DPP – 1 (Atomic Structure)

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Q 1. In Rutherford's experiment the number of α-particles scattered through an angle of 90° is 28 per minute. Then the number of particles scattered through an angle of 60° per minute by the same nucleus is –
(a) 28 per minute (b) 112 per minute
(c) 12.5 per minute (d) 7 per minute

Q 2. The ratio of the areas within 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

Q 3. An electron in hydrogen atom makes transition from n_1 to n_2 state. The time period of electron in initial state is 8 times than in final state then possible values of n_1 and n_2 are
(a) $n_1 = 4$ to $n_2 = 2$ (b) $n_1 = 8$ to $n_2 = 2$
(c) $n_1 = 8$ to $n_2 = 1$ (d) $n_1 = 6$ to $n_2 = 4$

Q 4. In Bohr model of hydrogen atom let R, V and E represent radius of orbit speed of electron and total energy of electron respectively. Which of following quantities are proportional to quantum number n?
(a) VR (b) RE/V
(c) $\frac{V}{E}$ (d) $\frac{R}{E}$

Q 5. The ground state and first excited state energies of hydrogen atom are – 13.6 eV and – 3.4 eV respectively. If potential energy in ground state is taken to be zero. Then:
(a) potential energy in the first excited state would be 20.4 eV
(b) total energy in the first excited state would be 23.8 eV
(c) kinetic energy in the first excited state would be 3.4 eV
(d) total energy in the ground state would be 13.6 eV

Q 6. The energy, the magnitude of linear momentum and orbital radius of an electron in a hydrogen atom corresponding to the quantum number n are E, P and r respectively. Then according to Bohr's theory of hydrogen atom:
(a) EPr is proportional to 1/n (b) P/E is proportional to n
(c) Er is constant for all orbits (d) Pr is proportional to n

Q 7. The magnetic field at the centre of a hydrogen atom due to the motion of the electron in the first Bohr orbit is B. The magnetic field at the centre due to the motion of the electron in the second Bohr orbit will be –

(a) B/4 (b) B/8 (c) B/32 (d) B/64

Q 8. Match the Column

COLUMN I	**COLUMN II**
(A) Angular speed	(P) $\propto \frac{n^3}{Z^2}$
(B) Time period	(Q) $\propto$ n
(C) Angular momentum	(R) $\propto \frac{Z^2}{n^3}$
(D) Magnetic moment	(S) $\propto \frac{Z^3}{n^5}$
(E) Magnetic Field	

Q 9. Let An be the area enclosed by the nth orbit in a hydrogen atom. The graph of $ln\left(\frac{A_n}{A_1}\right)$ against ln(n) will–

(a) be a straight line with slope 2
(b) be a straight line with slope 4
(c) be monotonically increasing nonlinear curve
(d) be a circle

Q 10. The size of a nucleus is of the order of 10^{-14} m. Calculate the order of the magnitude of velocities with which neutrons and protons move inside the nucleus. The mass of a neutron or proton = 1.675 × 10^{-27}kg.

(a) $10^7\ ms^{-1}$
(b) $10^6\ ms^{-1}$
(c) $10^5\ ms^{-1}$
(d) $10^4\ ms^{-1}$

Q 11. An electron is in an excited state in a hydrogen-like atom. It has a total energy of -3.4 eV. The kinetic energy of the electron is E and its de Broglie wavelength is λ.

(a) E = 6.8 eV, λ ~ 6.6 × 10^{-10} m
(b) E = 3.4 eV, λ ~ 6.6 × 10^{-10} m
(c) E = 3.4 eV, λ ~ 6.6 × 10^{-11} m
(d) E = 6.8 eV, λ ~ 6.6 × 10^{-11} m

COMPREHENSION (Q.12 TO Q.14)

Let us assume a different atomic model in which electron revolves around the nucleus (proton) at a separation r under the action of force which is different from electro-static force of attraction. The potential energy between an electron and the proton due to this force is given by U = –k/r^4 where k is a constant.

