Chapter 25

Atoms

1. 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 **[AIEEE-2009]**

   (1) $3 \rightarrow 2$

   (2) $4 \rightarrow 2$

   (3) $5 \rightarrow 4$

   (4) $2 \rightarrow 1$

2. 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) **[AIEEE-2012]**

   (1) $\dfrac{n^2h^2}{2(m_1+m_2)r^2}$

   (2) $\dfrac{2n^2h^2}{(m_1+m_2)r^2}$

   (3) $\dfrac{(m_1+m_2)n^2h^2}{2m_1m_2r^2}$

   (4) $\dfrac{(m_1+m_2)^2n^2h^2}{2m_1^2m_2^2r^2}$

3. 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 **[AIEEE-2012]**

   (1) 3 (2) 5

   (3) 6 (4) 2

4. In a hydrogen like atom electron makes 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 **[JEE (Main)-2013]**

   (1) $\dfrac{1}{n}$ (2) $\dfrac{1}{n^2}$

   (3) $\dfrac{1}{n^{3/2}}$ (4) $\dfrac{1}{n^3}$

5. Hydrogen ($_1H^1$), Deuterium ($_1H^2$), singly ionised Helium $(_2He^4)^+$ and doubly ionised lithium $(_3Li^6)^{++}$ all have one electron around the nucleus. Consider an electron transition from n = 2 to n = 1. If the wave lengths of emitted radiation are λ_1, λ_2, λ_3 and λ_4 respectively then approximately which one of the following is correct? **[JEE (Main)-2014]**

   (1) $4\lambda_1 = 2\lambda_2 = 2\lambda_3 = \lambda_4$

   (2) $\lambda_1 = 2\lambda_2 = 2\lambda_3 = \lambda_4$

   (3) $\lambda_1 = \lambda_2 = 4\lambda_3 = 9\lambda_4$

   (4) $\lambda_1 = 2\lambda_2 = 3\lambda_3 = 4\lambda_4$

6. As an electron makes a transition from an excited state to the ground state of a hydrogen-like atom/ion **[JEE (Main)-2015]**

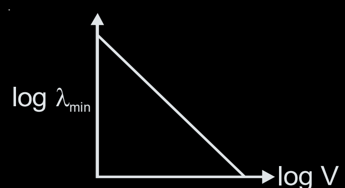
   (1) Its kinetic energy increases but potential energy and total energy decrease

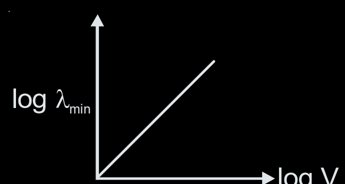
   (2) Kinetic energy, potential energy and total energy decrease

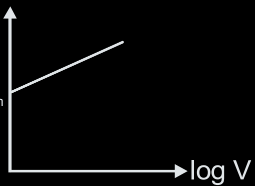
   (3) Kinetic energy decreases, potential energy increases but total energy remains same

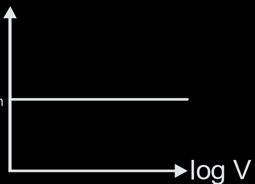
   (4) Kinetic energy and total energy decrease but potential energy increases

7. An electron beam is accelerated by a potential difference V to hit a metallic target to produce X-rays. It produces continuous as well as characteristic X-rays. If λ_{min} is the smallest possible wavelength of X-ray in the spectrum, the variation of log λ_{min} with log V is correctly represented in **[JEE (Main)-2017]**

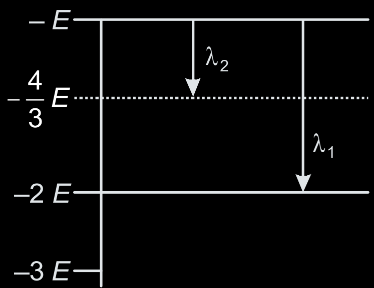
   (1) 

   (2) 

(3) $\log \lambda_{min}$ 

(4) $\log \lambda_{min}$ 

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



(1) $r = \frac{4}{3}$ (2) $r = \frac{2}{3}$

(3) $r = \frac{3}{4}$ (4) $r = \frac{1}{3}$

9. 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) **[JEE (Main)-2018]**

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

(3) $\Lambda_n^2 \approx A + B\lambda_n^2$ (4) $\Lambda_n^2 \approx \lambda$

10. If the series limit frequency of the Lyman series is ν_L, then the series limit frequency of the Pfund series is **[JEE (Main)-2018]**

(1) 25 ν_L (2) 16 ν_L

(3) $\nu_L/16$ (4) $\nu_L/25$

11. A hydrogen atom, initially in the ground state is excited by absorbing a photon of wavelength 980 Å. The radius of the atom in the excited state, in terms of Bohr radius a_0, will be

(hc = 12500 eV-Å) **[JEE (Main)-2019]**

(1) $4a_0$ (2) $9a_0$

(3) $25a_0$ (4) $16a_0$

12. In a hydrogen like atom, when an electron jumps from the M-shell to the L-shell, the wavelength of emitted radiation is λ. If an electron jumps from N-shell to the L-shell, the wavelength of emitted radiation will be **[JEE (Main)-2019]**

(1) $\frac{25}{16}\lambda$ (2) $\frac{16}{25}\lambda$

(3) $\frac{20}{27}\lambda$ (4) $\frac{27}{20}\lambda$

13. A particle of mass m moves in a circular orbit in a central potential field $U(r) = \frac{1}{2}kr^2$. If Bohr's quantization conditions are applied, radii of possible orbitals and energy levels vary with quantum number n as **[JEE (Main)-2019]**

