DPP – 2 (Atomic Structure)

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Q 1. An electron in H-atom makes a transition from n = 3 to n = 1. The recoil momentum of H-atom will be-
(a) 6.45×10^{-27} N s
(b) 6.8×10^{-27} N s
(c) 6.45×10^{-24} N s
(d) 6.8×10^{-24} N s

Q 2. Find binding energy of an electron in ground state of hydrogen like atom in whose spectrum the third line of corresponding Balmer series is 108.5 nm
(a) 54.4 eV
(b)13.6 eV
(c) 112.4 eV
(d)None of these

Q 3. In certain electronic transition from quantum level n to ground state in atomic hydrogen in one or more steps no line belonging to Brackett series is observed. The wave numbers which may be observed in Balmer series is
(a) $\frac{8R}{9}, \frac{5R}{36}$
(b) $\frac{3R}{16}, \frac{8R}{9}$
(c) $\frac{5R}{36}, \frac{3R}{16}$
(d) $\frac{3R}{4}, \frac{3R}{16}$

Q 4. When electron and its antiparticles (positron) revolve around their centre of mass. The system so formed is called positronium ion. In which part of electromagnetic spectrum does positronium ion radiate when it deexcites from its first excited state to ground state
(a) Ultraviolet
(b) Visible
(c) Infrared
(d) Insufficient information

Q 5. An electron with kinetic energy 9 eV is incident on hydrogen atom in its ground state, the collision
(a) Must be elastic
(b) May be partially elastic
(c) Must be completely inelastic
(d) May be completely inelastic

Q 6. An excited free hydrogen at rest undergoes transition from n = 3 to n = 1 emitting photon of wavelength λ then
(a) $\lambda < 103$ nm
(b) $\lambda > 103$ nm
(c) $\lambda = 103$ nm
(d) None of these

Q 7. A neutron moving with a speed v makes a head on collision with a hydrogen atom in ground state kept at rest. The minimum kinetic energy of neutron for which inelastic collision will take place is: (assume that mass of proton is nearly equal to the mass of neutron)

(a) 10.2 eV (b) 20.4 eV (c) 12.1 eV (d) 16.8 eV

Q 8. Hydrogen atoms absorb radiations of wavelength λ_0 and consequently emit radiations of 6 different wavelengths of which three wavelengths are shorter than λ_0. Choose the correct alternative(s)

(a) The final excited state of the atoms is n = 4
(b) The initial state of the atoms may be n = 2
(c) The initial state of the atoms may be n =3
(d) There are three transitions belonging to Lyman series

Q 9. In a hypothetical atom like that of hydrogen, the mass of the electrons is doubled. The energy E_0 and radius r_0 of the first Bohr orbit will be (a_0 = Bohr radius of hydrogen)

(a) E_0 = –27.2 eV ; $r_0 = \frac{a_0}{2}$
(b) E_0 = – 27.2 eV ; $r_0 = a_0$
(c) E_0 = – 13.6 eV ; $r_0 = a_0/2$
(d) E_0 = – 13.6 eV ; $r_0 = \frac{a_0}{2}$

Q 10. Suppose that the potential energy of an hypothetical atom consisting of a proton and an electron is given by $U = -ke^2/3r^3$. Then if Bohr's postulates are applied to this atom, then the radius of the nth orbit will be proportional to

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

Q 11. Whenever a hydrogen atom emits a photon in the Balmer series,

(a) it may emit another photon in the Balmer series
(b) it must emit another photon in the Lyman series
(c) the second photon will have a wavelength of about 122 nm
(d) it may emit a second photon, but the wavelength of this photon cannot be predicted

Q 12. A stationary He+ emitted a photon corresponding to the first line of Lyman series. This photon liberated a photoelectron from a stationary H-atom in the ground state. The velocity of the photoelectron will be –

(a) 3×10^7 m/s (b) 6×10^6 m/s
(c) 8×10^7 m/s (d) 3.1×10^6 m/

Q.13 An electron of energy 10.8 eV undergoes an inelastic collision with a hydrogen atom in its ground state. Then (assuming $m_H >> m_e$, neglecting recoil of atom) -

(a) the outgoing electron has energy 10.8 eV
(b)10.2 eV of the incident electrons energy is absorbed by H-atom and the electron would come out with 0.6 eV energy
(c) the entire energy is absorbed by H-atom and the electron stops
(d) none of the above

