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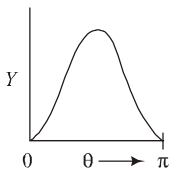
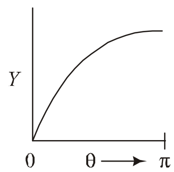
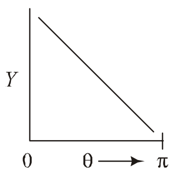
Atoms

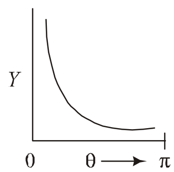
TOPIC 1 Atomic Structure and Rutherford's Nuclear Model

1. The graph which depicts the results of Rutherford gold foil experiment with α-particles is: **[8 Jan. 2020 I]**
θ: Scattering angle
Y: Number of scattered α-particles detected
(Plots are schematic and not to scale)

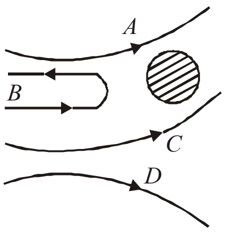
(a) 

(b) 

(c) 

(d) 

2. In the Rutherford experiment, α-particles are scattered from a nucleus as shown. Out of the four paths, which path is not possible? **[Online May 7, 2012]**



(a) D (b) B (c) C (d) A

3. An alpha nucleus of energy $\frac{1}{2}mv^2$ bombards a heavy nuclear target of charge Ze. Then the distance of closest approach for the alpha nucleus will be proportional to **[2006]**

(a) v^2 (b) $\frac{1}{m}$ (c) $\frac{1}{v^2}$ (d) $\frac{1}{\text{Ze}}$

4. An α-particle of energy 5 MeV is scattered through 180º by a fixed uranium nucleus. The distance of closest approach is of the order of **[2004]**

(a) 10^{-12} cm (b) 10^{-10} cm
(c) 10^{-14} cm (d) 10^{-15} cm

TOPIC 2 Bohr's Model and the Spectra of the Hydrogen Atom

5. A particle of mass 200 MeV/c^2 collides with a hydrogen atom at rest. Soon after the collision the particle comes to rest, and the atom recoils and goes to its first excited state. The initial kinetic energy of the particle (in eV) is $\frac{N}{4}$. The value of N is : **[NA Sep. 05, 2020 (I)]**

(Given the mass of the hydrogen atom to be 1 GeV/c^2)

6. In the line spectra of hydrogen atom, difference between the largest and the shortest wavelengths of the Lyman series is 304 Å. The corresponding difference for the Paschan series in Å is : ___________. **[NA Sep. 04, 2020 (I)]**

7. In a hydrogen atom the electron makes a transition from $(n + 1)^{\text{th}}$ level to the n^{th} level. If $n >> 1$, the frequency of radiation emitted is proportional to : **[Sep. 02, 2020 (II)]**

(a) $\frac{1}{n}$ (b) $\frac{1}{n^3}$
(c) $\frac{1}{n^2}$ (d) $\frac{1}{n^4}$

8. The energy required to ionise a hydrogen like ion in its ground state is 9 Rydbergs. What is the wavelength of the radiation emitted when the electron in this ion jumps from the second excited state to the ground state? **[9 Jan. 2020 II]**

(a) 24.2 nm (b) 11.4 nm
(c) 35.8 nm (d) 8.6 nm

9. The first member of the Balmer series of hydrogen atom has a wavelength of 6561 Å. The wavelength of the second member of the Balmer series (in nm) is ______. **[NA 8 Jan. 2020 II]**

10. The time period of revolution of electron in its ground state orbit in a hydrogen atom is 1.6×10^{-16} s. The frequency of revolution of the electron in its first excited state (in s^{-1}) is: **[7 Jan. 2020 I]**

(a) 1.6×10^{14} (b) 7.8×10^{14}
(c) 6.2×10^{15} (d) 5.6×10^{12}

11. An excited He^+ ion emits two photons in succession, with wavelengths 108.5 nm and 30.4 nm, in making a transition to ground state. The quantum number n, corresponding to its initial excited state is (for photon of wavelength »,

energy $E = \dfrac{1240eV}{\lambda(innm)}$ **[12 April 2019 II]**

(a) $n=4$ (b) $n=5$ (c) $n=7$ (d) $n=6$

12. The electron in a hydrogen atom first jumps from the third excited state to the second excited state and subsequently to the first excited state. The ratio of the respective wavelengths, λ_1/λ_2, of the photons emitted in this process is: **[12 April 2019 II]**

(a) 20/7 (b) 27/5 (c) 7/5 (d) 9/7

13. Consider an electron in a hydrogen atom, revolving in its second excited state (having radius 4.65 Å). The de-Broglie wavelength of this electron is : **[12 April 2019 II]**

(a) 3.5 Å (b) 6.6 Å (c) 12.9 Å (d) 9.7 Å

14. In Li^{++}, electron in first Bohr orbit is excited to a level by a radiation of wavelength λ. When the ion gets deexcited to the ground state in all possible ways (including intermediate emissions), a total of six spectral lines are observed. What is the value of λ ? **[10 April 2019 II]**
(Given : $h = 6.63 \times 10^{-34}$ Js; $c = 3 \times 10^8 ms^{-1}$)

(a) 11.4 nm (b) 9.4 nm (c) 12.3 nm (d) 10.8 nm

15. Taking the wavelength of first Balmer line in hydrogen spectrum (n = 3 to n = 2) as 660 nm, the wavelength of the 2nd Balmer line (n = 4 to n = 2) will be; **[9 April 2019 I]**

(a) 889.2 nm (b) 488.9 nm
(c) 642.7 nm (d) 388.9 nm

16. A He^+ ion is in its first excited state. Its ionization energy is: **[9 April 2019 II]**

(a) 48.36 eV (b) 54.40 eV
(c) 13.60 eV (d) 6.04 eV

17. Radiation coming from transitions $n = 2$ to $n = 1$ of hydrogen atoms fall on He^+ ions in $n = 1$ and $n = 2$ states. The possible transition of helium ions as they absorb energy from the radiation is : **[8 April 2019 I]**