(1) $r_n \propto n, E_n \propto n$ (2) $r_n \propto \sqrt{n}, E_n \propto n$

(3) $r_n \propto \sqrt{n}, E_n \propto \frac{1}{n}$ (4) $r_n \propto n^2, E_n \propto \frac{1}{n^2}$

14. 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

[JEE (Main)-2019]

(1) n = 2 → n = 4 (2) n = 2 → n = 5

(3) n = 2 → n = 3 (4) n = 1 → n = 4

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 **[JEE (Main)-2019]**

(1) 889.2 nm (2) 488.9 nm

(3) 388.9 nm (4) 642.7 nm

16. A He^+ ion is in its first excited state. Its ionization energy is **[JEE (Main)-2019]**

(1) 13.60 eV (2) 6.04 eV

(3) 48.36 eV (4) 54.40 eV

17. A proton, an electron, and a Helium nucleus, have the same energy. They are in circular orbits in a plane due to magnetic field perpendicular to the plane. Let r_p, r_e and r_{He} be their respective radii, then, **[JEE (Main)-2019]**

(1) $r_e < r_p < r_{He}$ (2) $r_e > r_p = r_{He}$

(3) $r_e < r_p = r_{He}$ (4) $r_e > r_p > r_{He}$

18. 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?

(Given: $h = 6.63 \times 10^{-34}$ Js; $c = 3 \times 10^8$ ms^{-1})

[JEE (Main)-2019]

(1) 11.4 nm (2) 12.3 nm

(3) 9.4 nm (4) 10.8 nm

19. 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 λ, energy $E = \frac{1240 \text{ eV}}{\lambda (\text{in nm})}$):

[JEE (Main)-2019]

(1) $n = 5$ (2) $n = 7$

(3) $n = 4$ (4) $n = 6$

20. 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

[JEE (Main)-2019]

(1) 7/5 (2) 27/5

(3) 9/7 (4) 20/7

21. 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 :

[JEE (Main)-2019]

(1) 3.5 Å (2) 12.9 Å

(3) 9.7 Å (4) 6.6 Å

22. 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 **[JEE (Main)-2020]**

(1) 1.6×10^{14}

(2) 7.8×10^{14}

(3) 5.6×10^{12}

(4) 6.2×10^{15}

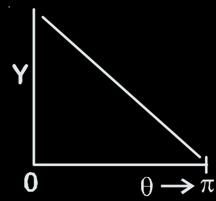
23. The graph which depicts the results of Rutherford gold foil experiment with α-particle is

θ : Scattering angle

Y : Number of scattered α-particles detected

(Plots are schematic and not to scale)

[JEE (Main)-2020]

(1)


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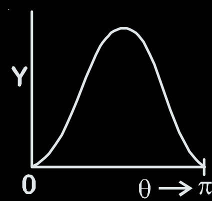

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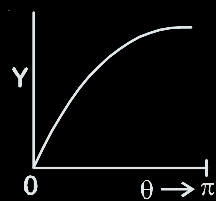

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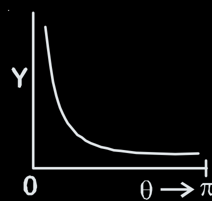


24. The energy required to ionise a hydrogen like ion in its ground state is 9 Rydbergs. What is the Wavelength of the radiation emitted when the electron in this ion jumps from the second excited state to the ground state? **[JEE (Main)-2020]**

(1) 11.4 nm (2) 24.2 nm

(3) 35.8 nm (4) 8.6 nm

25. In a hydrogen atom the electron makes a transition from $(n + 1)^{th}$ level to the n^{th} level. If $n >> 1$, the frequency of radiation emitted is proportional to

(1) $\frac{1}{n}$ (2) $\frac{1}{n^2}$

(3) $\frac{1}{n^3}$ (4) $\frac{1}{n^4}$

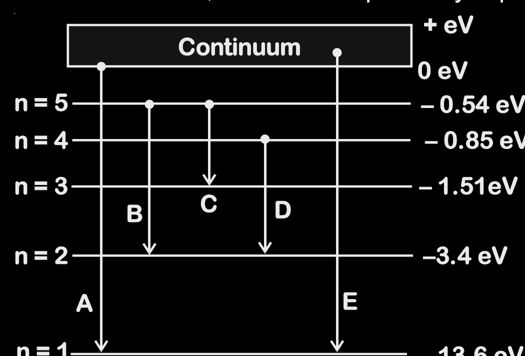
26. The first member of the Balmer series of hydrogen atom has a wavelength of 6561 Å. The wavelength of the second member of the Balmer series (in nm) is _______. **[JEE (Main)-2020]**

27. 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 Paschen series in Å is ______.

[JEE (Main)-2020]

28. In the given figure, the energy levels of hydrogen atom have been shown along with some transitions marked A, B, C, D and E. **[JEE (Main)-2021]**

The transitions A, B and C respectively represent:



(1) The ionization potential of hydrogen, second member of Balmer series and third member of Paschen series.

(2) The series limit of Lyman series, third member of Balmer series and second member of Paschen series.

(3) The series limit of Lyman series, second member of Balmer series and second member of Paschen series

(4) The first member of the Lyman series, third member of Balmer series and second member of Paschen series.

