BOHR'S THEORY AND PHYSICS OF ATOM
CHAPTER 43

1. $a_0 = \dfrac{\varepsilon_0 h^2}{\pi m e^2} = \dfrac{A^2T^2(ML^2T^{-1})^2}{L^2MLT^{-2}M(AT)^2} = \dfrac{M^2L^4T^{-2}}{M^2L^3T^{-2}} = L$

   $\therefore a_0$ has dimensions of length.

2. We know, $\bar{\lambda} = 1/\lambda = 1.1 \times 10^7 \times (1/n_1^2 - 1/n_2^2)$

   a) $n_1 = 2$, $n_2 = 3$

   or, $1/\lambda = 1.1 \times 10^7 \times (1/4 - 1/9)$

   or, $\lambda = \dfrac{36}{5 \times 1.1 \times 10^7} = 6.54 \times 10^{-7} = 654$ nm

   b) $n_1 = 4$, $n_2 = 5$

   $\bar{\lambda} = 1/\lambda = 1.1 \times 10^7\ (1/16 - 1/25)$

   or, $\lambda = \dfrac{400}{1.1 \times 10^7 \times 9} = 40.404 \times 10^{-7}$ m $= 4040.4$ nm

   for $R = 1.097 \times 10^7$, $\lambda = 4050$ nm

   c) $n_1 = 9$, $n_2 = 10$

   $1/\lambda = 1.1 \times 10^7\ (1/81 - 1/100)$

   or, $\lambda = \dfrac{8100}{19 \times 1.1 \times 10^7} = 387.5598 \times 10^{-7} = 38755.9$ nm

   for $R = 1.097 \times 10^7$; $\lambda = 38861.9$ nm

3. Small wave length is emitted i.e. longest energy

   $n_1 = 1$, $n_2 = \infty$

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

   $\Rightarrow \dfrac{1}{\lambda} = 1.1 \times 10^7 \left(\dfrac{1}{1} - \dfrac{1}{\infty}\right)$

   $\Rightarrow \lambda = \dfrac{1}{1.1 \times 10^7} = \dfrac{1}{1.1} \times 10^{-7} = 0.909 \times 10^{-7} = 90.9 \times 10^{-8} = 91$ nm.

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

   $\Rightarrow \lambda = \dfrac{1}{1.1 \times 10^{-7} z^2} = \dfrac{91 \text{ nm}}{4} = 23$ nm

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

   $\Rightarrow \lambda = \dfrac{91 \text{ nm}}{z^2} = \dfrac{91}{9} = 10$ nm

4. Rydberg's constant $= \dfrac{me^4}{8h^3C\varepsilon_0^2}$

   $m_e = 9.1 \times 10^{-31}$ kg, $e = 1.6 \times 10^{-19}$ c, $h = 6.63 \times 10^{-34}$ J-S, $C = 3 \times 10^8$ m/s, $\varepsilon_0 = 8.85 \times 10^{-12}$

   or, $R = \dfrac{9.1 \times 10^{-31} \times (1.6 \times 10^{-19})^4}{8 \times (6.63 \times 10^{-34})^3 \times 3 \times 10^8 \times (8.85 \times 10^{-12})^2} = 1.097 \times 10^7\ m^{-1}$

5. $n_1 = 2$, $n_2 = \infty$

   $E = \dfrac{-13.6}{n_1^2} - \dfrac{-13.6}{n_2^2} = 13.6\left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right)$

   $= 13.6\ (1/\infty - 1/4) = -13.6/4 = -3.4$ eV

6. a) $n = 1$, $r = \dfrac{\varepsilon_0 h^2 n^2}{\pi m Z e^2} = \dfrac{0.53 n^2}{Z} A°$

