{\nu}$ = wave number

= no. of wave in unit length

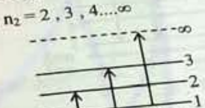
$\nu = c\,\bar{\nu}$

For H-atom , Z = 1 & therefore,

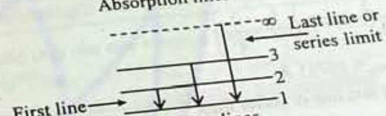
$$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

(1) Lyman series -

$n_1 = 1$, $n_2 = 2 , 3 , 4....\infty$



Absorption lines



Emission lines

For 1st line or series beginning

$n_1 = 1$, $n_2 = 2$

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

$\lambda_{max} = = 1216$ Å

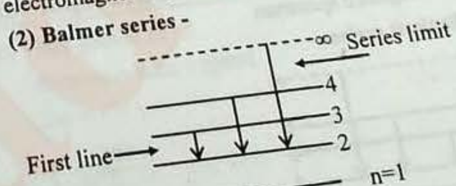
For series limit or last line $n_1 = 1$, $n_2 = \infty$

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

$\lambda_{min} = \frac{1}{R} = 912.68$ Å

- Remember - Lyman series is found in UV region of electromagnetic spectrum

(2) Balmer series -



Energy level diagram

$n_1 = 2$, $n_2 = 3 , 4 , 5 , 6, ...\infty$

wavelength of first line

i.e. maximum wavelength $\frac{1}{\lambda_{max}} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right]$

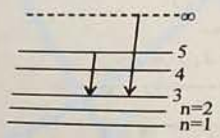
$\therefore \lambda_{max} = 6563Å$

wavelength of last line or series limit i.e. minimum wavelength

$\lambda_{min} = R\left[\frac{1}{2^2} - \frac{1}{\infty^2}\right]$; $\lambda_{min} = \frac{4}{R} = 3646Å$

- Balmer series is found only in emission spectrum
- Balmer series lies in the visible region of electromagnetic spectrum

(3) Paschen series -



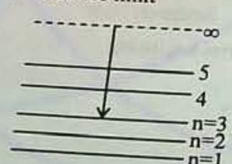
$n_1 = 3$, $n_2 = 4, 5, 6....$

For first line $n_1 = 3$, $n_2 = 4$

$\frac{1}{\lambda_{max}} = R\left[\frac{1}{3^2} - \frac{1}{4^2}\right]$

$\lambda_{max} = 18751$ Å

For last line or series limit



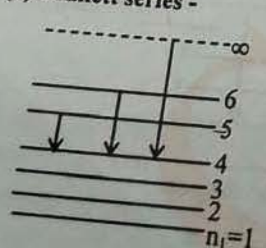
$n_1 = 3$, $n_2 = \infty$

$\frac{1}{\lambda_{min}} = R\left[\frac{1}{3^2} - \frac{1}{\infty^2}\right]$

$\lambda_{min} = \frac{9}{R} = 8107$ Å

- Paschen series is also found only in emission spectrum
- Paschen series is obtained in infrared region of electromagnetic spectrum

(4) Brakett series -



$n_1 = 4$, $n_2 = 5, 6, 7, ... \infty$

For first line $\frac{1}{\lambda_{max}} = R\left[\frac{1}{4^2} - \frac{1}{5^2}\right]$

$\lambda_{max} = 40477$ Å

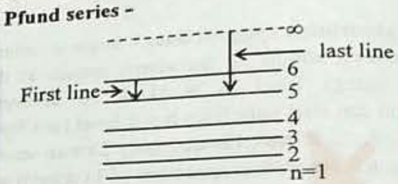
For last line or series limit

$\frac{1}{\lambda_{min}} = R\left[\frac{1}{4^2} - \frac{1}{\infty^2}\right]$

$\lambda_{min} = \frac{16}{R} = 14572$ Å

- Brakett series is also found only in emission spectrum
- Brakett series is also obtained in infrared region of electromagnetic spectrum

(5) Pfund series -



$n_1 = 5$, $n_2 = 6, 7, 8, ... \infty$

For first line $\frac{1}{\lambda_{max}} = R\left[\frac{1}{5^2} - \frac{1}{6^2}\right]$

$\lambda_{max} = 74515$ Å

For last line or series limit

$\frac{1}{\lambda_{min}} = R\left[\frac{1}{5} - \frac{1}{\infty^2}\right]$

$\lambda_{min} = \frac{25}{R} = 22768$ Å

- Pfund series is also obtained only in emission spectrum
- Pfund series is situated in the infrared region of electromagnetic spectrum

8. General points for spectral lines In every spectral series

(1) Wavelength of first line is maximum & last line is minimum.

(2) As the order of spectral series increases, wavelength also usually increases

$\lambda_{PF} > \lambda_{BR} > \lambda_P > \lambda_B > \lambda_L$

(3) Frequency of energy emission in lyman transitions are highest among all other series.

9. Concept of Reduced mass & its application in Bohr theory

(i) When mass of nucleus is assumed to be very-very large in comparison to mass of revolving particle then reduced mass is not to be applied otherwise it is to be applied

(ii) Bohr has assumed nucleus to be stationary is its all calculations.

(iii) Reduced mass of a system of particles of mass m_1 & m_2 is written by

$$\mu = \frac{m_1 m_2}{m_1 + m_2}$$

(iv) According to Bohr

$$\mu = \frac{m_e m_N}{m_e + m_N} = \frac{m_e m_N}{m_N}$$

$\therefore m_N >> m_e = m_e$

where m_N = mass of nucleus

(v) For Muon - Proton system

mass of muonic atom = 207 × mass of electron (m_{μ^-})

$$\therefore \mu = \frac{m_p \times m_{\mu^-}}{m_p + m_{\mu^-}} = \frac{1836 m_e \times 207 m_e}{(1836 + 207) m_e}$$

$\mu \approx 207$ m

$\mu \approx 186$

(vi) For electron - positron system

$$\mu = \frac{m_{e^-} \times m_{e^+}}{m_{e^-} + m_{e^+}}$$

$$\mu = \frac{m_e}{2}$$

m_e = mass of electron

(vii) radius in n^{th} orbit

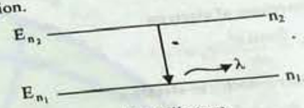
$$r_n = \frac{n^2}{z} \times 0.529 \times \frac{m_e}{\mu} \text{ Å}$$

(viii) Energy in n^{th} orbit

$$E_n = -\frac{z^2}{n^2} \times 13.6 \times \frac{\mu}{m_e} \text{ eV}$$

10. Concept of recoiling of an atom & determination of momentum & energy for recoil atoms

When ever any electron makes transition from any higher energy state to any lower energy state then photon is emitted & due to which in the back side atom is recoiled. The atom is recoiled by sharing some energy from the energy evolved during electronic transition.