Q.14 If we take into account the reality that both the nucleus and electron revolve around their common centre of mass. During electron transition from a higher state n_2, to a lower state, n_1, we find that the wavelength of the photon emitted is not given by the formula $\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ where R is the Rydberg constant. The correct wavelength, in that case depends on mass of electron (m) and mass of he nucleus (M) and is given by

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

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

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

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

Q.15 An H atom in ground state with kinetic energy 22eV hits another stationary H-atom in ground state. The collision:

(a) must be elastic

(b) may be elastic

(c) may be perfectly inelastic

(d) may be inelastic

Q.16 Wavelength of photon emitted by H atom in n = 4 to n = 2 transition is equal to wavelength of photon produced by He atom in

(a) n = 4 to n = 2 transition

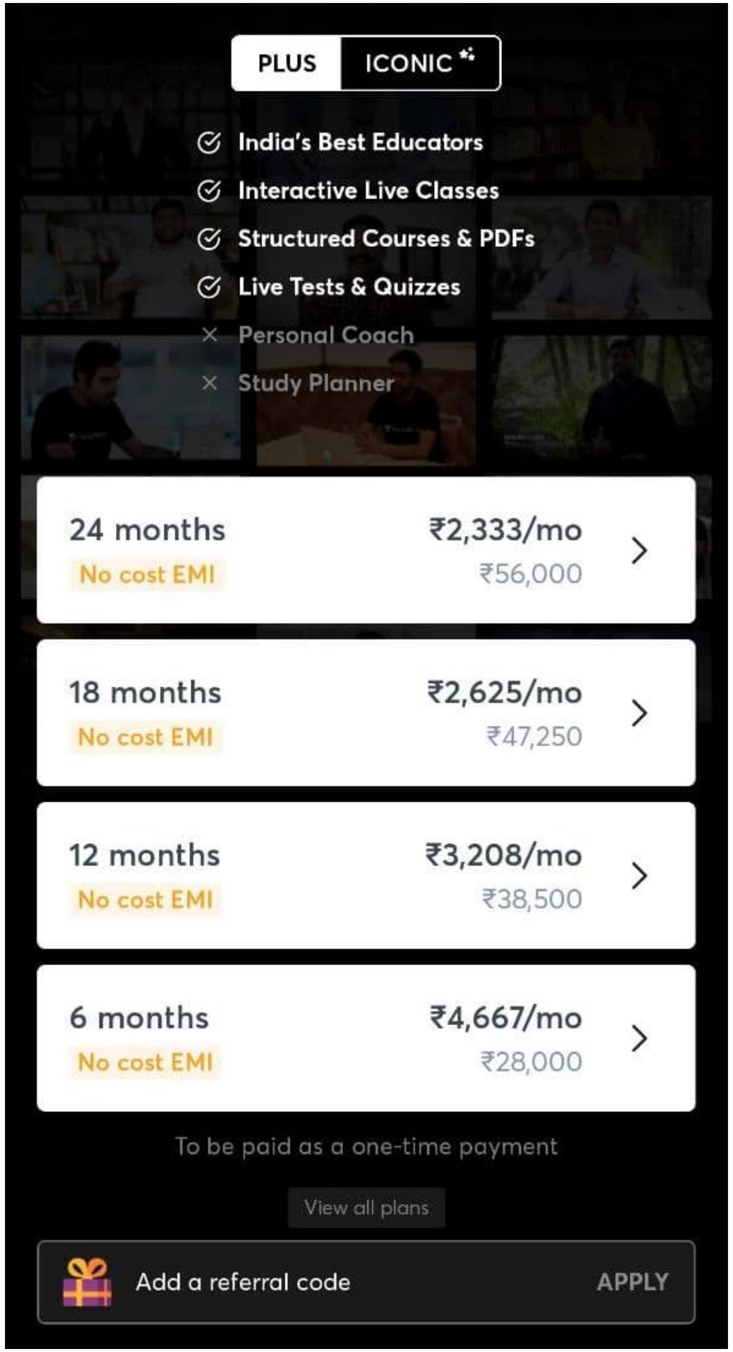
(b) n = 2 to n = 1 transition

(c) n = 6 to n = 3 transition

(d) n = 8 to n = 4 transition

Answer Key

Q.1 a	Q.2 a	Q.3 c	Q.4 a	Q.5 a
Q.6 b	Q.7 b	Q.8 a,b,d	Q.9 a	Q.10 b
Q.11 b,c	Q.12 d	Q.13 b	Q.14 d	Q.15 b,d
Q.16 d				