$= \dfrac{0.53 \times 1}{2}$ = 0.265 A°

$\varepsilon = \dfrac{-13.6 z^2}{n^2} = \dfrac{-13.6 \times 4}{1}$ = –54.4 eV

b) $n = 4$, $r = \dfrac{0.53 \times 16}{2}$ = 4.24 A

$\varepsilon = \dfrac{-13.6 \times 4}{164}$ = –3.4 eV

c) $n = 10$, $r = \dfrac{0.53 \times 100}{2}$ = 26.5 A

$\varepsilon = \dfrac{-13.6 \times 4}{100}$ = –0.544 A

7. As the light emitted lies in ultraviolet range the line lies in hyman series.

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

$$\Rightarrow \frac{1}{102.5 \times 10^{-9}} = 1.1 \times 10^7 \,(1/1^2 - 1/n_2^2)$$

$$\Rightarrow \frac{10^9}{102.5} = 1.1 \times 10^7 (1 - 1/n_2^2) \Rightarrow \frac{10^2}{102.5} = 1.1 \times 10^7 (1 - 1/n_2^2)$$

$$\Rightarrow 1 - \frac{1}{n_2^2} = \frac{100}{102.5 \times 1.1} \Rightarrow \frac{1}{n_2^2} = \frac{1 - 100}{102.5 \times 1.1}$$

$\Rightarrow n_2 = 2.97 = 3.$

8. a) First excitation potential of
$He^+ = 10.2 \times z^2 = 10.2 \times 4 = 40.8$ V

b) Ionization potential of L_1^{++}
$= 13.6 \text{ V} \times z^2 = 13.6 \times 9 = 122.4$ V

9. $n_1 = 4 \rightarrow n_2 = 2$

$n_1 = 4 \rightarrow 3 \rightarrow 2$

$$\frac{1}{\lambda} = 1.097 \times 10^7 \left(\frac{1}{16} - \frac{1}{4}\right)$$

$$\Rightarrow \frac{1}{\lambda} = 1.097 \times 10^7 \left(\frac{1-4}{16}\right) \Rightarrow \frac{1.097 \times 10^7 \times 3}{16}$$

$$\Rightarrow \lambda = \frac{16 \times 10^{-7}}{3 \times 1.097} = 4.8617 \times 10^{-7}$$

$= 1.861 \times 10^{-9} = 487$ nm

$n_1 = 4$ and $n_2 = 3$

$$\frac{1}{\lambda} = 1.097 \times 10^7 \left(\frac{1}{16} - \frac{1}{9}\right)$$

$$\Rightarrow \frac{1}{\lambda} = 1.097 \times 10^7 \left(\frac{9-16}{144}\right) \Rightarrow \frac{1.097 \times 10^7 \times 7}{144}$$

$$\Rightarrow \lambda = \frac{144}{7 \times 1.097 \times 10^7} = 1875 \text{ nm}$$

$n_1 = 3 \rightarrow n_2 = 2$

$$\frac{1}{\lambda} = 1.097 \times 10^7 \left(\frac{1}{9} - \frac{1}{4}\right)$$

$\Rightarrow \ \dfrac{1}{\lambda} = 1.097 \times 10^7 \left(\dfrac{4-9}{36}\right) \Rightarrow \dfrac{1.097 \times 10^7 \times 5}{66}$

$\Rightarrow \lambda = \dfrac{36 \times 10^{-7}}{5 \times 1.097} = 656$ nm

10. $\lambda = 228$ A°

$E = \dfrac{hc}{\lambda} = \dfrac{6.63 \times 10^{-34} \times 3 \times 10^8}{228 \times 10^{-10}} = 0.0872 \times 10^{-16}$

The transition takes place form n = 1 to n = 2

Now, ex. $13.6 \times 3/4 \times z^2 = 0.0872 \times 10^{-16}$

$\Rightarrow z^2 = \dfrac{0.0872 \times 10^{-16} \times 4}{13.6 \times 3 \times 1.6 \times 10^{-19}} = 5.3$

$z = \sqrt{5.3} = 2.3$

The ion may be Helium.