Q.12 Find the radius of nth Bohr's orbit–

(a) $r = \frac{\pi}{nh}\sqrt{km}$ (b) $r = \frac{2\pi}{nh}\sqrt{km}$
(c) $r = \frac{4\pi}{nh}\sqrt{km}$ (d) $r = \frac{8\pi}{nh}\sqrt{km}$

Q.13 The velocity in the nth orbit is given by–

(a) $V = \frac{nh}{8\pi^2 m\sqrt{km}}$ (b) $V = \frac{n^2 h}{8\pi^2 m\sqrt{km}}$

(c) $V = \frac{nh^2}{4\pi^2 m\sqrt{km}}$ (d) $V = \frac{n^2 h^2}{8\pi^2 m\sqrt{km}}$

Q.14 The total energy of the electron in the nth orbit is given by–

(a) $T.E. = \frac{-n^4 h^4}{128\pi^4 m^2 k}$ (b) $T.E. = \frac{n^4 h^4}{128\pi^4 m^2 k}$

(c) $T.E. = \frac{n^4 h^4}{256 k\pi^4 m^2}$ (d) $T.E. = \frac{-n^4 h^4}{256 k\pi^4 m^2}$

Q.15 An H like atom in ground state is placed in a uniform magnetic induction B such that plane normal of the electron orbit makes an angle of 30º with the magnetic induction. The torque acting on the orbiting electron is

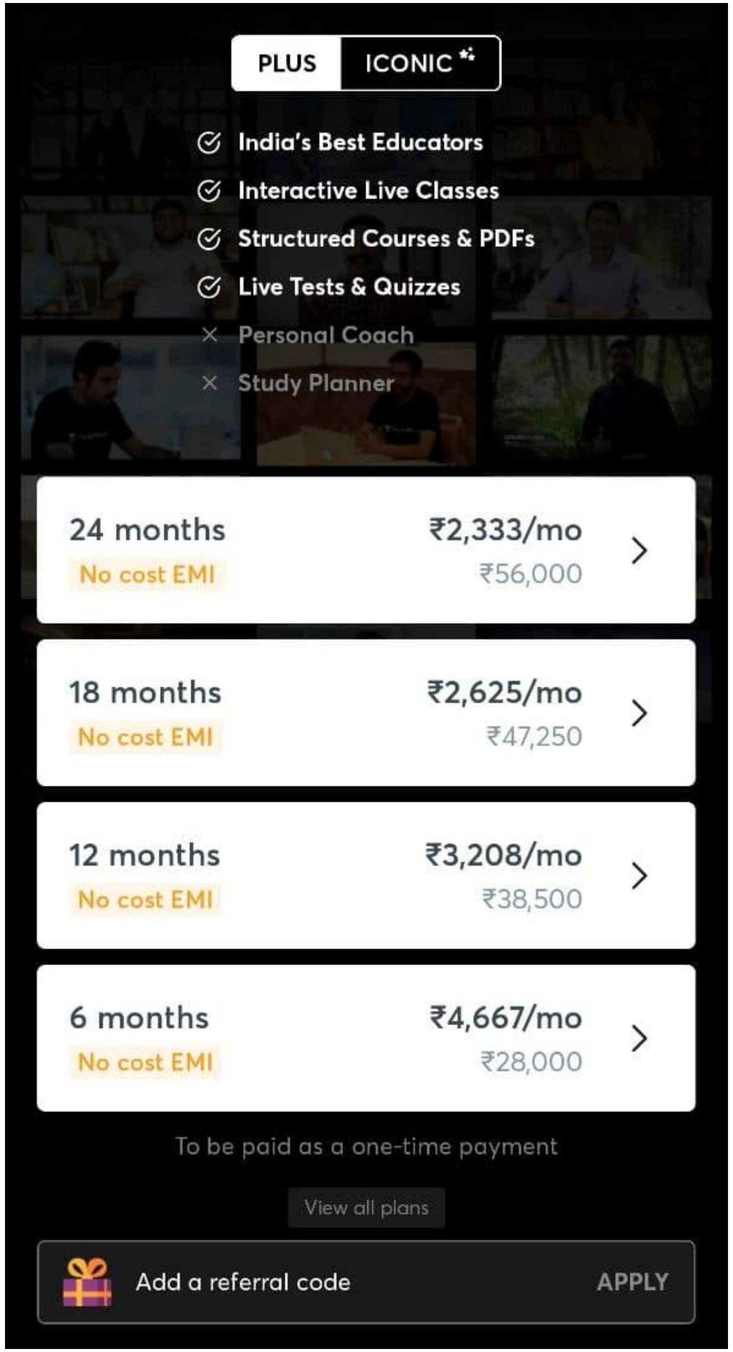
(a) $\frac{ehB}{8\pi m}$ (b) $\frac{eh}{4\pi m}$