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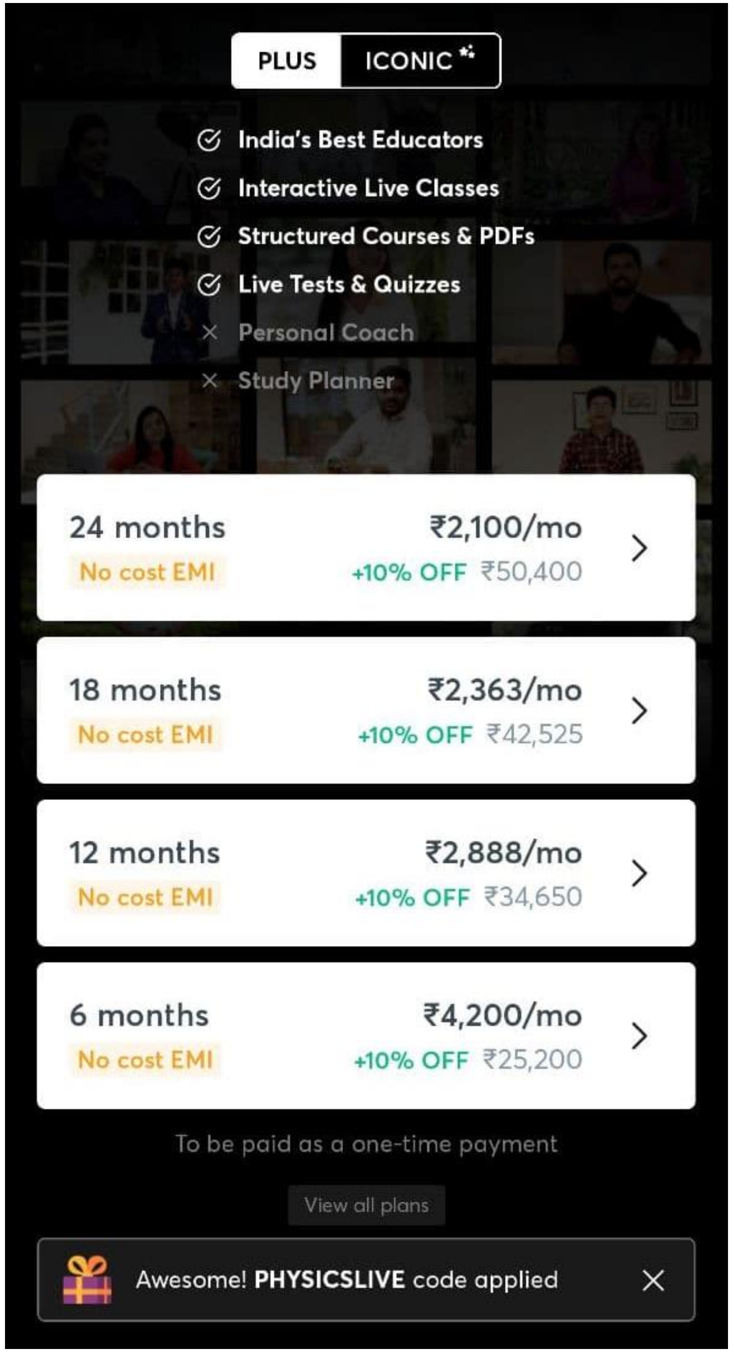

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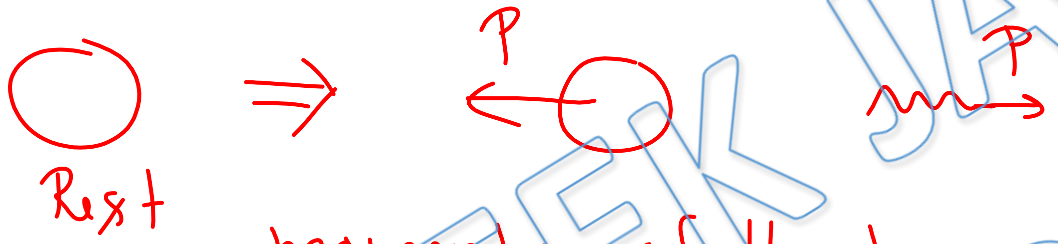
Physics DPP - Solution