(a) $n=2 \to n=3$ (b) $n=1 \to n=4$
(c) $n=2 \to n=5$ (d) $n=2 \to n=4$

18. A hydrogen atom, initially in the ground state is excited by absorbing a photon of wavelength 980Å. The radius of the atom in the excited state, in terms of Bohr radius a_0, will be: **[11 Jan 2019 I]**

(a) $25a_0$ (b) $9a_0$ (c) $16a_0$ (d) $4a_0$

19. In a hydrogen like atom, when an electron jumps from the M-shell to the L-shell, the wavelength of emitted radiation is l. If an electron jumps from N-shell to the L-shell, the wavelength of emitted radiation will be: **[11 Jan 2019 II]**

(a) $\frac{27}{20}\lambda$ (b) $\frac{16}{25}\lambda$ (c) $\frac{25}{16}\lambda$ (d) $\frac{20}{27}\lambda$

20. An electron from various excited states of hydrogen atom emit radiation to come to the ground state. Let λ_n, λ_g be the de Broglie wavelength of the electron in the n^{th} state and the ground state respectively. Let Λ_n be the wavelength of the emitted photon in the transition from the n^{th} state to the ground state. For large n, (A, B are constants) **[2018]**

(a) $\Lambda_n \approx A + \frac{B}{\lambda_n^2}$ (b) $\Lambda_n \approx A + B\lambda_n$

(c) $\Lambda_n^2 \approx A + B\lambda_n^2$ (d) $\Lambda_n^2 \approx \lambda$

21. If the series limit frequency of the Lyman series is v_1, then the series limit frequency of the P-fund series is : **[2018]**

(a) $25\,\nu_L$ (b) $16\,\nu_L$ (c) $\nu_L/16$ (d) $\nu_L/25$

22. The de-Broglie wavelength (λ_B) associated with the electron orbiting in the second excited state of hydrogen atom is related to that in the ground state (λ_G) by **[Online April 16, 2018]**

(a) $\lambda_B = \lambda_{G/3}$ (b) $\lambda_B = \lambda_{G/2}$
(c) $\lambda_B = 2\lambda_G$ (d) $\lambda_B = 3\lambda_G$

23. The energy required to remove the electron from a singly ionized Helium atom is 2.2 times the energy required to remove an electron from Helium atom. The total energy required to ionize the Helium atom completely is: **[Online April 15, 2018]**

(a) 20 eV (b) 79 eV (c) 109 eV (d) 34 eV

24. Muon (μ^{-1}) is negatively charged ($|q| = |e|$) with a mass $m_\mu = 200m_e$, where m_e is the mass of the electron and e is the electronic charge. If μ^{-1} is bound to a proton to form a hydrogen like atom, identify the correct statements **[Online April 15, 2018]**

(A) Radius of the muonic orbit is 200 times smaller than that of the electron

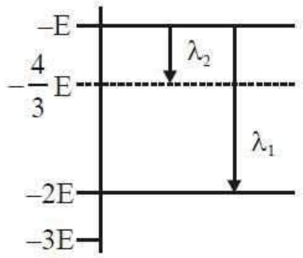
(B) the speed of the μ^{-1} in the nth orbit is $\frac{1}{200}$ times that of the election in the nth orbit

(C) The lonization energy of muonic atom is 200 times more than that of an hydrogen atom

(D) The momentum of the muon in the nth orbit is 200 times more than that of the electron

(a) (A), (B), (D) (b) (B), (D)
(c) (C), (D) (d) (A), (C), (D)

25. Some energy levels of a molecule are shown in the figure. The ratio of the wavelengths $r = \lambda_1/\lambda_2$, is given by **[2017]**



(a) $r = \frac{3}{4}$ (b) $r = \frac{1}{3}$ (c) $r = \frac{4}{3}$ (d) $r = \frac{2}{3}$

26. The acceleration of an electron in the first orbit of the hydrogen atom (z = 1) is : **[Online April 9, 2017]**

(a) $\frac{h^2}{\pi^2 m^2 r^3}$ (b) $\frac{h^2}{8\pi^2 m^2 r^3}$

(c) $\frac{h^2}{4\pi^2 m^2 r^3}$ (d) $\frac{h^2}{4\pi m^2 r^3}$

27. According to Bohr's theory, the time averaged magnetic field at the centre (i.e. nucleus) of a hydrogen atom due to the motion of electrons in the n^{th} orbit is proportional to : (n = principal quantum number) **[Online April 8, 2017]**

(a) n^{-4} (b) n^{-5} (c) n^{-3} (d) n^{-2}

28. A hydrogen atom makes a transition from n = 2 to n = 1 and emits a photon. This photon strikes a doubly ionized lithium atom (z = 3) in excited state and completely removes the orbiting electron. The least quantum number for the excited state of the ion for the process is : **[Online April 9, 2016]**

(a) 2 (b) 4 (c) 5 (d) 3

29. As an electron makes a transition from an excited state to the ground state of a hydrogen - like atom/ion : **[2015]**

(a) kinetic energy decreases, potential energy increases but total energy remains same
(b) kinetic energy and total energy decrease but potential energy increases
(c) its kinetic energy increases but potential energy and total energy decrease
(d) kinetic energy, potential energy and total energy decrease

30. The de–Broglie wavelength associated with the electron in the n = 4 level is : **[Online April 11, 2015]**

(a) $\frac{1}{4}$ th of the de–Broglie wavelength of the electron in the ground state.
(b) four times the de–Broglie wavelength of the electron in the ground state
(c) two times the de–Broglie wavelength of the electron in the ground state
(d) half of the de–Broglie wavelength of the electron in the ground state

31. If one were 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 n^{th} level will be : **[Online April 10, 2015]**

(a) $n\left(\frac{hqB}{2\pi m}\right)$ (b) $n\left(\frac{hqB}{8\pi m}\right)$

(c) $n\left(\frac{hqB}{4\pi m}\right)$ (d) $n\left(\frac{hqB}{\pi m}\right)$

32. The radiation corresponding to $3 \to 2$ transition of hydrogen atom falls on a metal surface to produce photoelectrons. These electrons are made to enter a magnetic field of 3×10^{-4} T. If the radius of the largest circular path followed by these electrons is 10.0 mm, the work function of the metal is close to: **[2014]**