(c) $\frac{2eh}{3\pi m}$ (d) Zero

Answer Key

Q.1 b	**Q.2 d**	**Q.3 a**	**Q.4 a,b,c**	**Q.5 a,b,c,d**
Q.6 a,b,c,d	**Q.7 c**	**Q.9 b**	**Q.10 a**	**Q.11 b**
Q.12 c	**Q.13 d**	**Q.14 c**	**Q.15 a**	

Ans.8 **A → R; B → P; C → Q; D → Q; E→ S**



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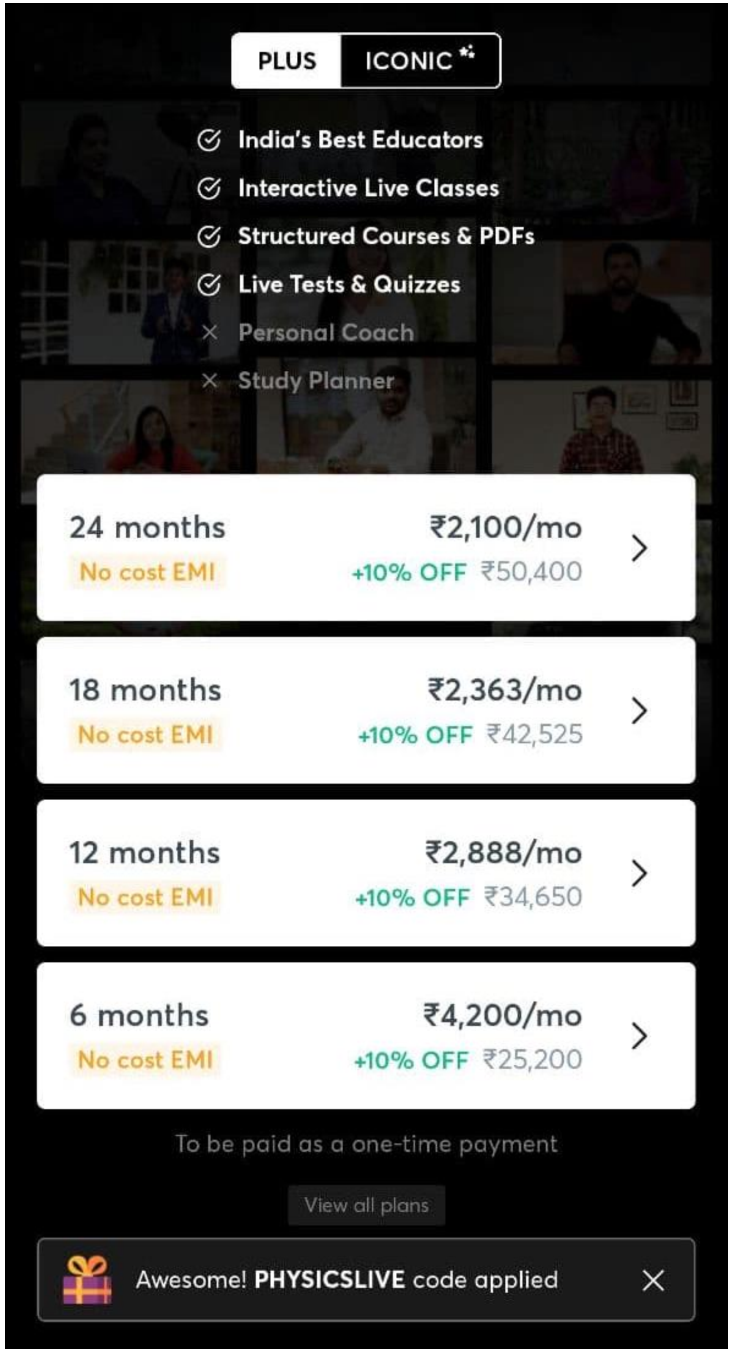