29. An X-ray tube is operated at 1.24 million volt. The shortest wavelength of the produced photon will be **[JEE (Main)-2021]**

(1) 10^{-3} nm (2) 10^{-2} nm

(3) 10^{-4} nm (4) 10^{-1} nm

30. According to Bohr atom model, in which of the following transitions will the frequency be maximum? **[JEE (Main)-2021]**

(1) n = 3 to n = 2 (2) n = 5 to n = 4

(3) n = 4 to n = 3 (4) n = 2 to n = 1

31. The wavelength of the photon emitted by a hydrogen atom when an electron makes a transition from n = 2 to n = 1 state is **[JEE (Main)-2021]**

(1) 490.7 nm (2) 121.8 nm

(3) 913.3 nm (4) 194.8 nm

32. The wavelength of an X-ray beam is 10 Å. The mass of a fictitious particle having the same energy as that of the X-ray photons is $\frac{x}{3}h$ kg. The value of x is _______.

(h = Planck's constant) **[JEE (Main)-2021]**

33. If λ_1 and λ_2 are the wavelengths of the third member of Lyman and first member of the Paschen series respectively, then the value of $\lambda_1 : \lambda_2$ is **[JEE (Main)-2021]**

(1) 1 : 3 (2) 7 : 108

(3) 7 : 135 (4) 1 : 9

34. The recoil speed of a hydrogen atom after it emits a photon in going from n = 5 state to n = 1 state will be **[JEE (Main)-2021]**

(1) 4.34 m/s

(2) 2.19 m/s

(3) 4.17 m/s

(4) 3.25 m/s

35. The first three spectral lines of H-atom in the Balmer series are given $\lambda_1, \lambda_2, \lambda_3$ considering the Bohr atomic model, the wavelengths of first and third spectral lines $\left(\frac{\lambda_1}{\lambda_3}\right)$ are related by a factor of approximately $x \times 10^{-1}$.

The value of x, to the nearest integer, is

[JEE (Main)-2021]

36. Which level of the single ionized carbon has the same energy as the ground state energy of hydrogen atom? **[JEE (Main)-2021]**

(1) 4 (2) 8

(3) 1 (4) 6

37. If an electron is moving in the n^{th} orbit of the hydrogen atom, then its velocity (v_n) for the n^{th} orbit is given as: **[JEE (Main)-2021]**

(1) $v_n \propto \frac{1}{n}$ (2) $v_n \propto n$

(3) $v_n \propto n^2$ (4) $v_n \propto \frac{1}{n^2}$

38. The atomic hydrogen emits a line spectrum consisting of various series. Which series of hydrogen atomic spectra is lying in the visible region? **[JEE (Main)-2021]**

(1) Balmer series

(2) Brackett series

(3) Lyman series

(4) Paschen series

39. A particle of mass m moves in a circular orbit in a central potential field $U(r) = U_0 r^4$. If Bohr's quantization conditions are applied, radii of possible orbitals r_n vary with $n^{\frac{1}{\alpha}}$, where α is_____.

[JEE (Main)-2021]

40. Imagine that the electron in a hydrogen atom is replaced by a muon (μ). The mass of muon particle is 207 times that of an electron and charge is equal to the charge of an electron. The ionization potential of this hydrogen atom will be :

[JEE (Main)-2021]

(1) 331.2 eV

(2) 2815.2 eV

(3) 13.6 eV

(4) 27.2 eV

41. An electron having de-Broglie wavelength λ is incident on a target in a X-ray tube. Cut-off wavelength of emitted X-ray is: **[JEE (Main)-2021]**

(1) 0 (2) $\frac{hc}{mc}$

(3) $\frac{2m^2c^2\lambda^2}{h^2}$ (4) $\frac{2mc\lambda^2}{h}$

42. The K_α X-ray of molybdenum has wavelength 0.071 nm. If the energy of a molybdenum atom with a K electron knocked out is 27.5 keV, the energy of this atom when an L electron is knocked out will be _______ keV. (Round off to the nearest integer)

[$h = 4.14 \times 10^{-15}$ eVs, $c = 3 \times 10^8$ ms^{-1}]

[JEE (Main)-2021]

43. A particular hydrogen like ion emits radiation of frequency 2.92×10^{15} Hz when it makes transition from n = 3 to n = 1. The frequency in Hz of radiation emitted in transition from n = 2 to n = 1 will be: **[JEE (Main)-2021]**

(1) 6.57×10^{15}

(2) 4.38×10^{15}

(3) 2.46×10^{15}

(4) 0.44×10^{15}

44. X different wavelengths may be observed in the spectrum from a hydrogen sample if the atoms are excited to states with principal quantum number n = 6? The value of X is _______.

[JEE (Main)-2021]

45. A free electron of 2.6 eV energy collides with a H^+ ion. This results in the formation of a hydrogen atom in the first excited state and a photon is released. Find the frequency of the emitted photon. ($h = 6.6 \times 10^{-34}$ J s)

(1) 0.19×10^{15} MHz

(2) 1.45×10^{9} MHz

(3) 9.0×10^{27} MHz

(4) 1.45×10^{16} MHz

46. Choose the correct option from the following options given below : **[JEE (Main)-2022]**

(1) In the ground state of Rutherford's model electrons are in stable equilibrium. While in Thomson's model electrons always experience a net-force

(2) An atom has a nearly continuous mass distribution in a Rutherford's model but has a highly non-uniform mass distribution in Thomson's model

(3) A classical atom based on Rutherford's model is doomed to collapse.

(4) The positively charged part of the atom possesses most of the mass in Rutherford's model but not in Thomson's model.