DPP- 2, Bohr Model : Spectrum, Atomic collision, Recoil of atom

By Physicsaholics Team

Q1) An electron in H-atom makes a transition from n = 3 to n = 1. The recoil momentum of H-atom will be-



momentum of H atom = momentum of photon

$= \frac{h}{\lambda} = 6.6 \times 10^{-34} \times R\left(\frac{1}{1^2} - \frac{1}{3^2}\right) = \frac{8}{9} \times 6.6 \times 1.1 \times 10^{-34} \times 10^{7}$

(a) 6.45×10^{-27} N s

(b) 6.8×10^{-27} N s

(c) 6.45×10^{-24} N s

(d) 6.8×10^{-24} N s

$P = \frac{7.26 \times 8}{9} \times 10^{-27}$

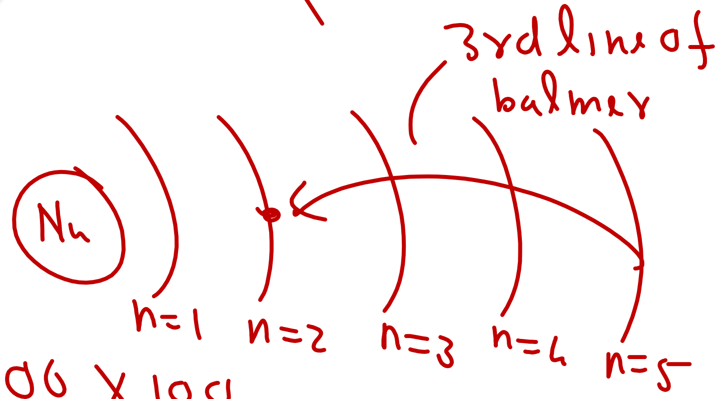
$= 6.448 \times 10^{-27}$

$$119.35 \times 21 = 11935 + 238700 = 2506.35$$

Q2) Find binding energy of an electron in ground state of hydrogen like atom in whose spectrum the third line of corresponding Balmer series is 108.5 nm

$$BE = (13.6\,eV)\,Z^2$$

$$\frac{1}{\lambda} = R Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \Rightarrow \frac{1}{108.5 \times 10^{-9}} = 1.1 \times 10^{7}\, Z^2 \left(\frac{1}{4} - \frac{1}{25}\right)$$



(a) 54.4 eV (b) 13.6 eV

(c) 112.4 eV (d) None of these

$$\Rightarrow \frac{1}{119.35 \times 10^{-2}} = Z^2 \frac{21}{100} \Rightarrow Z^2 = \frac{100 \times 100}{119.35 \times 21}$$

$$Z^2 = \frac{100 \times 100}{2500} = 4 \Rightarrow Z = 2 \Rightarrow BE = 13.6 \times 4\,eV$$

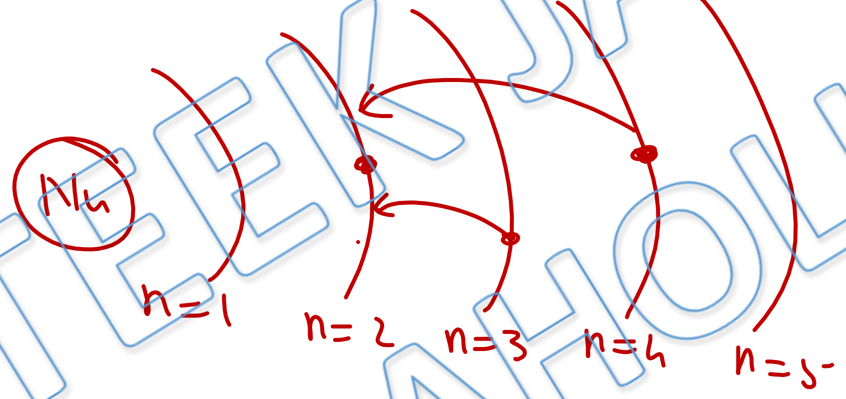
Q3) In certain electronic transition from quantum level n to ground state in atomic hydrogen in one or more steps no line belonging to Brackett series is observed. The wave numbers which may be observed in Balmer series is

