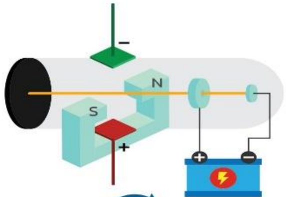
12.ATOMS

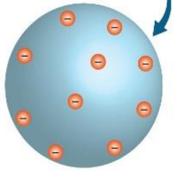
Physics Smart Booklet

Theory + NCERT MCQs + Topic Wise Practice MCQs + NEET PYQs

ATOMS



THOMSON'S ATOMIC MODEL
- Also known as pudding model
- Positive charge are uniformly distributed in the atom.
- Negative charge are embedded like seeds in watermelon.
- Overall atom is neutral



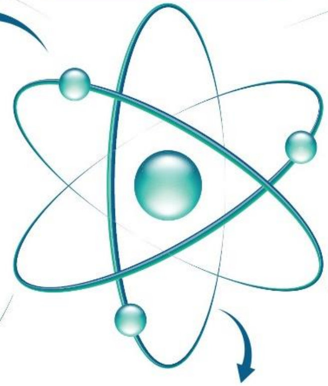
LIMITATIONS
- This model does not explain the presence of nucleus in the atom.
- This is not able to explain scattering of α - particles
- This is not able to explain the spectrum of atoms.

DISTANCE OF CLOSEST APPROACH
At closest approach, system only have electric potential energy.

$$K = U = \frac{1}{4\pi\varepsilon_o}\frac{(2e)(Ze)}{d}$$

$$\Rightarrow d = \frac{1}{4\pi\varepsilon_o}\frac{2ze^2}{K}$$

$$\Rightarrow d = \frac{1}{4\pi\varepsilon_o}\frac{2ze^2}{(\frac{1}{2}mv^2)}$$



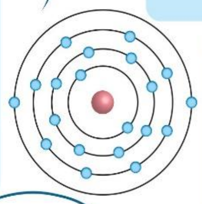
BOHR'S MODEL
(i) Valid for only one - electron atom.
(ii) Electron is revolving around the nucleus in a stable orbit.
(iii) Attractive Coulomb force between electron and nucleus is equal to the centripetal force of electron

$$\frac{Ze^2}{4\pi\varepsilon_o r} = \frac{mv^2}{r}$$

r = radius of orbit

LIMITATIONS
- This model not explain the stability of nucleus.
- This does not explain the line spectra of atom.

POSTULATES
- Electron in an atom could revolve in certain stable orbits with emission of radiant energy.
- $L = \frac{nh}{2\pi}$ L = angular momentum.
  h = Planck's constant = 6.6 × 10-34 JS
- $h\upsilon = E_i - E_f$
  E_i & E_f are the energies of initial & final states. $E_i > E_f$

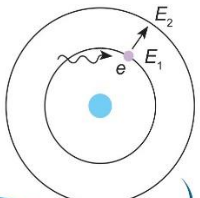


EXCITATION ENERGY

$E_{excitation} = E_2 - E_1$

E_1 = energy of lower orbit

E_2 = energy of higher orbit

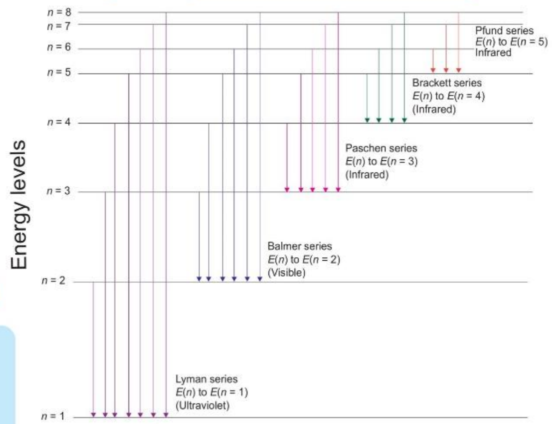


EXCITATION POTENTIAL

$$V_{excitation} = \frac{E_{excitation}}{e} = \frac{E_2 - E_1}{e}\text{(volts)}$$

IONIZATION ENERGY
- Minimum energy required to remove the electron.
- $E_{ionization} = \frac{13.6\,z^2}{n^2}$ volts

LINE SPECTRA OF THE HYDROGEN ATOM



(1) The wave number or wavelength of the emitted photon when electron jumps from higher orbital state 'N_2' to lower orbital state 'N_1' is

$$\bar{\nu} = \frac{1}{\lambda} = \frac{En_2 - En_1}{hc} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

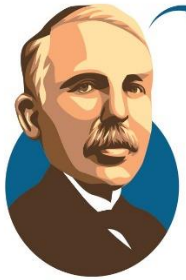
R = Rydberg is constant $= 1.097 \times 10^7\ m^{-1}$

(2) Number of spectral lines when electron jump from

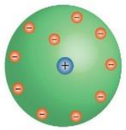
Nth orbit = $\frac{n(n-1)}{2}$

OUTCOMES
- Most of the α - particles went straight without any deviation.
- Same of α - particles were deflected by some angles.
- Very few α - particles were deflected by an angle 180°

CONCLUSIONS
- Positive charge was concentrated in small region of an atom is called nucleus
- Negative charge were revolving in circular orbit around the nucleus.



RUTHERFORD'S NUCLEAR MODEL OF AN ATOM
- α - particles were emitted by the radioactive element Bi^{214}_{83} & were bombarded on a thin gold foil.
- Scattered α - particles are collected on ZnS screen.



RADIUS OF NTH ORBIT

$$r_n = \frac{n^2h^2\varepsilon_o}{z\pi me^2} = \frac{0.53\,n^2}{z}\ \mathring{A}$$

$$r_n \propto \frac{n^2}{z},\ r_n \propto \frac{1}{m}$$

VELOCITY OF ELECTRON IN NTH ORBIT

$$v_n = \frac{ze^2}{2nh\varepsilon_o} = 2.19 \times 10^6\left(\frac{Z}{n}\right)\text{m/s}$$

ORBITAL FREQUENCY IN NTH ORBIT

$$f_n = \frac{v}{2\pi r} = \frac{e^4z^2}{4\varepsilon_o^2 n^3h^3}$$

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

POTENTIAL AND KINETIC ENERGY IN NTH ORBIT

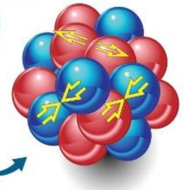
$$U_N = \frac{-1}{4\pi\varepsilon_o}\frac{Ze^2}{m} = \frac{me^4z^2}{4\varepsilon_o^2h^2n^2}$$

$$K_N = \frac{1}{2}mv^2 = \frac{me^4z^2}{8\varepsilon_o^2h^2n^2}$$

TOTAL ENERGY IN NTH ORBIT
- $E_N = K_N + U_N = \frac{-me^4z^2}{8\varepsilon_0^2h^2n^2}$
- $E_N = \frac{-13.6z^2}{n^2}$ eV
- $E_N \propto \frac{z^2}{n^2}, E_n \propto m$

IONIZATION POTENTIAL
- $V_{ionization} = \frac{E_{ionization}}{e} = \frac{13.6\,z^2}{n^2}$ volts

BINDING ENERGY
- Minimum energy required to bound the electron from nucleus.
- B.E. = $-E_{ionization} = \frac{-13.6\,z^2}{n^2}$ eV



Atoms

Atomic structure

For quite some time, matter was thought to be continuous but not discrete. Later Dalton, Avagadro, Thomson etc. made considerable contributions to understand the structure of matter. However, the first reasonably successful model was proposed by Rutherford based on his experiments on scattering of α-particles.

Rutherford's α-particle scattering experiment

A narrow collimated beam of α-particles from radioactive bismuth ($_{83}Bi^{214}$) source was directed against a thin gold foil (thickness ≈ 2×10^{-7} m). The angular distribution of the scattered α-particles was measured using a detector. The detector consisted of a zinc sulphide screen and a microscope. Each time an α-particle hits the zinc sulphide screen, a flash of light is seen.

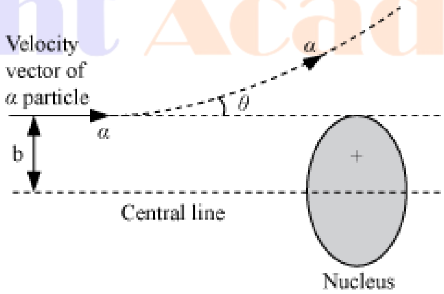
Observations

- Most of the α-particles went undeviated. A very small percentage of α-particles (roughly 0.14%) deflected through an angle of more than 1°.
- An insignificantly small number of α-particles are deflected by almost 180°, as if they bounced back. (Approximately one in 8000 α-particles deflected through more than 90°)

Explanation for observations

- An α-particle is so massive compared to the mass of an electron (roughly 7350 times) that most of the α-particles could pass through the foil undeflected.
- Only if we assume a concentration of complete positive charge in a very small space inside a gold atom, then the coulomb force of repulsion could be large enough to cause a bounce bank of an incident α-particle.
- Also, the passage of a large number of α-particles undeflected, is possible if almost the entire mass of the atom is confined to a very small region of space.
- This tiny central core of the atom which contains +ve charge and almost complete mass of the atom (99.95%) was named by Rutherford as *atomic nucleus*.

Impact parameter



The **impact parameter is the perpendicular distance of the initial velocity vector of the α-particle from the centre of the nucleus when it is far away from the atom.**

According to the theory of Rutherford's α-scattering experiment, impact parameter (b) of an α-particle of kinetic energy E_k, scattered at an angle θ is given by

$$b = \frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{E_k}\cot\left(\frac{\theta}{2}\right) = \frac{1}{4\pi\varepsilon_0}\frac{2Ze^2}{mv^2}\cot\left(\frac{\theta}{2}\right) \qquad \left(\text{since } E_k = \frac{1}{2}mv^2\right)$$

Distance of closest approach (size of the nucleus)

At this distance, the kinetic energy of the α-particle is transformed into electrostatic potential energy. Hence,

$$K = U$$

$$\frac{1}{2}mv^2 = \frac{1}{4\pi\varepsilon_0}.\frac{(2e)(Ze)}{r_0}$$

$$r_0 = \frac{1}{4\pi\varepsilon_0}.\frac{4Ze^2}{mv^2}$$

The distance of closest approach is of the order of 10^{-14} metre.

Rutherford concluded that

1. much of the space in an atom is empty.
2. the entire positive charge of the atom is concentrated at a very small region at its centre (the region is called nucleus).

3. since, the atom as a whole is electrically neutral, the negatively charged particles (electrons) revolve round the nucleus in circular orbits (the electrons are continuously accelerated towards the centre).

But according to well established ideas of classical electrodynamics, an accelerated charge must radiate energy. Therefore a revolving electron must radiate energy continuously and hence move in a helical orbit and finally collapse into the nucleus. Thus Rutherford's model fails to provide the picture of a **stable atom**. Also, the Rutherford's model does not explain the spectra of an atom.

Bohr's atom model

Neils Bohr modified Rutherford's model, which could explain

(a) the stability of an atom
(b) the spectral series of hydrogen atom.

Bohr's theory is applicable to hydrogen and hydrogen-like atoms only. *Example*: singly ionised helium, doubly ionised lithium etc.

The model is based on the following postulates

1. An electron can revolve round a nucleus in an orbit called a **stationary orbit** – from which no energy is radiated and the angular momentum of the electron is an integral multiple of $(h/2\pi)$

i.e., $mvr = \frac{nh}{2\pi}$ where n = 1, 2, 3 . . .

m = mass of electron,
v = orbital speed
r = orbital radius
h = Plank's constant

2. When an electron jumps from a higher energy orbit (E_2) to a lower energy orbit (E_1), the difference in the energy is emitted as a single packet of energy called a quantum or a photon.

i.e., $E_2 - E_1 = h\nu$ where ν is the frequency of photon.