47. The ratio for the speed of the electron in the 3rd orbit of He^+ to the speed of the electron in the 3rd orbit of hydrogen atom will be : **[JEE (Main)-2022]**

(1) 1 : 1

(2) 1 : 2

(3) 4 : 1

(4) 2 : 1

48. A hydrogen atom in its ground state absorbs 10.2 eV of energy. The angular momentum of electron of the hydrogen atom will increase by the value of:

(Given, Planck's constant = 6.6×10^{-34} Js).

[JEE (Main)-2022]

(1) 2.10×10^{-34} Js

(2) 1.05×10^{-34} Js

(3) 3.15×10^{-34} Js

(4) 4.2×10^{-34} Js

49. A beam of monochromatic light is used to excite the electron in Li^{++} from the first orbit to the third orbit. The wavelength of monochromatic light is found to be $x \times 10^{-10}$ m. The value of x is ___.

[Given hc = 1242 eV nm] **[JEE (Main)-2022]**

50. Given below are two statements:

Statement I: In hydrogen atom, the frequency of radiation emitted when an electron jumps from lower energy orbit (E_1) to higher energy orbit (E_2), is given as $hf = E_1 - E_2$.

Statement II: The jumping of electron from higher energy orbit (E_2) to lower energy orbit (E_1) is associated with frequency of radiation given as

$$f = \frac{(E_2 - E_1)}{h}.$$

This condition is Bohr's frequency condition.

In the light of the above statements, choose the correct answer from the options given below:

[JEE (Main)-2022]

(1) Both statement I and statement II are true

(2) Both statement I and statement II are false

(3) Statement I is correct but statement II is false

(4) Statement I is incorrect but statement II is true

51. The momentum of an electron revolving in n^{th} orbit is given by: (Symbols have their usual meanings) **[JEE (Main)-2022]**

(1) $\frac{nh}{2\pi r}$ (2) $\frac{nh}{2r}$

(3) $\frac{nh}{2\pi}$ (4) $\frac{2\pi r}{nh}$

52. The magnetic moment of an electron (e) revolving in an orbit around nucleus with an orbital angular momentum is given by: **[JEE (Main)-2022]**

(1) $\vec{\mu_L} = \frac{e\vec{L}}{2m}$ (2) $\vec{\mu_L} = -\frac{e\vec{L}}{2m}$

(3) $\vec{\mu_l} = -\frac{e\vec{L}}{m}$ (4) $\vec{\mu_l} = \frac{2e\vec{L}}{m}$

53. Hydrogen atom from excited state comes to the ground state by emitting a photon of wavelength λ. The value of principal quantum number 'n' of the excited state will be, (R: Rydberg constant) **[JEE (Main)-2022]**

(1) $\sqrt{\frac{\lambda R}{\lambda - 1}}$ (2) $\sqrt{\frac{\lambda R}{\lambda R - 1}}$

(3) $\sqrt{\frac{\lambda}{\lambda R - 1}}$ (4) $\sqrt{\frac{\lambda R^2}{\lambda R - 1}}$

54. $\frac{x}{x+4}$ is the ratio of energies of photons produced due to transition of an electron of hydrogen atom from its

(i) Third permitted energy level to the second level and

(ii) The highest permitted energy level to the second permitted level.

The value of x will be ______. **[JEE (Main)-2022]**

55. In the hydrogen spectrum, λ be the wavelength of first transition line of Lyman series. The wavelength difference will be "$a\lambda$" between the wavelength of 3rd transition line of Paschen series and that of 2nd transition line of Balmer series where a = ______. **[JEE (Main)-2022]**

56. The equation $\lambda = \frac{1.227}{x}$nm can be used to find the de-Broglie wavelength of an electron.

In this equation x stands for:

Where m = Mass of electron

P = Momentum of electron

K = Kinetic energy of electron

V = Accelerating potential in volts for electron

[JEE (Main)-2022]

(1) $\sqrt{mK}$ (2) $\sqrt{P}$

(3) $\sqrt{K}$ (4) $\sqrt{V}$

57. Find the ratio of energies of photons produced due to transition of an electron of hydrogen atom from its (i) second permitted energy level to the first level, and (ii) the highest permitted energy level to the first permitted level. **[JEE (Main)-2022]**

(1) 3 : 4 (2) 4 : 3

(3) 1 : 4 (4) 4 : 1

58. In Bohr's atomic model of hydrogen, let K, P and E are the kinetic energy, potential energy and total energy of the electron respectively. Choose the correct option when the electron undergoes transitions to a higher level: **[JEE (Main)-2022]**

(1) All K, P and E increase

(2) K decreases, P and E increase

(3) P decreases, K and E increase

(4) K increases, P and E decrease

❑ ❑ ❑

Chapter 25

Atoms

1. Answer (3)

Energy gap between 4th and 3rd state is more than the gap between 5th and 4th state,

