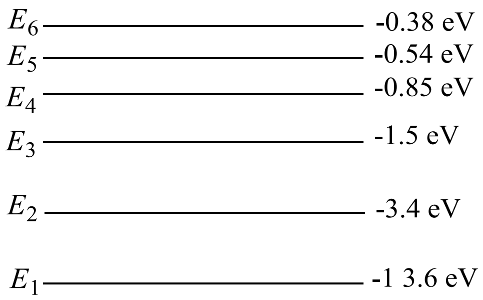
12.ATOMS

Single Correct Answer Type

1. The ratio of the speed of the electron in the first Bohr orbit of hydrogen and the speed of light is equal to (where e, h, and c have their usual meanings in cgs system)
a) $2\pi hc/e^2$ b) $er^2 h/2\pi c$ c) $e^2 c/2\pi h$ d) $2\pi e^2/hc$
2. In Fig, E_1 to E_6 represent some of the energy levels of an electron in the hydrogen atom



Which one of the following transitions produces a photon of wavelength in the ultraviolet region of the electromagnetic spectrum?
a) $E_2 - E_1$ b) $E_3 - E_2$ c) $E_4 - E_3$ d) $E_6 - E_4$
3. If elements of quantum number greater than n were not allowed, the number of possible elements in nature would have been
a) $\frac{1}{2}n(n+1)$ b) $\left\{\frac{n(n+1)}{2}\right\}^2$ c) $\frac{1}{6}n(n+1)(2n+1)$ d) $\frac{1}{3}n(n+1)(2n+1)$
4. The ratio between total acceleration of the electron in singly ionized helium atom and hydrogen atom (both in ground state) is
a) 1 b) 8 c) 4 d) 16
5. Consider a spectral line resulting from the transition $n = 5$ to $n = 1$, in the atoms and ions given below. The shortest wavelength is produced by
a) Helium atom b) Deuterium atom
c) Singly ionized helium d) Ten times ionized sodium atom
6. A hydrogen atom in around state absorbs 10.2 eV of energy. The orbital angular momentum of the electron is increased by
a) 1.05×10^{-34} Js b) 2.11×10^{-34} Js c) 3.16×10^{-34} Js d) 4.22×10^{-34} Js
7. In the Bohr model of a hydrogen atom, the centripetal force is furnished by the Coulomb attraction between the proton and the electron. If a_0 is the radius of the ground state orbit, m is the mass, and e is the charge on the electron and ε_0 is the permittivity of vacuum, then the speed of the electron is:
a) 0 b) $\frac{e}{\sqrt{\varepsilon_o a_o m}}$ c) $\frac{e}{\sqrt{4\pi\varepsilon_o a_o m}}$ d) $\sqrt{\frac{4\pi\varepsilon_o a_o m}{e}}$
8. As the electron in Bohr orbit of hydrogen atom passes from state $n = 2$ to $n = 1$, the KE (K) and PE (U) change as
a) K two-fold, U also two-fold b) K four-fold, U also four-fold
c) K four-fold, U two-fold d) K two-fold, U four-fold
9. An electron is in an excited state in a hydrogen like atom. It has a total energy $= -3.4$ eV. The kinetic energy of electron is E and its de Broglie wavelength is λ
a) $E = 6.8$ eV; $\lambda = 6.6 \times 10^{-10}$m b) $E = 3.4$ eV; $\lambda = 6.6 \times 10^{-10}$m
c) $E = 3.4$ eV; $\lambda = 6.6 \times 10^{-11}$m d) $E = 6.8$ eV; $\lambda = 6.6 \times 10^{-11}$m
10. When the voltage applied to an X-ray tube increases from $V_1 = 10$ kV to $V_2 = 20$ kV, the wavelength interval between K_α line and cut-off wavelength of continuous spectrum increase by a factor of 3. Atomic number of the metallic target is

a) 28 b) 29 c) 65 d) 66

11. A photon collides with a stationary hydrogen atom in ground state inelastically. Energy of the colliding photon is 10.2 eV. After a time interval of the order of micro second another photon collides with same hydrogen atom inelastically with an energy of 15n eV. What will be observed by the detector?
a) 2 photon of energy 10.2 eV.
b) 2 photon of energy of 1.4 eV.
c) One photon of energy 10.2 eV and an electron of energy 1.4 eV
d) One photon of energy 10.2 eV and another photon of energy 1.4 eV

12. A hydrogen-like atom emits radiations of frequency 2.7×10^{15} Hz when it makes a transition from $n = 2$ to $n = 1$. The frequency emitted in a transition from $n = 3$ to $n = 1$ will be
a) 1.8×10^{15} Hz b) 3.2×10^{15} Hz c) 4.7×10^{5} Hz d) 6.9×10^{15} Hz

13. Imagine an atom made of a proton and a hypothetical particle of double the mass of the electron but having the same charge as the electron. Apply the Bohr atom model and consider all possible transitions of this hypothetical particle to the first excited level. The longest wavelength photon that will be emitted has wavelength [given in terms of the Rydberg constant R for the hydrogen atom] equal to
a) $\frac{9}{5R}$ b) $\frac{36}{5R}$ c) $\frac{18}{5R}$ d) $\frac{4}{R}$

14. In a hydrogen atom, the electron is in n^{th} excited state. It comes down to first excited state by emitting 10 different wavelengths. The value of n is
a) 6 b) 7 c) 8 d) 9

15. If the series limit wavelength of the Lyman series for hydrogen atom is 912 Å, then the series limit wavelength for the Balmer series for the hydrogen atom is
a) 912 Å/2 b) 912 Å c) 912 × 2 Å d) 912 × 4 Å

16. An electron in the ground state of hydrogen has an angular momentum L_1 and an electron in the first excited state of lithium has an angular momentum L_2. Then
a) $L_1 = L_2$ b) $L_1 = 4L_2$ c) $L_2 = 2L_1$ d) $L_1 = 2L_2$

17. According to Bohr's theory of hydrogen atom, the product of the binding energy of the electron in the n^{th} orbit and its radius in the n^{th} orbit
a) Is proportional to n^2 b) Is inversely proportional to n^3
c) Has a constant value of 10.2 eV – Å d) Has a constant value of 7.2 eV – Å

18. The electron in a hydrogen atom makes a transition $n_1 \to n_2$, where n_1 and n_2 are the principal quantum numbers of the two states. Assume Bohr model is valid in this case. The frequency of the orbital motion of the electron in the initial state is 1/27 of that in the final state. The possible values of n_1 and n_2 are
a) $n_1 = 6, n_2 = 3$ b) $n_1 = 4, n_2 = 2$ c) $n_1 = 8, n_2 = 1$ d) $n_1 = 3, n_2 = 1$

19. Mark out the correct statement regarding X-rays
a) When fast moving electrons strike the metal target, they enter the metal target and in a very short time span come to rest, and thus an accelerated charged electron produces electromagnetic waves (X-rays)
b) Characteristic X-rays are produced due to transition of an electron from higher energy levels to vacant lower energy levels
c) X-rays spectrum is a discrete spectra just like hydrogen spectra
d) Both (a) and (b) are correct

20. The potential difference across the Coolidge tube is 20 kV and 10 mA current flows through the voltage supply. Only 0.5% of the energy carried by the electrons striking the target is converted into X-rays. The power carried by the X-ray beam is P. Then
a) $P = 0.1$ W b) $P = 1$ W c) $P = 2$ W d) $P = 10$ W

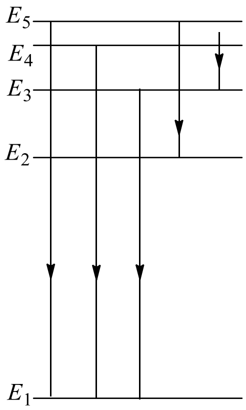
21. Check the correctness of the following statements about Bohr model of hydrogen atom:
(i) The acceleration of the electron in $n = 2$ orbit is more than that in $n = 1$ orbit
(ii) The angular momentum of the electron in $n = 2$ orbit is more than that in $n = 1$ orbit
(iii) The KE of the electron in $n = 2$ orbit is less than that in $n = 1$ orbit
a) All the statements are correct b) Only (i) and (ii) are correct

c) Only (ii) and (iii) are correct d) Only (iii) and (i) are correct

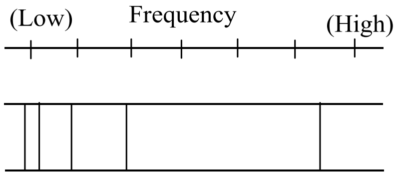
22. The shortest wavelength of Lyman series of hydrogen is equal to the shortest wavelength of Balmer series of a hydrogen-like atom of atomic number Z. The value of Z is

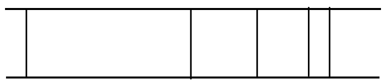
a) 4 b) 2 c) 3 d) 6

23. Figure shows five energy levels of an atom, one being much lower than the other four. Five transitions between the levels are indicated, each of which produces a photon of definite energy and frequency



Which one of the spectra below best corresponds to the set of transitions indicated?

a) 

b) 

c) 

d) 

24. The wavelength of radiation required to excite the electron from first orbit to third orbit in a doubly ionized lithium atom will be

a) 134.25 Å b) 125.5 Å c) 113.7 Å d) 110 Å

25. A hydrogen-like atom (atomic number Z) is in a higher excited state of quantum number n. This excited atom can make a transition to the first excited state by successively emitting two photons of energies 10.2 eV and 17.0 eV, respectively. Alternatively, the atom from the same excited state can make transition to the second excited state by successively emitting two photons of energies 4.25 eV and 5.95 eV, respectively. The values of n and Z are, respectively,

a) 6 and 6 b) 3 and 3 c) 6 and 3 d) 3 and 6

26. Difference between n^{th} and $(n+1)^{\text{th}}$ Bohr's radius of hydrogen atom is equal to $(n-1)^{\text{th}}$ Bohr' radius. The value of n is

a) 1 b) 2 c) 3 d) 4

27. When the hydrogen atom emits a photon in going from $n = 5$ to $n = 1$ state, its recoil speed is nearly

a) 10^{-4} ms^{-1} b) 2×10^{-2} ms^{-1} c) 4 ms^{-1} d) 8×10^{2} ms^{-1}

28. In a hydrogen atom following the Bohr's postulates, the product of linear momentum and angular momentum is proportional to $(n)^x$ where 'n' is the orbit number. Then 'x' is

a) 0 b) 2 c) -2 d) 1

29. The angular momentum of an electron in a hydrogen atom is proportional to:

a) $1/\sqrt{r}$ b) $1/r$ c) $\sqrt{r}$ d) r^2

30. When photons of wavelength λ_1 are incident on an isolated sphere suspended by an insulated thread, the corresponding stopping potential is found to be V. When photons of wavelength λ_2 are used, the corresponding stopping potential was thrice the above value. If light of wavelength λ_3 is used, calculate the stopping potential for this case

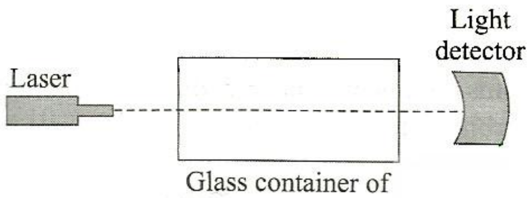
a) $\frac{hc}{e}\left[\frac{1}{\lambda_3}+\frac{1}{2\lambda_2}-\frac{1}{\lambda_1}\right]$ b) $\frac{hc}{e}\left[\frac{1}{\lambda_3}+\frac{1}{2\lambda_2}-\frac{3}{2\lambda_1}\right]$ c) $\frac{hc}{e}\left[\frac{1}{\lambda_3}+\frac{1}{\lambda_2}-\frac{1}{\lambda_1}\right]$ d) $\frac{hc}{e}\left[\frac{1}{\lambda_3}-\frac{1}{\lambda_2}-\frac{1}{\lambda_1}\right]$

31. The ratio of maximum to minimum possible radiation energy in Bohr's hypothetical hydrogen atom is

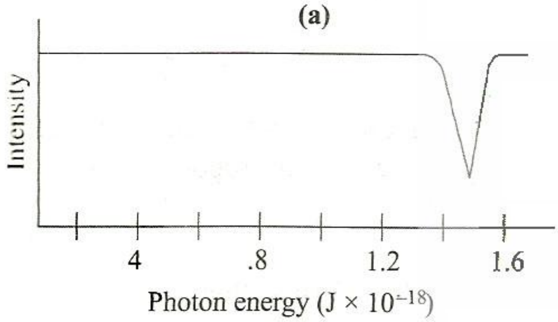
equal to

a) 2 b) 4 c) 4/3 d) 3/2

32. In order to determine the value of E_0, a scientist shines photon ("light particles") of various energies at a cloud of atomic hydrogen. Most of the hydrogen atoms occupy the ground state. A detector records the intensity of light transmitted through that cloud; see figure (a). Figure (b) is a graph of part of the scientist's data, showing the intensity of the transmitted light as a function of the photon energy. A hydrogen atom's electron is likely to absorb a photon only if the photon gives the electron enough energy to knock it into a higher shell



(a)



(b)

According to this experiment, what is the approximate value of E_0?

a) 1.6×10^{-18} J b) 2.1×10^{-18} J c) 3.2×10^{-18} J d) 6.4×10^{-18} J

33. Suppose two deuterons musts get as close as 10^{-14} m in order for the nuclear force to overcome the repulsive electrostatic force. The height of the electrostatic barrier is nearest to

a) 0.14 MeV b) 2.3 MeV c) 1.8 x 10 MeV d) 0.56 MeV

34. An electron of energy 11.2 eV undergoes an inelastic collision with a hydrogen atom in its ground state. [Neglect recoiling of atom as $m_{\mathrm{H}} \gg m_{\mathrm{e}}$]. Then in this case

a) The outgoing electron has energy 11.2 eV

b) The entire energy is absorbed by the H atom and the electron stops

c) 10.2 eV of the incident electron energy is absorbed by the H atom and the electron would come out with 1.0 eV energy

d) None of the above

35. The energy of an electron in an excited hydrogen atom is −3.4 eV. Then, according to Bohr's Theory, the angular momentum of this electron, in Js, is

a) 2.11×10^{-34} b) 3×10^{-34} c) 1.055×10^{-34} d) 0.5×10^{-34}

36. If an X-ray tube operates at the voltage of 10 kV, find the ratio of the de Broglie wavelength of the incident electrons to the shortest wavelength of X-rays produced. The specific charge of electron is 1.8×10^{11} C kg

a) 1 b) 0.1 c) 1.8 d) 1.2

37. In Bohr's model of hydrogen atom, let PE represent potential energy and TE the total energy. In going to a higher orbit,

a) PE increases, TE decreases b) PE decreases, TE increases

c) PE increases, TE increases d) PE decreases, TE decreases

38. The recoil of speed of hydrogen atom after it emits a photon in going from $n = 2$ state to $n = 1$ state is nearly [Take $R_\infty = 1.1 \times 10^7 \mathrm{m}^{-1}$ and $\mathrm{h} = 6.63 \times 10^{-34}$ Js]

a) 1.5 ms^{-1} b) 3.3 ms^{-1} c) 4.5 ms^{-1} d) 6.6 ms^{-1}

39. Transitions between three energy levels in a particular atom give rise to three spectral lines of wavelength, in increasing magnitudes, λ_1, λ_2 and λ_3. Which one of the following equations correctly relates

λ_1, λ_2 and λ_3?

a) $\lambda_1 = \lambda_2 - \lambda_3$ b) $\lambda_1 = \lambda_3 - \lambda_2$ c) $\frac{1}{\lambda_1} = \frac{1}{\lambda_2} + \frac{1}{\lambda_3}$ d) $\frac{1}{\lambda_1} = \frac{1}{\lambda_3} - \frac{1}{\lambda_2}$

40. If the K_α radiation of Mo ($Z = 42$) has a wavelength of 0.71 Å find the wavelength of the corresponding radiation of Cu ($Z = 29$)

a) 1 Å b) 2 Å c) 1.52 Å d) 1.25 Å

41. The ratio (in S.I. units) of magnetic dipole moment to that of the angular momentum of an electron of mass m kg and charge e coulomb in Bohr's orbit of hydrogen atom is

a) $\frac{e}{2m}$ b) $\frac{e}{m}$ c) $\frac{2e}{m}$ d) None of these

42. An electron in a hydrogen atom makes a transition from first excited state to ground state. The equivalent current due to circulating electron:

a) Increases 2 times b) Increases 4 times c) Increases 8 times d) Remains the same

43. If potential energy between a proton and an electron is given by $|U| = ke^2/2R^3$, where e is the charge of electron and R is the radius of atom, then radius of Bohr's orbit is given by (h = Planck's constant, k = constant)

a) $\frac{ke^2m}{h^2}$ b) $\frac{6\pi^2}{n^2}\frac{ke^2m}{h^2}$ c) $\frac{2\pi}{n}\frac{ke^2m}{h^2}$ d) $\frac{4\pi^2ke^2m}{n^2h^2}$

44. The power of an X-ray tube is 16 W. If the potential difference applied across the tube is 5 kV, then the number of electron striking the target per second is

a) 8.4×10^{16} b) 5×10^{17} c) 2×10^{16} d) 2×10^{19}

45. 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

46. The potential energy of an electron in the fifth orbit of hydrogen atom is

a) 0.54eV b) −0.54 eV c) 1.08 eV d) −1.08 eV

47. The largest wavelength in the ultraviolet region of the hydrogen spectrum is 122 nm. The smallest wavelength in the infrared region of the hydrogen spectrum (to the nearest integer) is

a) 802 nm b) 823 nm c) 1882 nm d) 1648 nm

48. The radius of the Bohr orbit in the ground state of hydrogen atom is 0.5 Å. The radius of the orbit of the electron in the third excited state of He^+ will be

a) 8 Å b) 4 Å c) 0.5 Å d) 0.25 Å

49. When an electron jumps from n_1^{th} orbit to n_2^{th} orbit, the energy radiated is given by

a) $hv = E_1/E_2$ b) $hv = E_2/E_1$ c) $hv = E_1 - E_2$ d) $hv = E_2 - E_1$

50. The voltage applied to an X-ray tube is 18 kV. The maximum mass of photon emitted by the X-ray tube will be

a) 2×10^{-13} kg b) 3.2×10^{-36} kg c) 3.2×10^{-32} kg d) 9.1×10^{-31} kg

51. In order to break a chemical bond in the molecules of human skin, causing sunburn, a photon energy of about 3.5 eV is required. This corresponds to wavelength in the

a) Infrared region b) X-ray region c) Visible region d) Ultraviolet region

52. Which of the following is true when Bohr gave his model for hydrogen atom?

a) It was not known that hydrogen lines could be explained as differences of terms like R/n^2 with R being a constant and n an integer

b) It was not known that positive charge is concentrated in a nucleus of small size

c) It was not known that radiant energy occurred in energy bundles defined by hv with h being a constant and v a frequency

d) Bohr knew terms like R/n^2 and in the process of choosing the allowed orbits to fit them he got "angular momentum = $n_i/2\pi$ as a deduction