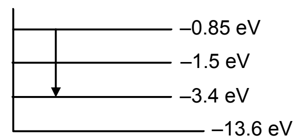
11. $F = \dfrac{q_1 q_2}{4\pi\varepsilon_0 r^2}$

[Smallest dist. Between the electron and nucleus in the radius of first Bohrs orbit]

$= \dfrac{(1.6 \times 10^{-19}) \times (1.6 \times 10^{-19}) \times 9 \times 10^9}{(0.53 \times 10^{-10})^2} = 82.02 \times 10^{-9} = 8.202 \times 10^{-8} = 8.2 \times 10^{-8}$ N

12. a) From the energy data we see that the H atom transists from binding energy of 0.85 ev to exitation energy of 10.2 ev = Binding Energy of –3.4 ev.

So, n = 4 to n = 2



b) We know = $1/\lambda = 1.097 \times 10^7$ (1/4 – 1/16)

$\Rightarrow \lambda = \dfrac{16}{1.097 \times 3 \times 10^7} = 4.8617 \times 10^{-7} = 487$ nm.

13. The second wavelength is from Balmer to hyman i.e. from n = 2 to n = 1

$n_1 = 2$ to $n_2 = 1$

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

$\Rightarrow \dfrac{1}{\lambda} = 1.097 \times 10^7 \left(\dfrac{1}{2^2} - \dfrac{1}{1^2}\right) \Rightarrow 1.097 \times 10^7 \left(\dfrac{1}{4} - 1\right)$

$\Rightarrow \lambda = \dfrac{4}{1.097 \times 3} \times 10^{-7}$

$= 1.215 \times 10^{-7} = 121.5 \times 10^{-9} = 122$ nm.

14. Energy at n = 6, $E = \dfrac{-13.6}{36} = -0.3777777$

Energy in groundstate = –13.6 eV

Energy emitted in Second transition = –13.6 –(0.37777 + 1.13)

= –12.09 = 12.1 eV

b) Energy in the intermediate state = 1.13 ev + 0.0377777

$= 1.507777 = \dfrac{13.6 \times z^2}{n^2} = \dfrac{13.6}{n^2}$

or, $n = \sqrt{\dfrac{13.6}{1.507}} = 3.03 = 3 = n$.

15. The potential energy of a hydrogen atom is zero in ground state.

An electron is board to the nucleus with energy 13.6 ev.,

Show we have to give energy of 13.6 ev. To cancel that energy.

Then additional 10.2 ev. is required to attain first excited state.

Total energy of an atom in the first excited state is = 13.6 ev. + 10.2 ev. = 23.8 ev.

16. Energy in ground state is the energy acquired in the transition of 2^{nd} excited state to ground state.
As 2^{nd} excited state is taken as zero level.

$$E = \frac{hc}{\lambda_1} = \frac{4.14\times10^{-15}\times3\times10^8}{46\times10^{-9}} = \frac{1242}{46} = 27 \text{ ev.}$$

Again energy in the first excited state

$$E = \frac{hc}{\lambda_{II}} = \frac{4.14\times10^{-15}\times3\times10^8}{103.5} = 12 \text{ ev.}$$

17. a) The gas emits 6 wavelengths, let it be in nth excited state.

$\Rightarrow \frac{n(n-1)}{2} = 6 \Rightarrow n = 4 \;\; \therefore$ The gas is in 4^{th} excited state.

b) Total no.of wavelengths in the transition is 6. We have $\frac{n(n-1)}{2} = 6 \Rightarrow n = 4$.

18. a) We know, $m\,\upsilon\,r = \frac{nh}{2\pi} \Rightarrow mr^2w = \frac{nh}{2\pi} \Rightarrow w = \frac{hn}{2\pi\times m\times r^2}$

$$= \frac{1\times6.63\times10^{-34}}{2\times3.14\times9.1\times10^{-31}\times(0.53)^2\times10^{-20}} = 0.413\times10^{17}\text{ rad/s} = 4.13\times10^{17}\text{ rad/s.}$$

19. The range of Balmer series is 656.3 nm to 365 nm. It can resolve λ and $\lambda + \Delta\lambda$ if $\lambda/\Delta\lambda = 8000$.