(a) 1.8 eV (b) 1.1 eV
(c) 0.8 eV (d) 1.6 eV

33. Hydrogen $({}_1H^1)$, Deuterium $({}_1H^2)$, singly ionised Helium $\left({}_2He^4\right)^+$ and doubly ionised lithium $\left({}_3Li^6\right)^{++}$ all have one electron around the nucleus. Consider an electron transition from n = 2 to n = 1. If the wavelengths of emitted radiation are $\lambda_1, \lambda_2, \lambda_3$ and λ_4 respectively then approximately which one of the following is correct? **[2014]**

(a) $4\lambda_1 = 2\lambda_2 = 2\lambda_3 = \lambda_4$
(b) $\lambda_1 = 2\lambda_2 = 2\lambda_3 = \lambda_4$
(c) $\lambda_1 = \lambda_2 = 4\lambda_3 = 9\lambda_4$
(d) $\lambda_1 = 2\lambda_2 = 3\lambda_3 = 4\lambda_4$

34. Match List - I (Experiment performed) with List-II (Phenomena discovered/associated) and select the correct option from the options given below the lists: **[Online April 19, 2014]**

List - I		List - II	
(1)	Davisson and Germer experiment	(i)	Wave nature of electrons
(2)	Millikan's oil drop experiment	(ii)	Charge of an electron
(3)	Rutherford experiment	(iii)	Quantisation of energy levels
(4)	Franck-Hertz experiment	(iv)	Existence of nucleus

(a) (1)-(i), (2)-(ii), (3)-(iii), (4)-(iv)
(b) (1)-(i), (2)-(ii), (3)-(iv), (4)-(iii)
(c) (1)-(iii), (2)-(iv), (3)-(i), (4)-(ii)
(d) (1)-(iv), (2)-(iii), (3)-(ii), (4)-(i)

35. The binding energy of the electron in a hydrogen atom is 13.6 eV, the energy required to remove the electron from the first excited state of Li^{++} is: **[Online April 9, 2014]**
(a) 122.4 eV (b) 30.6 eV
(c) 13.6 eV (d) 3.4 eV

36. Ina hydrogen like atom electron make transition from an energy level with quantum number n to another with quantum number (n – 1). If n>>1, the frequency of radiation emitted is proportional to : **[2013]**
(a) $\frac{1}{n}$ (b) $\frac{1}{n^2}$ (c) $\frac{1}{n^{3/2}}$ (d) $\frac{1}{n^3}$

37. A 12.5 eV electron beam is used to bombard gaseous hydrogen at room temperature. It will emit : **[Online April 25, 2013]**
(a) 2 lines in the Lyman series and 1 line in the Balmar series
(b) 3 lines in the Lyman series
(c) 1 line in the Lyman series and 2 lines in the Balmar series
(d) 3 lines in the Balmer series

38. In the Bohr's model of hydrogen-like atom the force between the nucleus and the electron is modified as $F = \frac{e^2}{4\pi\varepsilon_0}\left(\frac{1}{r^2}+\frac{\beta}{r^3}\right)$, where β is a constant. For this atom, the radius of the n^{th} orbit in terms of the Bohr radius $\left(a_0 = \frac{\varepsilon_0 h^2}{m\pi e^2}\right)$ is : **[Online April 23, 2013]**
(a) $r_n = a_0 n - \beta$ (b) $r_n = a_0 n^2 + \beta$
(c) $r_n = a_0 n^2 - \beta$ (d) $r_n = a_0 n + \beta$

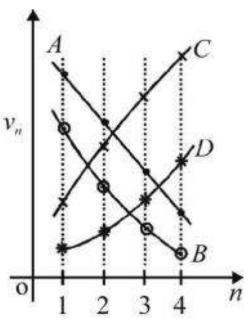
39. Orbits of a particle moving in a circle are such that the perimeter of the orbit equals an integer number of de-Broglie wavelengths of the particle. For a charged particle moving in a plane perpendicular to a magnetic field, the radius of the n^{th} orbital will therefore be proportional to : **[Online April 22, 2013]**
(a) n^2 (b) n (c) $n^{1/2}$ (d) $n^{1/4}$

40. In the Bohr model an electron moves in a circular orbit around the proton. Considering the orbiting electron to be a circular current loop, the magnetic moment of the hydrogen atom, when the electron is in n^{th} excited state, is : **[Online April 9, 2013]**
(a) $\left(\frac{e}{2m}\frac{n^2h}{2\pi}\right)$ (b) $\left(\frac{e}{m}\right)\frac{nh}{2\pi}$
(c) $\left(\frac{e}{2m}\right)\frac{nh}{2\pi}$ (d) $\left(\frac{e}{m}\right)\frac{n^2h}{2\pi}$

41. Hydrogen atom is excited from ground state to another state with principal quantum number equal to 4. Then the number of spectral lines in the emission spectra will be : **[2012]**
(a) 2 (b) 3 (c) 5 (d) 6

42. A diatomic molecule is made of two masses m_1 and m_2 which are separated by a distance r. If we calculate its rotational energy by applying Bohr's rule of angular momentum quantization, its energy will be given by : (n is an integer) **[2012]**
(a) $\frac{(m_1+m_2)^2 n^2 h^2}{2m_1^2 m_2^2 r^2}$ (b) $\frac{n^2h^2}{2(m_1+m_2)r^2}$
(c) $\frac{2n^2h^2}{(m_1+m_2)r^2}$ (d) $\frac{(m_1+m_2)n^2\hbar^2}{2m_1m_2r^2}$

43. Which of the plots shown in the figure represents speed (v_n) of the electron in a hydrogen atom as a function of the principal quantum number (n)? **[Online May 26, 2012]**



(a) B (b) D (c) C (d) A

44. A doubly ionised Li atom is excited from its ground state ($n = 1$) to $n = 3$ state. The wavelengths of the spectral lines are given by λ_{32}, λ_{31} and λ_{21}. The ratio $\lambda_{32}/\lambda_{31}$ and $\lambda_{21}/\lambda_{31}$ are, respectively **[Online May 12, 2012]**
(a) 8.1, 0.67 (b) 8.1, 1.2
(c) 6.4, 1.2 (d) 6.4, 0.67

45. A hypothetical atom has only three energy levels. The ground level has energy, $E_1 = -8$ eV. The two excited states have energies, $E_2 = -6$ eV and $E_3 = -2$ eV. Then which of the following wavelengths will not be present in the emission spectrum of this atom? **[Online May 12, 2012]**
(a) 207 nm (b) 465 nm
(c) 310 nm (d) 620 nm