(a) $\frac{8R}{9}, \frac{5R}{36}$

(b) $\frac{3R}{16}, \frac{8R}{9}$

(c) $\frac{5R}{36}, \frac{3R}{16}$ ✓

(d) $\frac{3R}{4}, \frac{3R}{16}$



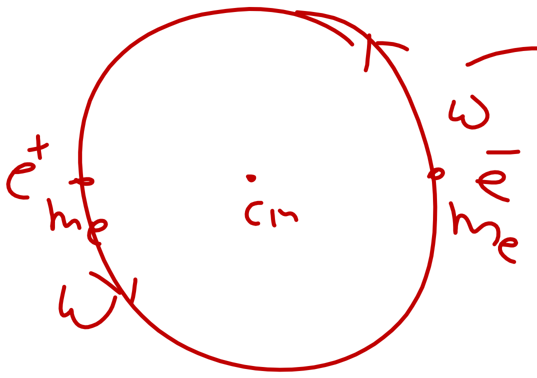
for n=3 to n=2

$$\frac{1}{\lambda} = R\left(\frac{1}{4} - \frac{1}{9}\right) = \frac{5R}{36}$$

for n=4 to n=2

$$\frac{1}{\lambda} = R\left(\frac{1}{4} - \frac{1}{16}\right) = \frac{(4-1)R}{16} = \frac{3R}{16}$$

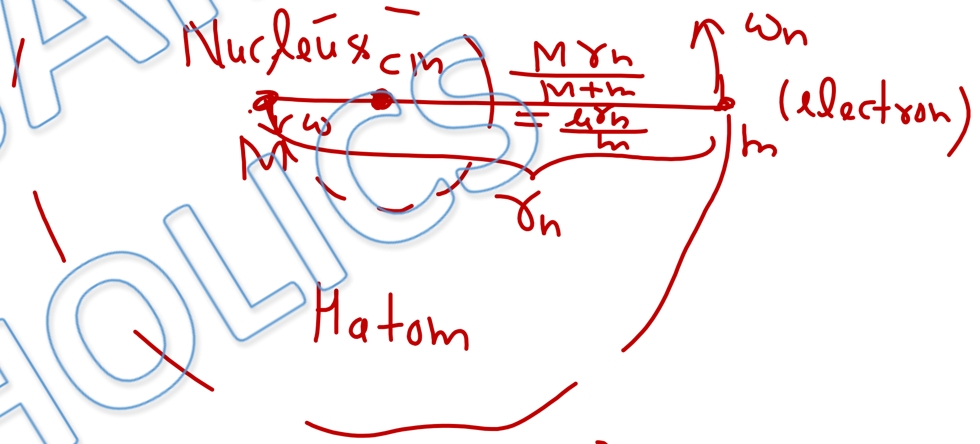
Q4) When electron and its antiparticles (positron) revolve around their centre of mass. The system so formed is called positronium ion. In which part of electromagnetic spectrum does positronium ion radiate when it deexcites from its first excited state to ground state



$R_{new} = C_0 \mu$

$= \frac{C_0 m_e}{2} = \frac{R}{2}$

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



(a)Ultraviolet (b)Visible

(c)Infrared (d)Insufficient information

$\frac{1}{\lambda} = \frac{3R}{8}$

$\lambda = \frac{8}{3R} = \frac{8\times10^{-7}}{3\times1.1}$

$= \frac{800}{33}\times10^{-9}$

$=$

$\mu r_n^2 \omega_n = \frac{nh}{2\pi}$ --(I)

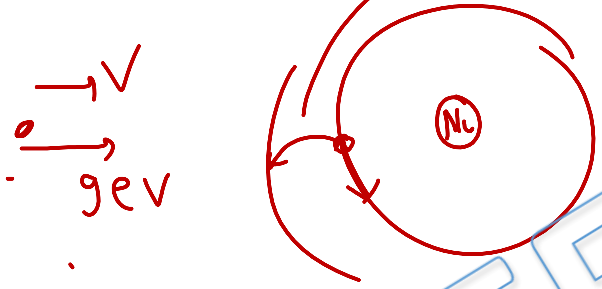
$m\left(\frac{\mu r_n}{m}\right)\omega_n^2 = \frac{Ze^2}{4\pi\epsilon_0 r_n^2}$ --(II)