If m = mass of recoil atom

v = velocity of recoil atom

Then $\frac{1}{2} mv^2 + \frac{hc}{\lambda} = E_{n_2} - E_{n_1} = \Delta E$

Recoil momentum of atom = $\frac{h}{\lambda}$ = momentum of photon

Recoil energy of atom = $\frac{p^2}{2m}$

11. Shortcoming's of Bohr's Atomic model

(i) It is valid only for one electron atoms. e.g : H, He^+, Li^{+2}, Na^{+10} etc.

(ii) Orbits were taken as circular but according to sommerfield these are elliptical.

(iii) Intensity of spectral lines could not be explained.

(iv) Nucleus was taken as stationary but it also rotates on its own axis.

(v) It could not be explained the minute structure in spectrum line.

(vi) This does not explain the zeeman effect (splitting up of spectral lines in magnetic field) & stark effect (splitting up in electric field)

(vii) This does not explain the doublets in the spectrum of some of the atoms like sodium (5890Å & 5896Å)

12. Important formulae

(1) Time period (T) :

distance = time × speed

$2\pi r = T \times v$

$$T = \frac{2\pi r}{v}$$

$$T_n = \frac{n^2 h^3}{4\pi k^2 z^2 m e^4}, \; T_n \propto \frac{n^3}{z^2}$$

(2) Frequency of revolution

$$f_n = \frac{v_n}{2\pi r_n} = \frac{4\pi k^2 z^2 m e^4}{n^3 h^3}\ ;\ f_n \propto \frac{z^2}{n^3}$$

(3) Momentum of electron

$$P_n = \frac{2\pi m k z^2}{nh} \quad P_n \propto \frac{1}{n}$$

(4) Angular velocity of electron

$$\omega_n = \frac{8\pi^3 k^2 z^2 m e^4}{n^3 h^3}\ ,\ \omega_n \propto \frac{z^2}{n^3}$$

(5) Current (I)

$$I = \frac{e}{T} = ev = \frac{ev}{2\pi r}\ ;\ I \propto \frac{z^2}{n^3}$$

(6) Magnetic moment of electron (M)

$$M = iA$$

$$M = \frac{eV}{2\pi r} \times \pi r^2\ ,\ M = \frac{evr}{2}$$

$$M = \frac{e(mvr)}{2m} = \frac{eJ}{2m};\ \frac{M}{J} = \frac{e}{2m},$$

$$M = \frac{e}{2m}\left(\frac{nh}{2\pi}\right) = n\left(\frac{eh}{4\pi m}\right)$$

$M = n\mu_B$ $\quad \mu_B$ = Bohr magneton

$= 9.3 \times 10^{-24}$ Amp.m^2.

$$M \propto n$$

(7) Magnetic field or Magnetic induction at the centre

$$B = \frac{\mu_0 i}{2r} = \frac{\mu_0 ev}{4\pi r^2}$$

(8)

4	- 0.85 eV
3	- 1.51 eV
2	- 3.4 eV
n = 1	- 13.6 eV

Energy levels values for H-atom

(9) Difference of energy levels in H-atom

$\Delta E_{12} = 10.2$ eV $\qquad \Delta E_{24} = 2.55$ eV

$\Delta E_{13} = 12.09$ eV $\qquad \Delta E_{23} = 1.89$ eV

$\Delta E_{14} = 12.75$ eV

(10) $\Delta E = \frac{hc}{\lambda^2}\Delta\lambda$

where λ = mean wavelength

$\Delta\lambda$ = difference in wavelength

ΔE = difference in energy levels

(11) Total no. of electron in a shell = $2n^2$

(12) Total no. electron in a subshell = $2(2\ell + 1)$

SOLVED EXAMPLES

Ex.1 A α particle after passing through a potential difference of V volt collides with a nucleus. If the atomic number of the nucleus is Z then the distance of closest approach of α-particle to the nucleus will be-

(A) $14.4\frac{Z}{V}$ Å (B) $14.4\frac{Z}{V}$ m

(C) $14.4\frac{Z}{V}$ cm (D) All of the above

Sol. $E_k = U,\ 2eV = \frac{k(Ze)(2e)}{d}$

$d = \frac{kZe}{V} = 9\times10^9\times1.6\times10^{-19}\left(\frac{Z}{V}\right)$,

$d = 14.4\times10^{-10}\left(\frac{Z}{V}\right)\text{m} = 14.4\left(\frac{Z}{V}\right)$ Å

Ex.2 The radius of hydrogen atom in the ground state is 5.3×10^{-11} m. If this atom collides with an electron then its values becomes 21.2×10^{-11} m. The value of principal quantum number will be-

(A) 2 (B) 16

(C) 3 (D) 4

Sol. $\because \frac{r_2}{r_1} = \left(\frac{n_2}{n_1}\right)^2,\ \therefore n_2^2 = \frac{n_1^2 r_2}{r_1}$

$\therefore\ n_2 = n_1\sqrt{\frac{r_2}{r_1}} \Rightarrow n_2 = 1\sqrt{\frac{21.2\times10^{-11}}{5.3\times10^{-11}}}$

$\Rightarrow n_2 = 2$

Ex.3 An electron revolves round a nucleus of charge Ze. In order to excite the electron from the state n = 3 to n = 4, the energy required is 66.0 eV. Z will be -

(A) 25 (B) 10 (C) 4 (D) 5

Sol. Energy of hydrogen atom

$= 13.6\left(\frac{1}{3^2}-\frac{1}{4^2}\right)\text{eV} = 13.6\times\frac{7}{144}\ \text{eV} = .66\ \text{eV}$

The ionisation potential of hydrogen

$= 13.6$ eV

$E_n \propto Z^2$

$\therefore\ Z^2 = \frac{66}{0.66} = 100,\ Z = 10$

Ex.4 A hydrogen atom rises from its n = 1 state to the n = 4 state by absorbing energy. If the potential energy of the atom in the n = 1 state be –13.6 eV, then potential energy in the n = 4 state will be -