46. The electron of a hydrogen atom makes a transition from the $(n + 1)^{th}$ orbit to the n^{th} orbit. For large n the wavelength of the emitted radiation is proportional to **[Online May 7, 2012]**
(a) n (b) n^3 (c) n^4 (d) n^2

47. Energy required for the electron excitation in Li^{++} from the first to the third Bohr orbit is : **[2011]**
(a) 36.3 eV (b) 108.8 eV
(c) 122.4 eV (d) 12.1 eV

48. The transition from the state $n = 4$ to $n = 3$ in a hydrogen like atom results in ultraviolet radiation. Infrared radiation will be obtained in the transition from : **[2009]**
(a) $3 \rightarrow 2$ (b) $4 \rightarrow 2$ (c) $5 \rightarrow 4$ (d) $2 \rightarrow 1$

49. Suppose an electron is attracted towards the origin by a force $\frac{k}{r}$ where 'k' is a constant and 'r' is the distance of the electron from the origin. By applying Bohr model to this system, the radius of the n^{th} orbital of the electron is found to be 'r_n' and the kinetic energy of the electron to be 'T_n'. Then which of the following is true? **[2008]**

(a) $T_n \propto \frac{1}{n^2}, r_n \propto n^2$

(b) T_n independent of n, $r_n \propto n$

(c) $T_n \propto \frac{1}{n}, r_n \propto n$

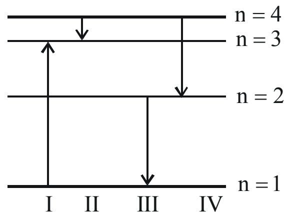
(d) $T_n \propto \frac{1}{n^3}, r_n \propto n^2$

50. Which of the following transitions in hydrogen atoms emit photons of highest frequency? **[2007]**

(a) $n = 1$ to $n = 2$ (b) $n = 2$ to $n = 6$

(c) $n = 6$ to $n = 2$ (d) $n = 2$ to $n = 1$

51. 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? **[2005]**



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

52. The wavelengths involved in the spectrum of deuterium $\left({}_1^2D\right)$ are slightly different from that of hydrogen spectrum, because **[2003]**

(a) the size of the two nuclei are different

(b) the nuclear forces are different in the two cases

(c) the masses of the two nuclei are different

(d) the attraction between the electron and the nucleus is differernt in the two cases

53. If 13.6 eV energy is required to ionize the hydrogen atom, then the energy required to remove an electron from $n = 2$ is **[2002]**

(a) 10.2 eV (b) 0 eV

(c) 3.4 eV (d) 6.8 eV

Hints & Solutions

1. **(c)**
2. **(c)** As α-particles are doubly ionised helium He^{++} i.e. Positively charged and nucleus is also positively charged and we know that like charges repel each other.
3. **(b)** Work done to stop the α particle is equal to K.E.

$$\therefore qV = \frac{1}{2}mv^2 \Rightarrow q \times \frac{K(Ze)}{r} = \frac{1}{2}mv^2$$

$$\Rightarrow r = \frac{2(2e)K(Ze)}{mv^2} = \frac{4KZe^2}{mv^2}$$

$$\Rightarrow r \propto \frac{1}{v^2} \text{ and } r \propto \frac{1}{m}.$$

4. **(a)** Distance of closest approach

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

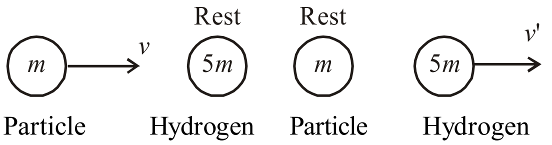
Energy, $E = 5\times10^6 \times 1.6\times10^{-19}$ J

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

$$\Rightarrow r_h = 5.2\times10^{-14}\,m = 5.3\times10^{-12}\text{ cm}$$

5. **(51)**

Before collision **After collision**



From linear momentum conservation, $L_i = L_f$

$$mV + 0 = 0 + 5mV' \Rightarrow V' = \frac{v}{5}$$

$$\text{Loss of KE } = KE_i - KE_f = \frac{1}{2}mv^2 - \frac{1}{2}(5m)\left(\frac{v}{5}\right)^2$$

$$= \frac{1}{2}mv^2\left(1-\frac{1}{5}\right) = \frac{4}{5}\left(\frac{mv^2}{2}\right)$$

$$= \frac{4}{5}KE_i = 10.2 \text{ eV}$$

[$\because$ Energy in first excited state of atom = 10.2 eV]

$$KE_i = 12.75\,\text{eV} = \frac{N}{4} \Rightarrow N = 51$$

The value of $N = 51$.

6. **(10553.14)**

From Bohr's formula for hydrogen atom,

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

$$R = 1.097\times10^7 \text{ m}^{-1}$$

For Lyman series :

$$\frac{1}{\lambda_{\text{min.}}} = R(1) = R \qquad \because n_2 = \infty \text{ and } n_1 = 1$$

$$\frac{1}{\lambda_{\text{max.}}} = R\left\{1-\frac{1}{4}\right\} = \frac{3R}{4} \qquad \because n_1 = 2,\ n_1 = 1$$

$$\therefore \lambda_{\text{max.}} - \lambda_{\text{min.}} = \frac{4}{3R} - \frac{1}{R} = \frac{1}{3R} = 304 \text{ (Given)}$$

For Paschen series :

$$\lambda'_{\text{min.}} = R\left(\frac{1}{9}\right) \text{ and } \lambda'_{\text{max.}} = R\left(\frac{1}{9}-\frac{1}{16}\right) = \frac{7R}{16\times9}$$

$$\lambda'_{\text{max.}} - \lambda'_{\text{min.}} = \frac{16\times9}{7R} - \frac{9}{R} = \frac{81}{7R}$$

$$\text{or, } \lambda'_{\text{max.}} - \lambda'_{\text{min.}} = \frac{81}{7R} = \frac{81\times3}{7\times3R} = \frac{81\times3}{7}\times304$$

$$\left(\because \frac{1}{3R} = 304\text{Å}\right)$$

$\therefore$ For Pachen series, $\lambda'_{\text{max.}} - \lambda'_{\text{min.}} = 10553.14$