$\therefore$ No.of wavelengths in the range $= \frac{656.3-365}{8000} = 36$

Total no.of lines 36 + 2 = 38 [extra two is for first and last wavelength]

20. a) $n_1 = 1$, $n_2 = 3$, $E = 13.6\,(1/1 - 1/9) = 13.6\times8/9 = hc/\lambda$

or, $\frac{13.6\times8}{9} = \frac{4.14\times10^{-15}\times3\times10^8}{\lambda} \Rightarrow \lambda = \frac{4.14\times3\times10^{-7}}{13.6\times8} = 1.027\times10^{-7} = 103$ nm.

b) As 'n' changes by 2, we may consider n = 2 to n = 4

then $E = 13.6\times(1/4 - 1/16) = 2.55$ ev and $2.55 = \frac{1242}{\lambda}$ or $\lambda = 487$ nm.

21. Frequency of the revolution in the ground state is $\frac{V_0}{2\pi r_0}$

[r_0 = radius of ground state, V_0 = velocity in the ground state]

$\therefore$ Frequency of radiation emitted is $\frac{V_0}{2\pi r_0} = f$

$\therefore C = f\lambda \Rightarrow \lambda = C/f = \frac{C2\pi r_0}{V_0}$

$\therefore \lambda = \frac{C2\pi r_0}{V_0} = 45.686$ nm = 45.7 nm.

22. KE = 3/2 KT = 1.5 KT, $K = 8.62\times10^{-5}$ eV/k, Binding Energy = $-13.6\,(1/\infty - 1/1) = 13.6$ eV.
According to the question, 1.5 KT = 13.6

$\Rightarrow 1.5\times8.62\times10^{-5}\times T = 13.6$

$\Rightarrow T = \frac{13.6}{1.5\times8.62\times10^{-5}} = 1.05\times10^5$ K

No, because the molecule exists an H_2^+ which is impossible.

23. $K = 8.62\times10^{-5}$ eV/k
K.E. of H_2 molecules = 3/2 KT
Energy released, when atom goes from ground state to no = 3

$\Rightarrow 13.6\,(1/1 - 1/9) \Rightarrow 3/2\text{ KT} = 13.6(1/1 - 1/9)$

$\Rightarrow 3/2\times8.62\times10^{-5}\text{ T} = \frac{13.6\times8}{9}$

$\Rightarrow T = 0.9349\times10^5 = 9.349\times10^4 = 9.4\times10^4$ K.

24. n = 2, T = 10^{-8} s

Frequency = $\dfrac{me^4}{4\varepsilon_0^2 n^3 h^3}$

So, time period = 1/f = $\dfrac{4\varepsilon o^2 n^3 h^3}{me^4} \Rightarrow \dfrac{4 \times (8.85)^2 \times 2^3 \times (6.63)^3}{9.1 \times (1.6)^4} \times \dfrac{10^{-24} - 10^{-102}}{10^{-76}}$

= $12247.735 \times 10^{-19}$ sec.

No.of revolutions = $\dfrac{10^{-8}}{12247.735 \times 10^{-19}}$ = 8.16×10^5

= 8.2×10^6 revolution.

25. Dipole moment (μ)

= n i A = 1 × q/t A = qfA

= $e \times \dfrac{me^4}{4\varepsilon_0^2 h^3 n^3} \times (\pi r_0^2 n^2) = \dfrac{me^5 \times (\pi r_0^2 n^2)}{4\varepsilon_0^2 h^3 n^3}$

= $\dfrac{(9.1 \times 10^{-31})(1.6 \times 10^{-19})^5 \times \pi \times (0.53)^2 \times 10^{-20} \times 1}{4 \times (8.85 \times 10^{-12})^2 (6.64 \times 10^{-34})^3 (1)^3}$

= $0.0009176 \times 10^{-20} = 9.176 \times 10^{-24}$ A - m^2.