And $\Delta E = \dfrac{hc}{\lambda}$

$\lambda_{5-4} > \lambda_{4-3}$

2. Answer (3)

3. Answer (3)

4. Answer (4)

$$f \propto \left(\frac{1}{(n-1)^2} - \frac{1}{(n)^2}\right)$$

$$f \propto \frac{n^2-(n-1)^2}{n^2(n-1)^2}$$

$$f \propto \frac{n^2-n^2-1+2n}{n^2(n-1)^2}$$

$$f \propto \frac{2n-1}{n^2(n-1)^2}$$

$$n >> 1 \Rightarrow f \propto \frac{1}{n^3}$$

5. Answer (3)

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

$\Rightarrow \quad \lambda \propto \dfrac{1}{Z^2}$ for given n_1 & n_2

$\Rightarrow \lambda_1 = \lambda_2 = 4\lambda_3 = 9\lambda_4$

6. Answer (1)

$$\text{PE} = -27.2\frac{z^2}{n^2}\text{eV}$$

$$\text{TE} = -\frac{13.6z^2}{n^2}\text{eV}$$

$$\text{KE} = \frac{13.6\,z^2}{n^2}\text{eV}$$

$\text{KE} = \dfrac{13.6}{n^2}\text{eV}$, As n decreases, KE$\uparrow$

$\text{PE} = -\dfrac{27.2}{n^2}\text{eV}$, as n decreases, PE$\downarrow$

$\text{TE} = -\dfrac{13.6}{n^2}\text{eV}$, as n decreases, TE$\downarrow$

7. Answer (1)

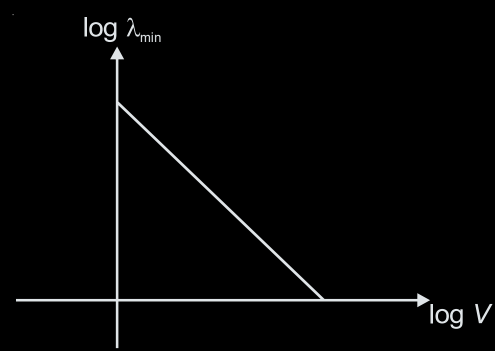
In X-ray tube

$$\lambda_{\text{min}} = \frac{hc}{eV}$$

$$\ln\lambda_{\text{min}} = \ln\left(\frac{hc}{e}\right) - \ln V$$

Slope is negative

Intercept on y-axis is positive



8. Answer (4)

From energy level diagram

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

$$\lambda_2 = \frac{hc}{\left(\frac{E}{3}\right)}$$

$$\therefore \quad \frac{\lambda_1}{\lambda_2} = \frac{1}{3}$$

9. Answer (1)

$$P_n = \frac{h}{\lambda_n}, P_g = \frac{h}{\lambda_g}$$

$$k = \frac{P^2}{2m} = \frac{h^2}{2m\lambda^2}, \ E = -k = -\frac{h^2}{2m\lambda^2}$$

$$E_n = -\frac{h^2}{2m\lambda_n^2}, \ E_g = -\frac{h^2}{2m\lambda_g^2}$$

$$E_n - E_g = \frac{h^2}{2m}\left(\frac{1}{\lambda_g^2} - \frac{1}{\lambda_n^2}\right) = \frac{hc}{\Lambda_n}$$

$$\frac{h^2}{2m}\left(\frac{\lambda_n^2 - \lambda_g^2}{\lambda_g^2 \lambda_n^2}\right) = \frac{hc}{\Lambda_n}$$

$$\Lambda_n = \frac{2mc}{h}\left(\frac{\lambda_g^2 \lambda_n^2}{\lambda_n^2 - \lambda_g^2}\right)$$

$$\Lambda_n = \frac{2mc\lambda_g^2}{h} \frac{\lambda_n^2}{\lambda_n^2\left(1 - \frac{\lambda_g^2}{\lambda_n^2}\right)}$$

$$= \frac{2mc\lambda_g^2}{h}\left[1 - \frac{\lambda_g^2}{\lambda_n^2}\right]^{-1}$$

$$= \frac{2mc\lambda_g^2}{h}\left[1 + \frac{\lambda_g^2}{\lambda_n^2}\right]$$

$$= \frac{2mc\lambda_g^2}{h} + \left(\frac{2mc\lambda_g^4}{h}\right)\frac{1}{\lambda_n^2}$$

$$= A + \frac{B}{\lambda_n^2}$$

$$A = \frac{2mc\lambda_g^2}{h}, \ B = \frac{2mc\lambda_g^4}{h}$$

10. Answer (4)

$$h\nu_L = E\left[\frac{1}{1^2} - \frac{1}{\infty}\right] = E$$

$$h\nu_P = E\left[\frac{1}{5^2} - \frac{1}{\infty}\right] = \frac{E}{25}$$

$$\Rightarrow \ \nu_P = \frac{\nu_L}{25}$$

11. Answer (4)

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

$$\Delta E = \frac{12500}{980} = 12.76 \text{ eV}$$

$E_n - E_1 = 12.76$

$E_n = E_1 + 12.76$

$= -13.6 + 12.76$

$E_n = -0.84 \text{ eV} = \frac{-13.6}{n^2} \text{ eV}$

$\Rightarrow n = 4$

$\Rightarrow r_n = 16a_0$

12. Answer (3)

$$\frac{1}{\lambda} = RZ^2\left[\frac{1}{4} - \frac{1}{9}\right] = \frac{5RZ^2}{36}$$

$$\frac{1}{\lambda_1} = RZ^2\left[\frac{1}{4} - \frac{1}{16}\right] = \frac{3RZ^2}{16}$$

$$\lambda_1 = \frac{16}{3RZ^2}, \ \lambda = \frac{36}{5RZ^2}$$

$$\frac{\lambda_1}{\lambda} = \frac{16 \times 5}{3 \times 36} = \frac{20}{27}$$

$$\lambda_1 = \frac{20}{27}\lambda$$

13. Answer (2)

$$F = \frac{-dU}{dr} = kr = \frac{mv^2}{r}$$

$$\Rightarrow \ v^2 = \frac{k}{m}r^2$$

$$\Rightarrow \ v = \sqrt{\frac{k}{m}}r \quad \text{... (i)}$$

$$\text{And, } mvr = \frac{nh}{2\pi} \quad \text{... (ii)}$$

Solving (i) and (ii)