(A) 3.4 eV (B) –1.54 eV

(C) 0.85 eV (D) –0.85 eV

Sol. $E_n = -\frac{Rch}{n^2}$

Given $E_1 = -13.6\ \text{eV} = -Rch$

E_4 = Energy of 4th state $= -\frac{Rch}{4^2} = \frac{E_1}{16}$,

$E_4 = -\frac{13.6}{16} = -0.85$ eV

Ex.5 The wavelength of the first line of lymen series for hydrogen is identical to that of the second line of Balmer series for some hydrogen like ion x. Energies of two levels of x will be : (Ground state binding energy of hydrogen atom = 13.6 eV)

(A) –54.4 eV, –6.07 eV

(B) –13.6 eV, –3.4 eV

(C) –3.4 eV, –13.6 eV

(D) –54.4 eV, –13.6 eV

Sol. We know that

$\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)$

For first line of Lyman series in hydrogen atom

$\frac{1}{\lambda_1} = R\left[\frac{1}{1^2}-\frac{1}{2^2}\right] = \frac{3R}{4}$

For second line of Balmer series of hydrogen like ion x

$\frac{1}{\lambda_2} = Z^2R\left[\frac{1}{2^2}-\frac{1}{4^2}\right] = \frac{3Z^2R}{16}$

Given that, $\lambda_1 = \lambda_2$

$\therefore\ \frac{3R}{4} = \frac{3Z^2R}{16} \Rightarrow Z = 2$

Energy of nth state of ion X is given by

$E_x = -\frac{13.4}{n^2}\times Z^2,\ (E_x)_1 = -\frac{13.4\times4}{1}$

$= -54.4$ eV

$(E_x)_2 = -\frac{13.4\times4}{4} = -13.6$ eV

Ex.6 The wavelength of the first member of the Balmer series in hydrogen spectrum is 6563 Å. Calculate the wavelength of first member of Lyman series in the same spectrum.

(A) 1000 Å (B) 1215.37 Å

(C) 1512 .37 Å (D) None

Sol. For the first member of the Balmer series

$$\bar{v} = \frac{1}{\lambda_1} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right]$$

$$= \frac{5}{36} R \qquad \text{.... (1)}$$

For the first member of Lyman series

$$\bar{v} = \frac{1}{\lambda_2} = R\left[\frac{1}{1^2} - \frac{1}{2^2}\right]$$

$$= \frac{3R}{4} \qquad \text{.... (2)}$$

Dividing eq. (1) by eq.(2), we get

$$\frac{\lambda_2}{\lambda_1} = \frac{5}{27} \quad \text{or} \quad \lambda_2 = \frac{5}{27}\lambda_1$$

$$\lambda_2 = \frac{5 \times 6563}{27} = 1215.37 \text{ Å}$$

Ex.7 The radius of first orbit of hydrogen atom is 0.53 Å and the electron is executing 6.54×10^{15} revolutions per second. The magnetic moment of electron will be-

(A) 9.3×10^{-24} Amp-m²
(B) 6.54×10^{-27} Amp-m²
(C) 6.54×10^{-24} Amp-m²
(D) 5.3×10^{-24} Amp - m²

Sol. $\mu = iA = efA = ef\pi r^2$

$\mu = 1.6 \times 10^{-19} \times 6.54 \times 10^{15} \times 3.14 \times (0.53 \times 10^{-10})^2$

$\Rightarrow \mu = 9.3 \times 10^{-24}$ Amp-m²

Ex.8 The wavelength of first and second lines of sodium are 5890 Å and 5896 Å respectively. Its first excitation potential will be-

(A) 4.1 V (B) 10.2 V
(C) 2.1 V (D) 3.7 V

Sol. In sodium spectrum only two lines are obtained whose wavelengths are 5890 Å and 5896 Å respectively.

The excitation energy between there energy levels will be-

$$\Delta E = \frac{hc}{e}\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right),\ \Delta E = \frac{hc}{\lambda}\left(\frac{\lambda_1 - \lambda_2}{\lambda_1\lambda_2}\right)$$

$$\Delta E = \frac{6.62 \times 10^{-34} \times 3 \times 10^8 \times 6 \times 10^{-10}}{1.6 \times 10^{-19} \times 5896 \times 5896 \times 10^{-20}}$$

$\Rightarrow \Delta E = 2.1$ eV,

Excitation potential $\Delta V = 2.1$ volt

Ex.9 The radius of first orbit of hydrogen atom is 0.53 Å. The radius of its fourth orbit will be-

(A) 0.193 Å (B) 4.24 Å
(C) 2.12 Å (D) 8.48 Å

Sol. $r_n = 0.53\, n^2,\ n = 4$

$\Rightarrow r_4 = 0.53 \times 16$

$\Rightarrow r_4 = 8.48$ Å

Ex.10 The wavelength of D_1 and D_2 lines of sodium are 5890 Å and 5896 Å respectively, if their mean wavelength is 6000 Å then the difference of exicted energy states will be

(A) 2×10^3 eV (B) 2×10^{-3} eV
(C) 2×10^6 eV (D) 2 eV

Sol. $E = \frac{hc}{\lambda} \quad \therefore \quad \Delta E = \frac{hc}{\lambda^2}\Delta\lambda$

$$\Delta E = \frac{6.62 \times 10^{-34} \times 3 \times 10^8 \times 6 \times 10^{-10}}{6000 \times 6000 \times 10^{-20}}$$

$\Rightarrow \Delta E = 3.31 \times 10^{-22}$ J

$$\Rightarrow \Delta E = \frac{3.31 \times 10^{-22}}{16 \times 10^{-19}} \approx 2 \times 10^{-3} \text{ eV}$$

Ex.11 An electron makes transition from n = 4 state to n = 1 state in hydrogen atom. The momentum of recoil hydrogen atom in kg-m/s will be-

(A) 12.75×10^{-19} (B) 13.6×10^{-19}
(C) 6.8×10^{-27} (D) zero

Sol. According to law of conservation of momentum of recoil atom

$$= \text{momentum of photon} = \frac{E_4 - E_1}{C}$$

$$\Rightarrow P = \frac{12.75 \times 1.6 \times 10^{-19}}{3 \times 10^8}$$

$= 6.8 \times 10^{-27}$ kg-m/s

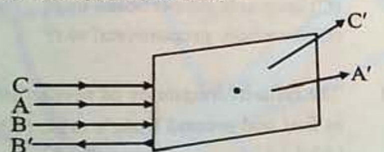
LEVEL # 1

Questions based on Scattering experiment

Q.1 The path of the scattered α-particles is -
(A) circular (B) parabolic
(C) elliptical (D) hyperbolic