List of expressions

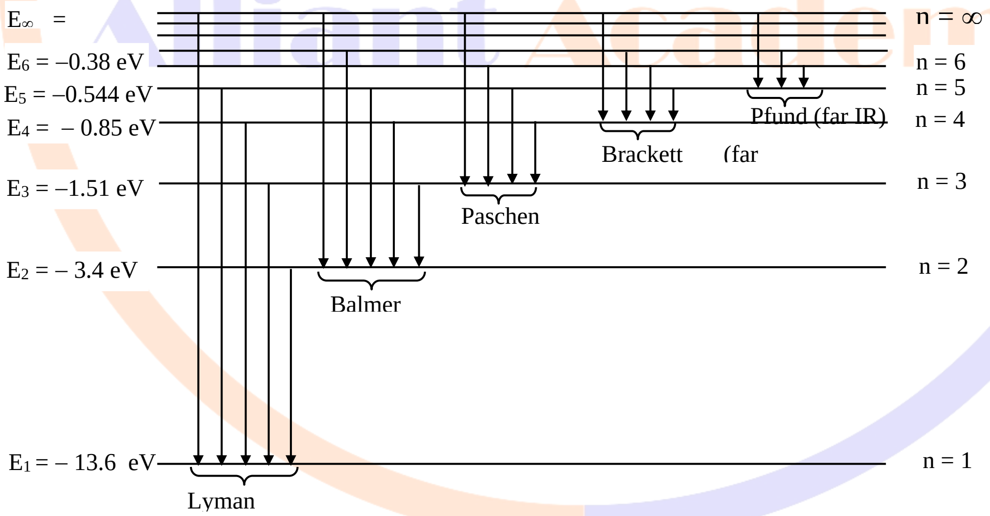
Bohr's quantisation rule	$mvr = \frac{nh}{2\pi}$, n = 1, 2, 3. . .	
Radius of the n^{th} orbit	$r = \frac{\epsilon_0 n^2 h^2}{\pi m Z e^2}$	$r = \left(\frac{n^2}{Z}\right) 0.53\ A°$
Speed of the electron in n^{th} orbit	$v_n = \frac{Ze^2}{2nh\varepsilon_0}$	$v = \left(\frac{Z}{n}\right) 2.16\times10^6\ ms^{-1}$
Kinetic energy of the electron in n^{th} orbit	$K.E = \frac{1}{2}\left(\frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{r}\right) J$	$KE = \left(\frac{Z^2}{n^2}\right) 13.6\ eV$
Potential energy of the electron	$P.E = \frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{r} J$	$PE = -2\left(\frac{Z^2}{n^2}\right) 13.6\ eV$
Total energy of the electron	$E = \frac{-mZ^2e^4}{8\varepsilon_0^2 n^2 h^2} J$	$TE = -\left(\frac{Z^2}{n^2}\right) 13.6\ eV$
Wavelength of emitted radiation and Wave number	$\therefore \nu = \frac{1}{\lambda} = R\ Z^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$	
Rydberg constant	$R_H = \frac{me^4}{8\varepsilon_0^2 ch^3} = 1.097\times10^7\ m^{-1}$	
Note: PE = 2 (TE) ; KE = | TE | ; KE = $\frac{\|PE\|}{2}$		

- As n increases, the numerical value of $[1/n^2]$ decreases. Since it is with a negative sign, its negativeness decreases. Therefore, the energy actually increases with the order number.
- The energy of an electron remains constant as long as it remains in a particular orbit.
- If an electron absorbs a photon of frequency ν such that $h\nu = E_2 - E_1$, it transits. Conversely if an electron jumps from a higher energy orbit to a lower energy orbit, it emits a photon of frequency ν such that $E_2 - E_1 = h\nu$.
- Here E_1 represents energy corresponding to a lower energy orbit and E_2 represents energy corresponding to higher energy orbit.
- Since n can take only integral values, r, v and E all can have only certain discrete values i.e., radius, orbital velocity (hence angular velocity) and energy are all quantised.
- n is also called principal quantum number.
- When n = 1, the energy is minimum. This state is called ground state. For n = 2, 3, 4,.... the atom is said to be in excited state.
- A spectral line is the result of an electron transition from higher energy state to lower energy state.

Energy level diagram

To understand the energy states of an atom and the electronic transitions, an energy level diagram is constructed. The diagram shown is for hydrogen.

Horizontal lines are drawn to represent the energy of an electron in different states. Vertical lines are drawn with arrow marks to indicate transitions. Arrows downwards as shown in the figure represent emission, while upward arrows represent absorption.



Spectral series in the hydrogen spectrum

Series	n_1	n_2	Region in the spectrum
Lyman	1	2, 3, 4, ...	Ultraviolet
Balmer	2	3, 4, 5	visible region [prominent lines are H_α (red) H_β, H_γ H_δ (violet)]
Paschen	3	4, 5, 6	Infra red
Bracket	4	5, 6, 7	Infra red
Pfund	5	6, 7, 8	Far infra red

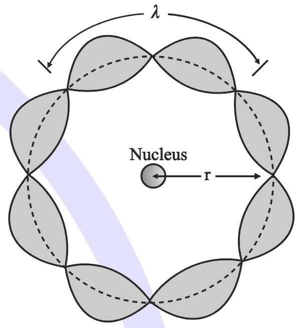
Ionisation and excitation potential

The energy required to send an electron from ground state orbit (n = 1) to an orbit at infinity (n = ∞) is called ionisation energy. Ionisation energy expressed in eV is numerically equal to ionisation potential

$$E_1 - E_\infty = \frac{me^4}{8\varepsilon_0^2 h^2} = 13.6\,eV$$

Thus, ionisation potential of hydrogen atom is 13.6 eV. The energy required to send an electron from one state to another higher energy state is called **excitation energy**. The excitation energy in terms of eV is numerically equal to **excitation potential.**

Bohr's quantization of angular momentum and de Broglie wavelength



For an electron moving in the n^{th} orbit of radius r_n, the circumference of the orbit is $2\pi r_n = n\lambda$ where n = 1, 2, 3, …..

Only those orbits are allowed where circumference is an integral multiple of wavelength λ.

The figure shows a standing matter wave on a circular orbit.

Illustrations

1. The Thomson plum pudding model envisages

(A) positively charged sphere having negatively charges moving inside the positive sphere.

(B) electrons revolving around the positively sphere in an elliptical path

(C) negative charges embedded in a positively charged sphere.

(D) electrons moving inside the positively charged sphere in circular orbits.

Ans (C)

According to Thomson's model an atom is a positively charged solid sphere and electrons are embedded in it in sufficient number so as to make the atom electrically neutral.

2. In an experiment on scattering of α-particles by a gold nucleus, the closest distance of approach in 30 fermi. If the velocity of the α-particle is doubled, the closest distance of approach will

(A) remain unaltered (B) double

(C) reduce to a value half of the original value (D) reduce to $(1/4)^{th}$ the original value

Ans (D)

The closest distance of approach is given by

$$r_0 = \frac{2Ze^2}{4\pi\varepsilon_0 E_k}$$

$$r_0 \propto \frac{1}{E_k}$$

Since $E_k = \frac{1}{2}mv^2$, $E_k \propto v^2$

$$\therefore \quad r_0 \propto \frac{1}{v^2}$$

When v is doubled

$$r_0' = \frac{r_0}{4}$$

Aliter

When v is doubled, kinetic energy increases to 4 times the values. Since $r_0 = \frac{2Ze^2}{4\pi\varepsilon_0 E_k}$

r_0 reduces to $\left(\frac{1}{4}\right)$ times the initial value.

3. In an experiment on scattering of α-particles, 100 α-particles are scattered per second at 60° with the incident direction. The number of α-particles scattered per second at 90° is

(A) zero (B) 100 (C) 50 (D) 25

Ans (D)

The number of particles (N_0) scattered at an angle θ is such that

$$N_0 \propto \frac{1}{\sin^4\left(\frac{\theta}{2}\right)}$$

$$\frac{(N_0)_2}{(N_0)_1} = \frac{\sin^4\left(\frac{60°}{2}\right)}{\sin^4\left(\frac{90°}{2}\right)} = \left(\frac{\sin 30°}{\sin 45°}\right) = \left(\frac{1/2}{1/\sqrt{2}}\right)^4 = \left(\frac{1}{\sqrt{2}}\right)^4 = \frac{1}{4}$$

$$\therefore\ (N_0)_2 = 100 \times \frac{1}{4} = 25$$

4. If Bohr radius is r_0, the corresponding de Broglie wavelength of the electron is

(A) $\left(\frac{2\pi}{r_0}\right)$ (B) $\left(\frac{r_0}{2\pi}\right)$ (C) $\left(\frac{1}{2\pi r_0}\right)$ (D) $2\pi r_0$

Ans (D)

We know for the first orbit of H-atom,

$$mvr_0 = \frac{nh}{2\pi}$$

$$mvr_0 = \frac{h}{2\pi} \qquad (\because\ n = 1)$$

$$mv = \frac{h}{2\pi r_0}$$

The expression for the de Broglie wavelength is

$$\lambda = \frac{h}{mv} = \frac{h}{(7/(2\pi r_0))}$$

$$\lambda = 2\pi r_0$$

5. The ratio of the velocity of an electron in the first orbit of hydrogen atom and of that in the first orbit of singly ionised helium is.

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

(C) 2 : 1 (D) 1 : 4

Ans (B)

The orbital velocity of an electron is given by $v = \frac{Ze^2}{2nh\varepsilon_0} \propto \frac{Z}{n}$

$$\frac{v_{1(H)}}{v_{1(He^+)}} = \frac{(Z/n)_H}{(Z/n)_{He}} = \frac{1}{2}$$

6. For an electron revolving in a H-like atom, the radii of the first three orbits are r_1, r_2 and r_3 and the corresponding period of revolution are T_1, T_2 and T_3, Then,

(A) $r_1 : r_2 : r_3 .....1:2:3.....\text{and } T_1 : T_2 : T_3 ......1:4:9$

(B) $r_1 : r_2 : r_3 .....1:4:9.....\text{and } T_1 : T_2 : T_3 ......1:4:9$

(C) $r_1 : r_2 : r_3 .....1:2:3.....\text{and } T_1 : T_2 : T_3 ......1:8:27$

(D) $r_1 : r_2 : r_3 .....1:4:9.....\text{and } T_1 : T_2 : T_3 ......1:8:27$

Ans (D)

In a H-like atom, $r \propto n^2$ and $T \propto n^3$

7. In the Bohr's model of a hydrogen atom, the centripetal force is furnished by the Coulomb attraction between the proton and the electron. If r_0 is the radius of the ground state orbit, m is the mass and e is the charge on the electron and is the permittivity of vacuum, the speed of the electron is

(A) zero (B) $\dfrac{e}{\sqrt{\varepsilon_0 r_0 m}}$ (C) $\dfrac{e}{\sqrt{4\pi\varepsilon_0 r_0 m}}$ (D) $\sqrt{\dfrac{4\pi\varepsilon_0 r_0 m}{e}}$

Ans (C)

$$\frac{mv^2}{a_0} = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r_0^2} \qquad \therefore\ v = \frac{e}{\sqrt{4\pi\varepsilon_0 r_0 m}}$$

8. The angular speed of the electron in the n^{th} orbit of Bohr's hydrogen atom is

(A) Inversely proportional to n (B) Inversely proportional to $\sqrt{n}$

(C) Inversely proportional to n^2 (D) Inversely proportional to n^3

Ans (D)

$\omega = \dfrac{v}{r}$. Further, $v \propto \dfrac{1}{n}$ and $r \propto n^2$

$$\therefore\ \omega \propto \left(\frac{1}{n^3}\right)$$

9. A H-atom and a Li^{++} ion are both in the second excited state. If l_H and l_{Li} are their respective electronic angular momenta, and E_H and E_{Li} their respective energies, then

(A) $l_H > l_{Li}$ and $|E_H| > |E_{Li}|$ (B) $l_H = l_{Li}$ and $|E_H| < |E_{Li}|$

(C) $l_H = l_{Li}$ and $|E_H| > |E_{Li}|$ (D) $l_H < l_{Li}$ and $|E_H| < |E_{Li}|$

Ans (B)

$mvr = \dfrac{nh}{2\pi} \Rightarrow$ In second excited state,

$n = 3 \Rightarrow l_H = l_{Li^{++}}$

Both H-atom and Li^{++} have same momenta $E = -13.6\left(\dfrac{z^2}{n^2}\right)eV \Rightarrow \left(E_{Li^{++}} > E_{H\text{-atom}}\right)_n$

10. Three energy levels 1, 2 and 3 of a certain atom possess energy values E_1, E_2, E_3 such that $E_1 > E_2 > E_3$. If λ_1, λ_2 and λ_3 are the wavelengths emitted corresponding to the transitions from 1 to 2, 2 to 3 and 1 to 3 respectively then

(A) $\lambda_3 = \lambda_1 + \lambda_2$ (B) $\lambda_3 = \dfrac{\lambda_1\lambda_2}{\lambda_1 + \lambda_2}$ (C) $\lambda_1 + \lambda_2 = \dfrac{\lambda_3}{2}$ (D) $\lambda_1^2 = \lambda_2^2 = \lambda_3^2$

Ans (B)

$$\Delta E = \frac{hc}{\lambda}$$

From the energy level diagram,

$$E_1 - E_3 = (E_1 - E_2) + (E_2 - E_3)$$

$$\frac{hc}{\lambda_3} = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2}\ ;\ \frac{1}{\lambda_3} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$$