53. Let v_1 be the frequency of series limit of Lyman series, v_2 the frequency of the first line of Lyman series, and v_3 the frequency of series limit of Balmer series. Then which of the following is correct?

a) $v_1 - v_2 = v_3$ b) $v_2 - v_1 = v_3$ c) $v_3 = \frac{1}{2}(v_1 + v_2)$ d) $v_2 + v_1 = v_3$

54. The wavelength of the second line of Balmer series in the hydrogen spectrum is 4861 Å. The wavelength of the first line is

a) $\frac{27}{20} \times 4861$ Å   b) $\frac{20}{27} \times 4861$ Å   c) 20×4861 Å   d) 4861 Å

55. The orbiting speed v_n of e^- in the n^{th} orbit in the case of positronium is x-fold compared to that in n^{th} orbit in a hydrogen atom, where x has the value

a) 1   b) $\sqrt{2}$ c) $1/\sqrt{2}$ d) 2

56. The frequency of revolution of an electron in n^{th} orbit is f_n. If the electron makes a transition from n^{th} orbit to $(n-1)^{\text{th}}$ orbit, then the relation between the frequency (v) of emitted photon and f_n will be

a) $v = f_n^2$ b) $v = \sqrt{f_n}$ c) $v = \frac{1}{f_n}$ d) $v = f_n$

57. Electron with energy 80 keV are incident on the tungsten target of an X-ray tube. K shell electrons of tungsten have -72.5 keV energy. X-rays emitted by the tube contain only

a) A continuous X-ray spectrum (Bremsstrahlung) with a minimum wavelength of -0.155 Å
b) A continuous X-ray spectrum (Bremsstrahlung) with all wavelengths
c) A continuous X-ray spectrum of tungsten
d) A continuous X-ray spectrum (Bremsstrahlung) with a minimum wavelength of 0.155 Å and the characteristic X-ray spectrum of tungsten

58. The wavelength of the first spectral line in the Balmer series of hydrogen atom is 6561 Å. The wavelength of the second spectral line in the Balmer series of singly ionized helium atom is

a) 1215 Å   b) 1640 Å   c) 2430 Å   d) 4687 Å

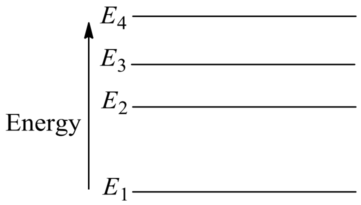
59. An X-ray tube is operating at 150 kV and 10 mA. If only 1% of the electric power is converted into X-rays, the rate at which the target is heated, in cal s^{-1}, is

a) 3.57   b) 35.7   c) 4.57   d) 15

60. K_α wavelength emitted by an atom of atomic number $Z = 11$ is λ. The atomic number for an atom that emits K_α radiation with wavelength 4λ is

a) 6   b) 4   c) 11   d) 44

61. Figure represents some of the lower energy levels of the hydrogen atom in simplified form
If the transition of an electron from E_4 to E_2 were associated with the emission of blue light, which one of the following transitions could be associated with the emission of red light?



a) E_4 to E_1 b) E_3 to E_1 c) E_3 to E_2 d) E_1 to E_3

62. Magnetic moment due to the motion of the electron in n^{th} energy of hydrogen atom is proportional to

a) n b) n^0 c) n^5 d) n^3

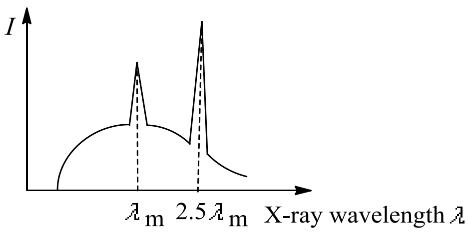
63. Consider a hypothetical annihilation of a stationary electron with a stationary positron. What is the wavelength of the resulting radiation?

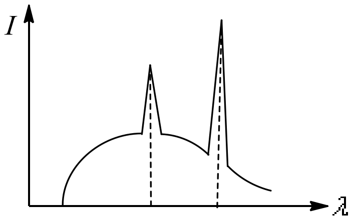
a) $\lambda = \frac{h}{m_0 c}$ b) $\lambda = \frac{2h}{m_0 c^2}$ c) $\lambda = \frac{h}{2m_0 c^2}$ d) None of these

64. A neutron having kinetic energy 5 eV is incident on a hydrogen atom in its ground state. The collision

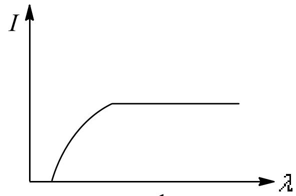
a) Must be elastic   b) Must be completely inelastic
c) May be partially elastic   d) Information is insufficient

65. When an electron accelerated by potential difference U is bombarded on a specific metal, the emitted X-rays spectrum obtained is shown in figure. If the potential difference is reduced to $U/3$, the correct spectrum is

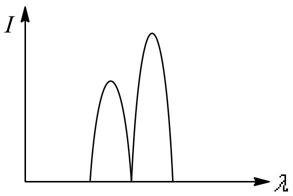


a) 

a.

b) 

b.

c) 

c.

d) 

c.

66. The orbital velocity of an electron in the ground state is v. If the electron is excited to energy state -0.54 eV, its orbital velocity will be
a) v b) $\frac{v}{3}$ c) $\frac{v}{5}$ d) $\frac{v}{7}$
67. If the average life time of an excited state of hydrogen is of the order of 10^{-8} s, then the number of revolutions an electron will make when it is in $n = 2$ state before coming to ground state will be [Take $a_0 = 0.53$ Å and all standard data if required]
a) 10^7 b) 8×10^6 c) 2×10^5 d) None of these
68. If an electron in $n = 3$ orbit of hydrogen atom jumps down to $n = 2$ orbit, the amount of energy released and the wavelength of radiation emitted are
a) 0.85 eV, 6566 Å b) 1.89 eV, 1240 Å c) 1.89 eV, 6566 Å d) 1.5 eV, 6566 Å
69. A proton of mass m moving with a speed v_0 approaches a stationary proton that is free to move. Assume impact parameter to be zero, i.e., head-on collision. How close will the incident proton go to other proton?
a) $\frac{e^3}{\pi\varepsilon_0 m^2 v_0}$ b) $\frac{e^3}{\pi\varepsilon_0 m v_0}$ c) $\frac{e^2}{\pi\varepsilon_0 m v_0^2}$ d) None of the above
70. In which of the following systems will the radius of the first orbit ($n = 1$) be minimum?
a) Doubly ionized lithium b) Singly ionized helium
c) Deuterium atom d) Hydrogen atom
71. In X-ray tube, when the accelerating voltage V is halved, the difference between the wavelength of K_α line and minimum wavelength of continuous X-ray spectrum
a) Remains constant b) Becomes more than two times
c) Becomes half d) Becomes less than two times
72. When an electron jumps from a level $n = 4$ to $n = 1$, the momentum of the recoiled hydrogen atom will be
a) 6.5×10^{-27} kg m s^{-1} b) 12.75×10^{-19} kg m s^{-1}
c) 13.6×10^{-27} kg m s^{-1} d) Zero
73. Two electrons are revolving around a nucleus at distances 'r' and '$4r$'. The ratio of their period is
a) 1:4 b) 4:1 c) 8:1 d) 1:8
74. A stationary hydrogen atom of mass M emits a photon corresponding to the first line of Lyman series. If R is the Rydberg's constant, the velocity that the atom acquires is
a) $\frac{3}{4}\frac{Rh}{M}$ b) $\frac{Rh}{4M}$ c) $\frac{Rh}{2M}$ d) $\frac{Rh}{M}$
75. Monochromatic radiations of wavelength λ are incident on a hydrogen sample in ground state. Hydrogen atom absorbs the light and subsequently emits radiations of 10 different wavelengths. The value of λ is

nearly

a) 203 nm b) 95 nm c) 80 nm d) 73 nm

76. If $n \gg 1$, then the dependence of frequency of photon emitted as a result of transition of an electron from n^{th} orbit to $(n-1)^{\text{th}}$ orbit, on n will be

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

77. The ionization potential of H atoms is 13.6 V. The energy difference between $n = 2$ and $n = 3$ levels is nearest to

a) 1.9 eV b) 2.3 eV c) 3.4 eV d) 4.5 eV

78. In the spectrum of singly ionized helium, the wavelength of a line observed is almost the same as the first line of Balmer series of hydrogen. It is due to transition of electron

a) From $n_1 = 6$ to $n_2 = 4$ b) From $n_1 = 5$ to $n_2 = 3$

c) From $n_1 = 4$ to $n_2 = 2$ d) From $n_1 = 3$ to $n_2 = 2$

79. A hydrogen atom is in an excited state of principal quantum number n. It emits a photon of wavelength λ when it returns to the ground state. The value of n is

a) $\sqrt{\lambda R(\lambda R - 1)}$ b) $\sqrt{\frac{\lambda(R-1)}{\lambda R}}$ c) $\sqrt{\frac{\lambda R}{\lambda R - 1}}$ d) $\sqrt{\lambda(R-1)}$

80. A sample of hydrogen is bombarded by electrons. Through what potential difference should the electrons be accelerated so that third line of Lyman series be emitted?

a) 2.55 V b) 10.2 V c) 12.09 V d) 12.75 V

81. A beam of 13.0 eV electrons is used to bombard gaseous hydrogen. The series obtained in emission spectra is/are

a) Lyman series b) Balmer series c) Bracket series d) All of these

82. The ratio of minimum to maximum wavelength in Balmer series is

a) 5:9 b) 5:36 c) 1:4 d) 3:4

83. An electron with kinetic energy E eV collides with a hydrogen atom in the ground state. The collision is observed to be elastic for

a) $0 < E < \infty$ b) $0 < E < 10.2$ eV c) $0 < E < 13.6$ eV d) $0 < E < 3.4$ eV

84. The electric potential between a proton and an electron is given by $V = V_0 \, \text{In} \frac{r}{r_0}$, where r_0 is a constant. Assuming Bohr's model to be applicable, write variation of r_n with n, n being the principal quantum number?

a) $r_n \propto n$ b) $r_n \propto \frac{1}{n}$ c) $r_n \propto n^2$ d) $r_n \propto \frac{1}{n^2}$

85. Which of the following statement is true regarding Bohr's model of hydrogen atom?

(I) Orbiting speed of an electrons decreases as it falls to discrete orbits away from the nucleus

(II) Radii of allowed orbits of electrons are proportional to the principal quantum number

(III) Frequency with which electrons orbit around the nucleus in discrete orbits is inversely proportional to the cube of principal quantum number

(IV) Binding force with which the electron is bound to the nucleus increase as it shifts to outer orbits

Select the correct answer using the codes given below:

a) I and II b) II and IV c) I, II and III d) II, III and IV

86. Hydrogen atoms in a sample are excited to $n = 5$ state and it is found that photons of all possible wavelengths are present, in the emission spactra. The minimum number of hydrogen atoms in the sample would be

a) 5 b) 6 c) 10 d) Infinite

87. The circumference of the second Bohr orbit of electron in hydrogen atom is 600 nm. The potential difference that must be applied between the plates so that the electrons have the de Broglie wavelength corresponding in this circumference is

a) 10^{-5} V b) $\frac{5}{3} \times 10^{-5}$ V c) 5×10^{-5} V d) 3×10^{-5} V

88. The wavelength of the spectral line that corresponds to a transition in hydrogen atom from $n = 10$ to ground state would be [In which part of electromagnetic spectrum this line lies?]
a) 92.25 nm, ultraviolet b) 92.25 nm, infrared c) 86.95 nm, ultraviolet d) 97.65 nm, ultraviolet

89. A photon collides with a stationary hydrogen atom in ground state inelastically. Energy of the colliding photon is 10.2 eV. Almost instantaneously, another photon collides with same hydrogen atom inelastically with an energy of 15 eV. What will be observed by the detector?
a) Two photons of energy 10.2 eV
b) Two photon of energy 1.4 eV
c) One photon of energy 10.2 eV and one electron of energy 1.4 eV
d) One electron having kinetic energy nearly 11.6 eV

90. In hydrogen spectrum, the shortest wavelength in Balmer series is λ. The shortest wavelength in Brackett series will be
a) 2λ b) 4λ c) 9λ d) 16λ

91. One of the lines in the emission spectrum of Li^{2+} has the same wavelength as that of the 2nd line of Balmer series in hydrogen spectrum. The electronic transition corresponding to this line is
a) $n = 4 \rightarrow n = 2$ b) $n = 8 \rightarrow n = 2$ c) $n = 8 \rightarrow n = 4$ d) $n = 12 \rightarrow n = 6$

92. The wavelength of the first line of Balmer series is 6563 Å. The Rydberg's constant is
a) 1.09×10^5 per m^{-1} b) 1.09×10^6 per m^{-1} c) 1.097×10^7 per m^{-1} d) 1.09×10^8 per m^{-1}

93. A hydrogen atom and a Li^{++} ion are both in the second excited state. If ℓ_H and ℓ_{LI} are their respective electronic angular momenta, and E_H and E_{Li} their respective energies, then
a) $\ell_H < \ell_{LI}$ and $|E_H| > |E_{LI}|$ b) $\ell_H = \ell_{LI}$ and $|E_H| < |E_{LI}|$
c) $\ell_H = \ell_{LI}$ and $|E_H| > |E_{LI}|$ d) $\ell_H < \ell_{LI}$ and $|E_H| < |E_{LI}|$

94. Given: mass number of gold = 197, density of gold= 19.7 g cm^{-3}, Avogadro's number = 6×10^{23}. The radius of the gold atom is approximately:
a) 1.5×10^{-8} m b) 1.5×10^{-9} m c) 1.5×10^{-10} m d) 1.5×10^{-12} m

95. Magnetic field at the center (at nucleus) of the hydrogen-like atoms (atomic number = z) due to the motion of electron in n^{th} orbit is proportional to
a) $\frac{n^3}{z^5}$ b) $\frac{n^4}{z}$ c) $\frac{z^2}{n^3}$ d) $\frac{z^3}{n^5}$

96. The recoil speed of a hydrogen atom after it emits a photon in going from $n = 5$ state to $n = 1$ state is
a) 4.718 ms^{-1} b) 7.418 ms^{-1} c) 4.178 ms^{-1} d) 7.148 ms^{-1}

97. The wavelength K_α of X-rays produced by the X-ray tube is 0.76 Å. The atomic number of the node material of the tube is
a) 30 b) 40 c) 50 d) 60

98. The force acting on the electron in a hydrogen atom depends on the principal quantum number as
a) $F \propto n^2$ b) $F \propto \frac{1}{n^2}$ c) $F \propto n^4$ d) $F \propto \frac{1}{n^4}$

99. As the quantum number increases, the difference of energy between conservative energy levels:
a) Decreases b) Increases
c) First decreases and then increases d) Remain the same

100. If 10,000 V are applied across an X-ray tube, find the ratio of wavelength of the incident electrons and shortest wavelength of X-ray coming out of the X-ray tube, given e/m, of electron = $1.8 \times 10^{11} C\ kg^{-1}$
a) 1:10 b) 10:1 c) 5:1 d) 1:5

101. The maximum angular speed of the electron of a hydrogen atom in a stationary orbit is
a) 6.2×10^{15} rad s^{-1} b) 4.1×10^{16} rad s^{-1} c) 24×10^{10} rad s^{-1} d) 9.2×10^6 rad s^{-1}

102. In interpreting Rutherford's experiments on the scattering of alpha particles by thin foils, one must examine what were the known factors, and what did the experiment conclude. Which of the following are true in this context?
a) The number of electrons in the target atom (i.e., Z) was settled by these experiments
b) The validity of Coulomb's law for distance as small as 10^{-13} was known before these experiments

c) The experiments settled that size of the nucleus could not be larger than a certain value

d) The experiments also settled that size of the nucleus could not be smaller than a certain value

103. An electron jumps from the 4th orbit to the 2nd orbit of hydrogen atom. Given: the Rydberg's constant $= 10^5\ \text{cm}^{-1}$. The frequency, in Hz, of the emitted radiation will be

a) $\frac{3}{16} \times 10^5$ b) $\frac{3}{6} \times 10^{15}$ c) $\frac{9}{16} \times 10^5$ d) $\frac{9}{16} \times 10^{15}$

104. The angular momentum of an electron in first orbit of Li^{++} ion is

a) $\frac{3h}{2\pi}$ b) $\frac{9h}{2\pi}$ c) $\frac{h}{2\pi}$ d) $\frac{h}{6\pi}$

105. 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 the 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

106. An electron and a photon have same wavelength. If p is the momentum of electron and E the energy of photon, the magnitude of p/E is S.I. unit is

a) 3.0×10^8 b) 3.33×10^{-9} c) 9.1×10^{-31} d) 6.64×10^{-34}

107. An electron revolving in an orbit of radius 0.5 Å in a hydrogen atom executes 10^{16} revolutions per second. The magnetic moment of electron due to its orbital motion will be

a) $1.256 \times 10^{-23}\text{A m}^2$ b) $653 \times 10^{-26}\text{A m}^2$ c) 10^{-3}A m^2 d) $256 \times 10^{-26}\text{A m}^2$

108. The frequency of emission line for any transition in positronium atom (consisting of a positron and an electron) is x times the frequency for the corresponding line in the case of H atom, where x is

a) $\sqrt{2}$ b) $1/2\sqrt{2}$ c) $1/2\sqrt{2}$ d) $1/2$

109. If the potential difference applied across a Coolidge tube is increased, then

a) Wavelength of K_α will increase b) λ_{min} will increase

c) Difference between wavelength of K_α and λ_{min} increases d) None of these

110. If R is the Rydberg constant for hydrogen, then the wave number of the first line in the Lyman series is

a) $\frac{R}{2}$ b) $2R$ c) $\frac{R}{4}$ d) $\frac{3R}{4}$

111. How many revolutions does an electron complete in one second in the first orbit of hydrogen atom?

a) 6.62×10^{15} b) 100 c) 1000 d) 1

112. Angular momentum (L) and radius (r) of a hydrogen atom are related as

a) $Lr =$ constant b) $Lr^2 =$ constant c) $Lr^4 =$ constant d) None of these

113. The total energy of an electron in the ground state of hydrogen atom is −13.6 eV. The potential energy of an electron is the ground state of Li^{2+} ion will be

a) 122.4 eV b) −122.4 eV c) 244.8 eV d) −244.8 eV

114. If elements with principal quantum number $n > 4$ were not allowed in nature, the number of possible elements would have been

a) 32 b) 60 c) 64 d) 4

115. An electron collides with a hydrogen atom in its ground state and excites it to $n = 3$. The energy given to hydrogen atom in this inelastic collision is [Neglect the recoiling of hydrogen atom]

a) 10.2 eV b) 12.1 eV c) 12.5 eV d) None of these

116. In terms of Rydberg constant R, the shortest wavelength in Balmer series of hydrogen atom spectrum will have wavelength

a) $1/R$ b) $4/R$ c) $3/2R$ d) $9/R$

117. An atom emits a spectral line of wavelength λ when an electron makes a transition between levels of energy E_1 and E_2. Which expression correctly relates λ, E_1 and E_2?