Q.2 Which of the following forces is responsible for α - particle scattering ?
(A) Gravitational (B) Nuclear
(C) Coulomb (D) Magnetic

Q.3 A beam of α-particle is incident on a gold foil. corresponding to the incident beams A, B and C, the emergent beams A′, B′ and C′. The transmission and deflection of α-particles through the foil take place such that -



(A) The number of α-particle in A′ is maximum and in B′ minimum
(B) The number of α-particles in A′ is minimum and in C′ maximum
(C) The number of α-particles in A′, B′ and in C′ is the same.
(D) The number of α-particles in B′ is minimum and in C′ maximum

Q.4 In Rutherford's experiment, the number of alpha particles scattered through an angle of 60° by a silver foil is 200 per minute. When the silver foil is replaced by a copper foil of the same thickness, the number of α-particles scattered through an angle of 60° per minute is -
(A) $200 \times \frac{Z_{Cu}}{Z_{Ag}}$ (B) $200\left(\frac{Z_{Cu}}{Z_{Ag}}\right)^2$
(C) $200 \times \frac{Z_{Ag}}{Z_{Cu}}$ (D) $200 \times \left(\frac{Z_{Ag}}{Z_{Cu}}\right)^2$

Q.5 In Rutherford's α-particle scattering experiment, the ratio of number of α-particles scattered through an angle of 60° and 120° is -
(A) 1 : 2 (B) $\sqrt{3}$: 1
(C) 3 : 1 (D) 9 : 1

Questions based on Distance of closest approach

Q.6 An α-particle of energy 5 MeV is scattered through 180° by a stationary uranium nucleus. The distance of closest approach is of the order of -
(A) 1Å (B) 10^{-10} cm
(C) 10^{-12} cm (D) 10^{-15} cm

Questions based on Radius and velocity of electron in circular orbit

Q.7 The radius of first orbit of hydrogen atom is 0.53Å. The radius of its fourth orbit will be -
(A) 0.193 Å (B) 4.24 Å
(C) 2.12 Å (D) 8.48 Å

Q.8 The ratio of the radius of a hydrogen like atom in the ground state & that of one in the second excited state is -
(A) 1 : 9 (B) 1 : 4
(C) 1 : 3 (D) 1 : 2

Q.9 If the radius of the first orbit of hydrogen atom is 5.29×10^{-11} meter, the radius of the second orbit will be -
(A) 21.16×10^{-11} m (B) 15.87×10^{-11} m
(C) 10.58×10^{-11} m (D) 2.64×10^{-11} m

Q.10 The velocity of an electron in ground state of H-atom is nearly
(A) 2×10^5 m/s (B) 2×10^6 m/s
(C) 2×10^7 m/s (D) 2×10^8 m/s

Q.11 The ratio of the radii of Bohr orbits in hydrogen atom in increasing order is -
(A) 2 : 4 : 8 : 16 (B) 2 : 3 : 4 : 5
(C) 1 : 3 : 6 : 9 (D) 1 : 4 : 9 : 16

Q.12 The radius of electron's second stationary orbit in Bohr's atom is R. The radius of the third orbit will be-

(A) 3R (B) 2.25 R

(C) 9 R (D) R/3

Q.13 The ratio of the area of orbit of first excited state of electron to the area of orbit of ground level, for hydrogen atom, will be -

(A) 2 : 1 (B) 4 : 1

(C) 8 : 1 (D) 16 : 1

Q.14 The electron in a hydrogen atom jumps from ground state to the higher energy state where its velocity is reduced to one-third its initial value. If the radius of the orbit in the ground state is r, the radius of new orbit will be -

(A) 3r (B) 9r

(C) $\frac{r}{3}$ (D) $\frac{r}{9}$

Q.15 The ratio of velocities of electron in H-atom in its first, second & third orbit respectively will be -

(A) 6 : 3 : 1 (B) 3 : 2 : 1

(C) 6 : 3 : 2 (D) 1 : 3 : 6

Q.16 From Bohr's theory the product of the radius and the velocity of the electron in different orbits is -

(A) constant

(B) proportional to the square root of radius

(C) proportional to the radius

(D) proportional to the square of the radius

Questions based on Energy of electron in Bohr's circular orbit

Q.17 Ionisation energy of a hydrogen like ion A is greater than that of another hydrogen like ion B. Let r,u, E and L represent the radius of the orbit, speed of the electron, energy of the atom and orbital angular momentum of the electron respectively. In ground state -

(A) $r_A > r_B$ (B) $u_A > u_B$

(C) $E_A > E_B$ (D) $L_A > L_B$

Q.18 Which of the following parameters are the same for all hydrogen-like atoms and ions in their ground states ?

(A) radius of the orbit

(B) speed of the electron

(C) energy of the atom

(D) orbital angular momentum of the electron

Q.19 Choose the correct relation from the following for hydrogen like atoms -

(A) $r_n = n^2r_1$, $E_n = E_1/n^2$, $v_n = v_1/n$

(B) $r_n = r_1/n^2$, $E_n = n^2E_1$, $v_n = v_1/n$

(C) $r_n = r^2/n^2$, $E_n = E_1/n^2$, $v_n = v_1/n^2$

(D) $r_n = n^2r$, $E_n = n^2E_1$, $v_n = n^2v_1$.

Q.20 The angular velocity of an electron moving in the nth orbit of Bohr hydrogen atom is -

(A) directly proportional to n

(B) inversely proportional to n

(C) inversely proportional to n^2

(D) inversely proportional to n^3

Q.21 The ratio of frequency of revolution of electrons in first and second Bohr's orbit of He-atom is -

(A) 4 : 1 (B) 1 : 4

(C) 8 : 1 (D) 1 : 8

Q.22 The ratio of the energies of the hydrogen atom in its first to second excited state is -

(A) 1/4 (B) 4/9

(C) 9/4 (D) 4

Q.23 The angular momentum of electron in hydrogen atom is proportional to -

(A) $\sqrt{r}$ (B) 1/r (C) r^2 (D) $1/\sqrt{r}$

Q.24 Which of the following products in a hydrogen atom are independent of the principal quantum number n ? The symbols have their usual meanings ?

(A) vn (B) Er (C) En (D) vr

Q.25 The energy of an atom (or ion) in its ground state is – 54.4 eV. It may be -

(A) hydrogen (B) deuterium

(C) He^+ (D) Li^{++}

Q.26 The ... Bohr ... (A) ... (C) ...

Q.27 Wh... gr...

Q.28

Q.29

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ms and ions in their

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from the following

$= v_1/n$
$= v_1/n$
$= v_1/n^2$
$n^2 v_1$.