JEE Main & Advanced, NSEP, INPhO, IPhO
Physics DPP - Solution

DPP- 1 Bohr Model : Bohr Model, Energy of Atom, Ionization Energy, Excitation Energy

By Physicsaholics Team

Q1) In Rutherford's experiment the number of α-particles scattered through an angle of 90° is 28 per minute. Then the number of particles scattered through an angle of 60° per minute by the same nucleus is -

$$N(\theta) \propto \frac{1}{\sin^4(\theta/2)}$$

$$\frac{N(90)}{N(60)} = \frac{\sin^4(30)}{\sin^4(45)}$$

(a) 28 per minute

(b) 112 per minute

(c) 12.5 per minute

(d) 7 per minute

$$\frac{28}{N(60)} = \frac{1/16}{1/4} = \frac{1}{4}$$

$$N(60) = 28 \times 4$$
$$= 112/\text{min}$$

Q2) The ratio of the areas within the electron orbits for the first excited state to the ground state for the hydrogen atom is -

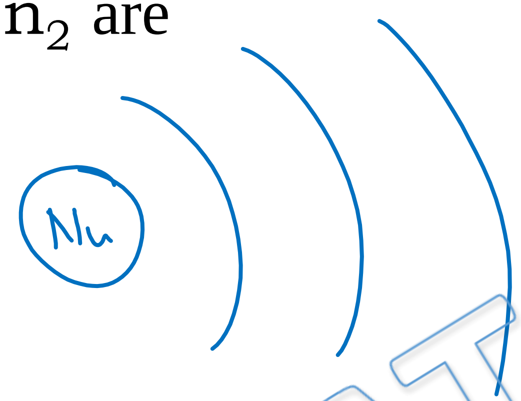
$\downarrow n=1$ $\quad$ $\downarrow n=2$

$$r = r_0 n^2$$

$$\frac{A_2}{A_1} = \frac{\pi r_2^2}{\pi r_1^2} = \frac{2^4}{1^4} = 16$$

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

Q3) An electron in hydrogen atom makes transition from n_1 to n_2 state. The time period of electron in initial state is 8 times than in final state then possible values of n_1 and n_2 are



T → time period , r → radius.

$T^2 \propto r^3 \propto n^6$

$T \propto n^3$

$n \propto T^{1/3} \Rightarrow n_1$ is 2 times of n_2.

(a) $n_1 = 4$ to $n_2 = 2$ ✓
(b) $n_1 = 8$ to $n_2 = 2$
(c) $n_1 = 8$ to $n_2 = 1$
(d) $n_1 = 6$ to $n_2 = 4$

Q4) In Bohr model of hydrogen atom let R, V and E represent radius of orbit, speed of electron and total energy of electron respectively. Which of following quantities are proportional to quantum number n?