a) $\lambda = \frac{hc}{E_1 + E_2}$ b) $\lambda = \frac{2hc}{E_1 + E_2}$ c) $\lambda = \frac{2hc}{E_1 - E_2}$ d) $\lambda = \frac{hc}{E_1 - E_2}$

118. In which of the following transitions will the wavelength be minimum?

a) $n_1 = 5$ to $n_2 = 4$ b) $n_1 = 4$ to $n_2 = 3$ c) $n_1 = 3$ to $n_2 = 2$ d) $n_1 = 2$ to $n_2 = 1$

119. An electron in a Bohr orbit of hydrogen atom with the quantum number n_2 has an angular momentum 4.2176×10^{-34} kg m^{2}s^{-2}. If the electron drops from this level to the next lower level, the wavelength of this line is

a) 18 nm b) 187.6 pm c) 1876 Å d) 1.876×10^4 Å

120. In hydrogen and hydrogen-like atoms, the ratio of $E_{4n} - E_{2n}$ and $E_{2n} - E_n$ varies with atomic number z and principal quantum number n as

a) $\frac{z^2}{n^2}$ b) $\frac{z^4}{n^4}$ c) $\frac{z}{n}$ d) None of these

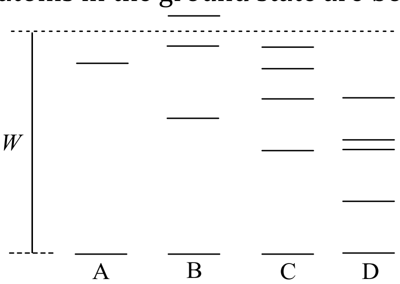
121. The wavelength of first line of Lyman series in hydrogen atom is 1216. The wavelength of first line of Lyman series for 10 times ionized sodium atom will be added

a) 0.1 Å b) 1000 Å c) 100 Å d) 10 Å

122. An alpha particle of energy 5 MeV is scattered through 180° by a fixed uranium nucleus. The distance of the closest approach is of the order of

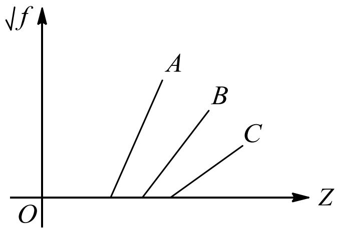
a) 10^{-15} cm b) 10^{-13} cm c) 10^{-12} cm d) 10^{-19} cm

123. Figure shows the electron energy levels, referred to the ground state (the lowest possible energy) as zero, for five different isolated atoms. Which atom can produce radiation of the shortest wavelength when atoms in the ground state are bombarded with electrons of energy W?



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

124. Figure shows Moseley's plot between $\sqrt{f}$ and Z, where f is the frequency and Z is the atomic number. Three lines A, B and C shown in the graph may represent



a) K_α, K_β and K_γ lines, respectively b) K_γ, K_β and K_α lines, respectively
c) K_α, L_α and M_α lines, respectively d) Nothing

125. The ionization energy of the ionized sodium atom Na^{10+} is:

a) 13.6 eV b) 13.6×11 eV c) (13.6/11) eV d) $13.6 \times (11^2)$ eV

126. Determine the maximum wavelength that hydrogen in its ground state can absorb. What would be the next smaller wavelength that would work?

a) 133 nm b) 13.3 nm c) 10.3 nm d) 103 nm

127. The longest wavelength that a singly ionised helium atom in its ground state will absorb is

a) 912 Å b) 304 Å c) 606 Å d) 1216 Å

128. Let the potential energy of a hydrogen atom in the ground state be zero. Then, its energy in the first excited state will be

a) 10.2 eV b) 13.6 eV c) 23.8 eV d) 27.2 eV

129. Which of the following parameters are the same for all hydrogen-like atoms and ions in their ground states?

a) Radius of the orbit b) Speed of the electron
c) Energy of the atom d) Orbital angular momentum of the electron

130. The minimum kinetic energy required for ionization of a hydrogen atom is E_1 is case electron is collided

with hydrogen atom. It is E_2 if the hydrogen ion is collided and E_3 when helium ion is collided. Then,

a) $E_1 = E_2 = E_3$ b) $E_1 > E_2 > E_3$ c) $E_1 < E_2 < E_3$ d) $E_1 > E_3 > E_2$

131. If 13.6 eV energy is required to ionize the hydrogen atom, then the energy required to remove an electron from $n = 2$ is

a) 10.2 eV b) 0 eV c) 3.4 eV d) 6.8 eV

132. The energy change is greatest for a hydrogen atom when its state changes from

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

133. If a hydrogen atom emits a photon of energy 12.1 eV, its orbital angular momentum changes by ΔL. Then, ΔL equals orbital angular momentum changes by ΔL. Then, ΔL equals

a) 1.05×10^{-34} Js b) 2.11×10^{-34} Js c) 3.16×10^{-34} Js d) 4.22×10^{-34}

134. X-rays emitted from a copper target and a molybdenum target are found to contain a line of wavelength 22.85 nm attributed to the K_α line of an impurity element. The K_α lines of copper ($Z = 29$) and molybdenum ($Z = 42$) have wavelengths 15.42 nm and 7.12 nm, respectively. The atomic number of the impurity element is

a) 22 b) 23 c) 24 d) 25

135. In the Bohr model of a π-mesin atom, a π-menon of mass m_π and of the same charge as the electron is in a circular orbit of radius r about the nucleus with an orbital angular momentum $h/2\pi$. If the radius of a nucleus of atomic number Z is given by $R = 1.6 \times 10^{-15} Z^{\frac{1}{3}}$ m, Then the limit on Z for which ($\varepsilon_0 h^2/\pi m e^2 =$ 0.53 Å and $m_\pi/m_e = 264$) π-mesic atoms might exist is

a) < 105 b) > 105 c) < 37 d) > 37

136. The electron in a hydrogen atom jumps from ground state to the higher energy state where its velocity is reduced to one-third its initial value. If the radius of the orbit in the ground state is r, the radius of new orbit will be

a) $3r$ b) $9r$ c) $\frac{r}{3}$ d) $\frac{r}{9}$

137. In which of the following transitions will the wavelength be minimum?

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

138. The approximate value of quantum number n for the circular orbit of hydrogen of 0.0001 mm in diameter is

a) 1000 b) 60 c) 10000 d) 31

139. Electrons in a hydrogen-like atom ($Z = 3$) make transitions from 4^{th} excited state to 3^{rd} excited state and from 3^{rd} to 2^{nd} excited state. The resulting radiations are incident on a metal plate to eject photoelectrons. The stopping potential for photoelectrons ejected by the shorter wavelength is 3.95 V. The stopping potential for the photoelectrons ejected by the longer wavelength is

a) 2.0 V b) 0.75 V c) 0.6 V d) None of the above

140. The velocity of an electron in the first orbit of H atom is v. The velocity of an electron in the 2^{nd} orbit of He^+ is

a) $2v$ b) v c) $\frac{v}{2}$ d) $\frac{v}{4}$

141. The radius of hydrogen atom in the ground state is 5.3×10^{-11} m. When struck by an electron, its radius is found to be 21.2×10^{-11} m. The principal quantum number of the final state will be

a) 1 b) 2 c) 3 d) 4

142. The minimum energy to ionize an atom is the energy required to

a) Add one electron to the atom

b) Excite the atom from its ground state to its first excited

c) Remove one outermost electron from the atom

d) Remove one innermost electron from the atom

143. The shortest wavelength produced in an X-ray tube operating at 0.5 million volt is

a) Dependent on the target element

b) About 2.5×10^{-12} m

c) Double of the shortest wavelength produced at 1 million volt

d) Dependent only on the target material

144. The shortest wavelength of the Brackett series of a hydrogen-like atom (atomic number $= z$) is the same as the shortest wavelength of the Balmer series of hydrogen atom. The value of z is

a) 2 b) 3 c) 4 d) 6

145. A sample of hydrogen atoms is in excited state (all the atoms). The photons emitted from this sample are made to pass through a filter through which light having wavelength greater than 800 nm can only pass. Only one type of photons are found to pass the filter. The sample's excited state initially is [Take $hc = 1240$ eV-nm, ground state energy of hydrogen atom $= -13.6$ eV]

a) 5th excited state b) 4th excited state c) 3rd excited state d) 2nd excited state

146. If first excitation potential of a hydrogen-like atom is V electron volt, then the ionization energy of this atom will be

a) V electron volt b) $\frac{3V}{4}$ electron volt

c) $\frac{4V}{3}$ electron volt d) Cannot be calculated by given information

147. In a hydrogen atom, the electron makes a transition from $n = 2$ to $n = 1$. The magnetic field produced by the circulating electron at the nucleus

a) Decreases 16 times b) Increases 4 times c) Decreases 4 times d) Increases 32 times

148. Hydrogen atoms are excited from ground state to the state of principal quantum number 4. Then, the number of spectral lines observed will be

a) 3 b) 6 c) 5 d) 2

149. The electric potential energy between a proton and an electron is given by $U = U_0 \ln r/r_0$, where r_0 is a constant. Assuming Bohr' model to be applicable, write variation of r with n, n being the principal quantum number

a) $r_n \propto n$ b) $r_n \propto 1/n$ c) $r_n \propto n^2$ d) $r_n \propto 1/n^2$

150. The angular momentum of an electron in an orbit is quantized because it is a necessary condition for the compatibility with

a) Wave nature of electron b) Particle nature of electron

c) Pauli's exclusion behavior d) None of these

151. A beam of electron accelerated by a large potential difference V is made to strike a metal target to produce X-rays. For which of the following values of V, will the resulting X-rays have the lowest minimum wavelength?

a) 10 kV b) 20 kV c) 30 kV d) 40 kV

152. A K_α X-ray emitted from a sample has a energy of 7.46 keV. Of which element is the sample made?

a) Calcium (Ca, $Z = 20$) b) Cobalt (Co $Z = 27$)

c) Cadmium (Cd $Z = 48$) d) Nickel (Ni, $Z = 28$)

153. In the above question, if the scientist continues taking data at higher photon energies, he will find the next major "dip" in the intensity graph at what photon energy?

a) $\frac{1}{9}E_0$ b) $\frac{8}{9}E_0$ c) $3E_0$ d) $9E_0$

154. The photon radiated from hydrogen corresponding to 2nd line of Lyman series is absorbed by a hydrogen-like atom 'X' in 2nd excited state. As a result then, the hydrogen-like atom 'X' makes a transition of n^{th} orbit

a) $X = He^+, n = 4$ b) $X = Li^{++}, n = 6$ c) $X = He^+, n = 6$ d) $X = Li^{++}, n = 9$

155. If the atom ${}_{100}Fm^{257}$ follows the Bohr model and the radius of ${}_{100}Fm^{257}$ is n times the Bohr radius, then find n.

a) 100 b) 200 c) 4 d) 1/4

156. In a hypothetical system, a particle of mass m and charge $-3q$ is moving around a very heavy particle charge q. Assume that Bohr's model is applicable to this system, then velocity of mass m in firsts orbit is

a) $\frac{3q^2}{2\varepsilon_0 h}$ b) $\frac{3q^2}{4\varepsilon_0 h}$ c) $\frac{3q}{2\pi\varepsilon_0 h}$ d) $\frac{3q}{4\pi\varepsilon_0 h}$

157. The electron in a hydrogen atom makes a transition from $n = n_1$ to $n = n_2$ state. The time period of the electron in the initial state is eight times that in the final state. The possible values of n_1 and n_2 are

a) $n_1 = 4, n_2 = 2$ b) $n_1 = 8, n_2 = 2$ c) $n_1 = 8, n_2 = 3$ d) $n_1 = 6, n_2 = 2$

158. When a hydrogen atom is raised from the ground state to fifth state:
a) Both KE and PE increase
b) Both KE and PE decrease
c) PE increases and KE decreases
d) PE decreases and KE increases

159. If the radius of an orbit is r and the velocity of electron in it is v, then the frequency of electron in the orbit will be
a) $2\pi rv$ b) $\frac{2\pi}{vr}$ c) $\frac{vr}{2\pi}$ d) $\frac{v}{2\pi r}$

160. Two hydrogen atoms are in excited state with electrons residing in $n = 2$. The first one is moving towards left and emits a photon of energy E_1 towards right. The second one is moving towards right with same speed and emits a photon of energy E_2 towards left. Taking recoil of nucleus into account, during the emission process
a) $E_1 > E_2$
b) $E_1 < E_2$
c) $E_1 = E_2$
d) Information insufficient

161. The wavelength of $K_\alpha X$-rays of two metals 'A' and 'B' are $4/1875R$ and $1/675R$, respectively, where 'R' is Rydberg's constant. The number of elements lying between 'A' and 'B' according to their atomic numbers is
a) 3 b) 6 c) 5 d) 4

162. In a hydrogen atom, the transition takes place from $n = 3$ to $n = 2$. If Rydberg's constant is $1.09 \times 10^7 \text{m}^{-1}$, the wavelength of the line emitted is
a) 6606 Å b) 4861 Å c) 4340 Å d) 4101 Å

163. If λ_1 and λ_2 are the wavelength of the first members of the Lyman and Paschen series, respectively, then $\lambda_1 : \lambda_2$ is
a) 1:3 b) 1:30 c) 7:50 d) 7:108

164. Three photons coming from excited atomic-hydrogen sample are picked up. Their energies are 12.1 eV, 10.2 eV, and 1.9 eV. These photons must come from
a) A single atom
b) Two atoms
c) Three atoms
d) Either two atoms or three atoms

165. Whenever a hydrogen atom emits a photon in the Balmer series
a) It need not emit any more photon
b) It may emit another photon in the Paschen series
c) It must emit another photon in the Lyman series
d) It may emit another photon in the Balmer series

166. The element which has a K_α X-rays line of wavelength 1.8 Å is
($R = 1.1 \times 10^7 \text{m}^{-1}$, b = 1 and $\sqrt{5/33} = 0.39$)
a) Co, $Z = 27$ b) Iron, $Z = 26$ c) Mn, $Z = 25$ d) Ni, $Z = 28$

167. The angular momentum of an electron in hydrogen atom is $4h/2\pi$. Kinetic energy of this electron is
a) 4.35 eV b) 1.51 eV c) 0.85 eV d) 13.6 eV

168. If wavelength of photon emitted due to transition of an electron from third orbit to first orbit in a hydrogen atom is λ, then the wavelength of photon emitted due to transition of electron from fourth orbit to second orbit will be
a) $\frac{128}{27}\lambda$ b) $\frac{25}{9}\lambda$ c) $\frac{36}{7}\lambda$ d) $\frac{125}{11}\lambda$

169. If the electron in an hydrogen atom jumps from an orbit with level $n_f = 3$ to an orbit with level $n_f = 2$, the emitted radiation has a wavelength given by
a) $\lambda = \frac{R}{6}$ b) $\lambda = \frac{36}{5R}$ c) $\lambda = \frac{6}{R}$ d) $\lambda = \frac{5R}{36}$

170. The speed of electrons in the second orbit of Be^{3+} ion will be
a) $\frac{c}{137}$ b) $\frac{2c}{137}$ c) $\frac{3c}{137}$ d) $\frac{4c}{137}$

Multiple Correct Answers Type

171. In an X-ray tube, the voltage applied is 20 kV. The energy required to remove an electron from L shell is 19.9 keV. In the X-rays emitted by the tube,
    a) Minimum wavelength will be 62.1 nm
    b) Energy of the characteristic x-rays will be equal to or less than 19.9 keV
    c) L_α X-ray may be emitted
    d) L_α X-ray will have energy 19.9 keV
172. The electron in a hydrogen atom makes a transition from an excited state to the ground state. Which of the following statements is true?
    a) Its kinetic energy increases and its potential and total energies decrease
    b) Its kinetic energy decreases, potential energy increases, and its total energy remains the same
    c) Its kinetic and total energies decrease and its potential, energy increases
    d) Its kinetic, potential and total energies decrease
173. Which of the following products, in a hydrogen atom, are independent of the principal quantum number n? The symbols have their usual meanings
    a) $\omega^2 r$ b) $\frac{E}{v^2}$ c) $v^2 r$ d) $\frac{E}{r}$
174. The shortest wavelength of X-rays emitted from an X-ray tube depends on
    a) The current in the tube
    b) The voltage applied to the tube
    c) The nature of the gas in the tube
    d) The atomic number of the target material
175. In Bohr's model of hydrogen atom:
    a) The radius of n^{th} orbit is proportional to n^2
    b) The total energy of electron in n^{th} orbit proportional to n
    c) The angular momentum of the electron in an orbit is an integral multiple of $h/2\pi$
    d) The magnitude of the potential energy of an electron in any orbit is greater than its kinetic energy
176. An X-ray tube is operating at 50 kV and 20 mA. The target material of the tube has mass of 1 kg and specific heat 495 J $\text{kg}^{-1}{}^\circ\text{C}^{-1}$. One percent of applied electric power is converted into X-rays and the remaining energy goes heating the target. Then,
    a) A suitable target material must have high melting temperature
    b) A suitable target material must have low thermal conductivity
    c) The average rate of rise of temperature of the target would be 2°C s^{-1}
    d) The minimum wavelength of X-rays emitted is about 0.25×10^{-10} m
177. In Bohr' model of the hydrogen atom
    a) The radius of the n^{th} orbit is proportional of n^2
    b) The total energy of the electron in n^{th} orbit is inversely proportional to n
    c) The angular momentum of the electron in an orbit is an integral multiple of $h/2\lambda$
    d) The magnitude of potential energy of the electron in any orbit is greater than its KE
178. Suppose the potential energy between an electron and a proton at a distance r is given by $Ke^2/3r^3$. Application of Bohr's theory to hydrogen atom in this cases shows that:
    a) Energy in the n^{th} orbit is proportional to n^6
    b) Energy is proportional to m^{-3} (m =mass of electron)
    c) Energy in the n^{th} orbit is proportional to n^{-2}
    d) Energy is proportional to m^3(m = mass of electron)
179. If the potential energy of the electron in the first allowed orbit in hydrogen atom is E; its
    a) Ionization potential is $-E/2$
    b) Kinetic energy is $-E/2$
    c) Total energy is $E/2$
    d) None of these
180. The electron in a hydrogen atom makes a transition $n_1 \rightarrow n_2$, where n_1 and n_2 are the principal quantum numbers of the two states. Assume the Bohr model to be valid. The time period of the electron in the initial state is eight times that in the final state. The possible values of n_1 and n_2 are

a) $n_1 = 4, n_2 = 2$ b) $n_1 = 8, n_2 = 2$ c) $n_1 = 8, n_2 = 1$ d) $n_1 = 6, n_2 = 3$