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: 4
: 8

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(D) $1/\sqrt{r}$

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(D) vr

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rium

Q.26 The kinetic energy of an electron in second Bohr orbit of hydrogen atom will be -
(A) 13.6 eV (B) 6.8 eV
(C) 3.4 eV (D) 1.7 eV

Q.27 When a hydrogen atom is raised from the ground state to an excited state -
(A) the P.E. decreases and K.E. increases
(B) the P.E. increases and K.E. decreases
(C) both K.E. and P.E. increases
(D) both K.E. and P.E. decrease

Q.28 The first excitation potential of given atom is 10.2 volt. Then ionization potential must be -
(A) 20.4 volt (B) 13.6 volt
(C) 30.6 volt (D) 40.8 volt

Q.29 If E_n and J_n are the magnitude of total energy and angular momentum of electron in the nth Bohr orbit respectively, then -
(A) $E \propto J_n^2$ (B) $E_n \propto \frac{1}{J_n^2}$
(C) $E \propto J_n$ (D) $E_n \propto \frac{1}{J_n}$

Q.30 The angular momentum of an electron in a given orbit is J. Its kinetic energy will be -
(A) $\frac{1}{2}\frac{J^2}{mr^2}$ (B) $\frac{Jv}{r}$
(C) $\frac{J^2}{2m}$ (D) $\frac{J^2}{2\pi}$

Q.31 The minimum energy in electron volt required to skip a ten times ionised sodium atom (i.e. Z = 11) of its last electron is -
(A) 13.6 eV (B) $\frac{13.6}{11}$ eV
(C) 13.6 × 11 eV (D) $13.6 \times (11)^2$ eV

Q.32 Total energy of electron in the first orbit of hydrogen atom is equal to the -
(A) total energy of electron in 2nd orbit of He^+
(B) total energy of electron in 3rd orbit of He^+
(C) total energy of electron in 2nd orbit of Li^{++}
(D) total energy of electron in 4^{th} orbit to Li^{++}

Q.33 As per Bohr model, the minimum energy (in eV) required to remove an electron from the ground state of doubly ionized Li atom (Z = 3) -
(A) 1.51 (B) 13.6
(C) 40.8 (D) 122.4

Q.34 An electron jumps from the 4th orbit to the 2nd orbit of hydrogen atom. Given : the Rydberg's constant $R = 10^5\ cm^{-1}$. The frequency in Hz of the emitted radiation will be -
(A) $\frac{3}{16} \times 10^5$ (B) $\frac{3}{6} \times 10^{15}$
(C) $\frac{9}{16} \times 10^{15}$ (D) $\frac{3}{4} \times 10^{16}$

Q.35 A hydrogen atom in ground state absorbs 10.2 eV of energy. The orbital angular momentum of the electron is increased by -
(A) 1.05×10^{-34} J-s (B) 2.11×10^{-34} J-s
(C) 3.16×10^{-34} J-s (D) 4.22×10^{-34} J-s

Q.36 The binding energy of H-atom in its ground state is 13.6 eV. The energies required to remove an electron from the three lowest orbits of the H-atom are respectively(in eV) -
(A) 13.6 , 10.2 , 3.4 (B) 13.6 , 3.4 , 1.5
(C) 10.2, 1.9, 0.7 (D) 13.6, 6.8 , 1.5

Q.37 The energy of an electron in the first Bohr orbit for hydrogen is –13.6 eV. Which one (s) of the following is (are) possible excited state (s) for electrons in Bohr orbits of hydrogen –
(A) – 3.4 eV (B) – 6.8 eV
(C) – 1.7 eV (D) 13.6 eV

Q.38 The binding energy of the hydrogen atom in the first excited state is –
(A) 13.6 eV (B) 10.2 eV
(C) 3.40 eV (D) 1.51 eV

Q.39 How much energy is required to remove the electron from a He^+ ion in its ground state ?
(A) 1.5 eV (B) 13.6 eV
(C) 54.4 eV (D) 122.4 eV

Q.40 The potential energy (U) and the kinetic energy (K) of an electron in the ground state of hydrogen atom is -
(A) U = – 13.6 eV ; K = – 13.6 eV
(B) U = – 27.2 eV ; K = – 13.6 eV
(C) U = – 27.2 eV ; K = + 13.6 eV
(D) U = – 6.8 eV ; K = – 6.8 eV

Questions based on Spectral lines

Q.41 A spectral line is emitted when an electron -
(A) rotates in the circular orbit
(B) rotates in the elliptical orbit
(C) jumps from lower orbit to higher orbit
(D) jumps from higher orbit to lower orbit

Q.42 Which of the following is true ?
(A) Lyman series is a continuous spectrum
(B) Paschen series is a line spectrum in the infrared
(C) Balmer series is a line spectrum in the ultraviolet
(D) The spectral series formula can be derived from the Rutherford model of the hydrogen atom

Q.43 The minimum wavelength in Lyman series is -
(A) $\frac{1}{R}$ (B) R (C) $\frac{1}{R_C}$ (D) R_c

Q.44 Out of the following transitions, the frequency of emitted photon will be maximum for -
(A) n = 5 to n = 3 (B) n = 6 to n = 2
(C) n = 2 to n = 1 (D) n = 1 to n = 2

Q.45 If an electron jumps from third orbit to second orbit in hydrogen atom, then the wavelength of emitted photons, will be -
(A) $\frac{36}{5R}$ (B) $\frac{5R}{36}$
(C) $\frac{4R}{34}$ (D) $\frac{34}{4R}$

Q.46 The wavelength of first line of Balmer series is 6563 Å. The wavelength of first line of Lyman series will be -
(A) 1215.4 Å (B) 2500 Å
(C) 7500 Å (D) 600 Å

Q.47 The wavelength of radiation required to excite an electron from first to third Bohr orbit in a doubly ionised lithium atom will be -
(A) 113.74 m (B) 113.74 cm
(C) 113.74 Å (D) 113.74 mm

Q.48 Any series of atomic hydrogen yet to be discovered will probably be found in the following region of the spectrum -
(A) X-ray (B) Ultraviolet
(C) Visible (D) far infrared

Questions based on Reduced mass concept

Q.49 The electron and positron form a positronium atom (e^-, e^+ revolve round the centre of mass of the system). Then, the ground state energy of this system is -
(A) –13.6 eV (B) –27.2 eV
(C) –6.8 eV (D) zero