(a) VR

(b) RE/V

(c) $\frac{V}{E}$

(d) $\frac{R}{E}$

$R \propto n^2$

$V \propto \frac{1}{n}$

$E \propto \frac{1}{n^2}$

$VR \propto n^2 \times \frac{1}{n} \propto n$

$\frac{RE}{V} \propto n$

$\frac{V}{E} \propto \frac{1 \times n^2}{n \times 1} \propto n$

$\frac{R}{E} \propto \frac{n^2}{1/n^2} \propto n^4$

Q5) The ground state and first excited state energies of hydrogen atom are – 13.6 eV and – 3.4 eV respectively. If potential energy in ground state is taken to be zero. Then:

E = −13.6 eV   E = −3.4 eV

U = −27.2 eV   U = −6.8 eV

KE of n = 2 = 3.4 eV

TE of ground state = −13.6 + 27.2 = 13.6 eV

(a) potential energy in the first excited state would be 20.4 eV

(b) total energy in the first excited state would be 23.8 eV

(c) kinetic energy in the first excited state would be 3.4 eV

(d) total energy in the ground state would be 13.6 eV

Increment in PE of ground state = Increment of PE of any state = 0 − (−27.2 eV) = 27.2 eV

PE of n = 2 = −6.8 + 27.2 = 20.4 eV

TME ,, ,, = −3.4 eV + 27.2 eV = 23.8 eV

Q6) The energy, the magnitude of linear momentum and orbital radius of an electron in a hydrogen atom corresponding to the quantum number n are E, P and r respectively. Then according to Bohr's theory of hydrogen atom:

$E \propto \frac{1}{n^2}$

$P \propto v \propto \frac{1}{n}$

$r \propto n^2$

(a) EPr is proportional to 1/n

(b) P/E is proportional to n

(c) Er is constant for all orbits

(d) Pr is proportional to n

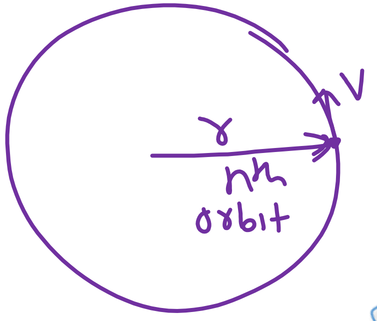
$EPr \propto \frac{1}{n^2} \times \frac{1}{n} \times n^2 \propto \frac{1}{n}$

$Pr \propto \frac{1}{n} \times n^2 \propto n$

$\frac{P}{E} \propto \frac{1}{n} \times \frac{n^2}{1} \propto n$

$Er \propto \frac{1}{n^2} \times n^2 \propto n^0$

Q7) The magnetic field at the centre of a hydrogen atom due to the motion of the electron in the first Bohr orbit is B. The magnetic field at the centre due to the motion of the electron in the second Bohr orbit will be -



$$B = \frac{\mu_0}{4\pi} \times \frac{ev \sin 90}{r^2} \propto \frac{v}{r^2} \propto \frac{1/n}{n^4} \propto \frac{1}{n^5}$$

(a) B/4 (b) B/8 (c) B/32 ✓ (d) B/64

$$\frac{B_1}{B_2} = \frac{n_2^5}{n_1^5}$$

$$\frac{B}{B_2} = \frac{32}{1}$$

Q8) Match the Column

$$\omega \propto \frac{v}{r} \propto \frac{Z/n}{n^2/Z} \propto \frac{Z^2}{n^3}$$

$$T = \frac{2\pi}{\omega} \propto \frac{1}{\omega} \propto \frac{n^3}{Z^2}$$

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

$$M = \frac{q\omega R^2}{2} \propto \frac{Z^2}{n^3} \times \frac{n^4}{Z^2} \propto n$$

COLUMN I	**COLUMN II**
(A) Angular speed	(P) $\propto \frac{n^3}{Z^2}$
(B) Time period	(Q) $\propto$ n
(C) Angular momentum	(R) $\propto \frac{Z^2}{n^3}$
(D) Magnetic moment	(S) $\propto \frac{Z^3}{n^5}$
(E) Magnetic Field	

$$\frac{M}{L} = \frac{q}{2m}$$

$$M = \frac{q}{2m} L \propto n$$

$$B = \frac{\mu_0}{4\pi} \frac{ev}{r^2} \propto \frac{Z/n}{n^4/Z^2} \propto \frac{Z^3}{n^5}$$