181. A hydrogen atom having kinetic energy E collides with a stationary hydrogen atom. Assume all motions are taking place along line of motion of the moving hydrogen atom. For this situation, mark out the correct statement(s)
 a) For $E \geq 20.4$ eV only, collision would be elastic
 b) For $E \geq 20.4$ eV only, collision would be inelastic
 c) For $E = 2.4$ eV, collision would be perfectly inelastic
 d) For $E = 18$ eV, the KE of initially moving hydrogen atom after collision is zero

182. 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, if emitted, will have a wavelength of about 122 nm
 d) It may emit a second photon, but the wavelength of this photon cannot be predicted

183. Which of the following statements are correct for an X-ray tube?
 a) On increasing potential difference between the filament and target, photon flux of X-rays increases
 b) On increasing potential difference between the filament and target, frequency of X-rays increases
 c) On increasing filament current, cut-off wavelength increases
 d) On increasing filament current, intensity of X-rays increases

184. Imagine an atom made up of a proton and a hypothetical particle of double the mass of the electron but having the same charge as the electron. Apply the Bohr atom model and consider all possible transitions of this hypothetical particle to the first excited level. The longest wavelength photon that will be emitted has wavelength λ (giving in terms of the Rydberg constant R for the hydrogen atom) equal to
 a) $9/(5R)$ b) $36/(5R)$ c) $18/(5R)$ d) $4/R$

185. A gas of monoatomic hydrogen is bombarded with a stream of electrons that have been accelerated from rest through a potential difference of 12.75 V. In the emission spectrum, one can observe lines of
 a) Lyman series b) Balmer series c) Paschen series d) Pfund series

186. Let A_n be the area enclosed by the n^{th} orbit in a hydrogen atom. The graph of In (A_n/A_1) against In(n)
 a) Will pass through origin
 b) Will be a straight line with slope 4
 c) Will be monotonically increasing nonlinear curve
 d) Will be a circle

187. Which of the following statements are true?
 a) The shortest wavelength of X-rays emitted from an X-ray tube depends on the current in the tube
 b) Characteristic X-ray spectra is sample as compared to optical spectra
 c) X-rays cannot be diffracted by means of an ordinary grating
 d) There exists a sharp limit on the short wavelength side for each continuous X-ray spectrum

188. Which of the following are in the ascending order of wavelength?
 a) $\mathrm{H}_\alpha, \mathrm{H}_\beta, \mathrm{H}_\gamma$ ... lines in Balmer series of hydrogen atom
 b) Lyman limit, Balmer limit, and Paschen limit in the hydrogen spectrum
 c) Violet, blue, yellow, and red colors in solar spectrum
 d) None of the above

189. The transition from the state $n = 4$ to $n = 3$ in a hydrogen-like atom results in ultra violet radiations. Infrared radiation will be obtained in the transition
 a) $2 \to 1$ b) $3 \to 2$ c) $4 \to 2$ d) $5 \to$

190. As per Bohr model, the minimum energy (in eV), required to remove an electron from the ground state of doubly ionized Li atom ($Z = 3$) is
 a) 1.51 b) 13.6 c) 40.8 d) 122.4

191. Energy liberated in the de-excitation of hydrogen atom from 3rd level to 1st level falls on a photo-cathode. Later when the same photo-cathode is exposed to a spectrum of some unknown hydrogen-like gas, excited to 2nd energy level, it is found that the de Broglie wavelength of the fastest photoelectrons now ejected has

decreased by a factor of 3. For this new gas, difference of energies of 2nd Lyman line and 1st Balmer line is found to be 3 times the ionization potential of the hydrogen atom. Select the correct statement(s):

a) The gas is lithium
b) The gas is helium
c) The work function of photo-cathode is 8.5 eV
d) The work function of photo-cathode is 5.5 eV

192. Which of the following statements about hydrogen spectrum are correct?
a) All the lines of Lyman series lie in ultraviolet region
b) All the line of Balmer series lie in visible region
c) All the lines of Paschen series lie in infrared region
d) None of the above

193. The third line of the Balmer series spectrum of a hydrogen like ion of atomic number Z equals to 108.5 nm. The binding energy of the electron in the ground state of these ions is E_{B}. Then
a) $Z = 2$
b) $E_{\mathrm{B}} = 54.4$ eV
c) $Z = 3$
d) $E_{\mathrm{B}} = 122.4$ eV

194. The potential difference applied to an X-ray tube is increased. As a result, in the emitted radiation
a) The intensity increases
b) The minimum wavelength increases
c) The intensity remains unchanged
d) The minimum wavelength decreases

195. If elements with principal quantum number $n > 4$ were not allowed in nature, the number of possible elements would be
a) 60
b) 32
c) 4
d) 64

196. According to Bohr's theory of hydrogen atom, for the electron in the n^{th} permissible orbit
a) Linear momentum $\propto \frac{1}{n}$
b) Radius of orbit $\propto n$
c) Kinetic energy $\propto \frac{1}{n^2}$
d) Angular momentum $\propto n$

197. According to Einstein's theory of relativity, mass can be converted into energy and vice-versa. The lightest elementary particle, taken to be the electron, has a mass equivalent to 0.51 MeV of energy. Then, we can say that
a) The minimum amount of energy available through conversion of mass into energy is 1.2 MeV
b) The least energy of a γ-ray photon that can be converted into mass is 1.02 MeV
c) Whereas the minimum energy released by conversion of mass into energy is 1.02 MeV, it is only a γ-ray photon of energy 0.51 MeV and above that can be converted into mass
d) Whereas the minimum energy released by conversion of mass into energy is 0.51 MeV, it is only a γ-ray photon of energy 1.02 MeV and above that can be converted into mass

198. X-ray from a tube with a target A of atomic number Z shows strong K lines for target A and weak K lines for impurities. The wavelength of K_α lines is λ_z for target A and λ_1 and λ_2 for two impurities
$\frac{\lambda_z}{\lambda_1} = 4$ and $\frac{\lambda_z}{\lambda_2} = \frac{1}{4}$
Assuming the screening constant of K_α lines to be unity, select the correct statement(s)
a) The atomic number of first impurity is $2z - 1$
b) The atomic number of first impurity is $2z + 1$
c) The atomic number of second impurity is $\frac{(z+1)}{2}$
d) The atomic number of second impurity is $\frac{z}{2} + 1$

199. According to Bohr's theory of the hydrogen atom, for the electron in the n^{th} allowed orbit:
a) The linear momentum is proportional to $(1/n)$
b) The radius is proportional to n
c) The kinetic energy is proportional to $(1/n^2)$
d) The angular momentum is proportional to n

200. Consider the spectral line resulting from the transition $n = 2 \rightarrow n = 1$ in the atoms and ions given below. The shortest wavelength is produced by
a) Hydrogen atom
b) Deuterium atom
c) Singly ionized helium
d) Doubly ionized lithium

201. When a hydrogen atom is excited from ground state to first excited state, then
a) Its kinetic energy increases by 20 eV
b) Its kinetic energy decreases by 10.2 eV
c) Its potential energy increases by 20.4 eV
d) Its angular momentum increases by 1.05×10^{-34}

Js

202. The K_α X-ray emission line of tungsten occurs at $\lambda = 0.02$ nm. The energy difference between K and L levels in this atom is about

a) 0.51 MeV b) 1.2 MeV c) 59 MeV d) 13.6 MeV

203. Electrons with energy 80 keV are incident on the tungsten target of an X-ray tube. K shell electrons of tungsten have -72.5 keV energy. X-rays emitted by the tube contain only

a) A continuous X-ray spectrum (Bremsstrahlung) with a minimum wavelength of -0.155 Å

b) Continuous X-ray spectrum (Bremsstrahlung) with all wavelengths

c) The characteristic X-ray spectrum of tungsten

d) A continuous X-ray spectrum (Bremsstrahlung) with a minimum wavelength of -0.155 Å and the characteristic X-ray spectrum of tungsten

204. Suppose frequency of emitted photon is f_0 when the electron of a stationary hydrogen atom jumps from a higher state m to a lower state n. If the atom is moving with a velocity v ($\ll c$) and emits a photon of frequency f during the same transition, then which of the following statements are possible?

a) f may be equal to f_0 b) f may be greater than f_0

c) f may be less than f_0 d) f cannot be equal to f_0

205. In Bohr's model of the hydrogen atom, let R, V, T, and E represent the radius of the orbit, speed of the electron, time period revolution of electron, and the total energy of the electron, respectively. The quantities proportional to the quantum number n are

a) VR b) RE c) $\frac{T}{R}$ d) $\frac{V}{E}$

206. Which of the following statements are correct?

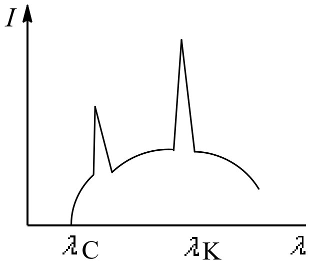
a) If angular momentum of the Earth due to its motion around the Sun were quantized according to the Bohr's relation $L = nh/2\pi$, then the quantum number n would be of the order of 10^{74}

b) If elements with principal quantum number >4 were not allowed in nature, then the number of possible elements would be 64

c) Rydberg's constant varies with mass number of the element

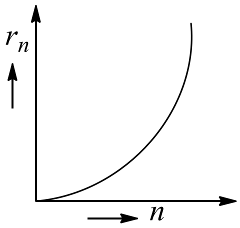
d) The ratio of the wave number of H_a line of Balmer series for hydrogen and that of H_a line of Balmer series for singly ionized helium is exactly 4

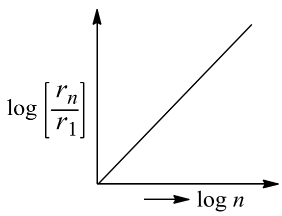
207. The intensity of X-rays from a Coolidge tube is plotted against wavelength λ as shown in figure. The minimum wavelength found is λ_C and the wavelength of the K_α line is λ_K. As the accelerating voltage is increased

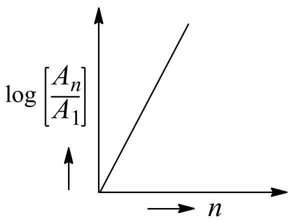


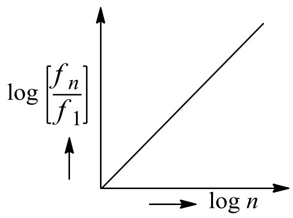
a) $\lambda_K - \lambda_C$ increases b) $\lambda_K - \lambda_C$ decreases c) λ_K increases d) λ_K decreases

208. If, in a hydrogen atom, radius of n^{th} Bohr orbit is r_n, frequency of revolution of electron in n^{th} orbit is f_n, and area enclosed by the n^{th} orbit is A_n, then which of the following graphs are correct?

a) 

b) 

c) 

d) 

209. Mark out the correct statement(s)
   a) Line spectra contain information about atoms only
   b) Line spectra contain information about both atoms and molecules
   c) Band spectra contain information about both atoms and molecules
   d) Band spectra contain information about molecules only
210. Continuous spectrum is produced by
   a) Incandescent electric bulb
   b) Sun
   c) Hydrogen molecules
   d) Sodium vapor lamp
211. X-rays are produced in an X-ray tube operating at a given accelerating voltage. The wavelength of the continuous X-rays has values from
   a) 0 and ∞
   b) $\lambda_{\min}$ to ∞; where $\lambda_{\min} > 0$
   c) 0 to $\lambda_{\max}$; where $\lambda_{\max} < \infty$
   d) $\lambda_{\min}$ to $\lambda_{\max}$; where $0 < \lambda_{\min} < \infty$
212. For a certain metal, the K absorption edge is at 0.172 Å. The wavelength of K_α, K_β and K_γ lines of K series are 0.210 Å, 0.192 Å, and 0.180 Å, respectively. The energies of K, L, and M orbits are E_K, E_L and E_M, respectively. Then
   a) $E_K = -13.04$ keV
   b) $E_L = -7.52$ keV
   c) $E_M = -3.21$ keV
   d) $E_K = 13.04$ keV
213. The X-ray beam coming from an X-ray tube will be
   a) Monochromatic
   b) Having all wavelengths smaller than a certain maximum wavelength
   c) Having all wavelengths larger than a certain minimum wavelength
   d) Having all wavelengths lying between a minimum and a maximum wavelength
214. Let $\lambda_\alpha, \lambda_\beta$ and λ'_α denotes the wavelength of the X-rays of the K_α, K_β and L_α lines in the characteristic X-rays for a metal. Then,
   a) $\lambda'_\alpha > \lambda_\alpha > \lambda_\beta$
   b) $\lambda'_\alpha > \lambda_\beta > \lambda_\alpha$
   c) $\frac{1}{\lambda_\beta} = \frac{1}{\lambda_\alpha} + \frac{1}{\lambda'_\alpha}$
   d) $\frac{1}{\lambda_\alpha} = \frac{1}{\lambda_\beta} + \frac{1}{\lambda'_\alpha}$
215. Hydrogen atoms absorb radiation of wavelength λ_0 and consequently emit radiations of 6 different wavelength of which two wavelengths are shorter than λ_0. Then,
   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
216. An X-ray tube is operated at 6.6 kV. In the continuous spectrum of the emitted X-rays, which of the following frequencies will be missing?
   a) 10^{18} Hz
   b) 1.5×10^{18} Hz
   c) 2×10^{18} Hz
   d) 2.5×10^{18} Hz
217. The mass number of a nucleus is
   a) Always less than its atomic number
   b) Always more than its atomic number
   c) Sometimes equal to its atomic number
   d) Sometimes more than and sometimes equal to its atomic number

Assertion - Reasoning Type

This section contain(s) 0 questions numbered 218 to 217. Each question contains STATEMENT 1(Assertion) and STATEMENT 2(Reason). Each question has the 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct.

a) Statement 1 is True, Statement 2 is True; Statement 2 **is** correct explanation for Statement 1

b) Statement 1 is True, Statement 2 is True; Statement 2 **is not** correct explanation for Statement 1

c) Statement 1 is True, Statement 2 is False

d) Statement 1 is False, Statement 2 is True

218

Statement 1: In He-Ne laser, population inversion takes place between energy levels of neon atoms.

Statement 2: Helium atoms have a meta-stable energy level.

219

Statement 1: In a hydrogen atom, energy of emitted photon corresponding to transition from $n = \infty$ to $n = 1$ is much greater as compared to transition from $n = \infty$ to $n = 2$

Statement 2: Wavelength of photon is directly proportional to the energy of emitted photon

220

Statement 1: The energy of a He^+ ion for a given n is almost exactly four times that of H atom for the same n

Statement 2: Photons emitted during transition between corresponding pairs of levels in He^+ and H have the same energy E and the same wavelength $\lambda = hc/E$

221

Statement 1: The different lines of emission spectra (like Lyman, Balmer etc) of atomic hydrogen gas are produced by different atoms.

Statement 2: The sample of atomic hydrogen gas consists of millions of atoms.

222

Statement 1: An alpha particle is a doubly ionized helium atom.

Statement 2: An alpha particle carries 2 units of positive charge.

223

Statement 1: It is difficult to excite nucleus to higher energy states by usual methods which we use to excite atoms like by heating or by irradiation of light.

Statement 2: Terms like ground state or excited state for nucleus are meaningless.

224

Statement 1: Bohr had to postulate that the electrons in stationary orbits around the nucleus do not radiate.

Statement 2: According to classical physics all moving electrons radiate.

225

Statement 1: In an X-ray tube, if the energy with which an electron strikes the metal target increases, then the wavelength of the characteristic X-rays also changes

Statement 2: Wavelength of characteristic X-rays depends only on the initial and final energy levels

Matrix-Match Type

This section contain(s) 0 question(s). Each question contains Statements given in 2 columns which have to be matched. Statements (A, B, C, D) in **columns I** have to be matched with Statements (p, q, r, s) in **columns II.**

226. Match the following:

Column-I		**Column- II**	
(A)	Characteristic X-ray	(p)	Inverse process of photoelectric effect
(B)	X-ray production	(q)	High potential difference
(C)	Cut-off wavelength	(r)	Moseley's law
(D)	Continuous X-ray	(s)	Emission of radiations

CODES :

	A	**B**	**C**	**D**
a)	P,q	r	s	q
b)	r,s	p,q	p,r	p
c)	r	p,q,r,s	q,	s
d)	s	q	p,q	r,s

227. Match the following:

Column-I		**Column- II**	
(A)	The voltage applied to X-ray tube is increased	(p)	Average KE of the electrons decreases
(B)	In photoelectric effect, work function of the target is increased	(q)	Average KE of the electrons increases
(C)	Stopping potential decrease	(r)	Cut-off wavelength decreased
(D)	Wavelength of K_∞ X-ray increased	(s)	Atomic number of target material decreases

CODES :

	A	**B**	**C**	**D**
a)	P,r	q,s	s	q
b)	s	p,q	q,r	p,r
c)	p,r	q,r	p,r	q,s
d)	q,r	p,r	p,r	s

228. Match the following lists.

Column-I	**Column- II**

(A) Burning candle		(p)	Line spectrum
(B) Sodium vapour		(q)	Continuous spectrum
(C) Bunsen flame		(r)	Band spectrum
(D) Dark lines in solar spectrum		(s)	Absorption spectrum

CODES :

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

229.

Column-I	Column- II
(A) K_α photon of aluminium	(p) Will be most energetic among the four
(B) K_β photon of aluminium	(q) Will be least energetic among the four
(C) K_α photon from sodium	(r) Will be more energetic than the lithium
(D) K_β photon of beryllium	(s) Constant speed

CODES :

	A	B	C	D
a)	Q,r	r,s	p,q	p,r
b)	r,s	q,r,s	r,s	q,r,s
c)	p,q	q,r	p,r	r,s
d)	q,r,s	p,q	r,s	p,r

230. Match the entries of Column I with the entries of Column II:

Column-I	Column- II
(A) Emission spectra	(p) Discrete
(B) Absorption spectra	(q) Continuous
(C) X-ray spectra	(r) Electronic Transition
(D) Thermal radiation spectra	(s) Quantum theory of electromagnetic radiation

CODES :

	A	B	C	D

a)	Q,r,s	p,q,r,s	q,r,s	q,r,s
b)	p,q	r,s	p,q,r,s	q,r
c)	r,s	p,q	q,r	q,r,s
d)	q,r,s	r,s	q,r,s	p,q

231. In each situation of Column I, a physical quantity related to orbiting electron in hydrogen-like atom is given. The terms 'Z' and 'n' given in Column II have usual meaning in Bohr' theory. Match the quantities in Column I with the terms they depend on it Column II

	Column-I		Column- II
(A)	Frequency of orbiting electron	(p)	Is directly proportional to Z^2
(B)	Angular momentum of orbiting electron	(q)	Is directly proportional to n
(C)	Magnetic moment of orbiting electron	(r)	Is inversely proportional to n^3
(D)	The average current due to orbiting of electron	(s)	Is independent of Z

CODES :

	A	B	C	D
a)	P,r	q,s	q,s	q,r
b)	q,s	p,r	q,r	p,q
c)	p,q	q,r	p,r	q,s
d)	q,r	p,q	q,s	p,s

232.