Q.50 The radius of first orbit of muon-proton system will be , if muon is 207 times heavier than electron -
(A) $\frac{0.529}{(186)^2}$ Å (B) $\frac{0.529}{(186)}$ Å
(C) 0.529 × 186 Å (D) 0.529 × $(186)^2$ Å

Q.51 The energy in the ground states of muon-proton system will be -
(A) –13.6 × 207 MeV (B) –13.6 × 186 eV
(C) 13.6 × 186 MeV (D) 13.6 × 207 eV

Questions based on Recoiling of atom

Q.52 An electron jumps from n = 4 to n = 1 state in H-atom. The recoil momentum of H-atom (in eV/C) is -
(A) 12.75 (B) 6.75
(C) 14.45 (D) 0.85

Q.53 An excited hydrogen atom initially at rest in n = 3 state, emits a photon by making a transition to ground to state. Then the momentum of the hydrogen atom will be (in N.s) -
(A) 6.45×10^{-27} (B) 6.63×10^{-34}
(C) 2.15×10^{-27} (D) none of the above

Q.1 In an electron orbital angu (h = Plank c
(A) h
(C) $\frac{h}{6\pi}$
Q.2 When a energy change
(A) 1.(
(C) 3.
Q.3 In B and of res is
Q.4
Q.5

LEVEL # 2

Q.1 In an electron transition inside a hydrogen atom, orbital angular momentum may change by (h = Plank constant) -

(A) h (B) $\frac{h}{\pi}$

(C) $\frac{h}{6\pi}$ (D) $\frac{h}{4\pi}$

Q.2 When a hydrogen atom emits a photon of energy 12.1 eV, its orbital angular momentum changes by -

(A) 1.05×10^{-34} J s (B) 2.11×10^{-34} J s

(C) 3.16×10^{-34} J s (D) 4.22×10^{-34} J s

Q.3 In Bohr model of the hydrogen atom, let R, V and E represent the radius of the orbit, the speed of electron and the total energy of the electron respectively. Which of the following quantities is proportional to the quantum number n ?

(A) R/E (B) E/V

(C) RE (D) VR

Q.4 If the radius of first orbit of hydrogen atom is 0.5 Å and the velocity of electron in this orbit is 2×10^6 m/s, then the electric current due to electron motion will be nearly -

(A) 1 mA (B) 1 μA

(C) 1 A (D) None of these

Q.5 The maximum Coulomb force that can act on the electron due to the nucleus in a hydrogen atom will be -

(A) 0.82×10^{-8} N (B) 0.082×10^{-8} N

(C) 8.2×10^{-8} N (D) 820×10^{-8} N

Q.6 The ionization potential of H-atom is 13.6 V. The H-atoms in ground state are excited by mono chromatic radiations of photon energy 12.09 eV. Then the number of spectral lines emitted by the excited atoms, will be -

(A) 1 (B) 2

(C) 3 (D) 4

Q.7 Assume that there exist an atom, according to Bohr model, whose first ionization potential is 20 V, then the value of first excitation potential for this atom will be -

(A) 5 V (B) 10 V

(C) 15 V (D) 25 V

Q.8 Consider the spectral line resulting from the transition n = 2 → n = 1 in the atoms and ions given below, the shortest wavelength is produced by -

(A) hydrogen atom

(B) deuterium atom

(C) singly ionized helium

(D) doubly ionized lithium

Q.9 Bohr's atom model assumes -

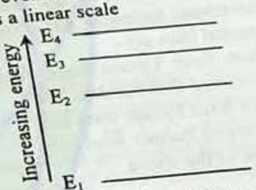
(A) the nucleus is of infinite mass and is at rest

(B) electron in a quantized orbit will not radiate energy

(C) mass of the electron remains constant

(D) all of these

Q.10 Figure represents in simplified form some of the energy levels of the hydrogen atom. The energy axis has a linear scale



If the transition of an electron from E_4 to E_2 were associated with the emission of blue light, which transition could be associated with the absorption of red light ?

(A) E_4 to E_1 (B) E_3 to E_2

(C) E_2 to E_3 (D) E_1 to E_4

Q.11 A mixture of ordinary hydrogen and tritium, is excited and its spectrum observed. Then, the ratio of the wavelengths of the H_α lines of the two kinds of hydrogen would be nearly -

(A) 1 : 1

(B) 1 : 3

(C) 3 : 1

(D) nothing can be predicted

Q.12 The second line of Balmer series has wavelength 4861 Å. The wavelength of the first line of Balmer series is -

(A) 1216 Å (B) 6563 Å

(C) 4340 Å (D) 4101 Å

Q.13 The ionisation potential of H atoms is 13.6 V. The energy difference between n = 2 and n = 3 levels is nearest to -

(A) 1.9 eV (B) 2.3 eV

(C) 3.4 eV (D) 4.5 eV

Q.14 If the wavelength of photon emitted due to transition of electron from third orbit to first orbit in a hydrogen atom is λ, then the wavelength of photon emitted due to of electron from fourth orbit to second orbit will be -

(A) $\frac{128}{27}\lambda$ (B) $\frac{25}{9}\lambda$

(C) $\frac{36}{7}\lambda$ (D) None of these

Q.15 If radiation of all wavelengths from ultraviolet to infrared is passed through hydrogen gas at room temperature absorption lines will be observed in the -

(A) Lyman series (B) Balmer series

(C) both (A) and (B) (D) neither (A) or (B)

Q.16 Electrons accelerated from rest by a potential difference of 12.75V, are bombarded on a mono-atomic hydrogen gas. Possible emission of spectral lines are -

(A) first three Lyman lines, first two Balmer lines and first Paschen line

(B) first three Lyman lines only

(C) First two Balmer lines only

(D) none of the above

Q.17 In hydrogen atom H_α-line arises due to transition $n = 3 \rightarrow n = 2$. In the spectrum of singly ionised helium there is a line having the same wavelength as the H_α line. This is due to the transition -

(A) $n = 3 \rightarrow n = 2$ (B) $n = 2 \rightarrow n = 1$

(C) $n = 5 \rightarrow n = 3$ (D) $n = 6 \rightarrow n = 4$

Q.18 Three photons coming from excited atomic-hydrogen sample are picked up. Their energies are 12.1 eV, 10.2 eV and 1.9 eV. These photons must come from -

(A) a single atom

(B) two atoms

(C) three atoms

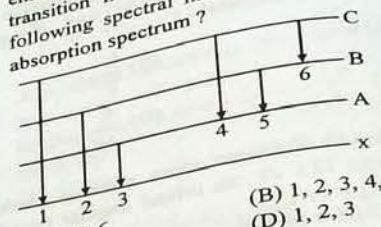
(D) either two atoms or three atoms

Q.19 Radiations of wavelength λ are incident on hydrogen in the ground state. A fraction of these radiations absorbed by these atoms. There are ten different wave in the emission spectrum of excited atoms. The λ will be -

(A) 1211Å (B) 912 Å

(C) 1211Å (D) 950.7 Å

Q.20 The figure indicates the energy level diagram of an atom and the origin of six spectral lines in emission (e.g. line no. 5 arises from the transition from level B to A). Which of the following spectral lines will also occur in the absorption spectrum ?