26. Magnetic Dipole moment = n i A = $\dfrac{e \times me^4 \times \pi r_n^2 n^2}{4\varepsilon_0^2 h^3 n^3}$

Angular momentum = mvr = $\dfrac{nh}{2\pi}$

Since the ratio of magnetic dipole moment and angular momentum is independent of Z.
Hence it is an universal constant.

Ratio = $\dfrac{e^5 \times m \times \pi r_0^2 n^2}{24\varepsilon_0 h^3 n^3} \times \dfrac{2\pi}{nh} \Rightarrow \dfrac{(1.6 \times 10^{-19})^5 \times (9.1 \times 10^{-31}) \times (3.14)^2 \times (0.53 \times 10^{-10})^2}{2 \times (8.85 \times 10^{-12})^2 \times (6.63 \times 10^{-34})^4 \times 1^2}$

= 8.73×10^{10} C/kg.

27. The energies associated with 450 nm radiation = $\dfrac{1242}{450}$ = 2.76 ev

Energy associated with 550 nm radiation = $\dfrac{1242}{550}$ = 2.258 = 2.26 ev.

The light comes under visible range
Thus, $n_1 = 2$, $n_2 = 3, 4, 5, \ldots\ldots$
$E_2 - E_3 = 13.6\ (1/2^2 - 1/3^2) = 1.9$ ev
$E_2 - E_4 = 13.6\ (1/4 - 1/16) = 2.55$ ev
$E_2 - E_5 = 13.6\ (1/4 - 1/25) = 2.856$ ev
Only $E_2 - E_4$ comes in the range of energy provided. So the wavelength corresponding to that energy will be absorbed.

$\lambda = \dfrac{1242}{2.55}$ = 487.05 nm = 487 nm

487 nm wavelength will be absorbed.

28. From transitions n =2 to n =1.
E = 13.6 (1/1 – 1/4) = 13.6 × 3/4 = 10.2 eV
Let in check the transitions possible on He. n = 1 to 2
$E_1 = 4 \times 13.6\ (1 - 1/4) = 40.8$ eV [E_1 > E hence it is not possible]
n = 1 to n = 3
$E_2 = 4 \times 13.6\ (1 - 1/9) = 48.3$ eV [E_2 > E hence impossible]
Similarly n = 1 to n = 4 is also not possible.
n = 2 to n = 3
$E_3 = 4 \times 13.6\ (1/4 - 1/9) = 7.56$ eV

n = 2 to n = 4

$E_4 = 4 \times 13.6\ (1/4 - 1/16) = 10.2$ eV

As, $E_3 < E$ and $E_4 = E$

Hence E_3 and E_4 can be possible.

29. $\lambda = 50$ nm

Work function = Energy required to remove the electron from $n_1 = 1$ to $n_2 = \infty$.

$E = 13.6\ (1/1 - 1/\infty) = 13.6$

$\frac{hc}{\lambda} - 13.6 = KE$

$\Rightarrow \frac{1242}{50} - 13.6 = KE \Rightarrow KE = 24.84 - 13.6 = 11.24$ eV.

30. $\lambda = 100$ nm

$E = \frac{hc}{\lambda} = \frac{1242}{100} = 12.42$ eV

a) The possible transitions may be E_1 to E_2

E_1 to E_2, energy absorbed = 10.2 eV

Energy left = 12.42 – 10.2 = 2.22 eV

$2.22\text{ eV} = \frac{hc}{\lambda} = \frac{1242}{\lambda}$ or $\lambda = 559.45 = 560$ nm

E_1 to E_3, Energy absorbed = 12.1 eV

Energy left = 12.42 – 12.1 = 0.32 eV

$0.32 = \frac{hc}{\lambda} = \frac{1242}{\lambda}$ or $\lambda = \frac{1242}{0.32} = 3881.2 = 3881$ nm

E_3 to E_4, Energy absorbed = 0.65

Energy left = 12.42 – 0.65 = 11.77 eV

$11.77 = \frac{hc}{\lambda} = \frac{1242}{\lambda}$ or $\lambda = \frac{1242}{11.77} = 105.52$

b) The energy absorbed by the H atom is now radiated perpendicular to the incident beam.