	Column-I		Column- II
(A)	Radius of orbit depends on principal quantum number as	(p)	Increase
(B)	Due to orbital motion of electron, magnetic field arises at the center of nucleus is proportional to principal quantum number as	(q)	Decrease
(C)	If electron is going from lower energy level to higher energy level, then velocity of electron will	(r)	Proportional to $\frac{1}{n^2}$
(D)	If electron is going from lower energy level to higher energy level, then total energy of electron will	(s)	Proportional to n^2
		(t)	Is proportional to $\frac{1}{n^5}$

CODES :

	A	B	C	D
a)	t	q	p	s

b)	p	r	s	t
c)	s	t	q	p
d)	q	p	r	s

233. Match the appropriate pairs from Lists I and II.

	Column-I		**Column- II**
(A)	Nitrogen molecules	(p)	Continuous spectrum
(B)	Incandescent solids	(q)	Absorption spectrum
(C)	Fraunhoffer lines	(r)	Band spectrum
(D)	Electric arc between iron roads	(s)	Emission spectrum

CODES :

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

234. Take the usual meanings of the symbols to match the following:

	Column-I		**Column- II**
(A)	Average kinetic energy of photoelectrons	(p)	Zero
(B)	Minimum kinetic energy of photoelectrons	(q)	$hc/\lambda - \lambda$
(C)	Maximum wavelength of continuous X-rays	(r)	hc/eV
(D)	Minimum wavelength of continuous X-rays	(s)	Not predictable

CODES :

	A	**B**	**C**	**D**
a)	p	q	r	s
b)	s	p	s	r
c)	r	s	p	q
d)	q	r	p	p

235.

	Column-I		**Column- II**
(A)	Radius of orbit is related with atomic number (Z)	(p)	Is proportional to Z

(B)	Current associated due to orbital motion of electron with atomic number (Z)	(q)	Is inversely proportion to Z
(C)	Magnetic field at the center due to orbital motion of electron related with Z	(r)	Is proportional to Z^2
(D)	Velocity of an electron related with atomic number (Z)	(s)	Is proportional to Z^3

CODES :

	A	**B**	**C**	**D**
a)	q	r	s	p
b)	p	q	r	s
c)	r	s	q	p
d)	s	p	q	r

236. The spectral lines of hydrogen-like atom fall within the wavelength range from 950 Å to 1350 Å. Then, match the following

	Column-I		**Column- II**
(A)	If it is atomic hydrogen atom and energy $E = -0.85$ eV	(p)	$\lambda = 1212$ Å and it corresponds to transition from 2 to 1
(B)	If it is atomic hydrogen atom and energy $E = -3.4$ eV	(q)	$\lambda = 134$ Å and it corresponds to transition from 2 to 1
(C)	If it is doubly ionized lithium atom, then	(r)	$\lambda = 303$ Å and it corresponds to transition from 2 to 1
(D)	If it is singly ionized helium atom, then	(s)	$\lambda = 970$ Å and it corresponds to transition from 4 to 1

CODES :

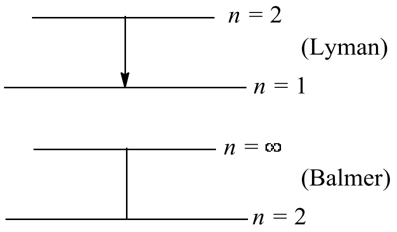
	A	**B**	**C**	**D**
a)	p	r	s	q
b)	s	p	q	r
c)	r	q	p	s
d)	q	s	r	p

Linked Comprehension Type

This section contain(s) 32 paragraph(s) and based upon each paragraph, multiple choice questions have to be answered. Each question has atleast 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct.

Paragraph for Question Nos. 237 to -237

Hydrogen is the simplest atom of nature. There is one proton in its nucleus and an electron moves around the nucleus in a circular orbit. According to Niels Bohr, this electron moves in a stationary orbit. When this electron is in the stationary orbit, it emits no electromagnetic radiation. The angular momentum of the electron is quantized, i.e., $mvr = (nh/2\pi)$, where $m =$ mass of the electron, $v =$ velocity of the electron in the orbit, $r =$ radius of the orbit, and $n = 1, 2, 3, \ldots$ When transition takes place from K^{th} orbit to J^{th} orbit, energy photon is emitted. If the wavelength of the emitted photon is λ, we find that $\frac{1}{\lambda} = R\left[\frac{1}{J^2} - \frac{1}{K^2}\right]$, where R is Rydberg's constant



On a different planet, the hydrogen atom's structure was somewhat different from ours, there the angular momentum of electron was $P = 2n(h/2\pi)$, i.e., an even multiple of $(h/2\pi)$
Answer the following questions regarding the other planet based on above passage:

237. The minimum permissible radius of the orbit will be

a) $\frac{2\varepsilon_0 h^2}{m\pi e^2}$ b) $\frac{4\varepsilon_0 h^2}{m\pi e^2}$ c) $\frac{\varepsilon_0 h^2}{m\pi e^2}$ d) $\frac{\varepsilon_0 h^2}{2m\pi e^2}$

Paragraph for Question Nos. 238 to - 238

In an ordinary atom, as a first approximation, the motion of the nucleus can be ignored. In a positronium atom, a positron replaces the proton of hydrogen atom. The electron and positron masses are equal and, therefore, the motion of the positron cannot be ignored. One must consider the motion of both electron and positron about their centre of mass. A detailed analysis shows that formulae of Bohr model apply to positronium atom provided that we replace m_e by what is known as the reduced mass of the electron. For positronium, the reduced mass is $m_e/2$

238. The orbital radius of the first excited level of positronium atom is
Where a_0 is the orbital radius of ground state of hydrogen atom

a) $4a_0$ b) $a_0/2$ c) $8a_0$ d) $2a_0$

Paragraph for Question Nos. 239 to - 239

The electrons in a H-atom kept at rest, jumps from the m^{th} shell to the n^{th} shell $(m > n)$. Suppose instead of emitting electromagnetic wave, the energy released is converted into kinetic energy of the atom. Assume Bohr model and conservation of angular momentum are valid. Now, answer the following questions:

239. What principle is violated here?

a) Laws of motion b) Energy conservation c) Nothing is violated d) Cannot be decided

Paragraph for Question Nos. 240 to - 240

The energy levels of a hypothetical one electron atom are shown in figure

$n = \infty$ ______________________ 0 eV
$n = 5$ ______________________ -0.80 eV
$n = 4$ ______________________ -1.45 eV
$n = 3$ ______________________ -3.08 eV
$n = 2$ ______________________ -5.30 eV
$n = 1$ ______________________ -15.6 eV

240. Find the ionization potential of the atom

a) 11.2 eV b) 13.5 eV c) 15.6 eV d) 12.6 eV

Paragraph for Question Nos. 241 to - 241

The electron in a hydrogen atom at rest makes a transition from $n = 2$ energy state to the $n = 1$ ground state

241. Find the energy (eV) of the emitted photon

a) 5.8 eV b) 8.3 eV c) 10.2 eV d) 12.7 eV

Paragraph for Question Nos. 242 to - 242

Consider a hypothetical hydrogen-like atom. The wavelength, in Å, for the spherical lines for transitions from $n = p$ to $n = 1$ are given by

$\lambda = \frac{1500p^2}{p^2-1}$ where $p = 1, 2, 3, 4, \ldots$

242. Find the wavelength of the most energetic photons in this series

a) 1800 Å b) 1500 Å c) 1300 Å d) 1650 Å

Paragraph for Question Nos. 243 to - 243

A sample of hydrogen gas in its ground state is irradiated with photons of 10.02 eV energies. The radiation from the above sample is used to irradiate two other samples of excited ionized He^+ and excited ionized Li^{2+}, respectively. Both the ionized samples absorb the incident radiation

243. How many spectral lines are obtained in the spectra of Li^{2+}?

a) 10 b) 15 c) 20 d) 17

Paragraph for Question Nos. 244 to - 244

A neutron of kinetic energy 65 eV collides inelastically with a singly ionized helium atom at rest. It is scattered at an angle 90° with respect to its original direction

244. Find the minimum allowed values of energy of the neutron

a) 0.39 eV b) 0.32 eV c) 0.25 eV d) 0.43 eV

Paragraph for Question Nos. 245 to - 245

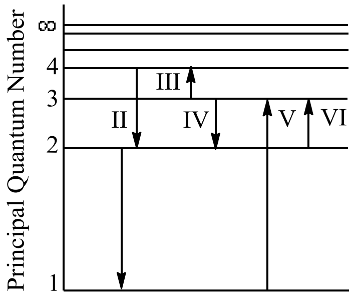
A electron and a photon are separated by a distance r so that the potential energy between them is $u = k \log r$, where k is a constant

245. In such an atom, radius of n^{th} Bohr's orbit is

a) $\frac{2nh}{\pi\sqrt{mk}}$ b) $\frac{nh}{2\pi\sqrt{2mk}}$ c) $\frac{nh}{2\pi\sqrt{mk}}$ d) $\frac{nh}{4\pi\sqrt{mk}}$

Paragraph for Question Nos. 246 to - 246

Pertain to the following statement and figure



The figure above shows as energy level diagram of the hydrogen atom. Several transitions are marked as I, II, III,… The diagram is only indicative and not to scale

246. In which transition is a Balmer series photon absorbed?

a) II b) III c) IV d) VI

Paragraph for Question Nos. 247 to - 247

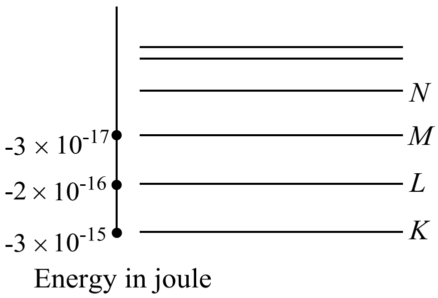
A certain species of ionized atoms produces emission line spectrum according to the Bohr model. A group of lines in the spectrum is forming a series in which the shortest wavelength is 22.79 nm and the longest wavelength is 41.02 nm. The atomic number of atom is Z
Based on above information, answer the following questions:

247. The value of Z is

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

Paragraph for Question Nos. 248 to - 248

Simplified model of electron energy levels for a certain atom is shown in figure. The atom is bombarded with fast moving electrons. The impact of one of these electrons can cause the removal of electron from K-level, thus creating a vacancy in the K-level. This vacancy in K-level is filled by an electron from L-level and the energy released in this transition can either appear as electromagnetic waves or may all be used to knock out an electron from M-level of the atom



Based on the above information, answer the following questions:

248. The minimum potential difference through which bombarding electron beam must be accelerated from

rest to cause the ejection of electron from K-level is

a) 18750 V b) 400 kV c) 2.16 kV d) 21.6 kV

Paragraph for Question Nos. 249 to - 249

A monochromatic beam of light having photon energy 12.5 eV is incident on a sample A of atomic hydrogen gas in which all atoms are in ground state. The emission spectra obtained from this sample is incident on another sample B of atomic hydrogen gas in which all atoms are in 1^{st} excited state

Based on the above information, answer the following questions:

249. The atoms of sample A after passing of light through it

a) May be in 1^{st} excited state b) May be in 2^{nd} excited state

c) May be in both 1^{st} and 2^{nd} excited states d) None of the above

Paragraph for Question Nos. 250 to - 250

An electron orbits a stationary nucleus of charge $+ze$, where z is a constant and e is the magnitude of electronic charge. It requires 47.2 eV to excite the electron from the second Bohr orbit to third Bohr orbit

250. The value of z is

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

Paragraph for Question Nos. 251 to - 251

When high energetic electron beam, (i.e., cathode rays) strike the heavier metal, then X-rays are produced. Spectrum of X-rays are classified into two categories: (i) continuous spectrum, and (ii) characteristic spectrum. The wavelength of continuous spectrum depends only on the potential difference across the electrode. But wavelength of characteristic spectrum depends on the atomic number (z)

251. The production of characteristic X-ray is due to the

a) Continuous acceleration of incident electrons towards the nucleus

b) Continuous retardation of incident electrons towards the nucleus

c) Electron transitions between inner shells of the target atom

d) Electron transitions between outer shells of the target atom

Paragraph for Question Nos. 252 to - 252

Light from a discharge tube containing hydrogen atom falls on the surface of a plate of sodium. The kinetic energy of the fastest photoelectrons emitted from sodium is 0.73 eV. The work function for sodium is 1.82 eV

252. The energy of the photons causing the photoelectric emission is

a) 2.55 eV b) 0.73 eV

c) 1.82 eV d) Information insufficient

Paragraph for Question Nos. 253 to - 253

The electron in a Li^{++} ion is in the n^{th} shell, n being very large. One of the K-electrons in another metallic atom has been knocked out. The second metal has four orbits. Now, we take two samples-one of Li^{++} ions and the other of the second metallic ions. Suppose the probability of electronic transition from higher to lower energy levels is directly proportional to the energy difference between the two shells. Take $hc = 1224$ eV nm, where h is Planck's constant and c the velocity of light in vacuum. It is found that major electromagnetic waves emitted from the two samples are identical. Now, answer the following questions:

253. What is the X-ray having least intensity emitted by the second sample?
a) K_α b) L_α c) M_α d) Data insufficient

Paragraph for Question Nos. 254 to - 254

Two hydrogen-like atoms A and B are of different and each atom has ratio of neutron to proton equal to unity. The difference in the energies between the first Lyman lines emitted by A and B is 81.6 eV. When the atoms A and B moving with the same velocity strike separately a heavy target, they rebound back with half of the speed before collision. However, in this process atom B imparts the target a momentum which is three times the momentum imparted to target by atom A

254. Atom A is
a) ${}_1^1H$ b) ${}_1^2H$ c) ${}_3^6Li$ d) ${}_2^4Li$

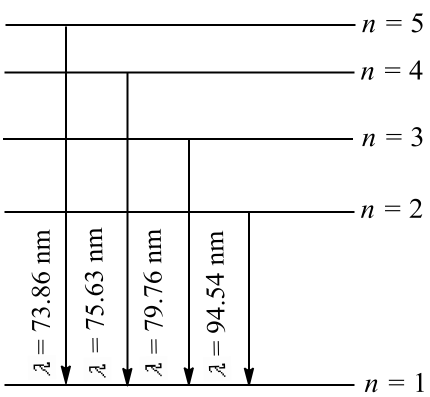
Paragraph for Question Nos. 255 to - 255

1.8 g of hydrogen is excited by irradiation. The study of spectra indicated that 27% of the atoms are in the first excited state, 15% of the atoms in the second excited state, and the rest in the ground state. The ground state ionization potential energy of hydrogen atom is 21.4×10^{-12} ergs

255. The number of atoms present in the second excited state is
a) 1.61×10^{23} b) 0.805×10^{23} c) 2.92×10^{23} d) 1.46×10^{23}

Paragraph for Question Nos. 256 to - 256

In a set of experiments on a hypothetical one-electron atom, the wavelengths of the photons emitted from transition ending in the ground state ($n = 1$) are shown in the energy level diagram (figure)



$\lambda_{5\to1} = 73.86$ nm
$\lambda_{4\to1} = 75.63$ nm
$\lambda_{3\to1} = 79.76$ nm

$\lambda_{2\to1} = 94.54$ nm

256. The energy of the atom in level $n = 1$ is nearly
   a) 13.14 eV b) 15.57 eV c) 17.52 eV d) 16.42 eV

Integer Answer Type

257. Find recoil speed (approximately in m/sec) when a hydrogen atom emits a photon during the transition from $n = 5$ to $n = 1$
258. The shortest wavelength of the Brackett series of a hydrogen-like atom (atomic number Z) is the same as the shortest wavelength of the Balmer series of hydrogen atom. Find the value of Z
259. An electron in nth excited state in a hydrogen atom comes down to first excited state by emitting ten different wavelengths. Find value of n (an integer)
260. The average lifetime for the $n = 3$ excited state of a hydrogen-like atom is 4.8×10^{-8} sec and that for the $n = 2$ state is 12.8×10^{-8} sec. The ratio of the average number of revolutions made in the $n = 2$ state of the average number of revolutions made in the $n = 3$ state before any transitions can take place from these states is
261. Heat at the rate of 200 W is produced in an X-ray tube operating at 20 kV. Find the current in the circuit. Assume that only a small fraction of the kinetic energy of electrons is converted into X-rays (in $\times 10^{-2}$ A)
262. A Bohr hydrogen atom undergoes a transition $n = 5$ to $n = 4$ and emits a photon of frequency f. Frequency of circular motion of electron in $n = 4$ orbit is f_4. The ratio f/f_4 is found to be 18/5m. State the value of m
263. An electron in hydrogen atom jumps from n_1 state to n_2 state, where n_1 and n_2 represent the quantum number of two states. The time period of revolution of electron in initial state is 8 times that in final state. Then the ratio of n_1 and n_2 is
264. An atom of atomic number $Z = 11$ emits K_α wavelength which is λ. Find the atomic number for an atom that emits K_α radiation with wavelength 4λ (an integer)
265. An electron in an H-atom kept at rest, jumps from the m^{th} shell to the n^{th} shell ($m > n$). Suppose instead of emitting electromagnetic wave, the energy released is converted into the kinetic energy of the atom. Assume Bohr model and conservation of angular momentum are valid. If I is the moment of inertia the angular velocity of the atom about the nucleus is $4(m - n)h/kI$. Calculate k
266. In the spectrum of singly ionized helium, the wavelength of a line observed is almost the same as the first line of Balmer series of hydrogen. It is due to transition of electron from $n_1 = 6$ to $n_2 =$ '*'. What is the value of '*'

: ANSWER KEY :