$$m\sqrt{\frac{k}{m}}r.r = \frac{nh}{2\pi}$$

$$\Rightarrow \ r \propto \sqrt{n}$$

And, E = PE + KE

$$= \frac{1}{2}kr^2 + \frac{1}{2}\frac{mk}{m}r^2$$

$$\Rightarrow \ E \propto r^2$$

$$\Rightarrow \ E \propto n$$

14. Answer (1)

Energy released by hydrogen atom

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

$$= 10.2\text{ eV}$$

Also, energy absorbed by He^+ ion in transition

$n = 2 \rightarrow n = 4$

$$\Delta E_2 = 13.6\times 4\times\left(\frac{1}{4}-\frac{1}{16}\right)=10.2\text{ eV}$$

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

15. Answer (2)

$$\frac{1}{\lambda_1}=R\left[\frac{1}{2^2}-\frac{1}{3^2}\right]$$

$$\frac{1}{\lambda_2}=R\left[\frac{1}{2^2}-\frac{1}{4^2}\right]$$

$$\frac{5\lambda_1}{36}=\frac{12\lambda_2}{4\times 16}$$

$$\lambda_2=\frac{5\times 660\times 64}{36\times 12}=489\text{ nm}$$

16. Answer (1)

$$E_n:\ \frac{-E_0 z^2}{n^2}=\frac{-E_0\times 4}{4}=-E_0$$

To ionise it E_0 energy must be supplied.

$\therefore\quad E_0 = 13.6$ eV

17. Answer (3)

Radius of circular path (r) in a perpendicular uniform magnetic field $=\dfrac{mv}{qB}=\dfrac{\sqrt{2mK}}{qB}$

For proton, electron and α-particle,

$m_\alpha = 4m_p$ and $m_p >> m_e$

Also $q_\alpha = 2q_p$ and $q_p = q_e$

$\therefore$ As KE of all the particles is same

then,

$$r\propto\frac{\sqrt{m}}{q}$$

$\therefore\quad r_\alpha = r_p > r_e$

18. Answer (4)

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

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

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

19. Answer (1)

$$\Rightarrow\ \Delta E_n=-\frac{E_0Z^2}{n^2}$$

Let it start from n to m and from m to ground.

Then $13.6\times 4\left|1-\dfrac{1}{m^2}\right|=\dfrac{hc}{30.4\ nm}$

$$\Rightarrow\ 1-\frac{1}{m^2}=0.7498\quad\Rightarrow 0.25=\frac{1}{m^2}$$

$\therefore\quad m = 2$, and now

$$13.6\times 4\left(\frac{1}{4}-\frac{1}{n^2}\right)=\frac{hc}{108.5\times 10^{-9}}$$

$n\approx 5$.

20. Answer (4)

$$\frac{1}{\lambda_1}=R\left[\frac{1}{9}-\frac{1}{16}\right]=R\frac{7}{144}\qquad\text{...(i)}$$

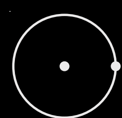
$$\frac{1}{\lambda_2}=R\left[\frac{1}{4}-\frac{1}{9}\right]=R\frac{5}{36}\qquad\text{...(ii)}$$

$$\Rightarrow\ \frac{\lambda_1}{\lambda_2}=\frac{\lambda_1}{\lambda_2}=\frac{5\times 144}{36\times 7}=\frac{20}{7}$$

21. Answer (3)

For $n = 3$,

$2\pi r = 3\times\lambda$



$$\Rightarrow\ \lambda=\frac{2\pi\times 4.65}{3}\ \text{Å}=9.7\ \text{Å}$$

22. Answer (2)

$T\ \alpha\ n^3$

$\therefore\quad T_2 = 8T = 8\times 1.6\times 10^{-16}$ s

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

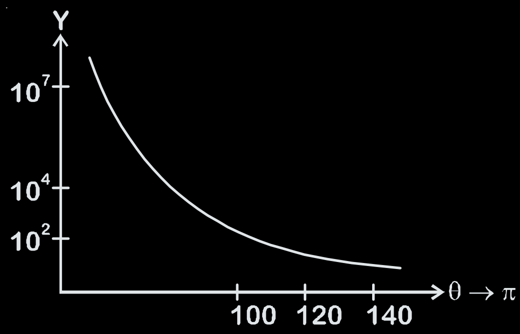
$$\approx 7.8\times 10^{14}\text{ Hz}$$

23. Answer (4)

In 1911, Ernest Rutherford publish a formula. Which indicates that number of particles (Y) that would be deflected by an angle ‘θ’ due to scattering is

$$Y_{(\theta)} = \frac{K}{\sin^4 \frac{\theta}{2}} \text{ where K = constant}$$

∴ Corresponding graph.