Q9) Let An be the area enclosed by the nth orbit in a hydrogen atom. The graph of $ln\left(\frac{A_n}{A_1}\right)$ against ln(n) will–

$r_n = (.53 Å)\, n^2$

$A_n = \pi r_n^2 = \pi (.53 Å)^2 n^4$

$A_1 = \pi (.53 Å)^2$

$\frac{A_n}{A_1} = n^4$

$\ln\left(\frac{A_n}{A_1}\right) = \ln n^4$

$\underbrace{\ln\left(\frac{A_n}{A_1}\right)}_{y} = \underbrace{4}_{\text{Slope}}\, \underbrace{\ln n}_{x}$

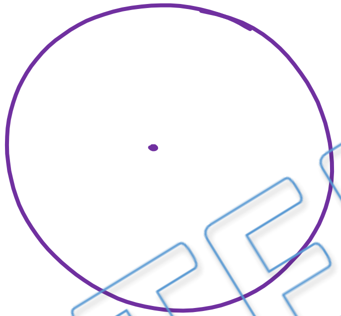
(a) be a straight line with slope 2

(b) be a straight line with slope 4 ✓

(c) be monotonically increasing nonlinear curve

(d) be a circle

Q10) The size of a nucleus is of the order of 10^{-14} m. Calculate the order of the magnitude of velocities with which neutrons and protons move inside the nucleus. The mass of a neutron or proton = 1.675×10^{-27} kg.



$r_{max} = 10^{-14}$ m

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

$v = \frac{nh}{2\pi m r}$

for min speed
$n = 1$
$r = 10^{-14}$ m

$v_{min} = \frac{h}{2\pi m \times 10^{-14}}$

$= \frac{6.6 \times 10^{-34}}{2\pi \times 1.67 \times 10^{-27} \times 10^{-14}}$

$= \left(\frac{66}{2\pi \times 1.67}\right) \times 10^{7}$

(a) $10^7\ ms^{-1}$ ✓

(b) $10^6\ ms^{-1}$

(c) $10^5\ ms^{-1}$

(d) $10^4\ ms^{-1}$

Q11) An electron is in an excited state in a hydrogen-like atom. It has a total energy of -3.4 eV. The kinetic energy of the electron is E and its de Broglie wavelength is λ.

$E = |TME| = 3.4\, eV$

$\lambda = \frac{h}{\sqrt{2mE}}$

$= \frac{6.6 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 3.4 \times 1.6 \times 10^{-19}}}$

$= \frac{6.6 \times 10^{-9}}{\sqrt{64 \times 9 \times 1.6}}$

$= \frac{660 \times 10^{-10}}{8 \times 3 \times 4}$

(a) E = 6.8 eV, λ ~ 6.6 × 10^{-10} m

(b) E = 3.4 eV, λ ~ 6.6 × 10^{-10} m ✓

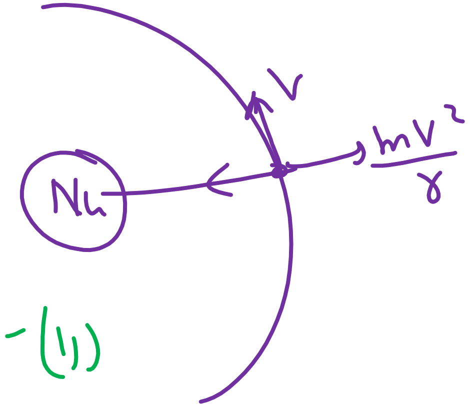
(c) E = 3.4 eV, λ ~ 6.6 × 10^{-11} m

(d) E = 6.8 eV, λ ~ 6.6 × 10^{-11} m

COMPREHENSION (Q12 to Q14)