(A) 4, 5, 6 (B) 1, 2, 3, 4, 5, 6

(C) 1, 4, 6 (D) 1, 2, 3

Q.21 A sample of hydrogen is bombarded by electrons. Through what potential difference should the electrons be accelerated so that second line of Balmer series be emitted ?

(A) 2.55 V (B) 10.2 V

(C) 12.09 V (D) 12.75 V

Q.22 Let ν_1 be the frequency of the series limit of the Lyman series, ν_2 be the frequency of the first line of the Lyman series, and ν_3 be the frequency of the series limit of the Balmer series -

(A) $\nu_1 - \nu_2 = \nu_3$ (B) $\nu_2 - \nu_1 = \nu_3$

(C) $\nu_3 - \frac{1}{2}(\nu_1 + \nu_2)$ (D) $\nu_1 + \nu_2 = \nu_3$

Q.23 For a sodium light, the two yellow lines occur at λ_1 and λ_2 wavelengths. If the mean of the two is takes as $\lambda = 6000$Å and $|\lambda_2 - \lambda_1| = 6$Å. Then the energy difference between the two levels corresponding to λ_1 and λ_2 is -

(A) 2×10^{-3} eV (B) 2 eV

(C) 2×10^{3} eV (D) few meV

Q.24 Energy levels A, B, C of a certain atom correspond to increasing values of energy, i.e. $E_A < E_B < E_C$. If $\lambda_1, \lambda_2, \lambda_3$, are the wavelengths of radiations for the transitions C → B, B → A and C → A respectively, which of the following statements is correct -

(A) $\lambda_3 = \lambda_1 + \lambda_2$ (B) $\lambda_3 = \frac{\lambda_1\lambda_2}{\lambda_1 + \lambda_2}$

(C) $\lambda_1 + \lambda_2 + \lambda_3 = 0$ (D) $\lambda_3^2 = \lambda_1^2 + \lambda_2^2$

Q.25 An excited hydr... wavelength λ in... R is the Rydbe... number n of th...

(A) $\sqrt{\lambda R}$

(C) $\sqrt{\frac{\lambda R}{\lambda R - \ldots}}$

Q.26 For hydro... $E_n = -\frac{13...}{...}$ number... its prin...

(A) 1.... (C) 6....

Q.27 In v... wa... (A... (C...

Q.28

Q.2...

Q.25 An excited hydrogen atom emits a photon of wavelength λ in returning to the ground state. If R is the Rydberg's constant, then the quantum number n of the excited state is -

(A) $\sqrt{\lambda R}$ (B) $\sqrt{\lambda R - 1}$

(C) $\sqrt{\frac{\lambda R}{\lambda R - 1}}$ (D) $\sqrt{\lambda R(\lambda R - 1)}$

Q.26 For hydrogen atom the energy of electron is $E_n = -\frac{13.6}{n^2}$ eV, where n = principal quantum number. The least energy which it can absorb in its primitive stage is -

(A) 1.00 eV (B) 3.40 eV

(C) 6.80 eV (D) 10.2 eV

Q.27 In which of the following transitions will the wavelength be minimum ?

(A) n = 5 to n = 4 (B) n = 4 to n = 3

(C) n = 3 to n = 2 (D) n = 2 to n = 1

Q.28 A hydrogen atom in the ground state is excited by radiations of wavelength 975Å. Then how many lines will be possible in the visible spectrum -

(A) 2 (B) 4

(C) 6 (D) 3

Q.29 The ratio of wavelength of first line of lyman series of doubly ionised lithium atom to that of the first line of Lyman series of deuterium ($_1H^2$) will be -

(A) 4 : 1 (B) 1 : 4

(C) 9 : 1 (D) 1 : 9

Q.30 If the difference of energies of an electron in the second and the fourth orbits of an atom is E, then the ionisation energy of that atom will be -

(A) $\frac{36}{15}E$ (B) $\frac{16}{3}E$

(C) $\frac{15}{36}E$ (D) $\frac{3}{16}E$

Q.31 Let the potential energy of a hydrogen atom in the ground state be zero. Then its energy in the first excited state will be -

(A) 10.2 eV (B) 13.6 eV

(C) 23.8 eV (D) 27.2 eV

Q.32 A photon of energy 10.2 eV corresponds to light of wavelength λ_0. Due to an electron transition from n = 2 to n = 1 in a hydrogen atom, light of wavelength λ is emitted. If we take into account the recoil of the atom when the photon is emitted -

(A) $\lambda = \lambda_0$

(B) $\lambda < \lambda_0$

(C) $\lambda > \lambda_0$

(D) the data is not sufficient to reach a conclusion

Q.33 If n >> 1, then the dependence of frequency of a photon, emitted as a result of transition of electron from nth orbit to (n – 1)th orbit, on n will be -

(A) $\nu \propto \frac{1}{n}$ (B) $\nu \propto \frac{1}{n^2}$

(C) $\nu \propto \frac{1}{n^3}$ (D) $\nu \propto \frac{1}{\nu^3}$

Q.34 Suppose that the potential energy of an hypothetical atom consisting of a proton and an electron is given by $U = -ke^2/3r^3$. Then if Bohr's postulates are applied to this atom, then the radius of the n^{th} orbit will be proportional to -

(A) n^2 (B) $1/n^2$ (C) n^3 (D) $1/n^3$

Q.35 In a hypothetical atom like that of hydrogen, the mass of the electrons is doubled. Then the energy E_0 and radius r_0 of the first Bohr orbit will be (a_0 = Bohr radius of hydrogen) -

(A) $E_0 = -27.2$ eV ; $r_0 = a_0/2$

(B) $E_0 = -27.2$ eV ; $r_0 = a_0$

(C) $E_0 = -13.6$ eV ; $r_0 = a_0/2$

(D) $E_0 = -13.6$ eV ; $r_0 = a_0$

LEVEL # 3

Q.1 According to Thomson's model, value of electric field intensity at a distance of 10^{-16} meter from centre while radius is taken as 10^{-15} meter for hydrogen atom is -
(A) 144×10^{17} v/m (B) 144×10^{18} v/m
(C) 9×10^{17} v/m (D) 9×10^{18} v/m