$\mu \rightarrow$ reduced mass

$R = C_0 m_e$

Q5) An electron with kinetic energy 9 eV is incident on hydrogen atom in its ground state, the collision

required energy = 10.2 eV



maximum KE loss in collision

$$= \frac{1}{2}\mu V_{rel}^2 = \frac{1}{2}\frac{m_e M}{m_e + M}V^2$$

$$= \frac{1}{2}m_e V^2 = 9\text{eV}$$

(a)Must be elastic (b)May be partially elastic

(c)Must be completely inelastic (d)May be completely inelastic

Q6) An excited free hydrogen at rest undergoes transition from n = 3 to n = 1 emitting photon of wavelength λ then

If H atom is fixed $\frac{1}{\lambda} = 1.1 \times 10^{7}\left(\frac{1}{1^2} - \frac{1}{3^2}\right) = \frac{8 \times 1.1}{9} \times 10^{7}$

$\lambda = \frac{9}{8.8} \times 10^{-7} = \frac{900 \text{ nm}}{8.8}$

$= 103 \text{ nm}$

If H atom is not fixed ⇒ H atom will recoil

⇒ some energy is taken by H atom as KE ⇒ energy of photon is less than $\frac{hc}{103 \text{ nm}}$

(a) $\lambda < 103$ nm

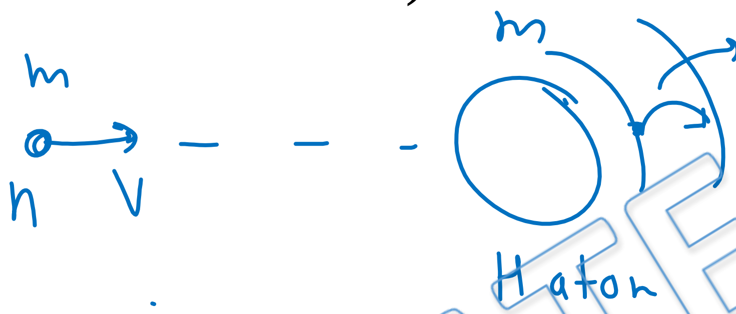
(b) $\lambda > 103$ nm ✓

(c) $\lambda = 103$ nm

(d) None of these

⇒ λ is greater than 103 nm.

Q7) A neutron moving with a speed v makes a head on collision with a hydrogen atom in ground state kept at rest. The minimum kinetic energy of neutron for which inelastic collision will take place is : (assume that mass of proton is nearly equal to the mass of neutron)



minimum required energy for transition = 10.2 eV

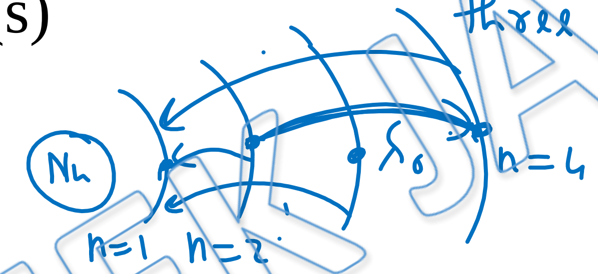
maximum possible energy loss $= \frac{1}{2} \times \left(\frac{m \times m}{m+m}\right) V^2 = \frac{1}{4} m V^2$

(a) 10.2 eV (b) 20.4 eV ✓ (c) 12.1 eV (d) 16.8 eV

$\frac{1}{4} m V^2 = 10.2\ eV$

Initial KE of neutron = 20.4 eV

Q8) Hydrogen atoms absorb radiations of wavelength λ_0 and consequently emit radiations of 6 different wavelenghs of which three wavelengths are shorter than λ_0. Choose the correct alternative(s)