7. **(b)** Total energy of electron in n^{th} orbit of hydrogen atom

$$E_n = -\frac{Rhc}{n^2}$$

Total energy of electron in $(n+1)^{\text{th}}$ level of hydrogen atom

$$E_{n+1} = -\frac{Rhc}{(n+1)^2}$$

When electron makes a transition from $(n+1)^{\text{th}}$ level to n^{th} level

Change in energy,

$$\Delta E = E_{n+1} - E_n$$

$$h\nu = Rhc\cdot\left[\frac{1}{n^2} - \frac{1}{(n+1)^2}\right] \qquad (\because E = h\nu)$$

$$\nu = R\cdot c\left[\frac{(n+1)^2 - n^2}{n^2(n+1)^2}\right]$$

$$\nu = R\cdot c\left[\frac{1+2n}{n^2(n+1)^2}\right]$$

For $n >> 1$

$$\Rightarrow \nu = R\cdot c\left[\frac{2n}{n^2\times n^2}\right] = \frac{2RC}{n^3}$$

$$\Rightarrow \nu \propto \frac{1}{n^3}$$

8. **(b)** According to Bohr's Theory the wavelength of the radiation emitted from hydrogen atom is given by

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

$\because$ Z = 3

$$\therefore \frac{1}{\lambda} = 9R\left(1 - \frac{1}{9}\right)$$

$$\Rightarrow \lambda = \frac{1}{8R} = \frac{1}{8\times 10973731.6} \quad (R = 10973731.6 \text{ m–1})$$

$\Rightarrow \lambda = 11.39$ nm

9. **(486.00)**

The wavelength of the spectral line of hydrogen spectrum is given by formula

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

Where, R = Rydberg constant

For the first member of Balmer series nF = 2, ni = 3

$$\therefore \frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) \quad ...(i)$$

For last member of Balmer series, nf = 2, ni = 4

$$\text{So, } \frac{1}{\lambda'} = R\left[\frac{1}{4} - \frac{1}{16}\right] \quad ...(ii)$$

Dividing (i) by (ii), we get

$$\Rightarrow \frac{\lambda'}{\lambda} = \frac{5\times 16}{9\times 4\times 3}$$

$$\Rightarrow \lambda' = \frac{5\times 4\times 656.1}{9\times 3}(nm) = 486\,nm$$

10. **(b)** For first excited state n' = 3

$$\text{Time period } T \propto \frac{n^3}{z^2}$$

$$\Rightarrow \frac{T_2}{T_1} = \frac{n'^3}{n^3}$$

$\therefore$ T2 = 8T1 = 8 × 1.6 × 10–16s

$$\therefore \text{Frequency, } \nu = \frac{1}{T_2} = \frac{1}{8\times 1.6\times 10^{-16}}$$

≈ 7.8 × 1014 Hz

11. **(b)** $E = E_1 + E_2$

$$13.6\frac{z^2}{n^2} = \frac{1240}{\lambda_1} + \frac{1240}{\lambda_2}$$

$$\text{or } \frac{13.6(2)^2}{n^2} = 1240\left(\frac{1}{108.5} + \frac{1}{30.4}\right)\times\frac{1}{10^{-9}}$$

On solving, n = 5

12. **(a)** $\frac{1}{\lambda_1} = R\left(\frac{1}{3^2} - \frac{1}{4^2}\right) = \frac{7R}{16\times 9}$

$$\text{And } \frac{1}{\lambda_2} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{5R}{36}$$

$$\text{Now } \frac{\lambda_1}{\lambda_2} = \frac{(5R/36)}{7R/(16\times 9)} = \frac{20}{7}$$

13. **(d)** $v = \frac{c}{137n} = \frac{c}{137\times 3}$

$$\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{\left(\frac{m\times c}{3\times 137}\right)} = \frac{h}{mc}\times(3\times 137) = 9.7\,\text{Å}$$

14. **(d)** Spectral lines obtained on account of transition from nth orbit to various lower orbits is $\frac{n(n-1)}{2}$

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

$\Rightarrow$ n = 4

$$\Delta E = \frac{hc}{\lambda} = \frac{-Z^2}{n^2}(13.6eV)$$

$$\Rightarrow \frac{1}{\lambda} = Z^2\left(\frac{13.6eV}{hc}\right)\left(\frac{1}{n_2^2} - \frac{1}{n_1^2}\right)$$

$$= (13.4)(3)^2\left[1 - \frac{1}{16}\right]eV$$

$$\Rightarrow \lambda = \frac{1242\times 16}{(13.4)\times(9)(15)}\text{nm} \simeq 10.8\text{nm}$$

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

$$\frac{1}{\lambda_2} = R\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = \frac{3R}{16}$$

$$\therefore \frac{\lambda_2}{\lambda_1} = \frac{80}{108}$$

$$\lambda_2 = \frac{80}{108}\lambda_1 = \frac{80}{108}\times 660 = 488.9\text{ nm.}$$

16. **(c)** $E_n = -13.6\frac{Z^2}{n^2}$

For He^+, $E_2 = \frac{-13.6(2)^2}{2^2} = -13.60\,eV$

Ionization energy $= 0 - E2 = 13.60$ eV

17. **(d)** Energy released by hydrogen atom for transition n = 2 to n = 1

$$\therefore\ \Delta E_1 = 13.6 \times \left(\frac{1}{1^2} - \frac{1}{2^2}\right) = \frac{3}{4} \times 13.6\ \text{eV}$$

= 10.2 eV

This energy is absorbed by He+ ion in transition from n = 2 to n = n1 (say)

$$\therefore\ \Delta E_2 = 13.6 \times 4 \times \left(\frac{1}{4} - \frac{1}{n_1^2}\right) = 10.2\ \text{eV}$$

$\Rightarrow$ n1 = 4

So, possible transition is n = 2 $\rightarrow$ n = 4

18. **(3)** Energy of photon $= \frac{hc}{\lambda} = \frac{12500}{980} = 12.75\text{eV}$

Energy of electron in n^{th} orbit is given by

$$\text{En} = \frac{-13.6}{n^2} \Rightarrow E_n - E_1 = -13.6\left[\frac{1}{n^2} \frac{-1}{1^2}\right]$$

$$\Rightarrow 12.75 = 13.6\left[\frac{1}{1^2} \frac{-1}{n^2}\right] \Rightarrow n = 4$$