Let us assume a different atomic model in which electron revolves around the nucleous (proton) at a seperation r under the action of force which is different from electro-static force of attraction. The potential energy between an electron and the proton due to this force is given by $U = -k/r^4$ where k is a constant.

$$F = -\frac{dU}{dr} = \frac{4k}{r^5} = \frac{mv^2}{r}$$



Q12) Find the radius of nth Bohr's orbit–

$$mv^2 r^4 = 4k \quad \text{---(1)}$$

$$m^2 v^2 r^2 = \frac{n^2 h^2}{(2\pi)^2} \quad \text{---(1)}$$

(a) $r = \frac{\pi}{nh}\sqrt{km}$

(b) $r = \frac{2\pi}{nh}\sqrt{km}$

(c) $r = \frac{4\pi}{nh}\sqrt{km}$ ✓

(d) $r = \frac{8\pi}{nh}\sqrt{km}$

$$\frac{r^2}{m} = \frac{4k \times 4\pi^2}{n^2 h^2}$$

$$r = \frac{4\pi\sqrt{km}}{nh}$$

Q13) The velocity in the nth orbit is given by–

$$r = \frac{4\pi}{nh}\sqrt{Km}$$

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

$$V = \frac{nh}{2\pi m} \times \frac{nh}{4\pi\sqrt{Km}} = \frac{n^2h^2}{8\pi^2 m\sqrt{Km}}$$

(a) $V = \dfrac{nh}{8\pi^2 m\sqrt{km}}$

(b) $V = \dfrac{n^2h}{8\pi^2 m\sqrt{km}}$

(c) $V = \dfrac{nh^2}{4\pi^2 m\sqrt{km}}$

(d) $V = \dfrac{n^2h^2}{8\pi^2 m\sqrt{km}}$ ✓

Q14) The total energy of the electron in the nth orbit is given by–

$KE = \frac{1}{2} m v^2 = \frac{1}{2} m \frac{n^4 \hbar^4}{64 \pi^4 m^2 K m} = \frac{n^4 \hbar^4}{128 \pi^4 m^2 K}$

$PE = -\frac{K}{r^4} = \frac{-K (n\hbar)^4}{(4\pi\sqrt{Km})^4} = -\frac{n^4 \hbar^4 K}{256 \pi^4 K^2 m^2}$

(a) $T.E. = \frac{-n^4h^4}{128\pi^4m^2k}$

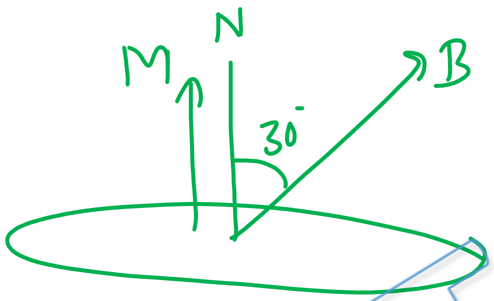
(b) $T.E. = \frac{n^4h^4}{128\pi^4m^2k}$

(c) $T.E. = \frac{n^4h^4}{256k\pi^4m^2}$ ✓

(d) $T.E. = \frac{-n^4h^4}{256k\pi^4m^2}$

$T.E. = + \frac{n^4 \hbar^4}{256 \pi^4 K m^2}$

Q15) An H like atom in ground state is placed in a uniform magnetic induction B such that plane normal of the electron orbit makes an angle of 30º with the magnetic induction. The torque acting on the orbiting electron is



$$\tau = MB\sin 30 = \frac{MB}{2}$$

$$= \frac{eL}{2m} \times \frac{B}{2}$$

$$= \frac{eB}{4m} \times \frac{nh}{2\pi}$$

$$= \frac{eBh}{8\pi m}$$

$$\frac{M}{L} = \frac{q}{2m} = \frac{e}{2m}$$

(a) $\frac{ehB}{8\pi m}$

(b) $\frac{eh}{4\pi m}$

(c) $\frac{2eh}{3\pi m}$

(d) Zero

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Chalo Niklo