$\rightarrow 10.2 = \frac{hc}{\lambda}$ or $\lambda = \frac{1242}{10.2} = 121.76$ nm

$\rightarrow 12.1 = \frac{hc}{\lambda}$ or $\lambda = \frac{1242}{12.1} = 102.64$ nm

$\rightarrow 0.65 = \frac{hc}{\lambda}$ or $\lambda = \frac{1242}{0.65} = 1910.76$ nm

31. $\phi = 1.9$ eV

a) The hydrogen is ionized

$n_1 = 1$, $n_2 = \infty$

Energy required for ionization = $13.6\ (1/n_1^2 - 1/n_2^2) = 13.6$

$\frac{hc}{\lambda} - 1.9 = 13.6 \Rightarrow \lambda = 80.1$ nm = 80 nm.

b) For the electron to be excited from $n_1 = 1$ to $n_2 = 2$

$E = 13.6\ (1/n_1^2 - 1/n_2^2) = 13.6(1 - ¼) = \frac{13.6 \times 3}{4}$

$\frac{hc}{\lambda} - 1.9 = \frac{13.6 \times 3}{4} \Rightarrow \lambda = 1242 / 12.1 = 102.64 = 102$ nm.

32. The given wavelength in Balmer series.

The first line, which requires minimum energy is from $n_1 = 3$ to $n_2 = 2$.

$\therefore$ The energy should be equal to the energy required for transition from ground state to n = 3.

i.e. E = 13.6 [1 – (1/9)] = 12.09 eV

$\therefore$ Minimum value of electric field = 12.09 v/m = 12.1 v/m

33. In one dimensional elastic collision of two bodies of equal masses.
The initial velocities of bodies are interchanged after collision.
$\therefore$ Velocity of the neutron after collision is zero.
Hence, it has zero energy.

34. The hydrogen atoms after collision move with speeds v_1 and v_2.
$mv = mv_1 + mv_2$ …(1)
$\frac{1}{2}mv^2 = \frac{1}{2}mv_1^2 + \frac{1}{2}mv_2^2 + \Delta E$ …(2)
From (1) $v^2 = (v_1 + v_2)^2 = v_1^2 + v_2^2 + 2v_1v_2$
From (2) $v^2 = v_1^2 + v_2^2 + 2\Delta E/m$
$= 2v_1v_2 = \frac{2\Delta E}{m}$ …(3)
$(v_1 - v_2)^2 = (v_1 + v_2)^2 - 4v_1v_2$
$\Rightarrow (v_1 - v_2) = v^2 - 4\Delta E/m$
For minimum value of 'v'
$v_1 = v_2 \Rightarrow v^2 - (4\Delta E/m) = 0$
$\Rightarrow v^2 = \frac{4\Delta E}{m} = \frac{4 \times 13.6 \times 1.6 \times 10^{-19}}{1.67 \times 10^{-27}}$
$\Rightarrow v = \sqrt{\frac{4 \times 13.6 \times 1.6 \times 10^{-19}}{1.67 \times 10^{-27}}} = 7.2 \times 10^4$ m/s.

35. Energy of the neutron is $\frac{1}{2} mv^2$.
The condition for inelastic collision is $\Rightarrow \frac{1}{2} mv^2 > 2\Delta E$
$\Rightarrow \Delta E = \frac{1}{4} mv^2$
ΔE is the energy absorbed.
Energy required for first excited state is 10.2 ev.
$\therefore \Delta E < 10.2$ ev
$\therefore 10.2 \text{ ev} < \frac{1}{4} mv^2 \Rightarrow V_{min} = \sqrt{\frac{4 \times 10.2}{m}}$ ev
$\Rightarrow v = \sqrt{\frac{10.2 \times 1.6 \times 10^{-19} \times 4}{1.67 \times 10^{-27}}} = 6 \times 10^4$ m/sec.