$\therefore$ Electron will excite to n = 4

We know that 'R' $\propto n^2$

$\therefore$ Radius of atom will be $16a_0$

19. **(d)** When electron jumps from M $\rightarrow$ L shell

$$\frac{1}{\lambda} = K\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{K \times 5}{36} \quad \text{..... (i)}$$

When eletron jumps from N $\rightarrow$ L shell

$$\frac{1}{\lambda'} = K\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = \frac{K \times 3}{16} \quad \text{....(ii)}$$

solving equation (i) and (ii) we get

$$\lambda' = \frac{20}{27}\lambda$$

20. **(a)** Wavelength of emitted photon from n^{th} state to the ground state,

$$\frac{1}{\Lambda_n} = RZ^2\left(\frac{1}{1^2} - \frac{1}{n^2}\right)$$

$$\Lambda_n = \frac{1}{RZ^2}\left(1 - \frac{1}{n^2}\right)^{-1}$$

Since n is very large, using binomial theorem

$$\Lambda_n = \frac{1}{RZ^2}\left(1 + \frac{1}{n^2}\right)$$

$$\Lambda_n = \frac{1}{RZ^2} + \frac{1}{RZ^2}\left(\frac{1}{n^2}\right)$$

As we know, $\lambda_n = \frac{2\pi r}{n} = 2\pi\left(\frac{n^2h^2}{4\pi^2 mZe^2}\right)\frac{1}{n} \propto n$

$$\Lambda_n \approx A + \frac{B}{\lambda_n^2}$$

21. **(d)** $h\nu_L = E_\infty - E_1$ ...(i)

$h\nu_f = E_\infty - E_5$ ...(ii)

$$E \propto \frac{z^2}{n^2} \Rightarrow \frac{E_5}{E_1} = \left(\frac{1}{5}\right)^2 = \frac{1}{25}$$

Eqn (i) / (ii) $\Rightarrow \frac{h\nu_L}{h\nu_f} = \frac{E_1}{E_5}$

$$\Rightarrow \frac{\nu_L}{\nu_f} = \frac{25}{1} \Rightarrow \nu_f = \frac{\nu_L}{25}$$

22. **(d)** de-Broglie wavelength, $\lambda = \frac{h}{P}$

$$\frac{\lambda_B}{\lambda_G} = \frac{P_a}{P_B} = \frac{mv_G}{mv_B}$$

Speed of electron $V \propto \frac{z}{n}$

so $\frac{\lambda_B}{\lambda_G} = \frac{n_B}{n_G} = \frac{3}{1} \Rightarrow \lambda_B = 3\lambda_G$

23. **(b)** Energy required to remove e^- from singly ionized helium atom $= \frac{(13.6)Z^2}{1^2} = 54.4\,\text{eV}$ $(\because Z = 2)$

Energy required to remove e^- from helium atom = x eV

According to question, 54.4 eV = 2.2x $\Rightarrow$ x = 24.73 eV

Therefore, energy required to ionize helium atom = (54.4 + 24.73) eV = 79.12 eV

24. **(d)** (A) Radius of muon $= \frac{\text{Radius of hydrogen}}{200}$

Radius of H atom $= r = \frac{\epsilon_0 n^2h^2}{\pi me^2}$

Radius of muon $= r_\mu = \frac{\epsilon_0 n^2h^2}{\pi \times 200\, me^2}$

$$r_\mu = \frac{r}{200}$$

(B) Velocity relation given is wrong

(C) Ionization energy in e^{-}H atom

$$E = \frac{+me^4}{8 \epsilon_0^2 n^2 h^2}$$

$$E_\mu = \frac{200me^4}{8 \epsilon_0^2 n^2 h^2} = 200E$$

(D) Momentum of H-atom

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

Hence (A), (C), (D) are correct.

25. **(b)** From energy level diagram, using $\Delta E = \frac{hc}{\lambda}$

For wavelength λ_1 $\Delta E = -E - (-2E) = \frac{hc}{\lambda_1}$

$$\therefore \quad \lambda_1 = \frac{hc}{E}$$

For wavelength λ_2 $\Delta E = -E - \left(-\frac{4E}{3}\right) = \frac{hc}{\lambda_2}$

$$\therefore \quad \lambda_2 = \frac{hc}{\left(\frac{E}{3}\right)} \qquad \therefore\ r = \frac{\lambda_1}{\lambda_2} = \frac{1}{3}$$

26. **(c)** Speed of electron in first orbit (n = 1) of hydrogen atom (z = 1),

$$v = \frac{e^2}{2\varepsilon_0 h}$$

radius of Bohr's first orbit,

$$r = \frac{h^2 \varepsilon_0}{\pi m e^2} \Rightarrow \varepsilon_0 = \frac{r \pi m e^2}{h^2} \qquad \text{....... (i)}$$

Acceleration of electron,

$$\frac{v^2}{r} = \frac{e^4}{4\varepsilon_0^2 h^2} \times \frac{\pi m e^2}{h^2 \varepsilon_0}$$

$$= \frac{e^4 \times \pi m e^2}{4h^4 \varepsilon_0^3} \qquad \text{....... (ii)}$$

eliminating ε_0 from eq (ii),

$$= \frac{e^4\ \pi m e^2 h^6}{4h^4 r^3 \pi^3 m^3 e^6} \qquad \text{from eq}^n \text{ (i)}$$

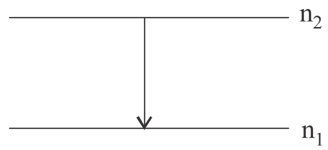
$$= \frac{h^2}{4\pi^2 m^2 r^3}$$

27. **(d)** Magnetic field at the centre of nucleus of H-atom,

$$B = \frac{\mu_0 I}{2r} \qquad \text{..... (i)}$$

According to Bohr's model, radius of orbit $r \propto n^2$ from eq. (i) we can also write as $B \propto n^{-2}$

28. **(b)** A hydrogen atom makes a transition from n = 2 to n = 1



Then wavelength $= Rcz^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] = Rc(1)^2\left[1 - \frac{1}{4}\right]$

$$\lambda = Rc\left[\frac{3}{4}\right] \qquad \text{...(1)}$$

For ionized lithium

$$\lambda = Rc(3)^2\left[\frac{1}{n^2}\right] = Rc\,9\left[\frac{1}{n^2}\right] \qquad \text{...(2)}$$

$$Rc\left[\frac{3}{4}\right] = Rc9\left[\frac{1}{n^2}\right]$$

$$\Rightarrow \frac{3}{4} = \frac{9}{n^2} \Rightarrow n = \sqrt{12} = 2\sqrt{3}$$

$\therefore$ The least quantum number must be 4.