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

11. The energy difference between the ground state and the first excited state of a hydrogen atom is 10.2 eV. The energy difference between the same two states in a doubly ionized lithium atom is

(A) 10.2 eV (B) 20.4 eV (C) 40.8 eV (D) 91.8 eV

Ans (D)

The energy difference $E = Z^2(E_2 - E_1)$

For hydrogen atom Z = 1 and $E_2 - E_1 = 10.2$ eV

For the doubly ionized lithium atom Z = 3

$\therefore$ $\Delta E = 3^2$ (10.2 eV) = 91.8 eV

12. The frequency of the first line of the Lyman series of the hydrogen atom is ν. The frequency of the same line corresponding to the singly ionised helium atom is

(A) 8 ν (B) 4 ν (C) 2 ν (D) ν

Ans (B)

Energy corresponding to an emitted spectral line

$$\Delta E = E_2 - E_1 \propto Z^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

In both the cases, for a given transition, $\nu \propto Z^2$

$$\frac{\nu_{He}}{\nu_H} = \left(\frac{Z_{He}}{Z_H}\right)^2 = \left(\frac{2}{1}\right)^2 = 4 \;;\; \nu_{He} = 4\nu_H$$

13. The first excitation potential of an atom is V. The ionization potential of the atom V_1 is

(A) $\frac{5}{4}V$ (B) $\frac{4}{3}V$ (C) $\frac{2}{3}V$ (D) $\frac{1}{3}V$

Ans (B)

$$E_{excitation} = E_{ionisation}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

For transition $n_1 = 1$ to $n_2 = 2$,

$$V_{excitation} = V_{ionisation}\left(\frac{1}{1} - \frac{1}{2^2}\right) = V_{ionisation}\left(\frac{3}{4}\right)$$

$$\therefore\; V_{ionisation} = \frac{4}{3}V_{excitation}$$

14. An excited hydrogen atom returns to the ground state by emitting a photon of wave length λ. The principal quantum number n of the excited state is [R is the Rydberg constant]

(A) $\left(1 - \frac{1}{\lambda R}\right)^{\frac{1}{2}}$ (B) $\left(\frac{\lambda R}{\lambda R - 1}\right)^{\frac{1}{2}}$ (C) $[\lambda R - 1]^{\frac{1}{2}}$ (D) $\frac{1}{(\lambda R - 1)^{\frac{1}{2}}}$

Ans (B)

$\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$. For the ground state $n_1 = 1$ and for the excited state $n_2 = n$.

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

or $n = \sqrt{\frac{\lambda R}{\lambda R - 1}}$

15. If R is the Rydberg constant for hydrogen, the wave-number of the first line in the Lyman series is

(A) $\frac{R}{2}$ (B) 2R (C) $\frac{R}{4}$ (D) $\frac{3R}{4}$

Ans (D)

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

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

wave-number $\bar{\nu} = \frac{3R}{4}$

16. The ratio of the magnetic dipole moment to that of the angular momentum of electron in a hydrogen atom is

(A) $\frac{e}{2m}$ (B) $\frac{e}{m}$ (C) $\frac{2e}{m}$ (D) $\frac{m}{e}$

Ans (A)

Magnetic dipole moment = IA,

where I = current due to the electron motion.

A = Area of the circular orbit

Current $I = \frac{e}{T} = \frac{e}{(2\pi r / v)} = \frac{ev}{2\pi r}$

$\therefore$ Magnetic moment = $I(\pi r^2) = \frac{ev}{2\pi r}(\pi r^2) = \frac{er^2\omega}{2}$ $(\because v = r\omega)$

Angular momentum = $mr^2\omega$

$\therefore$ Ratio is $\frac{(er^2\omega/2)}{(mr^2\omega)} = \frac{e}{2m}$

17. Electrons are bombarded to excite hydrogen atoms and six spectral lines are observed. If E_g is the ground state energy of hydrogen, the minimum energy the bombarding electrons should possess is

(A) $\frac{8E_g}{9}$ (B) $\frac{15E_g}{16}$ (C) $\frac{35E_g}{36}$ (D) $\frac{48E_g}{49}$

Ans (B)

Number of spectral lines = $\frac{1}{2}n(n-1)$

(n to ground transitions)

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

Ground state energy = $(-)E_g$

$\therefore$ for n = 4, energy of electron = $(-)\frac{E_g}{(4)^2} = -\frac{E_g}{16}$

$\therefore$ Energy of the bombarding electron $= -\frac{E_g}{16} - (-E_g) = \frac{15}{16}E_g$

18. The magnetic moment (μ) of an electron revolving around the nucleus varies with principal quantum number n as

(A) $\mu \propto n$ (B) $\mu \propto \frac{1}{n}$ (C) $\mu \propto n^2$ (D) $\mu \propto \frac{1}{n^2}$

Ans (A)

Magnetic moment = μ = IA ; $I = \frac{e}{T} = \frac{e}{(2\pi r/v)} = \frac{ev}{2\pi r}$

$\mu = \frac{evA}{2\pi r} \Rightarrow v \propto \frac{1}{n}, \frac{A}{r} \propto r \Rightarrow r \propto n^2;\ \mu \propto \left(\frac{1}{n}\right)(n^2) \Rightarrow \mu \propto n$

19. A photon of energy 10.2 eV collides inelastically with a hydrogen atom in ground state. After a certain time interval of few micro seconds, another photon of energy 15.0 eV collides inelastically with the same hydrogen atom. Then the observation made by a suitable detector is

(A) photon with energy 10.2 eV and an electron with energy 1.4 eV

(B) two photons of energy 10.2 eV

(C) two photons of energy 1.4 eV

(D) one photon with energy 3.4 eV and 1 electron with energy 1.4 eV

Ans (A)

10.2 eV photon on collision will excite H-atom to the first excited state but H-atom will return to ground state before next collision. Second photon will provide ionisation energy to H-atom, i.e., electron will be ejected with energy = 15 – 13.6 = 1.4 eV.

20. When the hydrogen atom emits a photon in a transition from n = 5 to n = 1 state, its recoil speed is nearly

(A) 10^{-4} ms^{-1} (B) 2×10^{-2} ms^{-1} (C) 4 ms^{-1} (D) 8×10^{2} ms^{-1}

Ans (C)

Photon energy $= h\nu = 13.6\left[1 - \frac{1}{25}\right] \text{eV} = 13 \text{ eV}$

Photon momentum = momentum of hydrogen atom:

$$p = \frac{h\nu}{c} \quad \text{or} \quad mv = \frac{h\nu}{c}$$

$$v = \frac{h\nu}{mc} = \frac{13 \times 1.6 \times 10^{-19}}{1.67 \times 10^{-27} \times 3 \times 10^{8}} \approx \frac{13}{3} \approx 4 \text{ ms}^{-1}$$

21. If the electron in a hydrogen atom jumps from 3rd orbit to 2nd orbit, the wavelength of the emitted radiation is

(A) $\lambda = \frac{36}{5R}$ (B) $\lambda = \frac{5R}{36}$ (C) $\lambda = \frac{6}{R}$ (D) $\lambda = \frac{R}{6}$

Ans (A)

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

$$\frac{1}{\lambda_{3\to2}} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = R\left(\frac{1}{4} - \frac{1}{9}\right) = \frac{5R}{36}$$

$$\frac{1}{\lambda_{3\to2}} = \frac{36}{5R}$$

22. Atomic hydrogen is excited to nth energy level. The maximum number of spectral lines which it can emit while returning to the ground state, is

(A) $\frac{1}{2}n(n-1)$ (B) $\frac{1}{2}n(n+1)$ (C) $n(n+1)$ (D) $n(n-1)$

Ans (A)

Example: If $n = 4$, 6 spectral lines are seen.

23. The kinetic energy of the electron in an orbit of radius r in a hydrogen atom is related to electron charge (e) as

(A) $\frac{e^2}{r^2}$ (B) $\frac{e^2}{2r}$ (C) $\frac{e^2}{r}$ (D) $\frac{e^2}{2r^2}$

Ans (B)

$$\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0}\left(\frac{Ze^2}{r^2}\right) = \frac{kZe^2}{r^2} \Rightarrow \frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{r^2}$$

For H-atom, Z = 1 ; $mv^2 = k \cdot \frac{e^2}{r}$

$$E_k = \frac{1}{2}mv^2 = \frac{1}{2}\frac{ke^2}{r} \;;\; \therefore E_k \propto \frac{e^2}{r}$$

24. In each of the following atoms or ions, electronic transition from n = 4 to n = 1 takes place. The frequency of the radiation emitted will be minimum for

(A) hydrogen atom (B) deuterium atom (C) He^{+} ion (D) Li^{2+} ion

Ans (A)

$$\nu = \frac{c}{\lambda} = cRZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \; ; \; \therefore \; \nu \propto Z^2$$

For minimum frequency of radiation ν, atomic number Z should be minimum and it is 1 for both H and deuterium – atoms.

Because of the effect of reduced mass, R is smaller for H-atom and hence ν is minimum for H.

25. Balmer gave an empirical formula for wavelength of visible radiations in the H-spectrum as $\lambda = \frac{kn^2}{n^2 - 4}\cdot$ The value of k in terms of Rydberg constant (R) is

(A) R (B) 4R (C) R/4 (D) 4/R

Ans (D)

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

For H-atom, Z = 1 ; For visible radiation, $n_1 = 2$

$$\therefore \frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n^2}\right) = \frac{R(n^2-4)}{4n^2} \Rightarrow \lambda = \frac{4n^2}{R(n^2-4)}$$

But it is given that $\lambda = \frac{kn^2}{n^2 - 4}$ $\therefore k = \frac{4}{R}$

26. For an ion having a single electron, the following wavelengths are observed. The wavelength λ is equal to

(A) 20 (B) 40 (C) 60 (D) 120

Ans (D)

$$E_3 - E_1 = (E_2 - E_1) + (E_3 - E_2) \; ; \; \frac{hc}{40} = \frac{hc}{60} + \frac{hc}{\lambda}$$

$$\frac{1}{\lambda} = \frac{1}{40} - \frac{1}{60} = \frac{60-40}{40 \times 60} = \frac{1}{120} \Rightarrow \lambda = 120 \text{ nm}$$

27. Ionisation potential of hydrogen atom is 13.6 V. Hydrogen atoms in the ground state are excited by monochromatic radiation of photon energy 12.09 eV. According to Bohr's theory, the spectral lines emitted by hydrogen will be

(A) Two (B) Three (C) Four (D) One

Ans (B)

Ionisation potential = 13.6 V

$\therefore$ Ionisation energy = 13.6 eV

Energy of incident radiation = 12.09 eV

$\therefore$ Energy gained by the electron = –12.09 – (–13.6) = 1.51 eV

$$E_n = -\frac{13.6}{n^2} = (-)1.51\text{eV}$$

$$\therefore n^2 = \frac{13.6}{1.51} \approx 9$$

$n = 3$

$\therefore$ 3 spectral lines are emitted

Aliter

When an electron transits from n_2 = n to n_1 = 1 level, number of spectral lines emitted = $n(n-1)/2$.

n = 3 $\therefore$ Number of spectral lines = 3.

28. A hydrogen sample is in a particular excited state A. Photons of energy 2.55 eV get absorbed by the sample to take some of the electrons to a further excited state B. The quantum numbers corresponding to the states A and B respectively are

(A) 2 and 4 (B) 3 and 5 (C) 3 and 6 (D) 4 and 7

Ans (A)

Refer the energy level diagram

Energy of a state in a hydrogen atom is $E_n = -\frac{13.6}{n^2} eV$

It is seen that $E_2 - E_4 = -3.4 - (-0.84) = -2.56$ eV

(–ve sign shows absorption of energy)

$\therefore$ The quantum numbers are 2 and 4.