1)	d	2)	a	3)	d	4)	b
5)	d	6)	a	7)	c	8)	b
9)	b	10)	b	11)	c	12)	b
13)	c	14)	a	15)	d	16)	c
17)	d	18)	d	19)	b	20)	b
21)	c	22)	b	23)	d	24)	c
25)	c	26)	d	27)	c	28)	a
29)	c	30)	b	31)	c	32)	b
33)	a	34)	c	35)	a	36)	b
37)	c	38)	b	39)	c	40)	b
41)	a	42)	c	43)	b	44)	c
45)	a	46)	d	47)	b	48)	b
49)	c	50)	c	51)	d	52)	d
53)	a	54)	a	55)	a	56)	d
57)	d	58)	a	59)	a	60)	a
61)	c	62)	a	63)	a	64)	a
65)	b	66)	c	67)	b	68)	c
69)	c	70)	a	71)	d	72)	a
73)	d	74)	a	75)	b	76)	c
77)	a	78)	a	79)	c	80)	d
81)	d	82)	a	83)	b	84)	a
85)	a	86)	b	87)	b	88)	a
89)	d	90)	b	91)	d	92)	c
93)	b	94)	c	95)	d	96)	c
97)	b	98)	d	99)	a	100)	a
101)	b	102)	c	103)	d	104)	c
105)	b	106)	b	107)	a	108)	d
109)	c	110)	d	111)	a	112)	d
113)	d	114)	b	115)	b	116)	b
117)	d	118)	d	119)	d	120)	d
121)	d	122)	c	123)	b	124)	d
125)	d	126)	d	127)	b	128)	c
129)	d	130)	c	131)	c	132)	a
133)	b	134)	c	135)	c	136)	b
137)	d	138)	d	139)	b	140)	b
141)	b	142)	c	143)	c	144)	a
145)	c	146)	c	147)	d	148)	b
149)	a	150)	a	151)	d	152)	d
153)	b	154)	d	155)	d	156)	a
157)	a	158)	c	159)	d	160)	b
161)	d	162)	a	163)	d	164)	d
165)	c	166)	a	167)	c	168)	a
169)	b	170)	b	1)	a,b,c	2)	a
	3)	b,c	4)	b			
5)	a,c,d	6)	a,c	7)	a,c,d	8)	
	a,b						
9)	a,b,c	10)	a,d	11)	b,c,d	12)	

	b,c						
13)	b,d	14)	c	15)	a,b,c	16)	
	a,b						
17)	b,c,d	18)	b,c	19)	d	20)	d
21)	b,c	22)	a,c	23)	a,b	24)	
	c,d						
25)	a	26)	a,c,d	27)	a,b	28)	
	a,c						
29)	a,c,d	30)	d	31)	b,c,d	32)	c
33)	d	34)	a,b,c	35)	a,c,d	36)	
	a,c						
37)	a	38)	a,b,c	39)	b,d	40)	
	a,b						
41)	b	42)	a,b,c	43)	c	44)	
	a,c						
45)	a,b,d	46)	c,d	47)	c,d	1)	b
	2)	c	3)	a	4)	b	
5)	b	6)	c	7)	c	8)	d
1)	c	2)	d	3)	d	4)	b
5)	a	6)	a	7)	c	8)	a
9)	b	10)	a	11)	b	1)	b
	2)	c	3)	a	4)	c	
5)	c	6)	b	7)	b	8)	b
9)	c	10)	d	11)	c	12)	a
13)	d	14)	a	15)	c	16)	a
17)	a	18)	b	19)	c	20)	d
1)	4	2)	2	3)	6	4)	9
5)	1	6)	5	7)	2	8)	6
9)	8	10)	4				

: HINTS AND SOLUTIONS :

1 **(d)**

$$v_n = k\frac{2\pi e^2}{nh}$$

We know that in cgs system $k = 1$

$\therefore v_{\mathrm{n}} = \frac{2\pi e^2}{nh} \Rightarrow v_1 = \frac{2\pi e^2}{h}$

So $\frac{v_1}{c} = \frac{2\pi e^2}{ch}$

2 **(a)**

The wavelengths of the hydrogen spectrum could be arranged in a formula or series named after its discoverer. For ultraviolet spectrum the series is called Lyman series, for visible spectrum the Balmer series, and for infrared region we have the Paschen series

The ultraviolet series is obtained when the energy of the atom falls from higher states to the energy level corresponding to $n = 1$. Thus, ultraviolet radiation can only be possible with transition from E_2 to E_1 out of the given transitions

3 **(d)**

For each principal quantum number n, number of electrons permitted equals the number of elements corresponding to the quantum number

(total number of electrons) $= \sum 2n^2$

$$= \frac{n(n+1)(2n+1)}{3}$$

4 **(b)**

$$a = \frac{v^2}{r}$$

$\therefore a \propto \frac{(z)^2}{(1/z)}$ (for $n = 1$)

or $a \propto z^3$

$$\therefore \frac{a_1}{a_2} = \left(\frac{2}{1}\right)^3 = 8$$

5 **(d)**

$$\frac{1}{\lambda} = Z^2 R\left(\frac{1}{1^2} - \frac{1}{5^2}\right)$$

Hence, λ is minimum when Z is maximum

6 **(a)**

$-13.6 - (-10.2) = -3.4$ eV

$\frac{-13.6}{n^2} = -3.4$ or $n^2 = \frac{13.6}{3.4} = 4$

or $n = 2$

Increase in angular momentum $= \frac{2h}{2\pi} - \frac{h}{2\pi} = \frac{h}{2\pi}$

$= \frac{6.625 \times 10^{-34}}{2 \times 3.14}$ Js

$= 1.05 \times 10^{-34}$ Js

7 **(c)**

$$\frac{mv^2}{a_o} = \frac{1}{4\pi\varepsilon_o}\frac{e^2}{a_0^2}$$

$$v = \frac{e}{\sqrt{4\pi\varepsilon_o a_o m}}$$

8 **(b)**

KE $\propto \frac{1}{n^2}$ and PE $\propto \frac{1}{n^2}$

9 **(b)**

Potential energy $= -2 \times$ kinetic energy $= -2E$

Total energy $= -2E + E = -3.4$ eV $= -E$

or $E = 3.4$ eV

$p =$ momentum, $m =$ mass of electron

$$E = \frac{p^2}{2m}$$

or $p = \sqrt{2mE}$

$= \sqrt{2 \times 9.1 \times 10^{-31} \times 3.4 \times 1.6 \times 10^{-19}} \approx 10^{-24}$

de Brogile wavelength $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mE}} = 6.6 \times 10^{-10}$ m

10 **(b)**

The cut-off wavelength when $V = V_1 = 10$ kV is

$$\lambda_1 = \frac{hc}{eV_1} = 1243.125 \times 10^{-13} \text{ m}$$

The cut off wavelength when $V = V_2 = 20$ kV is,

$$\lambda_2 = \frac{hc}{eV_2} = 621.56 \times 10^{-13} \text{m}$$

The wavelength corresponding to K_α line is,

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

From given information, $(\lambda - \lambda_2) = 3(\lambda - \lambda_1)$

Solving above equation, we get $Z = 29$

11 **(c)**

The first photon will excite the hydrogen atom (in ground state) in first excited state (as $E_2 - E_1 - 10.2$ eV). Hence, during de-excitation a photon of 10.2 eV will be released. The second photon of energy 15 eV can ionize the atom. Hence the balance energy ie,

$(15 - 13.6)$ eV $= 1.4$ eV is retained by the electron.

Therefore, by the second photon an electron of energy 1.4 eV will be released.

12 **(b)**

$$f = cZ^2 R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

$\Rightarrow 2.7 \times 10^{15} = cz^2R\left[\frac{1}{1^2} - \frac{1}{2^2}\right]$

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

Divide and solve to get: $f = 3.2 \times 10^{15}$ Hz

13 **(c)**

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

For longest wavelength, $n_1 = 2, n_2 = 3$

$\therefore \frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right]$ or $\frac{1}{\lambda} = R\left[\frac{1}{4} - \frac{1}{9}\right]$

$\Rightarrow \lambda = \frac{36}{5R}$ for electron,

But $\lambda \propto \frac{1}{m}$

So $\lambda' = \frac{1}{2} \times \frac{36}{5R} = \frac{18}{5R}$

14 **(a)**

Number of possible emission lines are $n(n-1)/2$ when an electron jumps from n^{th} state to ground state. In this question, this value should be $(n-1)(n-2)/2$

Hence, $10 = \frac{(n-1)(n-2)}{2}$

Solving this, we get $n = 6$

15 **(d)**

For Lyman series, the series limit wavelength is given by

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

For Balmer series, the series limit wavelength is given by

$\frac{1}{\lambda''} = R\left[\frac{1}{2^2} - \frac{1}{\infty^2}\right] = \frac{R}{4}$ or $\lambda'' = \frac{4}{R}$

Clearly,

$\lambda'' = 4\left[\frac{1}{R}\right]$ or $\lambda'' = 4\lambda$

16 **(c)**

$L_1 = (1)\frac{h}{2\pi}$ (i)

(Using Bohr' Quantization Rule)

In the first excited state of Li,

$L_2 = (2)\frac{h}{2\pi}$ (ii)

$\therefore \frac{L_2}{L_1} = 2$

17 **(d)**

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

Therefore, $E_n r_n$ is independent of n

Hence, $E_1 r_1 = (13.6 \text{ eV})(0.53 \text{ Å})$

$= 7.2$ eV-Å

$=$ constant

18 **(d)**

We know that frequency of orbital motion:

$f \propto \frac{1}{n^3}$ and given $f_1 = \frac{1}{27}f_2$

$\Rightarrow \left(\frac{n_2}{n_1}\right)^3 = \frac{f_1}{f_2} \Rightarrow \frac{n_2}{n_1} = \left(\frac{1}{27}\right)^{1/3} = \frac{1}{3}$

19 **(b)**

Option (a) explains the production of X-rays on the basis of electromagnetic theory of light, which is not able to explain the characteristic X-rays and cut-off wavelength, so option (a) is wrong

Option (b) correctly explains the production of characteristic X-rays

Option (c) is wrong as X-ray spectra is a continuous spectra having some peaks representing characteristic X-rays

20 **(b)**

$P = VI$

Therefore, total power drawn by Coolidge tube

$P_{\text{T}} = VI = 200$ W

As 0.5% of the energy is carried by electron,

Power carried by X-ray is

0.5% of $P_{\text{T}} = \frac{0.5}{100} \times 200 = 1$ W

The answer is (b)

21 **(c)**

Centripetal acceleration $= mv^2/r$

Further, as n increase, r also increases. Therefore, centripetal acceleration for $n = 2$ is less than that for $n = 1$. So, statement (i) is wrong. Statement (ii) and (iii) are correct

22 **(b)**

$R\left[\frac{1}{1^2} - \frac{1}{\infty^2}\right] = RZ^2\left[\frac{1}{2^2} - \frac{1}{\infty^2}\right]$ or $Z = 2$

23 **(d)**

The first three transitions from the left fall in the Lyman series of the hydrogen spectrum which corresponds to ultraviolet radiation

The fourth transition falls in the Balmer series of the spectrum which corresponds to the visible light emission. The last transition falls in the Paschen series which corresponds to the infrared radiation

Thus, frequencies of the last two transitions are closer to each other on the extreme left of the frequency spectrum whereas the frequencies of the first three transitions are closer to one another and fall on the right corner of the frequency spectrum

The spectrum of the transitions is thus best represented in diagram(d)

24 **(c)**

Required energy $= \left[\left(\frac{-13.6}{9}\right) - \left(\frac{-13.6}{1}\right)\right] \times 9$

$= \left[13.6 - \frac{13.6}{9}\right] 9 = 8 \times 13.6 \text{ eV}$

Wavelength $= \frac{12375}{8 \times 13.6} = 113.7$ Å

25 **(c)**

In the first case, transition is from n^{th} state to 2nd (1st excited) state

$\therefore (10.2 + 17.0) \text{ eV} = 13.6 \times Z^2 \left[\frac{1}{2^2} - \frac{1}{n^2}\right]$

In 2nd case, transition is from n^{th} state to 3rd state

$\therefore (4.25 + 5.95) \text{ eV} = 13.6\, Z^2 \left[\frac{1}{3^2} - \frac{1}{n^2}\right]$

Solving above equations, we get $n = 6$ and $Z = 3$

26 **(d)**

We know, $r_n \propto n^2$

So, $(n+1)^2 - n^2 = (n-1)^2 \Rightarrow n = 4$

27 **(c)**

Photon energy $= h\,f = 13.6 \left[1 - \frac{1}{25}\right] \text{ eV} = 13 \text{ eV}$

Photon momentum = momentum of hydrogen atom:

$\Rightarrow p = \frac{hf}{c}$ or $mv = \frac{hf}{c}$

$v = \frac{hf}{mc} = \frac{13 \times 1.6 \times 10^{-19}}{1.67 \times 10^{-27} \times 3 \times 10^8} = 4 \text{ ms}^{-1}$

28 **(a)**

Linear momentum $\Rightarrow mv \propto \frac{1}{n}$

Angular momentum $\Rightarrow mvr \propto n$

Therefore, product of linear momentum and angular momentum $\propto n^0$

29 **(c)**

Using Bohr's theory, $\frac{mv^2}{r} = \frac{ke^2}{r^2}$

$v^2 = \frac{ke^2}{mr} \Rightarrow L = mvr$

$\therefore L = m\sqrt{\frac{ke^2}{mr}}\, r \Rightarrow L = \sqrt{mke^2\, r}$

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

30 **(b)**

$\text{KE}_{\lambda_1} = \frac{hc}{\lambda_1} - \Psi = e\Delta V$

$\text{KE}_{\lambda_2} = \frac{hc}{\lambda_2} - \Psi = 2e\Delta V$

$\Rightarrow 3\left(\frac{hc}{\lambda_1} - \Psi\right) = \frac{hc}{\lambda_2} - \Psi$

$\Rightarrow \Psi = hc\left(\frac{3}{2\lambda_1} - \frac{1}{2\lambda_2}\right)$

$\Rightarrow \text{KE}_{\lambda_3} = \frac{hc}{\lambda_3} - hc\left[\frac{3}{2\lambda_1} - \frac{1}{2\lambda_2}\right]$

$= hc\left[\frac{1}{\lambda_3} + \frac{1}{2\lambda_2} - \frac{3}{2\lambda_1}\right]$

$e\Delta V = hc\left[\frac{1}{\lambda_3} + \frac{1}{2\lambda_2} - \frac{3}{2\lambda_1}\right]$

$\Delta V = \frac{hc}{e}\left[\frac{1}{\lambda_3} + \frac{1}{2\lambda_2} - \frac{3}{2\lambda_1}\right]$

31 **(c)**

$E_{\max} = 13.6 \text{ eV}; E_{\min} = 31.6\left(1 - \frac{1}{2^2}\right)$

$= \frac{3}{4} \times 13.4 \text{ eV}$

$\Rightarrow \frac{E_{max}}{E_{\min}} = \frac{4}{3}$

32 **(b)**

From figure (b), photons of energy 1.6×10^{-18} J get absorbed in large numbers, no lower energy photon gets absorbed. And according to the passage, substantial absorption occurs only if the photon bumps the ground state electron into a higher shell

Therefore, 1.6×10^{-18} J photon knocks a ground state electron ($n = 1$) into the first excited state ($n = 2$). Hence, the difference in energy between the ground state and the first excited state must be 1.6×0^{-18} J

Using $E_n = \frac{E_0}{n^2}$

$1.6 \times 10^{-18} = E_2 - E_1 = -\frac{E_0}{4} - \left(-\frac{E_0}{1}\right) = \frac{3}{4}E_0$

$\therefore E_0 = \frac{4}{3}(1.6 \times 10^{-18}\text{J}) = 2.1 \times 10^{-18}$ J

Therefore, the answer is (b)

33 **(a)**

Barrier height

$= \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r_e}\text{J} = \frac{1}{4\pi\varepsilon_0}\frac{e}{r_e}\text{eV}$

$= \frac{9 \times 10^9 \times 1.6 \times 10^{-19}}{10^{-14}} \text{eV} = 1.44 \times 10^5 \text{ eV}$

34 **(c)**

As the collision is inelastic, it means a part of kinetic energy is transformed into some other form due to collision. In this case, the kinetic energy of incident electron can be absorbed by H atom and it can absorb only 10.2 eV out of 11.2 eV, so that it can reach to 1st excited state and the electron leaves with remaining, i.e., 1.0 eV

35 **(a)**

$E_n = -3.4 \text{ eV}, E_n \propto \frac{1}{n^2}$

$E_1 = -13.6 \text{ eV}$

Clearly, $n = 2$

Angular momentum

$= \frac{nh}{2\pi} = \frac{2h}{2\pi} = \frac{h}{\pi} = 2.11 \times 10^{-34}$ Js

36 **(b)**

Kinetic energy gained by a charge q after being accelerated through a potential difference V volt, is given by

$qV = \frac{1}{2}mv^2$

$mV = \sqrt{2MqV}$

As $\lambda_\text{b} = \frac{h}{mV} = \frac{h}{\sqrt{2qmV}}$

For cut-off wavelength of X-rays, we have

$qV = \frac{hc}{\lambda_m}$

or $\lambda_\text{m} = \frac{hc}{qV}$

Now, $\frac{\lambda_b}{\lambda_m} = \frac{\sqrt{\frac{qV}{2m}}}{c}$

As $\frac{q}{m} = 1.8 \times 10^{11}\ \text{C kg}^{-1}$ for electron,

We have $\frac{\lambda_b}{\lambda_m} = \frac{\sqrt{1.8\times10^{11}\times10\times10^3/2}}{3\times10^8} = 0.1$

Therefore, the answer is (b)

37 **(c)**

Potential energy $= -C/r^2$ and total energy $= -Rhc/n^2$. With higher orbit, both r and n increase. So, both become less negative; hence both increase

38 **(b)**

$E = R_\infty ch \times \left[1 - \frac{1}{2^2}\right] = \frac{3}{4}R_\infty \times hc$

Momentum of photon emitted is,

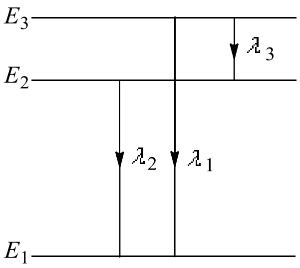
$p = \frac{E}{c} = \frac{3R_\infty h}{4}$

Recoiling speed of hydrogen atom is given by $v = P/m$, where m is the mass of hydrogen atom

$v = \frac{3R_\infty h}{4m} = \frac{3 \times 1.1 \times 10^7 \times 6.63 \times 10^{-34}}{4 \times 1.67 \times 10^{-27}}$
$= 3.3\ \text{ms}^{-1}$

39 **(c)**

Let the three energy levels be E_1, E_2, and E_3. The wavelengths λ_1, λ_2, and λ_3 of the spectral lines corresponding to the three energy transitions are depicted as shown in figure



$E = hf = \frac{h}{\lambda}$ or $E \propto \frac{1}{\lambda}$ (given $\lambda_1 < \lambda_2 < \lambda_3$)

Thus, for the three wavelengths, we have

$$\begin{cases} E_3 - E_2 = \dfrac{h}{\lambda_3} & \text{(i)} \\ E_2 - E_1 = \dfrac{h}{\lambda_2} & \text{(ii)} \\ E_3 - E_1 = \dfrac{h}{\lambda_1} & \text{(iii)} \end{cases}$$

Now, $E_3 - E_1 = (E_3 - E_2) + (E_2 - E_1)$

$\Rightarrow \frac{h}{\lambda_1} = \frac{h}{\lambda_3} + \frac{h}{\lambda_2} \Rightarrow \frac{1}{\lambda_1} = \frac{1}{\lambda_2} + \frac{1}{\lambda_3}$