three

no of different λ = $\frac{n(n-1)}{2}$

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

$n(n-1) = 12$

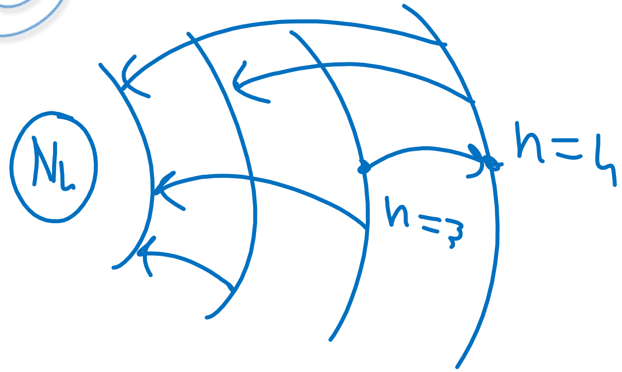
$n = 4$

(a) The final excited state of the atoms is n = 4

(b) The initial state of the atoms may be n = 2

(c) The initial state of the atoms may be n =3

(d) There are three transitions belonging to Lyman series



Q9) In a hypothetical atom like that of hydrogen, the mass of the electrons is doubled. The energy E_0 and radius r_0 of the first Bohr orbit will be (a_0 = Bohr radius of hydrogen)

(a) $E_0 = -27.2$ eV ; $r_0 = \frac{a_0}{2}$

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

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

(d) $E_0 = -13.6$ eV ; $r_0 = \frac{a_0}{2}$

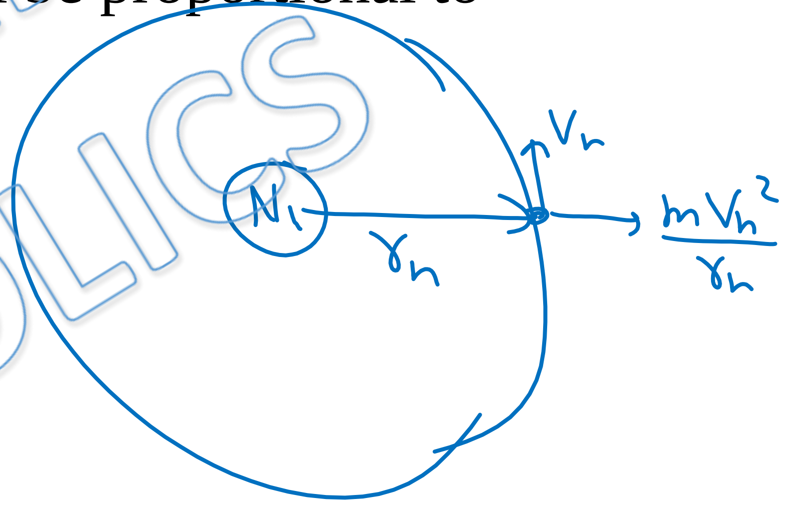
$E_0 = C_0 m_e$

$r_0 = \frac{C_1}{m_e}$

Q10) Suppose that the potential energy of an hypothetical atom consisting of a proton and an electron is given by U = – k$e^2/3r^3$. Then if Bohr's postulates are applied to this atom, then the radius of the nth orbit will be proportional to

$$U = -\frac{Ke^2}{3r^3}$$

$$F = -\frac{dU}{dr} = \frac{Ke^2}{3} \times \frac{3}{r^4} = \frac{Ke^2}{r^4}$$



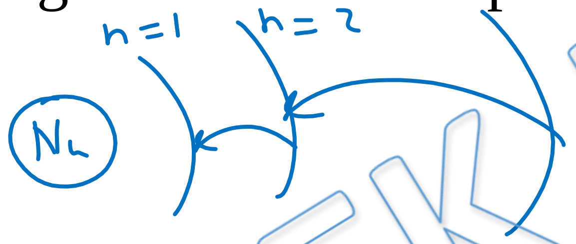
(a) n^2 (b) $1/n^2$ (c) n^3 (d) $1/n^3$

$$\frac{Ke^2}{r_n^4} = \frac{mv_n^2}{r_n} \Rightarrow mv_n^2 r_n^3 = Ke^2 \quad \text{--- (I)}$$

$$m^2 v_n^2 r_n^2 = \frac{n^2 h^2}{(2\pi)^2} \quad \text{--- (II)}$$

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

Q11) Whenever a hydrogen atom emits a photon in the Balmer series,



(a) it may emit another photon in the Balmer series

(b) it must emit another photon in the Lyman series

(c) the second photon will have a wavelength of about 122 nm

(d) it may emit a second photon, but the wavelength of this photon cannot be predicted

Q12) A stationary He+ emitted a photon corresponding to the first line of Lyman series. This photon liberated a photoelectron from a stationary H-atom in the ground state. The velocity of the photoelectron will be -