NCERT LINE BY LINE QUESTIONS

1. The thickness of gold foil used in α-particle scattering experiment was [NCERT Pg. 416]

(1) 2.1×10^{-7}m (2) 2.1×10^{-3}m (3) 3.1×10^{-10}m (4) 2.1×10^{-12}m

2. In α-particle scattering experiment number of α-particles scatter by more than 1° is about [NCERT Pg. 416]
(1) 0.3% (2) 0.24% (3) 0.20% (4) 0-14%

3. In α-particle scattering experiment, number of α-particles deflected by more than 90° is [NCERT Pg.416)
(1) 1 in 8000 (2) 1 in 2000
(3) 1 in 1000 (4) 1 in 10,0000

4. Rutherford's experiments suggested that the size of nucleus is about [NCERT Pg. 417]
(1) 10^{-14}m to 10^{-11}m (2) 10^{-16}m to 10^{-13}m
(3) 10^{-15}m to 10^{-14}m (4) 10^{-15}m to 10^{-10}m

5. In which of the following, will the radius of the first orbit (n = 1) be minimum? [NCERT Pg. 425]
(1) Doubly ionized lithium (2) Singly ionized helium
(3) Deuterium atom (4) Hydrogen atom

6. If 13.6 eV energy is required to separate a hydrogen atom into a proton and electron, then the velocity of revolving electron is [NCERT Pg; 425]
(1) 1.2 x 10^5 m/s (2) 2.2 x 10^6 m/s
(3) 3.2 x 10^6 m/s (4) 1.8 x 10^6 m/s

7. An electron in a hydrogen atom makes a transition from n = n_1 to n = n_2. The time period of revolution of the electron in the initial state is eight times that in final state. The possible value of n_1 and n_2 are [NCERT Pg. 429]
(1) $n_1=4, n_2=2$ (2) $n_1=8, n_2=2$
(3) $n_1=8, n_2=1$ (4) $n_1=6, n_2=2$

8. If muonic hydrogen atom is an atom in which a negatively charged muon (μ) of mass about $207m_e$ revolve around a proton, then first Bohr radius of this atom is (radius of electron orbit is 0.53 Å) [NCERT Pg. 437]
(1) 2.56×10^{-10}m (2) 2.56×10^{-11}m
(3) 2.56×10^{-12}m (4) 2.56×10^{-13}m

9. The minimum energy that must be given to a hydrogen atom in ground state so that it can emit an Hy line in Balmer series. [NCERT Pg. 429]
(1) 12.4 eV (2) 10.2 eV
(3) 13.06 eV (4) 12.75 eV

10. A hydrogen atom initially in the ground state absorbs a photon and is excited to n = 4 level, then the wavelength of photon is nearly [NCERT Pg. 427)
(1) 790 Å (2) 870 Å (3) 970 Å (4) 1070 Å

11. The wavelength of first line of Lyman series is 1215 A, the wavelength of first line of Balmer series will be [NCERT Pg. 421]
(1) 4545 Å (2) 5295Å (3) 6563 Å (4) 6750 Å

12. The ratio of the speed of electron in the ground state of hydrogen atom to the speed of light in vacuum is [NCERT Pg. 425]
(1) $\frac{1}{2}$ (2) $\frac{2}{237}$ (3) $\frac{1}{137}$ (4) $\frac{1}{237}$

13. Ionization potential of hydrogen atom is 13.6 eV. Hydrogen atoms in the ground state are excited by monochromatic radiation of photon energy 12.1 eV. According to Bohr's theory, the spectral lines emitted by hydrogen will be [NCERT Pg. 429]
(1) One (2) Two (3) Three (4) Five

14. Bohr's basic idea of discrete energy levels in atoms and process of emission of photons from the higher levels to the lower levels was experimentally confirmed by experiments performed by [NCERT Pg. 428]
(1) Michelson-Morley (2) Millikan
(3) Joule (4) Franck and Hertz

15. If E is the energy of n^{th} orbit of hydrogen atom, the energy of n^{th} orbit of He^{+} ion will be (NCERT Pg. 425)
(1) E (2) 2 E (3) 3E (4) 4E

16. The shortest wavelength present in, the Paschen series of spectral lines is nearly [NCERT Pg. 429]
(1) 720 nm (2) 790 nm (3) 800nm (4) 820 nm

17. If there are N atoms in a source of Laser light and each atom is emitting light with intensity I, then the total intensity produced by it is [NCERT Pg. 432]
(1) NI (2) N^2I (3) N^3I (4) N^4I

18. Which of the following statements is true for hydrogen atom? (n is principal quantum number of orbit) [NCERT Pg. 425]
(1) Angular momentum $\propto \frac{1}{n}$
(2) Radius of orbit $\propto \frac{1}{n}$
(3) Magnitude of linear momentum of electron in any orbit $\propto \frac{1}{n}$
(4) Energy Of electron in any Orbit $\propto \frac{1}{n^3}$

19. The first spectral series of hydrogen atom was discovered by [NCERT Pg. 421]
(1) Balmer (2) Lyman (3) Paschen **(4)** Bohr

20. In a hydrogen atom, total energy of electron is [NCERT Pg. 420]
(1) $\frac{e^2}{4\pi\varepsilon_0 r}$ (2) $\frac{-e^2}{4\pi\varepsilon_0 r}$ (3) $\frac{-e^2}{8\pi\varepsilon_0 r}$ (4) $\frac{e^2}{8\pi\varepsilon_0 r}$

NCERT BASED PRACTICE QUESTIONS

1. In a Rutherford scattering experiment when a projectile of charge Z_1 and mass M_1 approaches a target nucleus of charge Z_2 and mass M_2, the distance of closest approach is r_0.
The energy of the projectile is:
(1) directly proportional to $M_1 \times M_2$
(2) directly proportional to Z_1Z_2
(3) directly proportional to Z_1
(4) directly proportional to mass M_1

2. The Bohr model of Atom:
(1) Assumes that the angular momentum of electrons is quantised.
(2) Uses Einstein's photoelectric equation.
(3) Predicts continuous emission spectra for atoms
(4) Predicts the same emission spectra for all types of atoms.

3. According to Bohr's theory of hydrogen atom, for the electron in the nth allowed orbit the:

I. Linear momentum is proportional to 1/n.

II. Radius is proportional to n.

III. Kinetic energy is proportional to $1/n^2$.

IV. Angular momentum is proportional to n.

Choose the correct option from the codes given below:

(1) I, III and IV (2) Only I (3) I and II (4) Only III

4. A hydrogen atom and Li^{++} ion are both in the second excited state. If LH and LLi are their respective electronic angular momenta and EH and ELi their respective energies, then:

(1) $L_H > L_{Li}$ and $|E_H| > |E_{Li}|$

(2) $L_H = L_{Li}$ and $|E_H| < |E_{Li}|$

(3) $L_H = L_{Li}$ and $|E_H| > |E_{Li}|$

(4) $L_H < L_{Li}$ and $|E_H| < |E_{Li}|$

5. The minimum energy to ionise an atom is the energy required to:

(1) add one electron to the gaseous state of atom

(2) excite the atom from its ground state to its first excited state.

(3) remove one outermost electron from the gaseous state of atom

(4) remove an innermost electron from the gaseous state of atom

6. As an electron makes transition from an excited state to the ground state of a hydrogen like atom/ion:

(1) Kinetic energy decrease, potential energy increases but total energy remains same

(2) Kinetic energy and total energy decrease but potential energy increases

(3) Its kinetic energy increases but potential energy and total energy decreases

(4) Kinetic energy, potential energy and total energy decrease

7. If we have to apply Bohr model to a particle of mass m and charge q moving in a plane under the influence of a magnetic field B, the energy of the charged particle in the nth level will be:

(1) $n\left(\frac{hqB}{2\pi m}\right)$ (2) $n\left(\frac{hqB}{4\pi m}\right)$ (3) $n\left(\frac{hqB}{8\pi m}\right)$ (4) $n\left(\frac{hqB}{\pi m}\right)$

8. In a hypothetical system, a particle of mass m and charge (–3q) is moving around a very heavy particle charge q. Assume that Bohr's model is applicable to this system, then velocity of mass m in first orbit is:

1) $\frac{3q^2}{2\varepsilon_0 h}$ 2) $\frac{3q^2}{4\varepsilon_0 h}$ 3) $\frac{3q}{2\pi\varepsilon_0 h}$ 4) $\frac{3q}{4\pi\varepsilon_0 h}$

9. An electron of energy 11.2 eV undergoes an inelastic collision with a hydrogen atom in its ground state. [Neglect recoiling of atom as $m_H >> m_e$].

Then in this case:

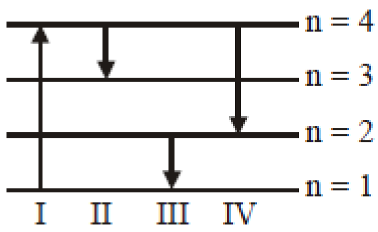
(1) The outgoing electron has energy 11.2 eV

(2) The entire energy is absorbed by the H-atom and the electron stop.

(3) 10.2 eV of the incident electron energy is absorbed by the H-atom and electron would come out with 1.0 eV energy.

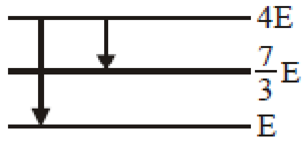
(4) None of the above

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



(1) III (2) IV (3) I (4) II

11. The following diagram indicates the energy levels of a certain atom when the system moves from 4E level to E. A photon of wavelength λ_1 is emitted. The wavelength of photon during its transition from $\frac{7}{3}E$ level to E is λ_2. The ratio $\frac{\lambda_1}{\lambda_2}$ will be :



1) 2) 3) 4)

12. The wavelengths involved in the spectrum of deuterium $\left({}_1^2D\right)$ are slightly different from that of hydrogen spectrum, because:

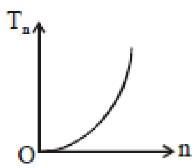
(1) Size of the two nuclei are different

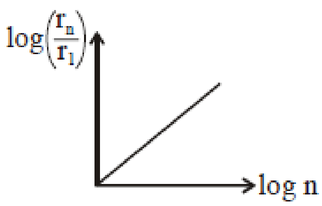
(2) nuclear forces are different in the two cases

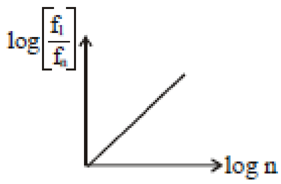
(3) masses of the two nuclei are different

(4) Attraction between the electron and the nucleus is different in the two cases.

13. If in hydrogen atom, radius of n^{th} Bohr orbit is r_n. Time period and frequency of revolution of electron in n^{th} orbit are T_n and f_n choose the correct option:

(1) 

(2) 

(3) 

(4) All of the above

14. The hydrogen ion consists of:

(1) One neutron only (2) One proton only

(3) One proton and one electron

(4) One proton, one neutron and one electron

15. In an atom for the electron to revolve around the nucleus, the necessary centripetal force is obtained from the following force excerted by the nucleus on the electron:

(1) Nuclear force (2) Gravitational force

(3) Magnetic force (4) Electrostatic force

16. Ruther ford model could not explain the:

(1) Electronic structure of an atom (2) Stability of an atom
(3) Both (1) and (2) (4) None

17. On bombarding a beam of a particles on the atom of gold foil, a few particles get deflected whereas most of them go straight and remains undeflected. This is due to:
(1) The nucleus occupy much smaller volume as compared to the volume of atom
(2) The force of repulsion on fast moving a particles is very small
(3) The neutrons in the nucleus do not have any effect of a particles
(4) The force of attraction on a particles by the oppositely charged electron is not sufficient

18. According to the Thomson model of an atom, mass of the atom is assumed to be:
(1) Uniformly distributed over the atom
(2) Randomly distributed over the atom
(3) Partially distributed over the atom
(4) None of these

19. The spectrum of radiation emitted by a substance after absorbing energy is called:
(1) absorption spectrum (2) emission spectrum
(3) white light spectrum (4) none of the above

20. According to the Bohr's model of hydrogen atom:
(1) Total energy of electron is quantised
(2) Angular momentum of the electron is quantised and given as $\frac{nh}{2\pi}$
(3) Both (1) and (2) (4) Neither (1) nor (2)

21. The frequency of EMW emitted by the revolving electron is equal to (According to classical theory):
(1) Double of the frequency of revolution
(2) Equal to the frequency of revolution
(3) Less than frequency of revolution (4) Cannot say

22. If total energy of electron in an orbit is equal to E, is positive:
(1) Electron will revolve in an closed orbit
(2) Electron will not follow a closed orbit around the nucleus.
(3) Electron will be bound to nucleus
(4) Cannot say

23. Which one is not a failure of Bohr model:
(1) not applicable for more than one electron
(2) define frequency of radiation emitted by hydrogen atom
(3) Unable to explain the relative intensity of the frequency of spectrum
(4) Does not include electrical forces between electrons

24. Bohr's atomic model suggests that:
(1) Electrons have a particle as well as wave character
(2) Atomic spectrum of atom should contain only five lines
(3) Electron in hydrogen atom can have only certain values of angular momentum
(4) All of the above

25. According to Bohr theory the energy of an electron in the orbit:
(1) changes with time (2) does not change with time
(3) change with pressure (4) none of the above

26. The only series of lines appear in the visible region in the electro magnetic spectrum of hydrogen is:
(1) Lyman series (2) Balmer series
(3) Paschen series (4) Pfund series

27. The emission spectra of atoms in gaseous phase do not show a continous spread of wavelength from red to violet, rather they emit light only at specific wavelength with dark spaces between them. Such spectra is/are called:
(1) line spectra (2) atomic spectra
(3) both (1) and (2) (4) none of these