29. **(c)** Kinetic energy of electron is

$$K.E. \propto \left(\frac{Z}{N}\right)^2$$

When the electron makes transition from excited state to ground state, then *n* increases and kinetic energy increases.

Total energy = – KE

$\therefore$ Total energy also decreases.

Potential energy is lowest for ground state.

30. **(b)** De-Broglie wavelength of electron $\lambda = \frac{h}{mV}$

As we know, $V \propto \frac{1}{n}$

So, $\lambda \propto n$

$\lambda_4 = 4\lambda_1$

λ_1 is the de-Broglie wavelength of the electron in the ground state.

31. **(c)** $qVB = \frac{mv^2}{r}$ ....(i)

$$\frac{nh}{2\pi} = mvr \qquad \text{....(ii)}$$

Multiplying equation (i) and (ii),

$$\frac{qBnh}{2\pi} = m^2v^2$$

Now multiplying both sides by $\frac{1}{2m}$,

$$n\frac{qBh}{4\pi m} = \frac{1}{2}mv^2$$

i.e. $KE = n\left[\frac{qBh}{4\pi m}\right]$

32. **(b)** Radius of circular path followed by electron is given by,

$$r = \frac{m\upsilon}{qB} = \frac{\sqrt{2meV}}{eB} = \frac{1}{B}\sqrt{\frac{2m}{e}V}$$

$$\Rightarrow \quad V = \frac{B^2r^2e}{2m} = 0.8V$$

For transition between 3 to 2.

$$E = 13.6\left(\frac{1}{4} - \frac{1}{9}\right) = \frac{13.6 \times 5}{36} = 1.88eV$$

Work function = 1.88 eV – 0.8 eV = 1.08 eV ≈ 1.1eV

33. **(c)** Wave number $\frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1^2} - \frac{1}{n^2}\right]$

$$\Rightarrow \lambda \propto \frac{1}{Z^2}$$

$\therefore \lambda Z^2 =$ constant

By question $n = 1$ and $n_1 = 2$

Then, $\lambda_1 = \lambda_2 = 4\lambda_3 = 9\lambda_4$

34. **(b)**

(1) Davisson and Gemner experiment-wave nature of electrons.

(2) Millikan's oil drop experiment - charge of an electron.

(3) Rutherford experiment - Existance of nucleus.

(4) Frank-Hertz experiment - Quantisation of energy levels.

35. **(b)** For first excited state, n = 2 and for Li^{++} Z = 3

$$E_n = \frac{13.6}{n^2} \times Z^2 = \frac{13.6}{4} \times 9 = 30.6 \text{ eV}$$

36. **(d)** $\Delta E = h\nu$

$$\nu = \frac{\Delta E}{h} = k\left[\frac{1}{(n-1)^2} - \frac{1}{n^2}\right] = \frac{k(2n-1)}{n^2(n-1)^2}$$

$$\approx \frac{2k}{n^3} \quad \text{or} \quad \nu \propto \frac{1}{n^3}$$

37. **(a)** $E = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{E} = \frac{6.62 \times 10^{-34} \times 3 \times 10^8}{12.5 \times 1.6 \times 10^{-19}} = 993\,\text{Å}$

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

(where Rydberg constant, $R = 1.097 \times 10^7$)

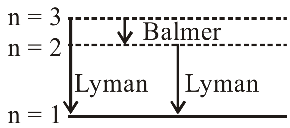
or, $\frac{1}{993 \times 10^{-10}} = 1.097 \times 10^7\left(\frac{1}{1^2} - \frac{1}{n_2^2}\right)$

Solving we get $n_2 = 3$

Spectral lines

Total number of spectral lines = 3

Two lines in Lyman series for $n_1 = 1$, $n_2 = 2$ and $n_1 = 1$, $n_2 = 3$ and one in Balmer series for $n_1 = 2$, $n_2 = 3$



38. **(c)** As $F = \frac{mv^2}{r} = \frac{e^2}{4\pi\epsilon_0}\left(\frac{1}{r^2} + \frac{\beta}{r^3}\right)$

and $mvr = \frac{nh}{2\pi} \Rightarrow v = \frac{nh}{2\pi mr}$

$$\therefore \quad m\left(\frac{nh}{2\pi mr}\right)^2 \times \frac{1}{r} = \frac{e^2}{4\pi\epsilon_0}\left(\frac{1}{r^2} + \frac{\beta}{r^3}\right)$$

or, $\frac{1}{r^2} + \frac{\beta}{r^3} = \frac{mn^2h^2 4\pi\epsilon_0}{4\pi^2m^2e^2r^3}$

or, $\frac{a_0n^2}{r^3} = \frac{1}{r^2} + \frac{\beta}{r^3} \qquad \left(\because a_0 = \frac{\epsilon_0 h^2}{m\pi e^2} \text{ Given}\right)$

For n^{th} atom

$\therefore \ r_n = a_0n^2 - \beta$

39. **(c)** According to the question,

$$2\pi r = n\lambda = \frac{nh}{p} = \frac{nh}{mv}$$

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

$F = qv_B = \frac{mv^2}{r}$ or, $q_B = \frac{mv}{r} = \frac{nh}{2\pi r.r}$

or, $r^2 = \frac{nh}{2\pi qB}$ or, $r = \sqrt{\frac{nh}{2\pi qB}}$

i.e., $r \propto n^{1/2}$

40. **(c)** Magnetic moment of the hydrogen atom, when the electron is in n^{th} excited state, i.e., $n' = (n+1)$

As magnetic moment $M_n = I_nA = i_n(\pi r_n^2)$

$$i_n = eV_n = \frac{mz^2e^5}{4\varepsilon_0^2 n^3 h^3}$$

$$r_n = \frac{n^2h^2}{4\pi^2 kzme^2}\left(k = \frac{1}{4\pi\epsilon_0}\right)$$

Solving we get magnetic moment of the hydrogen atom for n[th] excited state

$$M_{n'} = \left(\frac{e}{2m}\right)\frac{nh}{2\pi}$$

41. **(d)** For ground state, the principal quantum no. $(n) = 1$. Principal quantum number 4 belongs to 3rd excited state. The possible number of the spectral lines from a state n to ground state is