40 **(b)**

Use Moseley's law

41 **(a)**

As magnetic moment, $\mu_\text{B} = \frac{1}{2}evr$

$L = mvr \Rightarrow vr = \frac{L}{m}$

$\therefore \mu_\text{B} = \frac{1}{2}\frac{eL}{m} \Rightarrow \frac{\mu_\text{B}}{L} = \frac{e}{2m}$

42 **(c)**

$i = \frac{q}{T}$

Now $T^2 \propto r^3 \propto n^6 \Rightarrow i \propto \frac{1}{n^3}$

43 **(b)**

$U = -\frac{ke^2}{2R^3}, F = -\frac{dU}{dR} = -\frac{3ke^2}{2R^4}$

But, $F = \frac{mv^2}{R} \Rightarrow \frac{mv^2}{R} = \frac{3ke^2}{2R^4}$

Also, $mvR = \frac{nh}{2\pi}$

Solve to get: $R = \frac{6\pi^2 ke^2 m}{n^2h^2}$

44 **(c)**

Let n be the number of electrons per second striking the target, $P = VI$

$16\text{W} = (5 \times 10^3) \times ne$

$\therefore n = \frac{16}{5 \times 10^3 \times 1.6 \times 10^{-19}} = 2 \times 10^{16}$

45 **(a)**

The recoil momentum of atom is same as that of photon but in opposite direction

Hence, recoil momentum:

$P = \frac{E}{c} = \frac{12.09 \times 1.6 \times 10^{-19}}{3 \times 10^8}\text{Ns} = 6.45 \times 10^{27}\ \text{Ns}$

Note that almost whole of the energy will be carried away by the photon because it is very light in comparison to H atom

46 **(d)**

$E = -\frac{13.6}{5^2}\text{eV}$

$E = -0.544\ \text{eV}$

$E_\text{p} = -2 \times 0.544\ \text{eV} = -1.088\ \text{eV}$

47 **(b)**

The series in U-V region is Lyman series. Longest wavelength corresponds to, minimum energy which occurs in transition from n=2 to n=1.

$$\therefore \qquad 122 = \frac{\frac{1}{R}}{\left(\frac{1}{1^2}-\frac{1}{2^2}\right)} \qquad \text{... (i)}$$

The smallest wavelength in the infrared region corresponds to maximum energy of Paschen series.

$$\therefore \qquad \lambda = \frac{\frac{1}{R}}{\left(\frac{1}{3^2}-\frac{1}{\infty}\right)} \qquad \text{... (ii)}$$

Solving Eqs.(i) and (ii) , we get

$\lambda = 823.5$ nm

48 **(b)**

For third excited state, $n = 4$

$$r_n = r_0 \frac{n^2}{2}$$

or $r_1 = 0.5 \times \frac{4\times4}{2}$ Å $= 4$ Å

49 **(c)**

This is Bohr' postulate

50 **(c)**

Energy of photon is given by mc^2. Now, the maximum energy of photon is equal to the maximum energy of electrons $= eV$

Hence, $mc^2 = eV \Rightarrow m = \frac{eV}{c^2}$

$$= \frac{1.6\times10^{-19}\times18\times10^3}{(3\times10^8)^2} = 3.2\times10^{-32} \text{ kg}$$

51 **(d)**

$$\lambda = \frac{hc}{E} = \frac{1240 \text{ eV} - \text{nm}}{3.5 \text{ eV}} = 354 \text{ nm}$$

This wavelength is in the ultraviolet region

52 **(d)**

a. No, since Balmer formula was known

b. No, since Rutherford scattering experiment was known

c. No, since Einstein's photon theory was known

d. Bohr's chose 'allowed' energy levels $\propto 1/n^2$ and these led to angular momentum quantized as a derivation

53 **(a)**

Series limit means the shortest possible wavelength (maximum photon energy) and first line means the largest possible wavelength (minimum photon energy) in the series

$v = C\left[\frac{1}{n^2}-\frac{1}{m^2}\right]$ (where C is a constant)

For series limit of Lyman series:

$n = 1, m = \infty \Rightarrow v_1 = C$

For firsts line of Lyman series:

$n = 1, m = 2 \Rightarrow v_2 = 3C/4$

For series limit of Balmer series:

$n = 2, m = \infty \Rightarrow v_3 = C/4$

54 **(a)**

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

$$\frac{1}{\lambda_2} = R\left[\frac{1}{4}-\frac{1}{16}\right]$$

$$\frac{1}{\lambda_2} = R\left[\frac{3}{16}\right] \text{ or } \lambda_2 = \frac{16}{3R}$$

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

$$\frac{1}{\lambda_1} = R\left[\frac{1}{4}-\frac{1}{9}\right]$$

$$\frac{1}{\lambda_1} = \frac{5R}{36} \text{ or } \lambda_1 = \frac{36}{5R}$$

$$\therefore \frac{\lambda_1}{\lambda_2} = \frac{36}{5R}\times\frac{3R}{16} = \frac{27}{20}$$

or $\lambda_1 = \frac{27}{20}\times 4861$ Å

55 **(a)**

$mv_n^2 = K/r_n$. Since modified m is half and modified r_n is double, v_n remains the same as in H-atom

Note: Positronium is an atom in which an electron (e^-) and a positron (e^+) go around their center of mass. Bohr's conditions hold for it, as used in hydrogen atom, but the mass m_e of the electron is replaced by the modified mass $\mu = (m_e\, m_p)/(m_e + m_p)$, where m_e is the positronium mass, which is equal to m. With this, one may treat the electron going round the positron and apply the equations used for hydrogen atom case

56 **(d)**

$$mr\omega^2 = \frac{he^2}{r^2} \text{ or } \omega^2 = \frac{ke^2}{mr^3}$$

or $4\pi^2 f_n^2 = \frac{ke^2}{mr^3}$ or $f_n^2 = \frac{ke^2}{4\pi^2 mr^3}$

But, $r = \frac{1}{k}\times\frac{n^2h^2}{4\pi^2me^2}$

$$\therefore f_n^2 = \frac{ke^2(k\times4\pi^2me^2)^2}{4\pi^2m(n^2h^2)^3}$$

or $f_n^2 = \frac{k^4e^8(4\pi^2)^2m^2}{(n^2h^2)^3}$

or $f_n = \frac{4\pi^2k^2me^4}{n^3h^3}$

Again, $hv = k^2\frac{2\pi^2me^4}{h^2}\left[\frac{1}{(n-1)^2}-\frac{1}{n^2}\right]$

or, $v = k^2\frac{2\pi^2me^4}{h^3}\left[\frac{n^2-(n-1)^2}{n^2(n-1)^2}\right]$

or $v = k^2\frac{2\pi^2me^4}{h^3}\left[\frac{(2n-1)}{n^2(n-1)^2}\right]$

If n is very large, then

$$v = k^2\frac{2\pi^2ke^4}{h^3}\times\frac{2n}{n^4}$$

or $v=\frac{4\pi^2k^2me^4}{n^3h^3}=f_n$

57 **(d)**

As $\lambda_0=\frac{hc}{E}=1.55\times10^{-11}$ m

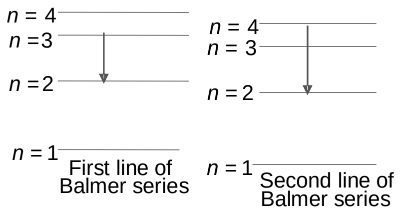
$\therefore\ \lambda_0=0.155$ Å

Which is the minimum wavelength of continuous X-rays which carry energy equivalent of energy of incident electrons

Now, as the energy of incident radiation is more than that of K-shell electrons, the characteristic X-rays appear as peaks on the continuous spectrum

Therefore, (d) is the answer

58 **(a)**



For hydrogen or hydrogen type atoms

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

In the transition from $ni\rightarrow\ nf$

$$\therefore\quad \lambda\propto\frac{1}{Z^2\left(\frac{1}{n_f^2}-\frac{1}{n_i^2}\right)}$$

$$\therefore\quad \frac{\lambda_2}{\lambda_1}=\frac{Z_1^2\left(\frac{1}{n_f^2}-\frac{1}{n_i^2}\right)_1}{Z_2^2\left(\frac{1}{n_f^2}-\frac{1}{n_i^2}\right)_2}$$

$$\lambda_2=\frac{\lambda_1Z_1^2\left(\frac{1}{n_f^2}-\frac{1}{n_i^2}\right)_1}{Z_2^2\left(\frac{1}{n_f^2}-\frac{1}{n_i^2}\right)_2}$$

Substituting the values, we have

$$=\frac{(6561)(1)^2\left(\frac{1}{2^2}-\frac{1}{3^2}\right)}{(2)^2\left(\frac{1}{2^2}-\frac{1}{4^2}\right)}=\ 1215\text{ Å}$$

59 **(a)**

$P=VI=150\times10^3\times10\times10^{-3}=1500\text{ Js}^{-1}$

Heating rate of target $=\frac{1500}{4.2}\times\frac{1}{100}=3.57\text{ cal s}^{-1}$

60 **(a)**

From Moseley's law, $\sqrt{v}=a(Z-1)$ for K_α X-ray

i. e., $\frac{1}{\sqrt{\lambda}}=a(Z-1)$

Given, $\frac{1}{\sqrt{\lambda}}=a(11-1)$ and $\frac{1}{\sqrt{4\lambda}}=a(Z-1)$

Dividing, we get $Z=6$

61 **(c)**

For emission of a photon with greater wavelength, energy gap should be less

Blue light falls in the Balmer series and it is obtained when the atom makes transition from E_4 to E_3. Red light also falls in the Balmer series and it has a lower frequency compared to blue light. By quantum theory of radiation, the energy change E is proportional to the frequency of electromagnetic radiation f by $E=hf$. Thus, red light is associated with a smaller energy change from a lower energy level (compared to E_4) to the first excited state E_2. Hence, the only possible transition that result in the emission of red light is the E_3 to E_2 transition

62 **(a)**

$$\frac{\text{Magnetic moment}}{\text{Angular momentum}}=\frac{e}{2m}$$

$\therefore$ Magnetic moment $\propto$ angular momentum

$$\propto n\qquad\left(\because L=n\frac{h}{2\pi}\right)$$

63 **(a)**

From conservation of momentum, two identical photons travel in opposite directions with equal magnitude of momentum and energy hc/λ

From conservation of energy, we have

$$\frac{hc}{\lambda}+\frac{hc}{\lambda}=m_0C^2+m_0C^2$$

$$\lambda=\frac{h}{m_0C}$$

Therefore, the answer is (a)

64 **(a)**

For a collision of neutron with hydrogen atom in ground state to be inelastic (partial or complete), the minimum KE of striking neutron must be 20.4 eV. [This condition is derived in theory]

As the energy of the given incident neutron is less than 2.4 eV, the collision must be elastic

65 **(b)**

λ_{m} will increase to $3\lambda_{\text{m}}$ due to decrease in the energy of bombarding electrons. Hence, no characteristic X-rays will be visible, only continuous X-ray will be produced

66 **(c)**

$$E_n=-\frac{13.6}{n^2}\Rightarrow n^2=-\frac{13.6}{-0.54}$$

or $n^2=25.2$ or $n=5$(nearly)

As $v\propto1/n$, so $v_n=\frac{v}{5}$

67 **(b)**

Time period for n^{th} energy level electron is,

$$T=\frac{2\pi r_n}{v_n}=\frac{4\pi^2m}{h}\times\frac{r_n^2}{n}$$

$$r_n=n^2a_0$$

$$T=\frac{4\pi^2m}{h}\times n^3a_0^2$$

Required number of revolutions, $N = \frac{10^{-8}}{T}$

After substituting $n = 2, m = 9.1 \times 10^{-31}$ kg, and $h = 6.63 \times 10^{-34}$ J-s, we get $N = 8 \times 10^6$

68 **(c)**

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

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

$$\Rightarrow \lambda = \frac{36}{5R} = \frac{36 \times 10^{-7}}{5 \times 1.097} = 6.566 \times 10^{-7}$$

$\lambda = 6566$ Å

$$E = \frac{hc}{\lambda} = \frac{6.64 \times 10^{-34} \times 3 \times 10^8}{6.566 \times 10^{-7}}$$
$$= 3.03 \times 10^{-19} \text{ J}$$

$\therefore E = 1.89$ eV

69 **(c)**

The protons move toward each other till their relative velocity becomes equal to zero. At the closest distance of approach, both the proton will be moving with the same velocity

As coulombian repulsive force is internal for the system of protons, we can apply the law of conservation of momentum

$\therefore mv_0 = 2mv$

Change in KE $= \frac{1}{2}mv_0^2 - 2 \times \frac{1}{2}m\left(\frac{v_0}{2}\right)^2$

This change in energy is equal to the electrical potential energy

$$\frac{mv_0^2}{2} - m\left(\frac{v_0}{2}\right)^2 = \frac{e^2}{4\pi\varepsilon_0 r}$$

$$\therefore r = \frac{e^2}{\pi\varepsilon_0 m v_0^2}$$

70 **(a)**

Radius of first orbit, $r \propto 1/Z$. For doubly ionized lithium, Z will be maximum. Hence, for doubly ionized lithium r will be minimum

71 **(d)**

$\Delta\lambda = \lambda_{K_\alpha} - \lambda_{\min}$

When V is halved $\lambda_{\min}$ becomes two times but λ_{K_α} remains the same

$\therefore \Delta\lambda'' = \lambda_{K_\alpha} - 2\lambda_{\min}$

$= 2(\Delta\lambda) - \lambda_{K_\alpha}$

$\therefore \Delta\lambda'' < 2(\Delta\lambda)$

72 **(a)**

Momentum of the recoiled hydrogen atom

= momentum of the emitted photon

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

$$= 6.6 \times 10^{-34} \times 10^{+7}\left(\frac{1}{1} - \frac{1}{16}\right)$$

$= 6.5 \times 10^{-27}$ kg m s^{-1}

73 **(d)**

$T^2 \propto R^3$

$$\frac{T_R}{T_{4R}} = \left(\frac{R}{4R}\right)^{3/2} = \left(\frac{1}{4}\right)^{3/2} = \frac{1}{8}$$

74 **(a)**

From conservation of momentum:

$$MV = \frac{h}{\lambda} = hR\left(1 - \frac{1}{4}\right) \Rightarrow V = \frac{3}{4}\frac{hR}{M}$$

75 **(b)**

In the emission spectrum 10 lines are observed, so the energy level (n) to which the sample has been excited after absorbing the radiation is given by

$$\frac{n(n-1)}{2} = 10$$

Which gives $n = 5$

So, $\frac{hc}{\lambda} = 13.6\left(1 - \frac{1}{5^2}\right)$ eV

$$\frac{1242}{\lambda} \text{eV} - \text{nm} = 13.6 \times \frac{24}{25} \text{ eV}$$

$\therefore \lambda = 95$ nm

76 **(c)**

$$v = \frac{4\pi^2 k^2 m e^4}{n^3 h^3}$$

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

77 **(a)**

$$13.6\left(\frac{1}{2^2} - \frac{1}{3^2}\right) \text{eV} = 1.9 \text{ eV}$$

78 **(a)**

For the first line of Balmer series of hydrogen,

$$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{5R}{36} \Rightarrow \lambda = \frac{36}{5R}$$

For singly ionized helium $(Z = 2)$,

$$\frac{1}{\lambda'} = 4R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

Given $\lambda' = \lambda$

For $n_1 = 6$ to $n_2 = 4$

$$\frac{1}{\lambda'} = 4R\left(\frac{1}{4^2} - \frac{1}{6^2}\right) = \frac{20\,R}{144} = \frac{5R}{36}$$

It corresponds to transition from $n_1 = 6$ to $n_2 = 4$

79 **(c)**

$$\frac{hc}{\lambda} = Rhc(1 - 1/n^2)$$

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

80 **(d)**

$13.6 - 0.85 = 12.75$ eV

So, 12.75 V is the required potential difference

81 **(d)**

As the electron beam is having energy of 13 eV, it can excite the atom to the states whose energy is less than or equal to 0.6 eV (13.6 − 13). $E_5 = 0.544$ eV and $E_4 = 0.85$ eV. So, the electron beam can excite the hydrogen gas maximum to 4th energy state, hence the transit electron can come back to ground state from either of three excited states, thus emitting Lyman, Balmer and Paschen series

82 **(a)**

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

$$\frac{\lambda_{\min}}{\lambda_{\max}} = \frac{\left(\frac{1}{2^2} - \frac{1}{3^2}\right)}{\left(\frac{1}{2^2} - \frac{1}{\propto}\right)} = \frac{5}{9}$$

83 **(b)**

For an elastic collision to take place, there must be no loss in the energy of electron. The hydrogen atom will absorb energy from the colliding electron only if it can go from ground state to first excited state, i.e., from $n = 1$ to $n = 2$ state. For this, hydrogen atom must absorb energy

$E_2 - E_1 = -3.4 - (-13.6) = 10.2$ eV

So, if the electron possesses energy less than 10.2 eV, it would never lose it and hence collision would be elastic

84 **(a)**

$$U = eV = eV_0 \ln\left(\frac{r}{r_0}\right)$$

$$\therefore \quad |F| = \left|-\frac{dU}{dr}\right| = \frac{eV_0}{r}$$

This force will provide the necessary centripetal force. Hence

$$\frac{mv^2}{r} = \frac{eV_0}{r}$$

or $\quad v = \sqrt{\frac{eV_0}{m}} \quad$ ....(i)

Moreover

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

Dividing Eq. (ii) by Eq. (i), we have

$$mr = \left(\frac{nh}{2\pi}\right)\sqrt{\frac{m}{eV_0}}$$

Or $\quad r_n \propto n$

85 **(a)**

In case of Bohr's model of hydrogen atom

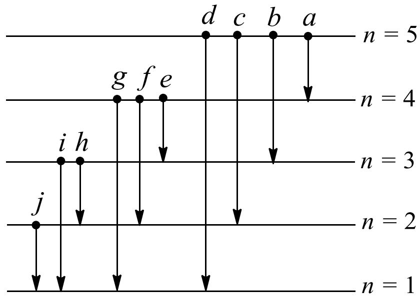
Frequency $= \frac{v}{2\pi r}$

Here, $v \propto \frac{1}{n}$ and $r \propto n^2$

$\therefore$ Frequency $\propto \frac{1}{n^3}$

86 **(b)**

The wavelengths present in emission spectra are shown in figure



Transitions a, e, h and j can be performed by a single atom also. This is also true about transitions b and i, other transitions require one atom each