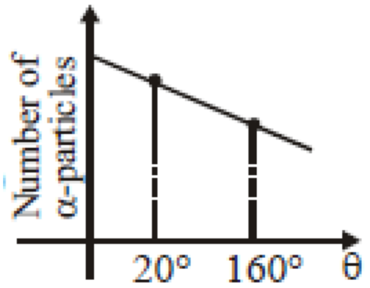
28. What kind of spectrum for electromagnetic radiation is obtained from solids and rarefied gases at a given temperature?
(1) Solids $\rightarrow$ Continuous; gases $\rightarrow$ discrete
(2) Solids $\rightarrow$ discrete ; gases $\rightarrow$ discrete
(3) Solids $\rightarrow$ Continuous; gases $\rightarrow$ continuous
(4) Solids $\rightarrow$ discrete ; gases $\rightarrow$ continuous

29. The most important contribution by Niel Bohr for explaination of Hydrogen atom was?
(1) Theory of stable orbits
(2) Angular momentum Quantization
(3) Energy level quantization (4) e^- has dual nature

30. Choose the correct alternative:-
(1) Emission spectrum $\rightarrow$ White background with dark lines
Absorption spectrum $\rightarrow$ Dark background with bright lines
(2) Emission spectrum $\rightarrow$ Dark background with bright lines
Absorption spectrum $\rightarrow$ White background with dark lines.
(3) 1 & 2 both (4) None of these

31. JJ Thomson's experiment revealed that
(1) atoms are smallest entities of matter
(2) atoms are round in shape
(3) atoms are electrically neutral
(4) atoms contains negatively charged particles

32. Graph of total number of α -particles scattered at different angles is



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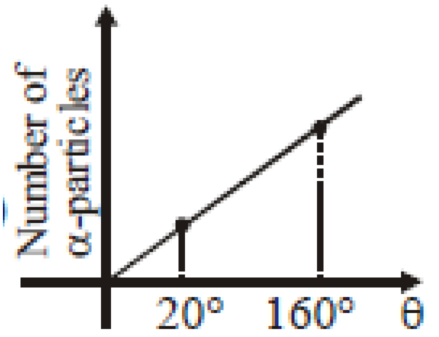

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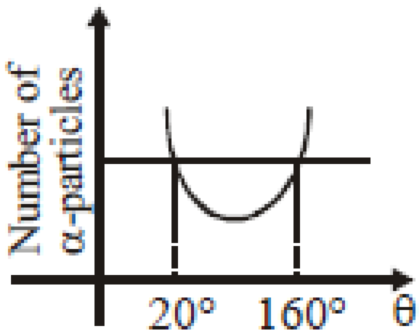

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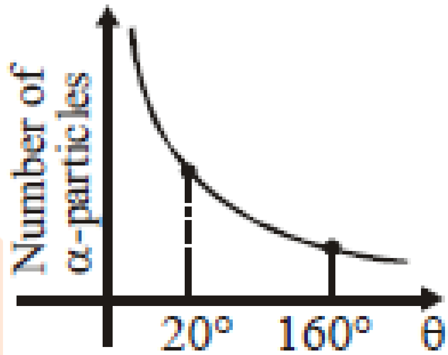
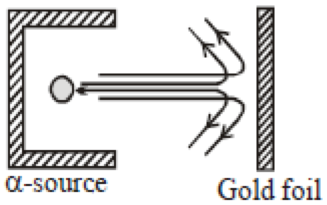
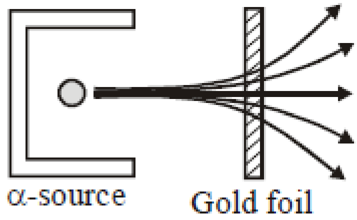


(4)

33. Correct figure of Geiger-Marsden experiment is



(1)



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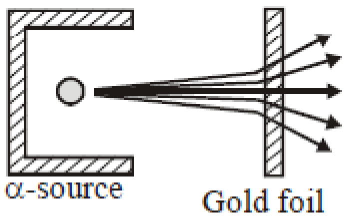
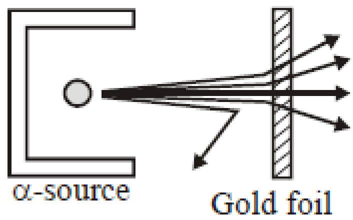


(3)



(4)

34. Rutherford's atomic model could account for

I. concept of stationary orbits

II. the positively charged central core of an atom

III. origin of spectra

IV. stability of atoms

Choose the correct option from the codes given below.

(1) Only I is correct
(2) Only II is correct
(3) I, III and IV are correct
(4) All of these

35. A line emission spectrum of a material is

(1) unique like a fingerprint
(2) same for all
(3) may be same for few elements
(4) depends on excitation produced

36. Frequency of emitted radiation due to a revolving electron is

(1) less than frequency of revolving electron

(2) more than frequency of revolving electron

(3) equals to frequency of revolving electron

(4) not related to frequency of revolving electron

37. According to classical electromagnetic theory, emission spectrum of Rutherford atom must be

(1) a line emission spectrum

(2) a line absorption spectrum

(3) a continuous spectrum

(4) a band absorption spectrum

38. Which of these statements are correct regarding Bohr's model of hydrogen atom?

I. Orbiting speed of electron decreases as it shift to discrete orbits away from nucleus.

II. Radii of allowed orbits of electron are proportional to the principal quantum number.

III. Frequency of revolution of an electron is inversely proportional to the cube of principal quantum number.

IV. Binding force with which electron is bound to nucleus increases as electron shifts to outer orbits.

(1) I and III
(2) II and IV
(3) I, II and III
(4) II, III and IV

39. In Bohr's model where

(1) linear momentum is conserved while angular momentum is not conserved

(2) potential energy is conserved while kinetic energy is not conserved

(3) only potential energy is quantised

(4) only angular momentum is quantised

40. The de-Broglie wavelength of an electron in first Bohr's orbit is

(1) equal to $\frac{1}{4}$ of circumference of orbit

(2) equal to $\frac{1}{2}$ of circumference of orbit

(3) equal to twice of circumference of orbit

(4) equal to the circumference of orbit

41. If electron of hydrogen atom makes a transition from an excited state to ground state, then

(1) its KE increases and PE as well as TE decreases

(2) its KE decreases, PE increases and total energy same

(3) its KE and TE decrease and potential energy increases

(4) its kinetic, potential and total energy decreases

42. The simple Bohr model cannot be directly applied to calculate the energy levels of an atom with many electrons as

(1) electrons not subjected to a central force

(2) electrons are colliding with each other
(3) electrons are subjected to screening effects
(4) force between nucleus and electrons is not subjected to Coulomb's force

43. In Bohr's atomic model, in going to a higher level (PE = potential energy, TE = total energy)
(1) PE decreases, TE increases
(2) PE increases, TE increases
(3) PE decreases, TE decreases
(4) PE increases, TE decreases

44. Bohr's second postulate defines the stable orbits on the basis of
(1) linear momentum of electron
(2) angular momentum of electron
(3) kinetic energy of electron
(4) total energy of electron

45. A set of atoms in an excited state decays
(1) in general to any of the states with lower energy
(2) into a lower state only when excited by an external electric field
(3) all together simultaneously into a lower state
(4) to emit photons only when they collide

46. When white light is passed through an unexcited gas (in rarified state), then transmitted light consists of
(1) few bright lines in dark background
(2) few dark lines in bright background
(3) alternate dark and bright lines
(4) alternate dark and bright bands

47. In an absorption spectrum, dark lines corresponds to same wavelengths which were found in emission line spectrum of gas. Above statement is
(1) correct for all gases
(2) correct only for hydrogen like atoms
(3) incorrect for all gases
(4) incorrect except for hydrogen

TOPIC WISE PRACTICE QUESTIONS

Topic 1: Atomic Structure, Rutherford's Nuclear Model of Atom

1. According to classical theory, the path of an electron in Rutherford atomic model is
(a) spiral (b) circular (c) parabolic (d) straight line

2. When an a-particle of mass 'm' moving with velocity 'v' bombards on a heavy nucleus of charge 'Ze', its distance of closest approach from the nucleus depends on v as :

(a) $\frac{1}{v}$ (b) $\frac{1}{\sqrt{v}}$ (c) $\frac{1}{v^2}$ (d) v

3. An $\alpha-$particle of 10 MeV collides head-on with a copper nucleus (Z = 29) and is deflected back. Then, the minimum distance of approach between the centres of the two is:

(a) 8.4×10^{-15} cm (b) 8.4×10^{-15} m (c) 4.2×10^{-15} m (d) 4.2×10^{-15} cm

4. An a-particle of energy 5 MeV is scattered through 180° by a fixed uranium nucleus. The distance of closest approach is of the order of

(a) 10^{-12} cm (b) 10^{-10} cm (c) 10^{-20} cm (d) 10^{-15} cm

5. In Rutherford scattering experiment, what will be the correct angle for $\alpha-$scattering for an impact parameter, b = 0?

(a) 90° (b) 270° (c) 0° (d) 180°

6. Rutherford scattering experiment was explained by making following assumptions that

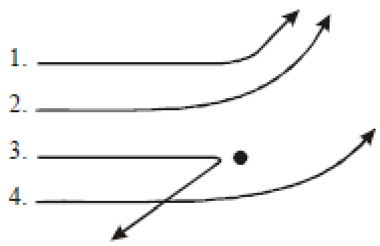
(a) the collision is inelastic

(b) the nucleus can be treated as a point particle

(c) the nucleus is light

(d) None of these

7. The diagram shows the path of four a-particles of the same energy being scattered by the nucleus of an atom simultaneously which of those is not physically possible?



(a) 3 and 4 (b) 2 and 3 (c) 1 and 4 (d) 4 only

8. The significant result deduced from the Rutherford's scattering experiment is that

(a) whole of the positive charge is concentrated at the centre of atom

(b) there are neutrons inside the nucleus

(c) a-particles are helium nuclei

(d) electrons are embedded in the atom

9. Which one did Rutherford consider to be supported by the results of experiments in which $\alpha-$particles were scattered by gold foil?

(a) The nucleus of an atom is held together by forces which are much stronger than electrical or gravitational forces

(b) The force of repulsion between an atomic nucleus and an $\alpha-$particle varies with distance according to inverse square law

(c) $\alpha-$particles are nuclei of Helium atoms

(d) Atoms can exist with a series of discrete energy levels

10. Value of Impact parameter will be zero, when scattering angle is

(a) $\pi/2$ (b) π (c) $2\pi/3$ (d) $3\pi/2$

11. The correct relation between scattering angle (θ), impact parameter (b) and distance of closest approach (D) is

(a) $\sin\theta = Db$ (b) $\tan\frac{\theta}{2} = \frac{D}{2b}$ (c) $\frac{\cos\theta}{b} = D$ (d) $\cot\frac{\theta}{2} = \frac{b}{2D}$

12. In a Rutherford experiment, the number of particles scattered at 90° angle are 28 per minute then number of scattered particles at an angle 60° and 120° will be
(a) 117 per minute, 25 per minute
(b) 50 per minute, 12.5 per minute
(c) 100 per minute, 200 per minute
(d) 112 per minute, 12.4 per minute

13. In Rutherford's experiment, the number of a-particles scattered through an angle of 60^0 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 $\alpha-$ particles scattered through an angle of 60^0 per minute is:
(a) $\frac{200 \times Z_{Cu}}{Z_{Ag}}$ (b) $200 \times \left(\frac{Z_{Cu}}{Z_{Ag}}\right)^2$ (c) $200 \times \frac{Z_{Ag}}{Z_{Cu}}$ (d) $200 \times \left(\frac{Z_{Ag}}{Z_{Cu}}\right)^2$

14. The distance between the a-particle and target nucleus in an a-scattering experiment is equal to distance of closest approach, when the scattering angle is
(a) $\pi/2$ (b) π (c) $\pi/4$ (d) $\pi/3$

15. In Rutherford scattering experiment, a-particles scattered at angle θ by a target, then which of the following is correct for Impact parameter "b"?
(a) $b \propto \sec^2\theta$ (b) $b \propto \sec^3\theta$ (c) $b \propto \tan\left(\frac{\theta}{2}\right)$ (d) $b \propto \cot\left(\frac{\theta}{2}\right)$

16. In Rutherford scattering experiment, the number of $\alpha-$particles scattered at 60° is 5×10^6. The number of $\alpha-$particles scattered at 120° will be
(a) 15×10^6 (b) $\frac{3}{5} \times 10^6$ (c) $\frac{5}{9} \times 10^6$ (d) None of these