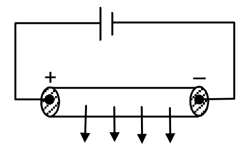
36. a) $\lambda = 656.3$ nm
Momentum $P = E/C = \frac{hc}{\lambda} \times \frac{1}{c} = \frac{h}{\lambda} = \frac{6.63 \times 10^{-34}}{656.3 \times 10^{-9}} = 0.01 \times 10^{-25} = 1 \times 10^{-27}$ kg-m/s
b) $1 \times 10^{-27} = 1.67 \times 10^{-27} \times v$
$\Rightarrow v = 1/1.67 = 0.598 = 0.6$ m/s
c) KE of atom $= \frac{1}{2} \times 1.67 \times 10^{-27} \times (0.6)^2 = \frac{0.3006 \times 10^{-27}}{1.6 \times 10^{-19}}$ ev $= 1.9 \times 10^{-9}$ ev.

37. Difference in energy in the transition from n = 3 to n = 2 is 1.89 ev.
Let recoil energy be E.
$\frac{1}{2} m_e [V_2^2 - V_3^2] + E = 1.89 \text{ ev} \Rightarrow 1.89 \times 1.6 \times 10^{-19}$ J
$\therefore \frac{1}{2} \times 9.1 \times 10^{-31}\left[\left(\frac{2187}{2}\right)^2 - \left(\frac{2187}{3}\right)^2\right] + E = 3.024 \times 10^{-19}$ J
$\Rightarrow E = 3.024 \times 10^{-19} - 3.0225 \times 10^{-25}$

38. $n_1 = 2$, $n_2 = 3$
Energy possessed by H_α light
$= 13.6 \, (1/n_1^2 - 1/n_2^2) = 13.6 \times (1/4 - 1/9) = 1.89$ eV.
For $H\alpha$ light to be able to emit photoelectrons from a metal the work function must be greater than or equal to 1.89 ev.

39. The maximum energy liberated by the Balmer Series is $n_1 = 2$, $n_2 = \infty$
$E = 13.6(1/n_1^2 - 1/n_2^2) = 13.6 \times 1/4 = 3.4$ eV
3.4 ev is the maximum work function of the metal.

40. Wocs = 1.9 eV
The radiations coming from the hydrogen discharge tube consist of photons of energy = 13.6 eV.
Maximum KE of photoelectrons emitted
= Energy of Photons – Work function of metal.
= 13.6 eV – 1.9 eV = 11.7 eV



41. $\lambda = 440$ nm, e = Charge of an electron, $\phi = 2$ eV, V_0 = stopping potential.
We have, $\frac{hc}{\lambda} - \phi = eV_0 \Rightarrow \frac{4.14 \times 10^{-15} \times 3 \times 10^{8}}{440 \times 10^{-9}} - 2eV = eV_0$
$\Rightarrow eV_0 = 0.823$ eV $\Rightarrow V_0 = 0.823$ volts.

42. Mass of Earth = Me = 6.0×10^{24} kg
Mass of Sun = Ms = 2.0×10^{30} kg
Earth – Sun dist = 1.5×10^{11} m

$mvr = \frac{nh}{2\pi}$ or, $m^2 v^2 r^2 = \frac{n^2h^2}{4\pi^2}$ …(1)

$\frac{GMeMs}{r^2} = \frac{Mev^2}{r}$ or $v^2 = GMs/r$ …(2)

Dividing (1) and (2)

We get $Me^2 r = \frac{n^2h^2}{4\pi^2 GMs}$

for n = 1

$r = \sqrt{\frac{h^2}{4\pi^2 GMsMe^2}} = 2.29 \times 10^{-138}$ m $= 2.3 \times 10^{-138}$ m.

b) $n^2 = \frac{Me^2 \times r \times 4 \times \pi^2 \times G \times Ms}{h^2} = 2.5 \times 10^{74}$.