24. Answer (1)

Z = 3

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

$$\lambda = \frac{1}{8R} = \frac{1}{8 \times 10973731.6}$$

$$\lambda = 11.39 \text{ nm}$$

25. Answer (3)

$$E = -E_0 \times \frac{1}{n^2}$$

$$\Rightarrow \quad \Delta E = -E_0 \times \frac{2}{n^3} \times (\Delta n)$$

$$\Rightarrow \quad h\nu = 2E_0 \times 1 \times \frac{1}{n^3}$$

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

26. Answer (486.00)

$$\Delta E = \frac{hC}{\lambda} = \Delta E_0 \left[\frac{1}{4} - \frac{1}{9}\right] \quad \text{...(i)}$$

$$\text{So, } \frac{hC}{\lambda'} = \Delta E_0 \left[\frac{1}{4} - \frac{1}{16}\right] \quad \text{...(ii)}$$

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

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

27. Answer (10553.14)

For Lyman series

$$\Delta E_0 = \frac{hc}{\lambda_1} \Rightarrow \lambda_1 = \frac{hc}{\Delta E_0}$$

$$\Delta E_0 \times \frac{3}{4} = \frac{hc}{\lambda_2} \Rightarrow \lambda_2 = \frac{4hc}{3\Delta E_0}$$

$$\Delta\lambda = \frac{hc}{\Delta E_0}\left(\frac{4}{3}-1\right) = \frac{hc}{\Delta E_0}\frac{1}{3} = 304 \quad \text{...(i)}$$

For Paschen series

$$\frac{\Delta E_0}{9} = \frac{hc}{\lambda_1} \Rightarrow \lambda_1 = \frac{9hc}{\Delta E_0}$$

$$\frac{7\Delta E_0}{144} = \frac{hc}{\lambda_2} \Rightarrow \lambda_2 = \frac{144hc}{7\Delta E_0}$$

$$\Delta\lambda' = \frac{hc}{\Delta E_0}\left(\frac{144}{7}-9\right) = \frac{hc}{\Delta E_0}\left(\frac{81}{7}\right)$$

$$\Rightarrow \quad \Delta\lambda' = \frac{81 \times 3 \times 304}{7} \Rightarrow \Delta\lambda' = 10553.14$$

28. Answer (2)

A corresponds to transition from ∞ to 1.

B corresponds to transition from n = 5 to n = 2.

C corresponds to transition from n = 5 to n = 3.

29. Answer (1)

$$\lambda_{min} = \frac{hc}{eV}$$

$$= \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{1.6 \times 10^{-19} \times 1.24 \times 10^6}$$

$= 1.0 \times 10^{-12}$ m

$= 10^{-3}$ nm

30. Answer (4)

Energy in transition is maximum for n = 2 to n = 1, hence the frequency.

31. Answer (2)

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

$$= R \times \left(\frac{3}{4}\right)$$

$$\Rightarrow \quad \lambda = \frac{4}{3R} = \frac{4}{3 \times 1.09 \times 10^7}$$

$= 121.8$ nm

32. Answer (10)

$$E = \frac{hc}{\lambda} = mc^2$$

$$\Rightarrow \quad m = \frac{h}{\lambda c} = \frac{h}{10 \times 10^{-10} \times 3 \times 10^8} = \frac{10}{3} h \text{ kg}$$

33. Answer (3)

$$\frac{1}{\lambda_1} = R\left[\frac{1}{1} - \frac{1}{16}\right] \Rightarrow \lambda_1 = \frac{16}{15R}$$

$$\frac{1}{\lambda_2} = R\left[\frac{1}{9} - \frac{1}{16}\right] \Rightarrow \lambda_2 = \frac{144}{7R}$$

$$\frac{\lambda_1}{\lambda_2} = \frac{16}{15R} \times \frac{7R}{144} = \frac{7}{135}$$

34. Answer (3)

$$P = \frac{E}{C}$$

$$mv = \frac{E}{C}$$

$$\Rightarrow \quad v = \frac{E}{mC} = \frac{(13.6) \times 24 \times 1.6 \times 10^{-19}}{25 \times 1.66 \times 10^{-27} \times 3 \times 10^8}$$

$v \simeq 4.17$ m/s

35. Answer (15)

$$\frac{1}{\lambda_1} = R\left(\frac{1}{4} - \frac{1}{9}\right)$$

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

$$\frac{1}{\lambda_3} = R\left(\frac{1}{4} - \frac{1}{25}\right)$$

$$\frac{\lambda_1}{\lambda_3} = \frac{21}{100} \times \frac{36}{5} = 1.512$$

36. Answer (4)

$$\because \quad E = E_0 \times \frac{Z^2}{n^2}$$

$$\Rightarrow \quad E_0 = E_0 \times \frac{Z^2}{n^2}$$

$\Rightarrow \quad n = Z = 6$

37. Answer (1)

$$\because \quad v_n = v_0\left(\frac{Z}{n}\right)$$

$$\Rightarrow \quad v_n \propto \frac{1}{n}$$

38. Answer (1)

Balmer series lie in visible region.