17. The distance of closest approach of a certain nucleus is 7.2 fm and it has a charge of 1.28×10^{-17} C. The number of neutrons inside the nucleus of an atom is
(a) 136 (b) 142 (c) 140 (d) 132

18. In a Rutherford scattering experiment when a projectile of charge Z_1 and mass M_1 approaches a target nucleus of charge Z_2 and mass M_2, the distance of closest approach is r0. The energy of the projectile is
(a) directly proportional to Z_1, Z_2 (b) inversely proportional to Z_1
(c) directly proportional to mass M_1 (d) directly proportional to $M_1 \times M_2$

19. If the collision between the incident $\alpha-$particle whose kinetic energy is T and electric charge 2e and the nucleus were head on. The correct relation between the distance of closest approach D and T is
(a) $D \propto \frac{1}{T}$ (b) $D \propto T$ (c) $D \propto T^2$ (d) $D \propto \frac{1}{T^2}$

Topic 2: Bohr's Model and the Spectra of the Hydrogen Atom

20. If the angular momentum of an electron in an orbit is J then the K.E. of the electron in that orbit is
(a) $\frac{J^2}{2mr^2}$ (b) $\frac{Jv}{r}$ (c) $\frac{J^2}{2m}$ (d) $\frac{J^2}{2\pi}$

21. In an atom, the two electrons move round the nucleus in circular orbits of radii R and 4R. The ratio of the time taken by them to complete one revolution is
(a) 1/4 (b) 4/1 (c) 8/1 (d) 1/8

22. 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 is

(a) $\frac{3}{16}\times10^5$ (b) $\frac{3}{16}\times10^{15}$ (c) $\frac{9}{16}\times10^{15}$ (d) $\frac{3}{4}\times10^{15}$

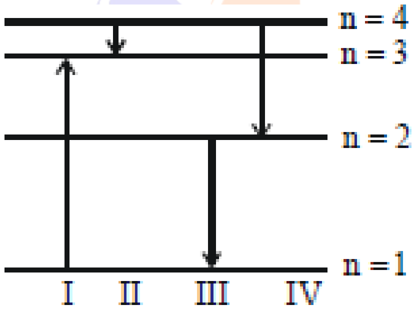
23. Current due to the orbital motion of an electron revolving in nth Bohr's orbit is proportional to

(a) $1/n^3$ (b) n^3 (c) n^2 (d) n

24. The ionisation potential of H-atom is 13.6 V. When it is excited from ground state by monochromatic radiations of 970.6 Å, the number of emission lines will be (according to Bohr's theory)

(a) 10 (b) 8 (c) 6 (d) 4

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



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

26. In the hydrogen atom spectrum λ_{3-1} and λ_{2-1} represent wavelengths emitted due to transition from second and first excited states to the ground state respectively. The value of $\frac{\lambda_{2-1}}{\lambda_{3-1}}$ is

(a) 27/32 (b) 32/27 (c) 4/9 (d) 9/4

27. The time period of an electron in nth Bohr's orbit is proportional to

(a) n^3 (b) n^2 (c) n (d) 1/n

28. In a hydrogen atom following the Bohr's postulates the product of linear momentum and angular momentum is proportional to $(n)^x$ where 'n' is the orbit number. Then 'x' is

(a) 0 (b) 2 (c) –2 (d) 1

29. The transition from the state n = 3 to n = 1 in a hydrogen like atom results in ultraviolet radiation. Infrared radiation will be obtained in the transition from

(a) 2 $\rightarrow$1 (b) 3 $\rightarrow$2 (c) 4 $\rightarrow$2 (d) 4 $\rightarrow$3

30. The wavelength of the first line of Lyman series for hydrogen atom is equal to that of the second line of Balmer series for a hydrogen like ion. The atomic number Z is

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

31. The energy of a hydrogen atom in the ground state is – 13.6 eV. The energy of He^+ in the first excited state is

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

32. Electron in hydrogen atom first jumps from third excited state to second excited state and then from second excited to the first excited state. The ratio of the wavelength $\lambda_1 : \lambda_2$ emitted in the two cases is

(a) 7/5 (b) 27/20 (c) 27/5 (d) 20/7

33. According to the Bohr theory of H-atom, the speed of the electron, its energy and the radius of its orbit varies with the principal quantum number n, respectively, as

(a) $\frac{1}{n}, n^2, \frac{1}{n^2}$ (b) $n^2, \frac{1}{n}, n^2$ (c) $n, \frac{1}{n^2}, , \frac{1}{n^2}$ (d) $\frac{1}{n}, \frac{1}{n^2}, n^1$

34. In terms of Bohr radius a_0, the radius of the second Bohr orbit of a hydrogen atom is given by

(a) 4 a_0 (b) 8 a_0 (c) $\sqrt{2}\, a_0$ (d) 2 a_0

35. Which of the following series in the spectrum of hydrogen atom lies in the visible region of the electromagnetic spectrum?

(a) Paschen series (b) Balmer series (c) Lyman series (d) Brackett series

36. If the ka radiation of Mo (Z = 42) has a wavelength of 0.71Å. Calculate the wavelength of the corresponding radiation of Cu (Z = 29).

(a) 1.52Å (b) 2.52Å (c) 0.52Å (d) 4.52Å

37. The third line of Balmer series of an ion equivalent to hydrogen atom has wavelength of 108.5 nm. The ground state energy of an electron of this ion will be

(a) 3.4 eV (b) 13.6 eV (c) 54.4 eV (d) 122.4 eV

38. Excitation energy of a hydrogen like ion in its excitation state is 40.8 eV. Energy needed to remove the electron from the ion in ground state is

(a) 54.4 eV (b) 13.6 eV (c) 40.8 eV (d) 27.2 eV

39. Hydrogen atom is excited from ground state to another state with principal quantum number equal to 5. Then the number of spectral lines in the emission spectra will be :

(a) 9 (b) 15 (c) 8 (d) 10

40. The angular speed of the electron in the nth orbit of Bohr hydrogen atom is

(a) directly proportional to n (b) inversely proportional to $\sqrt{n}$

(c) inversely proportional to n^2 (d) inversely proportional to n^3

41. Which of the following statements are true regarding Bohr's model of hydrogen atom?

(a) Orbiting speed of electron decreases as it shifts to discrete orbits away from the nucleus

(b) Radii of allowed orbits of electron are inversely proportional to the principal quantum number

(c) Frequency with which electrons orbit around the nucleus in discrete orbits is inversely proportional to the cube of principal quantum number

(d) The force with which the electron is bound to the nucleus increases as it shifts to outer orbits

42. Energy of an electron in an excited hydrogen atom is –3.4 eV. Its angular momentum will be

(a) 3.72×10^{-34}Js (b) 2.10×10^{-34}Js (c) 1.51×10^{-34} Js (d) 4.20×10^{-34}Js

43. The largest wavelength in the ultraviolet region of the hydrogen spectrum is 122 nm. The smallest wavelength in the infrared region of the hydrogen spectrum (to the nearest integer) is

(a) 802 nm (b) 823 nm (c) 1882 nm (d) 1648 nm

44. Taking Rydberg's constant RH = 1.097×10^7m, second wavelength of Balmer series in hydrogen spectrum is

(a) 3000 Å (b) 2960 Å (c) 4280 Å (d) 4863 Å

45. The ratio of areas between the electron orbits for the first excited state to the ground state for the hydrogen atom is

(a) 2 : 1 (b) 4 : 1 (c) 8 : 1 (d) 16 : 1

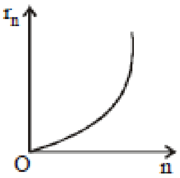
46. Consider an electron in the nth orbit of a hydrogen atom in the Bohr's model. The circumference of the orbit can be expressed in terms of the de Broglie wavelength λ of that electron as

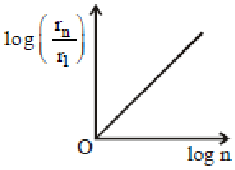
(a) 0.529 $n\lambda$ (b) $\sqrt{n}\,\lambda$ (c) (13.6) λ (d) $n\lambda$

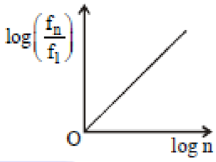
47. In Hydrogen spectrum, the wavelength of Ha line is 656 nm, whereas in the spectrum of a distant galaxy, Ha line wavelength is 706 nm. Estimated speed of the galaxy with respect to earth is

(a) 2×10^8 m/s (b) 2×10^7m/s (c) 2×10^6 m/s (d) 2×10^5 m/s

48. If in hydrogen atom, radius of nth Bohr orbit is r_n, frequency of revolution of electron in nth orbit is f_n, choose the correct option.

(a) 

(b) 

(c) 

(d) Both (a) and (b)

49. Out of the following which one is not a possible energy for a photon to be emitted by hydrogen atom according to Bohr's atomic model?

(a) 1.9 eV (b) 11.1 eV (c) 13.6 eV (d) 0.65 eV

50. The ground state energy of H-atom 13.6 eV. The energy needed to ionize H-atom from its second excited state is

(a) 1.51 eV (b) 3.4 eV (c) 13.6 eV (d) 12.1 eV

51. The electron of a hydrogen atom makes a transition from the $(n + 1)$th orbit to the nth orbit. For large n the wavelength of the emitted radiation is proportional to

(a) n (b) n^3 (c) n^4 (d) n^2

52. According to Bohr's model of hydrogen atom

(a) the linear velocity of the electron is quantised

(b) the angular velocity of the electron is quantised

(c) the linear momentum of the electron is quantised

(d) the angular momentum of the electron is quantised

53. When an electron jumps from the fourth orbit to the second orbit, one gets the

(a) second line of Lyman series

(b) second line of Paschen series

(c) second line of Balmer series

(d) first line of Pfund series

54. The ratio of the longest to shortest wavelengths in Brackett series of hydrogen spectra is

(a) 25/9 (b) 17/6 (c) 9/5 (d) 4/3

55. The ionization energy of hydrogen atom is 13.6 eV. Following Bohr's theory, the energy corresponding to a transition between 3rd and 4th orbit is

(a) 3.40 eV (b) 1.51 eV (c) 0.85 eV (d) 0.66 eV

56. The shortest wavelength in Balmer's series for Hydrogen atom is ...*A*... and this is obtained by substituting ...*B* ... in Balmer's formula. Here, *A* and *B* refer to

(a) 656.3 nm, $n = 3$ (b) 486.1 nm, $n = 4$ (c) 410.2 nm, $n = 5$ (d) 364.6 nm, $n = \infty$

57. In an inelastic collision an electron excites as hydrogen atom from its ground state to a M-shell state. A second electron collides instantaneously with the excited hydrogen atom in the M-state and ionizes it. At least how much energy the second electron transfers to the atom in the M-state?

(a) + 3.4 eV (b) + 1.51 eV (c) – 3.4 eV (d) – 1.51 eV

58. As the quantum number increases, the difference of energy between consecutive energy levels

(a) remain the same

(b) increases

(c) decreases

(d) sometimes increases and sometimes decreases.