43. $m_e Vr = \frac{nh}{z\pi}$ …(1)

$\frac{GM_nM_e}{r^2} = \frac{m_eV^2}{r} \Rightarrow \frac{GM_n}{r} = \nu^2$ …(2)

Squaring (2) and dividing it with (1)

$\frac{m_e^2 v^2 r^2}{\nu^2} = \frac{n^2h^2r}{4\pi^2 Gm_n} \Rightarrow me^2 r = \frac{n^2h^2r}{4\pi^2 Gm_n} \Rightarrow r = \frac{n^2h^2r}{4\pi^2 Gm_n me^2}$

$\Rightarrow \nu = \frac{nh}{2\pi r m_e}$ from (1)

$\Rightarrow \nu = \frac{nh 4\pi^2 GM_nM_e^2}{2\pi M_e n^2h^2} = \frac{2\pi GM_nM_e}{nh}$

KE $= \frac{1}{2} m_e V^2 = \frac{1}{2} m_e \frac{(2\pi GM_nM_e)^2}{nh} = \frac{4\pi^2 G^2 M_n^2 M_e^3}{2n^2h^2}$

PE $= \frac{-GM_nM_e}{r} = \frac{-GM_nM_e 4\pi^2 GM_nM_e^2}{n^2h^2} = \frac{-4\pi^2 G^2 M_n^2 M_e^3}{n^2h^2}$

Total energy = KE + PE $= \frac{2\pi^2 G^2 M_n^2 M_e^3}{2n^2h^2}$

44. According to Bohr's quantization rule

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

'r' is less when 'n' has least value i.e. 1

or, $mv = \frac{nh}{2\pi R}$ …(1)

Again, $r = \frac{mv}{qB}$, or, $mv = rqB$ …(2)

From (1) and (2)

$rqB = \frac{nh}{2\pi r}$ [q = e]

$\Rightarrow r^2 = \frac{nh}{2\pi eB} \Rightarrow r = \sqrt{h/2\pi\, eB}$ [here n = 1]

b) For the radius of nth orbit, $r = \sqrt{\frac{nh}{2\pi eB}}$.

c) $mvr = \frac{nh}{2\pi}$, $r = \frac{mv}{qB}$

Substituting the value of 'r' in (1)

$mv \times \frac{mv}{qB} = \frac{nh}{2\pi}$

$\Rightarrow m^2v^2 = \frac{nheB}{2\pi}$ [n = 1, q = e]

$\Rightarrow v^2 = \frac{heB}{2\pi m^2} \Rightarrow$ or $v = \sqrt{\frac{heB}{2\pi m^2}}$.

45. even quantum numbers are allowed

$n_1 = 2$, $n_2 = 4 \rightarrow$ For minimum energy or for longest possible wavelength.

$E = 13.6\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = 13.6\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = 2.55$

$\Rightarrow 2.55 = \frac{hc}{\lambda}$

$\Rightarrow \lambda = \frac{hc}{2.55} = \frac{1242}{2.55} = 487.05$ nm = 487 nm

46. Velocity of hydrogen atom in state 'n' = u

Also the velocity of photon = u

But u << C

Here the photon is emitted as a wave.

So its velocity is same as that of hydrogen atom i.e. u.

$\therefore$ According to Doppler's effect

frequency $v = v_0\left(\frac{1+u/c}{1-u/c}\right)$

as u <<< C $1 - \frac{u}{c} = q$

$\therefore v = v_0\left(\frac{1+u/c}{1}\right) = v_0\left(1+\frac{u}{c}\right) \Rightarrow v = v_0\left(1+\frac{u}{c}\right)$

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