39. Answer (3)

$U(r) = U_0 r^4$

$$F(r) = -\frac{dU(r)}{dr} = -4U_0 r^3$$

$$\frac{mv_n^2}{r_n} = 4U_0 r_n^3 \qquad .....(1)$$

$$mvr_n = n\frac{h}{2\pi} \qquad .....(2)$$

$$r_n \propto n^{\frac{1}{3}}$$

40. Answer (2)

Ionization potential is directly proportional to mass of revolving particle

$$\Rightarrow \quad \frac{IP_{muon}}{IP_{electron}} = \frac{m_{muon}}{m_{electron}}$$

$\Rightarrow \quad IP_{muon} = 207 \times IP_{electron}$

$= 207 \times 13.6$ eV

$= 2815.2$ eV

41. Answer (4)

$$p = \frac{h}{\lambda}$$

$$\frac{p^2}{2m} = \frac{hc}{\lambda_0}$$

$$\frac{h^2}{2m\lambda^2} = \frac{hc}{\lambda_0}$$

$$\lambda_0 = \frac{2mc\lambda^2}{h}$$

42. Answer (10)

$$\lambda_{K_\alpha} = \frac{hc}{E_K - E_L}$$

$$E_L = E_K - \frac{hc}{\lambda_{K_\alpha}}$$

$$= 27.5 \times 10^3 - \frac{4.14 \times 10^{-15} \times 3 \times 10^8}{0.071 \times 10^{-9}} \text{ eV}$$

= 27.5 – 17.49 KeV

= 10 KeV

43. Answer (3)

We know, $\frac{1}{\lambda} = R_H Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$

$$\Rightarrow f = \frac{C}{\lambda} = Z^2 R_H C \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$$

Now, $2.92 \times 10^{15} = Z^2 R_H C \left(\frac{1}{1^2} - \frac{1}{3^2} \right)$ ...(i)

$f = Z^2 R_H C \left(\frac{1}{1^2} - \frac{1}{2^2} \right)$ ...(ii)

from (i)/(ii)

$$\frac{2.92 \times 10^{15}}{f} = \frac{\frac{8}{9}}{\frac{3}{4}} = \frac{8}{9} \times \frac{4}{3}$$

$$f = \frac{27}{32} \times 2.92 \times 10^{15} \text{ Hz}$$

= 2.46×10^{15} Hz

44. Answer (15)

Possible number of wavelength = ${}^nC_2$

= 15

45. Answer (2)

$$hf = 2.6 + 13.6 \times \frac{1}{4}$$

= 6 eV

$$\Rightarrow f = \frac{6 \times 1.6 \times 10^{-19}}{6.6 \times 10^{-34}}$$

= 1.45×10^9 MHz

46. Answer (3)

An atom based on classical theory of Rutherford's model should collapse as the electrons in continuous circular motion that is a continuously accelerated charge should emit EM waves and so should lose energy. These electrons losing energy should soon fall into heavy nucleus collapsing the whole atom.

47. Answer (4)

We know that $v \propto \frac{Z}{n}$

$$\Rightarrow \text{Required ratio} = \frac{\frac{2}{3}}{\frac{1}{3}}$$

= 2 : 1

48. Answer (2)

$$-13.6 + 10.2 = \frac{-13.6}{n^2}$$

$$\Rightarrow \frac{13.6}{n^2} = 3.4$$

$\Rightarrow$ n = 2

$$\Rightarrow \Delta L = 2 \times \frac{h}{2\lambda} - 1 \times \frac{h}{2\lambda}$$

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

$$\Rightarrow \Delta L \simeq 1.05 \times 10^{-34} \text{ Js}$$

49. Answer (114)

$$E(\text{in eV}) = 13.6 \times 9 \left(1 - \frac{1}{9} \right)$$

= 13.6 × 8 eV

$$\Rightarrow \lambda = \frac{12420}{13.6 \times 8} \text{Å}$$

= 114.15 Å

50. Answer (4)

Radiation is not emitted but absorbed when an electron jumps from low energy to high energy.

Also, $E_2 - E_1$ is the energy of photon

$\Rightarrow$ $E_2 - E_1 = hf$

$$\Rightarrow f = \frac{E_2 - E_1}{h}$$

51. Answer (1)

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

$\Rightarrow \quad mv = \frac{nh}{2\pi r}$

52. Answer (2)

$\because \quad \vec{\mu} = \frac{q\vec{L}}{2m}$

$\Rightarrow \quad \vec{\mu} = \frac{-e\vec{L}}{2m}$

53. Answer (2)

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

$\Rightarrow \frac{1}{\lambda R} = 1 - \frac{1}{n^2}$

$\Rightarrow \frac{1}{n^2} = 1 - \frac{1}{\lambda R} = \frac{\lambda R - 1}{\lambda R}$

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

54. Answer (5)

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

$\frac{\frac{1}{2^2} - \frac{1}{3^2}}{\frac{1}{2^2}} = \frac{x}{x+4}$

$\Rightarrow \quad \frac{9-4}{9 \times 4 \times \frac{1}{4}} = \frac{x}{x+4} = \frac{5}{9}$

$x = 5$

55. Answer (5)

$\frac{1}{\lambda} = R_H\left(\frac{1}{1^2} - \frac{1}{2^2}\right)$

$\frac{1}{\lambda_3} = R_H\left(\frac{1}{3^2} - \frac{1}{6^2}\right)$

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

$\therefore \quad \lambda_3 - \lambda_2 = a\lambda$

$a = 5$

56. Answer (4)

$\because \lambda = \frac{1.227}{\sqrt{V}}$ nm

$\Rightarrow \quad x = \sqrt{V}$

57. Answer (1)

$E_1 = E_0\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = E_0 \times \frac{3}{4}$

$E_2 = E_0$

$\therefore \quad \frac{E_1}{E_2} = \frac{3}{4}$

58. Answer (2)

$T.E. = \frac{-Z^2 me^4}{8(nh\varepsilon_0)^2}$

$P.E. = \frac{-Z^2 me^4}{4(nh\varepsilon_0)^2}$

$K.E. = \frac{Z^2 me^4}{8(nh\varepsilon_0)^2}$

As electron makes transition to higher level, total energy and potential energy increases (due to negative sign) while the kinetic energy reduces.

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