59. The energy of electron in the nth orbit of hydrogen atom is expressed as $E_n = \frac{-13.6}{n^2}eV$. The shortest wavelength of Lyman series will be

(a) 910 Å (b) 5463 Å (c) 1315 Å (d) None of these

60. In the hydrogen atom, an electron makes a transition from n = 2 to n = 1. The magnetic field produced by the circulating electron at the nucleus

(a) decreases 16 times (b) increases 4 times
(c) decreases 4 times (d) increases 32 times

NEET PREVIOUS YEARS QUESTIONS

1. The ratio of kinetic energy to the total energy of an electron in a Bohr orbit of the hydrogen atom, is **[2018]**

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

2. The ratio of wavelengths of the last line of Balmer series and the last line of Lyman series is :- **[2017]**

(a) 1 (b) 4 (c) 0.5 (d) 2

3. Given the value of Rydberg constant is $10^7 m^{-1}$, the wave number of the last line of the Balmer series in hydrogen spectrum will be : **[2016]**

(a) $0.025 \times 10^4\ m^{-1}$ (b) $0.5 \times 10^7\ m^{-1}$ (c) $0.25 \times 10^7\ m^{-1}$ (d) $2.5 \times 10^7\ m^{-1}$

4. When an a-particle of mass 'm' moving with velocity 'v' bombards on a heavy nucleus of charge 'Ze', its distance of closest approach from the nucleus depends on m as : **[2016]**

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

5. Consider 3rd orbit of He+ (Helium), using non-relativistic approach, the speed of electron in this orbit will be [given K = 9 × 10⁹ constant, Z = 2 and h (Plank's Constant) = 6.6 × 10⁻³⁴ J s] **[2015]**

(a) 1.46×10^6 m/s (b) 0.73×10^6 m/s (c) 3.0×10^8 m/s (d) 2.92×10^6 m/s

6. Two particles of masses m_1, m_2 move with initial velocities u_1 and u_2. On collision, one of the particles get excited to higher level, after absorbing energy ε. If final velocities of particles be v_1 and v_2 then we must have **[2015]**

(a) $\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 - \varepsilon$

(b) $\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 - \varepsilon = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$

(c) $\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 + \varepsilon = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$

(d) $m_1u_1^2 + m_2u_2^2 - \varepsilon = m_1v_1^2 + m_2v_2^2$

7. In the spectrum of hydrogen, the ratio of the longest wavelength in the Lyman series to the longest wavelength in the Balmer series is **[2015]**

(a) $\frac{9}{4}$ (b) $\frac{27}{5}$ (c) $\frac{5}{27}$ (d) $\frac{4}{9}$

8. Hydrogen atom in ground state is excited by a monochromatic radiation of l = 975 Å. Number of spectral lines in the resulting spectrum emitted will be **[2014]**

(a) 3 (b) 2 (c) 6 (d) 10

9. The total energy of an electron in an atom in an orbit is –3.4 eV. Its kinetic and potential energies are, respectively: **[NEET– 2019]**

(1) –3.4 eV, –3.4 eV (2) –3.4 eV, –6.8 eV

(3) 3.4 eV, –6.8 eV (4) 3.4 eV, 3.4 eV

10. The radius of the first permitted Bohr orbit for the electron, in a hydrogen atom equals 0.51 Å and its ground state energy equals –13.6 eV. If the electron in the hydrogen atom is replaced by muon (μ^-) [charge same as electron and mass 207 m_e], the first Bohr radius and ground state energy will be : **[NEET – 2019 (ODISSA)]**

(1) 0.53×10^{-13} m, –3.6 eV (2) 25.6×10^{-13} m, –2.8 eV

(3) 2.56×10^{-13} m, –2.8 eV (4) 2.56×10^{-13} m, –13.6 eV

11. The total energy of an electron in the n^{th} stationary orbit of the hydrogen atom can be obtained by **[NEET– 2020 (COVID-19)]**

(1) $E_n = \frac{13.6}{n^2}$ eV (2) $E_n = -\frac{13.6}{n^2}$ eV (3) $E_n = -\frac{1.36}{n^2}$ eV (4) $E_n = -13.6 \times n^2$ eV

12. For which one of the following. Bohr model is not valid? **[NEET– 2020]**

1) singly ionized neon atom (Ne^+) 2) Hydrogen atom

3) Singly ionized helium atom (He^+) 4) Deuteron atom

NCERT LINE BY LINE QUESTIONS – ANSWERS

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

NCERT BASED PRACTICE QUESTIONS - ANSWERS

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

TOPIC WISE PRACTICE QUESTIONS - ANSWERS

1)	1	2)	3	3)	2	4)	1	5)	4	6)	2	7)	4	8)	1	9)	2	10)	2
11)	2	12)	4	13)	2	14)	2	15)	4	16)	3	17)	1	18)	1	19)	1	20)	1

21) 4	22) 3	23) 1	24) 3	25) 2	26) 1	27) 1	28) 1	29) 4	30) 2
31) 1	32) 3	33) 4	34) 1	35) 2	36) 1	37) 3	38) 1	39) 4	40) 4
41) 1	42) 2	43) 2	44) 4	45) 4	46) 4	47) 2	48) 4	49) 2	50) 1
51) 2	52) 4	53) 3	54) 1	55) 4	56) 4	57) 2	58) 3	59) 1	60) 4

NEET PREVIOUS YEARS QUESTIONS-ANSWERS

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

TOPIC WISE PRACTICE QUESTIONS - SOLUTIONS

1. **(a)** According to classical theory, the path on an electron in Rutherford atomic model is spiral.
2. **(c)** At closest distance of approach, the kinetic energy of the particle will convert completely into electrostatic potential energy.

   Kinetic energy K.E. $=\frac{1}{2}mv^2$

   Potential energy P.E. $=\frac{KQq}{r}$
3. **(b)** Given $\alpha-$particle have 10Mev at distance of closet approach, all the KE energy of $\alpha-$particle converted into potential Energy of system

   $10\times10^6 ev=$ PE at distance of closest approach

   $$10\times10^6\times1.6\times10^{-19}J=\frac{K(ze)\times(+2e)}{d}$$

   $$d=\frac{9\times10^9\times29\times2\times(1.6\times10^{-19})^2}{10\times1.6\times10^{-19}\times10^6}$$

   $d=835.2\times10^{-17}m;\ d=8.4\times10^{-15}m$
4. **(a)** Distance of closest approach $r_0=\frac{Ze(2e)}{4\pi\varepsilon_0\left(\frac{1}{2}mv^2\right)}$

   Energy, $E=5\times10^6\times1.6\times10^{-19}J$

   $$\therefore r_0=\frac{9\times10^9\times(92\times1.6\times10^{-19})(2\times1.6\times10^{-19})}{5\times10^6\times1.6\times10^{-19}}$$

   $\Rightarrow r=5.2\times10^{-14}m=5.3\times10^{-12}cm$
5. **(d)** $b=\frac{Ze^2\cot\left(\frac{\theta}{2}\right)}{4\pi\varepsilon_0 k_i}=0\Rightarrow\cot\left(\frac{\theta}{2}\right)=0$

   $\Rightarrow\frac{\theta}{2}=90^0$ or $\theta=180^0$
6. **(b)** the nucleus can be treated as a point particle
7. **(d)** $\alpha-$a-particle cannot be attracted by the nucleus.
8. **(a)** The significant result deduced from the Rutherford's scattering is that whole of the positive charge is concentrated at the centre of atom i.e. nucleus.
9. **(b)** The force of repulsion between an atomic nucleus and an a-particle varies with distance according to inverse square law
10. **(b)** It deflect by an angle of 180^0
11. **(b)** $\tan\frac{\theta}{2}=\frac{D}{2d}$
12. **(d)** No. of particles scattered through an angle

$$\theta = N(\theta) = \frac{k\not{Z}^2}{\sin^4\left(\frac{\theta}{2}\right)(K.E.)^2}$$

$$\therefore 28 = \frac{4kcz^2}{(K.E.)^2} \text{ for } \theta = 90° \quad \therefore \frac{kz^2}{(K.E.)^2} = \frac{28}{4} = 7$$

$$\therefore N(60°) = \frac{7}{\sin^4\left(\frac{60°}{2}\right)} = 16 \times 7 = 112\,/\text{min.}$$

$$N(120°) = \frac{7}{\sin^4\left(\frac{120°}{2}\right)} = 12.4\,/\,\text{min}$$

13. **(b)** $200\left(\frac{Z_{Cu}}{Z_{Ag}}\right)^2$

14. **(b)** The distance between the a-particle and target nucleus in an a-scattering experiment is equal to distance of closest approach, when the scattering angle is 180^0

15. **(d)** $b = \frac{2Ze^2 \cot\frac{\theta}{2}}{4\pi\varepsilon_0 m v_0^2} \qquad b \propto \cot\frac{\theta}{2}$

16. **(c)** $N \propto \frac{1}{\sin^4\theta/2};\ \frac{N_2}{N_1} = \frac{\sin^4(\theta_1/2)}{\sin^4(\theta_2/2)}$

or $\frac{N_2}{5\times10^6} = \frac{\sin^4(60^0/2)}{\sin^4(120^0/2)}$

or $\frac{N_2}{5\times10^6} = \frac{\sin^4 30^0}{\sin^4 60^0}$

or $N_2 = 5\times10^6 \times \left(\frac{1}{2}\right)^4\left(\frac{2}{\sqrt{3}}\right)^4 = \frac{5}{9}\times10^6$

17. **(a)** $R=R_0A^{1/3}$

Here , R $=7.2\times10^{-15}$m, R0$=1.2\times10^{-15}=7.2\times10^{-15}$m

$$\therefore \left(\frac{R}{R_0}\right)^3 = \left(\frac{7.2\times10^{-15}}{1.2\times10^{-15}}\right)^3 = (6)^3 = 216$$

Also, atomic number $Z = \frac{q}{e} = \frac{1.28\times10^{17}}{1.6\times10^{-19}} = 80$

Therefore, number of neutrons

N=A−Z=216−80=136

18. **(a)** The kinetic energy of the projectile is given by

$$\frac{1}{2}mv^2 = \frac{Ze(2e)}{4\pi\varepsilon_0 r_0} = \frac{Z_1Z_2}{4\pi\varepsilon_0 r_0}$$

Thus energy of the projectile is directly proportional to Z_1, Z_2

19. **(a)** $T = 2Ze^2/4\pi\varepsilon_0 D$ **;** $T \propto \frac{1}{D}$

20. **(a)** Angular momentum = mrv = J $\qquad \therefore v = \frac{J}{mr}$

K. E. of electron $= \frac{1}{2}mv^2 = \frac{1}{2}m\left(\frac{J}{mr}\right)^2 = \frac{J^2}{2mr^2}$

21. **(d)** $\frac{R_1}{R_2} = \frac{n_1^2}{n_2^2} = \frac{1}{4} \qquad \therefore \frac{n_1}{n_2} = \frac{1}{2}$

$$\frac{T_1}{T_2}=\left(\frac{n_1}{n_2}\right)^3=\left(\frac{1}{2}\right)^3=\frac{1}{8}$$

22. **(c)** $v=\frac{c}{\lambda}=cR\left(\frac{1}{p^2}-\frac{1}{n^2}\right)=cR\left(\frac{1}{4}-\frac{1}{16}\right)$

$$=\frac{3\times10^8\times10^7\times12}{64}=\frac{9}{16}\times10^{15}\,Hz$$

23. (a) Time period of revolution, $T=\frac{2\pi r}{v}$

Frequency of revolution, $f=\frac{v}{2\pi r}$

$v\propto\frac{1}{n}
r\propto n^2$ and hence $f\propto\frac{1}{n^3}$

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

$$\Rightarrow\frac{1}{970.6\times10^{-10}}=1.097\times10^7\left[\frac{1}{1^2}-\frac{1}{n_2^2}\right]\Rightarrow n_2=4$$

Number of emission line $N=\frac{n(n-1)}{2}=\frac{4\times3}{2}=6$

25. (b) The energy diagram is drawn with appropriate scale to indicate difference in energy levels.
The largest energy difference between states is between 1 and 2.
1 wouldn't release a photon, it would absorb energy.
The largest jump releasing energy would be the 3rd.

26. **(a)** $\frac{1}{\lambda_{3-1}}=R\left(\frac{1}{1^2}-\frac{1}{3^2}\right)=\frac{8R}{9}$

$$\frac{1}{\lambda_{2-1}}=R\left(\frac{1}{1^2}-\frac{1}{2^2}\right)=\frac{3R}{4}\Rightarrow\frac{\lambda_{3-1}}{\lambda_{2-1}}=\frac{27}{32}$$

27. **(a)** As we know that time period of revolution of an electron is
$T=2\pi r/v$,
And $r\propto n^2/Z^2$ and $v\propto Z/n$
$\therefore T\propto n3/Z^2$ and for H -atom
$Z=1, T\propto n^3$

28. (a) According to Bohr's model of an atom:
Speed of the electron in nth orbit, $v_n=2.18\times10^6\,Z/n$ m/s

Angular momentum of an electron in the nth orbit, $L_n=\frac{nh}{2\pi}$

Thus, $L_n\times(mv_n)=\frac{nh}{2\pi}\times m\left(2.18\times10^6\right)\frac{Z}{n}\propto n^0\Rightarrow x=0$

29. **(d)** $\because$ The frequency of the transition $v\propto\frac{1}{n^2}$

30. **(d)** For first line of Lyman series of hydrogen

$$\frac{hc}{\lambda_1}=Rhc\left(\frac{1}{1^2}-\frac{1}{2^2}\right)$$

For second line of Balmer series of hydrogen like ion

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

By question $\lambda_1 = \lambda_2 \Rightarrow \left(\frac{1}{1} - \frac{1}{2}\right) = Z^2\left(\frac{1}{4} - \frac{1}{16}\right)$ or $Z = 2$

31. **(a)** Energy of a H-like atom in it's nth state is given by

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

For, first excited state of He+, n = 2, Z = 2

$$\therefore E_{He^+} = -\frac{4}{2^2} \times 13.6 = -13.6eV$$

32. **(c)** We know, $\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

Where R is the Rydberg constant

For case (1) $n_1 = 3$ and $n_2 = 2$

$$\frac{1}{\lambda_1} = R\left(\frac{1}{3^2} - \frac{1}{2^2}\right) = -\frac{5R}{36}$$

$$\Rightarrow \lambda_1 = -\frac{36}{5R} \text{-----------(i)}$$

For case (ii) $n_1 = 2$ and $n_2 = 1$

$$\frac{1}{\lambda_2} = R\left(\frac{1}{2^2} - \frac{1}{1^2}\right) = -\frac{3R}{4}$$

$$\Rightarrow \lambda_2 = -\frac{4}{3R} \text{--------(ii)}$$

From (i) and (ii), we get $\frac{\lambda_1}{\lambda_2} = \frac{-\frac{36}{5R}}{-\frac{4}{3R}} = \frac{27}{5}$

33. (d) According to Bohr's theory of hydrogen atom

(i) The speed of electron in *n*th orbit

$$v_n = \frac{Ze^2}{2\varepsilon_0 nh}$$

or $v_n \propto \frac{1}{n}$

(ii) The energy of electron in the *n*th orbit

$$E_n = -\frac{me^4}{8\varepsilon_0^2 h^2} \cdot \frac{Z^2}{n^2}$$

$$= -13.6 \frac{Z^2}{n^2} eV$$

or $E_n \propto \frac{1}{n^2}$

(iii) The radius of the electron in the *n*th orbit

$$r_n = \frac{n^2 h^2 \varepsilon_0}{\pi m Z e^2} = 0.53 \frac{n^2}{2} \overset{0}{A}$$

$$r_n \propto n^2$$

34. **(a)** As $r \propto n^2$, therefore, radius of 2nd Bohr's orbit = 4 a_0.