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

42. **(d)** The energy of the system of two atoms of diatomic molecule $E = \frac{1}{2}I\omega^2$

where I = moment of inertia

ω = Angular velocity = $\frac{L}{I}$,

L = Angular momentum

$$I = \frac{1}{2}(m_1r_1{}^2 + m^2r_2^2)$$

Thus, $E = \frac{1}{2}(m_1r_1{}^2 + m_2r_2{}^2)\omega^2$ ... (i)

$$E = \frac{1}{2}(m_1r_1^2 + m_2r_2{}^2)\frac{L^2}{I^2}$$

$L = n\hbar$

(According to Bohr's Hypothesis)

$$E = \frac{1}{2}(m_1r_1{}^2 + m_2r_2^2)\frac{L^2}{(m_1r_1^2 + m_2r_2^2)^2}$$

$$E = \frac{1}{2}\frac{L^2}{(m_1r_1^2 + m_2r_2^2)} = \frac{n^2h^2}{8\pi^2(m_1r_1^2 + m_2r_2^2)}$$

$$E = \frac{(m_1 + m_2)n^2h^2}{8\pi^2 r^2 m_1 m_2}$$

43. **(a)** Velocity of electron in n^{th} orbit of hydrogen atom is given by :

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

Substituting the values we get,

$$V_n = \frac{2.2\times10^6}{n}\text{m/s} \quad \text{or} \quad V_n \propto \frac{1}{n}$$

As principal quantum number increases, velocity decreases.

44. **(c)** $\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ where R = Rydberg constant

$$\frac{1}{\lambda_{32}} = \left(\frac{1}{4} - \frac{1}{9}\right) = \frac{5}{36} \quad \Rightarrow \quad \lambda_{32} = \frac{36}{5}$$

Similarly solving for λ_{31} and λ_{21}

$$\lambda_{31} = \frac{9}{8} \text{ and } \lambda_{21} = \frac{4}{3}$$

$$\therefore \quad \frac{\lambda_{32}}{\lambda_{31}} = 6.4 \text{ and } \frac{\lambda_{21}}{\lambda_{31}} \simeq 1.2$$

45. **(b)** $E = \frac{hc}{\lambda}$

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

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

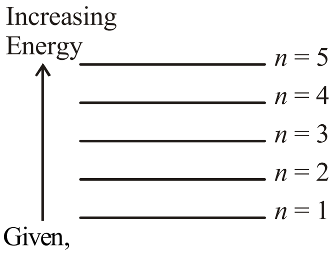
Therefore, for large n, $\lambda_{max} \propto n^3$

47. **(b)** Energy of excitation (ΔE) is

$$\Delta E = 13.6\,z^2\left(\frac{1}{n_1} - \frac{1}{n_2}\right)eV$$

$$\Rightarrow \Delta E = 13.6\,(3)^2\left(\frac{1}{1^2} - \frac{1}{3^2}\right) = 108.8\,eV$$

48. **(c)** It is given that transition from the state $n = 4$ to $n = 3$ in a hydrogen like atom result in ultraviolet radiation. For infrared radiation $\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ should be less. The only option is $5 \rightarrow 4$.



49. **(b)** Given,

Centripetal force = $\frac{k}{r}$

Then

$$\frac{k}{r} = \frac{mv^2}{r}$$

$\Rightarrow \quad k = mv^2 \qquad \Rightarrow \quad Tn = \frac{1}{2}mv^2 = \frac{1}{2}k$

Tn is independent of n

Also,

Angular momentum, $L = \frac{nh}{2\pi}$

$\Rightarrow \quad mvr_n = \frac{nh}{2\pi} \quad (\because L = mvr)$

$$\Rightarrow \quad r_n = \frac{nh}{2\pi\sqrt{km}} \quad \left(\begin{matrix}\because m^2v^2 = km \\ \text{or } mv = \sqrt{km}\end{matrix}\right)$$

Clearly, $r_n \propto n$

50. **(d)** We have to find the frequency of emitted photons. For emission of photons electron should makes a transition from higher energy level to lower energy level. so, option (a) and (b) are incorrect.

Frequency of emitted photon is given by

$$h\nu = -13.6\left(\frac{1}{n_2^2} - \frac{1}{n_1^2}\right)$$

For transition from $n = 6$ to $n = 2$,

$$\nu_1 = \frac{-13.6}{h}\left(\frac{1}{6^2} - \frac{1}{2^2}\right) = \frac{2}{9} \times \left(\frac{13.6}{h}\right)$$

For transition from $n = 2$ to $n = 1$,

$$\nu_2 = \frac{-13.6}{h}\left(\frac{1}{2^2} - \frac{1}{1^2}\right) = \frac{3}{4} \times \left(\frac{13.6}{h}\right).$$

$\therefore \nu_1 < \nu_2$

51. **(b)** Eenrgy of radiation that corresponds to energy difference between two energy levels n_1 and n_2 is given as

$$E = Rhc\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] \qquad \therefore \ E \,\alpha \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

E will be maximum for the transition for which $\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$ is maximum. Here n_2 is the higher energy level.

Clearly, $\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$ is maximum for the third transition, *i.e.*, $2 \rightarrow 1$. I transition is showing the absorption of energy.

52. **(c)** The wavelength of spectrum is given by

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

where $R = \dfrac{1.097 \times 10^7}{1 + \frac{m}{M}}$

where m = mass of electron

M = mass of nucleus.

Thus, wavelength involved in the spectrum of hudrogen like atom depends upon masses of nucleus. The mass number of hydrogen and deuterium is 1 and 2 respectively, so spectrum of deuterium will be different from hydrogen.

53. **(c)** The energy required to remove the electron from the n^{th} orbit of hydrogen is given by

$$E_n = \frac{13.6}{n^2} \text{ eV/atom}$$

For $n = 2$, $E_n = \frac{13.6}{4} = 3.4\,eV$

Therefore the energy required to remove electron from $n = 2$ is $+3.4$ eV.