Q.2 When electron revolve in a stable orbit then which one acceleration produces -
(A) Radial (B) Tangential
(C) Both (D) None

Q.3 Electron in a hydrogen atom makes transition from n = 3 to n = 2 in 10^{-8} s. The order of the torque acting on the electron in this period is -
(A) 10^{-34} N-m (B) 10^{-26} N-m
(C) 10^{-42} N-m (D) 10^{-8} N-m

Q.4 Find the ratio of magnetic dipole moment to angular momentum in a hydrogen like atom -
(A) $\frac{e}{m}$ (B) $\frac{e}{2m}$ (C) $\frac{e}{3m}$ (D) $\frac{2e}{m}$
(E) $\frac{3e}{m}$

Q.5 If A_n is the area enclosed in the nth orbit in a hydrogen atom then the graph $\log\left(\frac{A_n}{A_1}\right)$ against log n -
(A) will have slope 2 (straight line)
(B) will have slope 4 (straight line)
(C) will be a monotonically increasing nonlinear curve
(D) will be a circle

Q.6 According to Bohr model, the diameter of first orbit of hydrogen atom will be -
(A) 1 Å (B) 0.529 Å
(C) 2.25 Å (D) 0.725 Å

Q.7 For ionising an excited hydrogen atom the energy required in eV will be -
(A) a little less than 13.6
(B) 13.6
(C) more than 13.6
(D) 3.4 or less

Q.8 In Humphery series electron jumps -
(A) $n_2 = 6$ to $n_1 = 5$
(B) $n_2 = 7, 8, 9$ .... to $n_1 = 6$
(C) $n_2 = 5$ to $n_1 = 4$
(D) None

Q.9 Energy of atom is given as –
(A) $-13.6\, z^2$ (B) $\frac{-13.6 z^2}{n^2}$
(C) $\frac{-13.6}{z^2}$ (D) none of these

Q.10 Value of Rydberg constant is -
(A) $10^7\ m^{-1}$
(B) $10^5\ m^{-1}$
(C) depends on mass of nucleus
(D) can't say anything

Q.11 Ionisation potential for hydrogen atom in its ground state is -
(A) 13.6 eV (B) 13.6 volt
(C) 10.2 eV (D) None

Q.12 When electron jumps n = 2 to n = 1 in H atom then emitted energy is -
(A) exactly 10.2 eV
(B) about 10.2 eV
(C) May be something less or more than 10.2 eV
(D) None

Q.13 The electron in a hydrogen atom makes a transition from an excited state to the ground state. Which of the following statements is true -
(A) Its kinetic energy increases and its potential and total energies decrease.
(B) Its kinetic energy decreases, potential energy increases and its total energy remains the same.
(C) Its kinetic and total energies decrease and its potential energy increases
(D) Its kinetic, potential and total energies decrease

Q.14 The difference o... energy level of h... same energy dif... number 10 and...
(A) 2040 eV
(C) 510 eV

Statement Type Q...
(A) If both St... true, and... explanati...
(B) If both S... true bu... explana...
(C) If State... false.
(D) If Sta... true.

Q.15 Stat... free... Sta... fre...

Q.16 S...

Q.17

Q.14 The difference of energies between first two energy level of hydrogen atom is 10.2 eV. The same energy difference for an atom with charge number 10 and mass number 20 will be -
(A) 2040 eV (B) 1020 eV
(C) 510 eV (D) 102 eV.

Statement Type Questions :

(A) **If both Statement- I and Statement- II are true, and Statement - II is the correct explanation of Statement– I.**
(B) **If both Statement - I and Statement - II are true but Statement - II is not the correct explanation of Statement – I.**
(C) **If Statement - I is true but Statement - II is false.**
(D) **If Statement - I is false but Statement - II is true.**

Q.15 **Statement I :** Distance of closest approach for free target is more than that for fixed target.
Statement II : Total energy is conserved for free target but not for fixed target.

Q.16 **Statement I :** Fraunhoffer lines are found in solar spectrum.
Statement II : Some wavelengths are absorbed by chromo sphere of sun.

Q.17 **Statement I :** Most part of atom is empty and atom is spherical and hollow.
Statement II : Most α-particles passed with large deflection through gold foil when it was bombarded with high speed α-particles.

Q.18 **Statement I :** The angular momentum of electron in a closed shell is always continuously varying with speed of electron.
Statement II : The angular momentum of electron is given by equation $mvr = \frac{nh}{2\pi}$.

Q.19 **Statement I :** Lyman series involves higher energy transitions than Balmer series.
Statement II : Lyman series falls in UV region, whereas Balmer series falls in visible region.

Q.20 **Statement I :** Total energy of revolving electron in any stationary orbit is negative.
Statement II : Energy is a scalar quantity which can only be positive or negative.

Q.21 **Statement I :** Balmer series lies in the visible region of electro magnetic spectrum.
Statement II : For Balmer series $\lambda = \frac{3648 Å n^2}{n^2 - 4}$ where n = 3, 4, 5,.... and wavelength of visible light-ranges from 3800 Å to 7200Å.

Q.22 **Statement I :** Electron can emit 6 types of photons during transition from n = 4 to n = 1.
Statement II : Number of photons emitted can never be less than 5.

Q.23 **Statement I :** An electron jumps from 5^{th} to 2^{nd} shell, number of possible transition state = 3.
Statement II : Possible transition state $= \Sigma\Delta n = \Sigma(5-2)$

Q.24 **Statement I :** In outermost orbit energy of electron is most negative.
Statement II : In such orbit electron is at maximum distance from nucleus.

Passage Based Questions :

Passage - I

A mixture of hydrogen atom (in ground sate) and hydrogen like atom (z) (in their first excited state) is being excited by electrons which have been accelerated by same potential difference 'V', After excitation when they come in to ground state, the wavelength of emitted light are found in the ratio 5 : 1.

Q.25 The final excited state of hydrogen like atom is-
(A) 3 (B) 4
(C) 5 (D) 6

Q.26 The final excited state of hydrogen atom is -
(A) 2 (B) 3
(C) 4 (D) 5

Q.27 Identify the other ion -
(A) He^+ (B) Li^{+2}
(C) Be^{+3} (D) None of these