$E_1 = -\frac{13.6 eV \times 4}{1^2} = -54.4 eV$ energy of photon liberated

$E_2 = -\frac{13.6 eV \times 4}{2^2} = -13.6 eV$ $= 40.8 eV$

BE of H atom

KE of electron $= 40.6 eV - 13.6 eV$

$= 27 eV$

(a) 3×10^7 m/s

(b) 6×10^6 m/s

(c) 8×10^7 m/s

(d) 3.1×10^6 m/s

$\frac{1}{2} m V^2 = 27 eV \Rightarrow V^2 = \frac{27 \times 1.6 \times 10^{-19} \times 2}{9.1 \times 10^{-31}}$

$V^2 = 9.6 \times 10^{12}$

$V = \sqrt{9.6} \times 10^6$

Q13) An electron of energy 10.8 eV undergoes an inelastic collision with a hydrogen atom in its ground state. Then (assuming $m_H >> m_e$, neglecting recoil of atom) -

(a) the outgoing electron has energy 10.8 eV

(b) 10.2 eV of the incident electrons energy is absorbed by H-atom and the electron would come out with 0.6 eV energy

(c) the entire energy is absorbed by H-atom and the electron stops

(d) none of the above

Maximum possible energy loss $= \frac{1}{2}\frac{m\not{M}}{m+M}V_{rel}^2 = \frac{1}{2}mV^2 = 10.8\ eV$

Energy offered by moving electron $= 10.8\ eV$

Energy which the H atom can accept $= \underline{10.2\ eV}, 12.1\ eV$ - - -

Q14) If we take into account the reality that both the nucleus and electron revolve around their common centre of mass. During electron transition from a higher state, n_2, to a lower state, n_1, we find that the wavelength of the photon emitted is not given by the formula $\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ where R is the Rydberg constant. The correct wavelength, in that case depends on mass of electron (m) and mass of he nucleus (M) and is given by

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

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

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

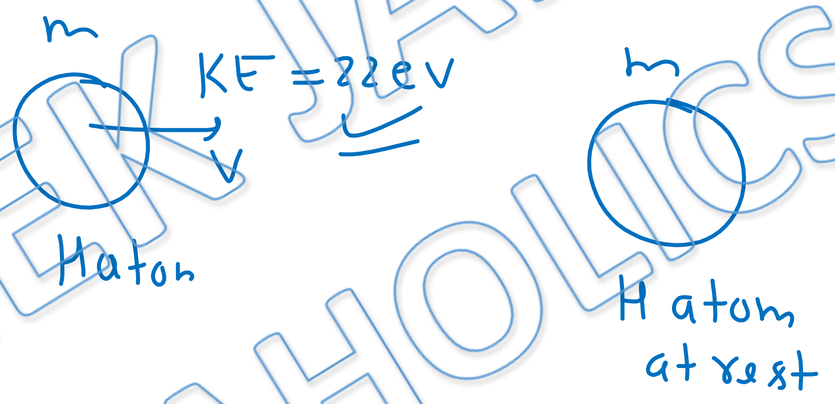
(d) $\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)\left(\frac{M}{M+m}\right)$ ✓

$R = C_0 m_e$

$\Downarrow$

$R' = C_0 \mu = \frac{C_0 m_e M}{m_e + M} = \frac{RM}{m_e + M}$

Q15) An H atom in ground state with kinetic energy 22eV hits another stationary H-atom in ground state. The collision:



(a) must be elastic

(b) may be elastic

(c) may be perfactly inelastic

(d) may be inelastic

maximum possible energy loss

$$= \frac{1}{2}\mu V_{rel}^2 = \frac{1}{2}\frac{m \times m}{m+m}V^2 = \frac{1}{2} \times \left(\frac{1}{2}mv^2\right)$$

$= 11eV$ (In case of P inelastic collision)

energy required for transition = 102eV, 121eV

Q16) Wavelength of photon emitted by H atom in n = 4 to n = 2 transition is equal to wavelength of photon produced by He atom in

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

(a) n = 4 to n = 2 transition

(b) n = 2 to n = 1 transition

(c) n = 6 to n = 3 transition

(d) n = 8 to n = 4 transition ✓

for H like atom $n_2 Z$ to $n_1 Z$ where Z is atomic no

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

$$\lambda' = \lambda$$

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Chalo Niklo