35. **(b)** Transition from higher states to n = 2 lead to emission of radiation with wavelengths 656.3 nm and 365.0 nm. These wavelengths fall in the visible region and constitute the Balmer series.

36. **(a)** $\frac{(Z_{MO}-1)^2}{(Z_{Cu}-1)^2}=\frac{\lambda_{Cu}}{\lambda_{MO}}$ **or** $\left(\frac{41}{28}\right)^2=\frac{\lambda_{Cu}}{0.71}$

$\therefore \lambda_{Cu}=0.71\times\left(\frac{41}{28}\right)^2=1.52\overset{0}{A}$

37. **(c)** For third line of Balmer series $n_1 = 2$, $n_2 = 5$

$\therefore \frac{1}{\lambda}RZ^2\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]$ gives $Z^2=\frac{n_1^2n_2^2}{(n_2^2-n_1^2)\lambda R}$

On putting values Z = 2

From $E=-\frac{13.6Z^2}{n^2}=\frac{-13.6(2)^2}{(1)^2}=-54.4eV$

38. **(a)** Excitation energy $\Delta E = E_2 - E_1 = 13.6\ Z^2\left[\frac{1}{1^2}-\frac{1}{2^2}\right]$

$\Rightarrow 40.8=13.6\times\frac{3}{4}\times Z^2 \Rightarrow Z=2$

Now required energy to remove the electron from ground state

$=\frac{+13.6Z^2}{(1)^2}=13.6(Z)^2=54.4eV$

39. **(d)** The possible number of the spectral lines is given

$=\frac{n(n-1)}{2}=\frac{5(5-1)}{2}=10$

40. **(d)** Angular speed $\propto n^3$

41. **(a)** Orbital speed varies inversely as the radius $v\propto\frac{1}{n}$

42. **(b)** The electron is in the second orbit $(n=2)$

Hence $L=\frac{nh}{2\pi}=\frac{2h}{2\pi}=\frac{6.6\times10^{-34}}{\pi}$

$=2.11\times10^{-34}\ J-\sec$

43. **(b)** $\frac{1}{\lambda}=R\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]$

The largest wavelength in the ultraviolet region of the hydrogen spectrum corresponds to the transition $n_1=2$ to $n_2=1$ (Lyman series).

Thus, $\frac{1}{122}nm=R\left[1-\frac{1}{4}\right]=\frac{3R}{4}$

Which gives $R=\frac{4}{3\times122nm}$

The smallest wavelength λ in the infrared region of the hydrogen spectrum corresponds to $n_1=\infty$ and $n_2=3$ (Paschen series).

Therefore, $\frac{1}{\lambda}=R\left[\frac{1}{3^2}-\frac{1}{\infty}\right]=\frac{R}{9}\Rightarrow\lambda=\frac{9}{R}=\frac{9\times3\times122nm}{4}=823nm$

44. **(d)** $\frac{1}{\lambda}=R\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]$

For second wavelength, $n_1 = 2$, $n_2 = 4 \Rightarrow \lambda_2 = 4861$ Å

45. **(d)** $r\propto n^2\Rightarrow\pi r^2\propto n^4$

46. **(d)** Circumference, $2\pi rn=n\lambda$

47. **(b)** $\frac{1}{\lambda^{|}}=\frac{1}{\lambda}\sqrt{\frac{c-v}{c+v}}$

Here, $\lambda^{|}$ = 706 nm, λ = 656 nm

$\therefore \frac{c-v}{c+v}=\left(\frac{\lambda}{\lambda^{|}}\right)^2=\left(\frac{656}{706}\right)^2=0.86\Rightarrow\frac{v}{c}=\frac{0.14}{1.86}$

48. **(d)** Radius of n[th] orbit $r_n \propto n^2$, graph between r_n and n is

a parabola. Also, $\frac{r_n}{r_1}=\left(\frac{n}{1}\right)^2 \Rightarrow \log_e\left(\frac{r_n}{r_1}\right)=2\log_e(n)$

Comparing this equation with y = mx + c,

Graph between $\log_e\left(\frac{r_n}{r_1}\right)$ and $\log_e(n)$ will be a straight line, passing from origin.

Similarly it can be proved that graph between

$\log_e\left(\frac{f_n}{f_1}\right)$ and $\log_e(n)$ is a straight line. But with negative slops.

49. (b) The energy of nth orbit of hydrogen atom is given by $E_n=-\frac{13.6}{n^2}eV$

Therefore, E_1=−13.6eV

$E_2=-\frac{13.6}{2^2}=-3.4eV$

$E_3=-\frac{13.6}{3^2}=-1.5eV$; $E_4=-\frac{13.6}{4^2}=-0.85eV$

So, $E_3-E_2=-1.5-(-3.4)=1.9Ev$ and $E_4-E_3=-0.85-(-1.5)=.0.65eV$

Hence correct answer is 11.1eV

50. **(a)** Second excited state corresponds to $n = 3$

$\therefore E=\frac{13.6}{3^2}eV=1.51eV$

51. **(b)** If $n_1 = n$ and $n_2 = n + 1$

Maximum wavelength $\lambda_{\max}=\frac{n^2(n+1)^2}{(2n+1)R}$

Therefore, for large $\lambda_{\max}\propto n^3$

52. **(d)** According to Bohr's model, $mvr=\frac{nh}{2\pi}$, where n is an integer.

53. **(c)** When the electron drops from any orbit to second orbit, then wavelength of line obtained belongs to Balmer series

54. **(a)** For Brackett series $\frac{1}{\lambda_{\max}}=R\left[\frac{1}{4^2}-\frac{1}{5^2}\right]=\frac{9}{25\times16}R$

and $\frac{1}{\lambda_{\min}}=R\left[\frac{1}{4^2}-\frac{1}{\infty^2}\right]=\frac{R}{16}\Rightarrow\frac{\lambda_{\max}}{\lambda_{\min}}=\frac{25}{9}$

55. **(d)** $E=E_4-E_3$

$=-\frac{13.6}{4^2}-\left(-\frac{13.6}{3^2}\right)=-0.85+1.51=0.66eV$

56. **(d)** The shortest wavelength occurs when an electron makes a transitions from $n=\infty$ to $n = 2$ state.

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

57. (b) Given that the electron is in M state. This corresponds to the principal quantum number n=3

From Bohr's model, energy of a state with quantum number n is given by E = $-\frac{13.6}{n^2}$

Thus, the energy of the electron in M shell is $E = -\frac{13.6}{3^2} \approx -1.51 eV$

In order to ionise the atom, the minimum energy required is thus +1.51 eV

58. (c) The energy of an electron revolving in an orbit is:

$$E = \frac{-me^4}{8n^2h^2\varepsilon_0^2}$$

where, variables have their usual meanings.

$$\Rightarrow E_n \propto \frac{1}{n^2}$$

$$\Delta E_{n,n-1} = E_n - E_{n-1} = \frac{1}{(n-1)^2} + \frac{1}{n^2} = \frac{2n-1}{n^2-n}$$

59. (a) $\frac{1}{\lambda_{min}} = R\left[\frac{1}{(1)^2} - \frac{1}{\infty}\right] \Rightarrow \lambda_{min} = \frac{1}{R} \approx 910 \overset{0}{A}$

60. (d) $\because B = \frac{\mu_0 I}{2r}$ and $I = \frac{e}{T}$

$$B = \frac{\mu_0 e}{2rT}\left[r \propto n^2, T \propto n^5\right]; \ B \propto \frac{1}{n^5}$$

NEET PREVIOUS YEARS QUESTIONS-EXPLANATIONS

1. **(b)** In a Bohr orbit of the hydrogen atom

Kinetic energy, $k = \frac{kze^2}{2r_n}$

Total energy, $E = \frac{-kze^2}{2r_n}$

So, Kinetic energy : total energy = 1 : –1

2. **(b)** For last line of Balmer series : $n_1 = 2$ and $n_2 = \infty$

$$\frac{1}{\lambda_B} = RZ^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] \Rightarrow \lambda_B = \frac{4}{R} \text{ --------(i)}$$

For last line of Lyman series : $n_1 = 1$ and $n_2 = \infty$

$$\frac{1}{\lambda_L} = RZ^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] \Rightarrow \lambda_L = \frac{1}{R} \text{ --------(ii)}$$

Dividing equation (i) by (ii) $\frac{\lambda_B}{\lambda_L} = \frac{\frac{4}{R}}{\frac{1}{R}} = 4$

3. **(c)** According to Bohr's theory, the wave number of the last line of the Balmer series in hydrogen spectrum,
For hydrogen atom z = 1

$$\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_2^2} - \frac{1}{n_1^2}\right) = 10^7 \times 1^2\left(\frac{1}{2^2} - \frac{1}{\infty^2}\right)$$

$\Rightarrow$ wave number $\frac{1}{\lambda} = 0.25 \times 10^7 m^{-1}$

4. **(a)** At closest distance of approach, the kinetic energy of the particle will convert completely into electrostatic potential energy.

Kinetic energy K.E. $= \frac{1}{2}mv^2$

Potential energy P.E. $= \frac{KQq}{r}$

$$\frac{1}{2}mv^2 = \frac{KQq}{r} \Rightarrow r \propto \frac{1}{m}$$

5. **(a)** Speed of electron in nth orbit

$$V_n = \frac{2\pi KZe^2}{nh}$$

V = (2.19 × 10^6 m/s) $\frac{Z}{n}$

V = (2.19 × 10^6) $\frac{2}{3}$

(Z = 2 & n = 3)

V = 1.46 × 10^6 m/s

6. **(b)** By law of conservation of energy,

$K.E_f = K.E_i$ – excitation energy (ε)

$$\frac{1}{2}mv_1^2 + \frac{1}{2}mv_2^2 = \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 - \varepsilon$$

7. **(c)** For Lyman series $(2 \to 1)$

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

For Balmer series $(3 \to 2)$

$$\frac{1}{\lambda_B} = R\left[\frac{1}{4} - \frac{1}{9}\right] = \frac{5R}{36}$$

$$\Rightarrow \frac{\lambda_L}{\lambda_B} = \frac{\frac{4}{3R}}{\frac{36}{5R}} = \frac{4}{36}\left(\frac{5}{3}\right) = \frac{5}{27}$$

8. **(c)** For the $\lambda = 975$ Å

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

where R is the Rydberg constant

Solving we get $n_2 = n = 4$

($\because n_1 = 1$ ground state)

Therefore number of spectral lines

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

9. TE = .3.4 eV

KE = .T.E PE = 2T.E

KE = +3.4 eV : PE = .6.8 eV

10. $m = 207m_e$, Bohr radius $r_e = 1/m_e$

For fire, Bohr orbit $r_e = 0.53 \times 10^{-10} m$

So, at equilibrium $mr = m_e r_e$

Muonic hydrogen atom radius $r = 2.56 \times 10^{-13} m$

Also, $E_e \propto m_e; E_e = -13.6 eV$

$\Rightarrow E_e / E = m_e / m \Rightarrow E = -2.81 eV$

11. For hydrogen atom

$$E = -\frac{13.6}{n^2} eV$$

12. Bohr model is not valid for the atoms on ion's having more than 1 electron. Single ionized Ne atom has 9 electrons, hence Bohr model is not applicable