87 **(b)**

de Broglie wavelength of electron in hydrogen atom

$$= \frac{h}{mv} = \frac{2\pi r_n}{n}$$

For second Bohr orbit, $\lambda = \frac{600\times10^{-9}}{2} = 3000 \times 10^{-9}$m

$$\lambda = \sqrt{\frac{150}{V}}\,\text{Å} = 300\ \text{Å}$$

$$\therefore V = \frac{150}{(3000)^2} = \frac{5}{3} \times 10^{-5}\ \text{V}$$

88 **(a)**

$$\frac{hc}{\lambda} = 13.6\left[\frac{1}{1^2} - \frac{1}{10^2}\right] = 13.6 \times 0.99$$

$$\lambda = \frac{1242}{13.6 \times 0.99}\ \text{nm} = 92.25\ \text{nm}$$

The line belongs to UV part of electromagnetic spectrum

89 **(d)**

Total energy received by the atom will be 25.2 eV. 13.6 eV energy is needed to remove the electron from the attraction of the nucleus. Rest of the energy will be almost available in the form of KE of electron

90 **(b)**

For shortest wavelength in Balmer series,

$n_1 = 2; n_2 = \infty$

$$\therefore \frac{1}{\lambda} = R\left[\frac{1}{4} - \frac{1}{\infty}\right] \text{ or } \lambda = \frac{4}{R}$$

For shortest wavelength in Brackett series,

$n_1 = 4; n_2 = \infty$

$$\therefore \frac{1}{\lambda'} = R\left[\frac{1}{4^2} - \frac{1}{\infty^2}\right]$$

or $\lambda' = \frac{16}{R} = 4 \times \frac{4}{R} = 4\lambda$

91 **(d)**

For 2nd line of Balmer series in hydrogen spectrum, corresponds to 4 → 2 transition of

hydrogen atom
It is equivalent to $4 \times 3 \rightarrow 2 \times 3$ i.e., $12 \rightarrow 6$ transition of Li^{2+}

92 **(c)**

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

or $R = \frac{36}{5\lambda} = \frac{36}{5 \times 6563 \times 10^{-10}} \text{m}^{-1}$

$= \frac{36000}{5 \times 6563} \times 10^7 \text{m}^{-1} = 1.097 \times 10^7 \text{m}^{-1}$

93 **(b)**

L will be same for both because it does not depend upon Z. But for energy

$(E_n)_{\text{Li}} = -\frac{Z^2 \times 13.6}{n^2}$ and $(E_n)_{\text{H}} = -\frac{13.6}{n^2}$

Clearly, $|E_{\text{H}}| < |E_{\text{Li}}|$

94 **(c)**

Volume occupied by one mole of gold

$= \frac{197 \text{ g}}{19.7 \text{ gm}^{-3}} = 10 \text{ cm}^3$

Volume of one atom

$= \frac{10}{6 \times 10^{-23}} = \frac{5}{3} \times 10^{23} \text{ cm}^3$

Let r be the radius of the atom. Therefore,

$\frac{4}{3}\pi r^3 = \frac{5}{3} \times 10^{23}$ or $r \cong 1.5 \times 10^{-10}$ m

95 **(d)**

$B_n = \frac{\mu_0 I_n}{2r_n}$

or $B_n \propto \frac{I_n}{r_n}$

$\propto \frac{(f_n)}{r_n}$

$\therefore B_n \propto \frac{(v_n/r_n)}{r_n}$

$\propto \frac{v_n}{(r_n)^2}$

$\propto \frac{(z/n)}{(n^2/z)^2}$

$\propto \frac{z^3}{n^5}$

96 **(c)**

$E = R_\infty hc \left(1 - \frac{1}{25}\right)$

Momentum of photon emitted is $p = \frac{E}{c} = R_\infty h\left(\frac{24}{25}\right)$

Recoil momentum of H atom will also be p

$mv = p$

$v = \frac{p}{m} = \frac{(1.097 \times 10^7)(6.626 \times 10^{-34})24}{(25)(1.67 \times 10^{-27})}$

$\therefore v = 4.178 \text{ ms}^{-1}$

97 **(b)**

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

For K_α line, $n_1 = 1$ and $n_2 = 2$

$\frac{1}{\lambda} = Z^2 R_\infty \left(\frac{3}{4}\right)$

$Z = \sqrt{\frac{4}{3\lambda R_\infty}}$

$= 39.9 \approx 40$

98 **(d)**

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

But $v \propto \frac{1}{n}$ and $r \propto n^2$

$\Rightarrow F \propto \frac{1}{n^4}$

99 **(a)**

Total energy for n^{th} level $= -\frac{13.6}{n^2}$ eV

$E_2 - E_1 = -13.6\left(\frac{1}{4} - \frac{1}{1}\right) = \frac{13.6 \times 3}{4}$

$= 0.75 \times 13.6$ eV

$E_3 - E_2 = -13.6\left(\frac{1}{9} - \frac{1}{4}\right) = \frac{13.6 \times 5}{36}$

$= 0.14 \times 13.6$ eV

$E_4 - E_3 = -13.6\left(\frac{1}{16} - \frac{1}{9}\right) = \frac{13.6 \times 7}{144}$ eV

$= 0.05 \times 13.6$ eV

Obviously, the difference of energy between consecutive energy levels decreases

100 **(a)**

For the incident electron,

$\frac{1}{2}mv^2 = Ve$

$p^2 = 2meV$

de Broglie wavelength of incident electron,

$\lambda_1 = \frac{h}{p} = \frac{h}{\sqrt{2mVe}}$

Shortest X-ray wavelength, $\lambda_2 = \frac{hc}{Ve}$

$\therefore \frac{\lambda_1}{\lambda_2} = \frac{Ve}{c\sqrt{2mVe}} = \frac{1}{c}\sqrt{\left(\frac{V}{2}\right)\frac{e}{m}}$

$= \frac{\sqrt{\frac{10^4}{2} \times 1.8 \times 10^{11}}}{3 \times 10^8} = 0.1 = \frac{1}{10}$

or $\lambda_1 : \lambda_2 = 1:10$

101 **(b)**

Maximum angular speed will be in its ground state. Hence,

$\omega_{\text{max}} = \frac{v_1}{r_1} = \frac{2.2 \times 10^6}{0.529 \times 10^{-10}}$

$= 4.1 \times 10^{16}$ rad s^{-1}

102 **(c)**

a. Z was taken from X-ray scattering experiments
b. Validity not known earlier; established by Rutherford's experiments
c. Yes, the experiments said $r < \frac{Ze^2}{2\pi\varepsilon_0\left(\frac{1}{2}mv^2\right)}$
This sets upper limit for r
d. Lower limit of r not set

103 **(d)**
$\frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{4^2}\right]$
or $\frac{f}{c} = R\left[\frac{1}{4} - \frac{1}{16}\right]$
or $f = cR\left[\frac{1}{4} - \frac{1}{16}\right]$
$= 3 \times 10^8 \times 10^7 \times \frac{3}{16}$
$= \frac{9}{16} \times 10^{15}$ Hz

104 **(c)**
Angular momentum, $mvr = n\frac{h}{2\pi} = \frac{h}{2\pi}(n = 1)$
which is independent of Z

105 **(b)**
Let v = speed of neutron before collision,
v_1 = speed of neutron after collision,
v_2 = speed of proton or hydrogen atom after collision,
and ΔE = energy of excitation
From conservation of linear momentum
$mv = mv_1 + mv_2$ (i)
From conservation of energy,
$\frac{1}{2}mv^2 = \frac{1}{2}mv_1^2 + \frac{1}{2}mv_2^2 + \Delta E$ (ii)
From Eq. (i),
$v^2 = v_1^2 + v_2^2 + 2v_1v_2$
From Eq. (ii),
$v^2 = v_1^2 + v_2^2 + \frac{2\Delta E}{m}$
$\therefore 2v_1v_2 = \frac{2\Delta E}{m}$
$\therefore (v_1 - v_2)^2 = (v_1 + v_2)^2 - 4v_1v_2$
$\Rightarrow (v_1 - v_2)^2 = v^2 - 4\frac{\Delta E}{m}$
As $v_1 - v_2$ must be real, therefore
$v^2 - 4\frac{\Delta E}{m} \geq 0$
or $\frac{1}{2}mv^2 \geq 2\Delta E$
The minimum energy that can be absorbed by hydrogen atom in ground state to go into excited state is 10.2 eV. Therefore,
$\frac{1}{2}mv_{\text{min}}^2 = 2 \times 10.2$ eV
$= 20.4$ eV

106 **(b)**
$\lambda = \frac{h}{p}$ (for electron)
or $p = h/\lambda$
and $E = \frac{hc}{\lambda}$ (for photon)
$\therefore \frac{p}{E} = \frac{1}{c} = \frac{1}{3 \times 10^8} = 3.33 \times 10^{-9}\text{s m}^{-1}$

107 **(a)**
$M = IA = ef\pi r^2$
$= 1.6 \times 10^{-19} \times 10^{16} \times 3.14$
$\times (0.5 \times 10^{-10})^2$ A m^2
$= 1.256 \times 10^{-23}$ Am^2

108 **(d)**
Rydberg's constant determines the frequencies. We have $R \propto m$. So, modified R for positronium atom is half of H atom. Hence, frequencies are reduced to half

109 **(c)**
The characteristic X-ray depends on the material used

110 **(d)**
$\frac{1}{\lambda} = R\left[\frac{1}{1^2} - \frac{1}{2^2}\right]$
or $\frac{1}{\lambda} = R\left[1 - \frac{1}{4}\right]$ or $\frac{1}{\lambda} = \frac{3R}{4}$
Hence, wavelength $\frac{1}{\lambda} = \frac{3R}{4}$

111 **(a)**
Frequency of electron revolution:
$f = \frac{mZ^2e^4}{4\varepsilon_0^2n^3h^3}$,
Put the various values to get
$f = 6.62 \times 10^{15}\frac{Z^2}{n^3}$
Now, put $Z = 1$ and $n = 1$ to get
$f = 6.62 \times 10^{15}$ Hz

112 **(d)**
$r = \frac{\varepsilon_0 n^2h^2}{e^2\pi m}$
$= \frac{\varepsilon_0(2\pi L)^2}{\varepsilon^2\pi m}\left(L = n\frac{h}{2\pi} \text{ or } nh = 2\pi L\right)$
$\therefore Lr^{-\frac{1}{2}} = \text{constant}$

113 **(d)**
$E_\text{p} = -\frac{ke^2}{r}, E = \frac{ke^2}{2r}$
So, $E_\text{p} = 2E = 2(-13.6)$ eV $= -27.2$ eV
Potential energy of electron in the ground state of Li^{2+} ion is
$= -3^2 \times 27.2$ eV or -244.8 eV

114 **(b)**
$N = \sum 2n^2$
$N = 2(1^2 + 2^2 + 3^2 + 4^2) = 60$

115 **(b)**

The energy taken by hydrogen atom corresponds to its transition from $n = 1$ to $n = 3$ state

ΔE (given to hydrogen atom)

$$= 13.6\left(1 - \frac{1}{9}\right) = 13.6 \times \frac{8}{9} = 12.1 \text{ eV}$$

116 **(b)**

Frequency $= R\left(\frac{1}{2^2} - \frac{1}{\infty^2}\right)c$

Hence, $\lambda = \frac{4}{R}$

117 **(d)**

By quantum theory of radiation, the energy change ΔE between energy levels is proportional to the frequency of electromagnetic radiation f and is given by

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

Hence, $\lambda = \frac{hc}{\Delta E} = \frac{hc}{E_1 - E_2}$

118 **(d)**

In transition of electron from higher energy level to lower energy level, the wavelength is given by $\lambda = hc/\Delta E$, where ΔE is the energy difference between two levels

For minimum λ, ΔE should be maximum, so (d) is the correct option

119 **(d)**

Angular momentum, $L = 4.2176 \times 10^{-34} = \frac{n_2 h}{2\pi}$

$\Rightarrow n_2 = 4$

For the transition from $n_2 = 4$ to $n_1 = 3$, the wavelength of spectral line $= \lambda$

$$\frac{1}{\lambda} = \frac{13.6}{hc}\left(\frac{1}{3^2} - \frac{1}{4^2}\right)$$

$$= \frac{13.6 \text{ eV}}{1240 \text{ eV nm}}\left(\frac{7}{9 \times 16}\right)$$

$$\lambda = \frac{1240 \times 144}{13.6 \times 7} = 1876 \text{ nm} = 18760 \text{ Å}$$

$$= 1.876 \times 10^4 \text{ Å}$$

120 **(d)**

$$\frac{E_{4n} - E_{2n}}{E_{2n} - E_n} = \frac{\frac{E_1}{16n^2} - \frac{E_1}{4n^2}}{\frac{E_1}{4n^2} - \frac{E_1}{n^2}} = \frac{1}{4} = \text{constant}$$

121 **(d)**

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

Now, $\lambda_{\text{Na}} = \frac{1216}{11 \times 11} \approx 10 \text{ Å}$

122 **(c)**

Use $E = \frac{1}{4\pi\varepsilon_0}\frac{(Ze)(e)}{r_0}$

123 **(b)**

From the graphs given, atom in graph B will absorb most of the energy W from the electron and re-radiate, in all directions, radiation of shortest wavelength when the atom returns to its ground state

124 **(d)**

The K, L, and M lines have different intercepts. The intercept of K is more than that of L, which in turn is more than that of M

125 **(d)**

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

126 **(d)**

When wavelength is maximum, the energy is minimum. Hence, this is from the ground state to the first excited state, for which the energy is $13.6 \text{ eV} - 3.4 \text{ eV} = 10.2 \text{ eV}$

Hence, the required wavelength is 122 nm

The text possibility is to jump from the ground state to the second excited state, which requires $= 13.6 - 1.5 = 12.1$ eV

Hence, it corresponds to a wavelength

$$\lambda = \frac{c}{v} = \frac{hc}{E_3 - E_1} = \frac{(6.63 \times 10^{-34}) \times (3 \times 10^8)}{(12.1) \times (1.6 \times 10^{-19})}$$

$$= 103 \text{ nm}$$

Therefore, (d) is the answer

127 **(b)**

$$\lambda = \frac{912 \text{ Å}}{Z^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]}$$

For singly ionized helium atom $Z = 2$

For the wavelength to be longest, $n_1 = 1, n_2 = 2$

$$\therefore \lambda = \frac{912 \text{ Å}}{(2^2)\left[1 - \frac{1}{4}\right]} = \frac{912}{3} = 304 \text{ Å}$$

128 **(c)**

Making potential energy zero increases the value of total energy by $13.6 - (-13.6) = 27.2$ eV

Now, actual energy in second orbit $= -3.4$ eV

Hence, new value is $(-3.4 + 27.2)$ eV $= 23.8$ eV

129 **(d)**

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

Clearly, L is constant and independent of Z

130 **(c)**

Assuming that ionization occurs as a result of a completely inelastic collision, we can write

$$mv - 0 = (m + m_{\text{H}})u$$

Where m is the mass of incident particle, m_{H} the mass of hydrogen atom, v_0 the initial velocity of incident particle, and u the final common velocity of the particle after collision. Prior to collision, the KE of the incident particle was

$$E_0 = \frac{mv_0^2}{2}$$

The total kinetic energy after collision

$$E = \frac{(m + m_H)u^2}{2} = \frac{m^2 v_0^2}{2(m + m_H)}$$

The decrease in kinetic energy must be equal to ionization energy. Therefore,

$$E_1 = E_0 - E = \left(\frac{m_H}{m + m_H}\right) E_0$$

i.e., $\frac{E_1}{E_0} = \frac{1}{1 + \frac{m}{m_H}}$

i.e., the greater the mass m, the smaller the fraction of initial kinetic energy that be used for ionization

131 **(c)**

$\frac{13.6}{4}$ eV $= 3.4$ eV

132 **(a)**

In this case, there is the widest energy gap

133 **(b)**

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

$E_1 = -13.6$ eV

$E_2 = -3.4$ eV

$E_3 = -1.50$ eV

$E_4 = -0.85$ eV

From above, we can see that

$E_3 - E_1 = 12.1$ eV

i.e., the electron must be making a transition from $n = 3$ to $n = 1$ level

$$\Delta L = (3 - 1)\frac{h}{2\pi} = \frac{h}{\pi}$$

$= 2.11 \times 10^{-34}$ Js

134 **(c)**

Using Moseley's law, $v^{1/2} = a(z - b)$

$$\left(\frac{c}{\lambda_1}\right)^{1/2} = a(z_1 - b) \text{ and } \left(\frac{c}{\lambda_2}\right)^{1/2} = a(z^2 - b)$$

$$\left(\frac{\lambda_2}{\lambda_1}\right)^{\frac{1}{2}} = \frac{a(z_1 - b)}{a(z_2 - b)} \Rightarrow \left(\frac{7.12}{15.42}\right)^{\frac{1}{2}} = \frac{(29 - b)}{(42 - b)}$$

$(42 - b) = 1.47(29 - b) \Rightarrow b = 1.44$

$$\left(\frac{\lambda_1}{\lambda}\right)^{\frac{1}{2}} = \frac{(z - 1.44)}{(z_1 - 1.44)}$$

$$\left(\frac{15.42}{22.85}\right)^{\frac{1}{2}}(27.56) = z - 1.44 \Rightarrow = 24$$

135 **(c)**

The angular momentum is $mvr = \frac{nh}{2\pi} \Rightarrow n = 1$

Centripetal force, $\frac{mv^2}{r} = \frac{Ze^2}{4\pi\varepsilon_0 r^2}$

$$r = \frac{\varepsilon_0 n^2 h^2}{\pi m_\pi e^2 Z} = \left(\frac{\varepsilon_0 h^2}{\pi m_e e^2}\right)\left(\frac{m_e}{m_\pi}\right)\frac{1}{Z}$$

$$= \frac{0.53 \times 10^{-10}}{264\, Z} = \frac{200 \times 10^{-15}}{Z} \quad \left[\because \frac{m_\pi}{m_e} = 264\right]$$

Since r cannot be less than nuclear radius,

$r > 1.6\, Z^{\frac{1}{3}} \times 10^{-15}$m

or $\frac{200\times10^{-15}}{Z} > 1.6 \times 10^{-15}\, Z^{\frac{1}{3}}$

$$\Rightarrow Z < \left(\frac{200}{1.6}\right)^{\frac{3}{4}} < 37$$

136 **(b)**

$v = \frac{1}{137}\frac{c}{n}$ or $v \propto \frac{1}{n}$

Since v is reduced to one-third, therefore

$n = 3$

Now, $r \propto n^2$

137 **(d)**

λ_{min} is found for $n = 2 \rightarrow 1$ since energy gap is maximum

138 **(d)**

$$\frac{0.001}{2} \times 10^{-3} = (0.5 \times 10^{-10})n^2$$

$\left\{\begin{matrix}\text{Because radius of } n^{\text{th}} \text{ orbit is equal to} \\ r_n = n^2 r_0, \text{ where } r_0 = 0.529 \text{ Å}\end{matrix}\right\}$

$\therefore n^2 = 1000$

or $n = 31$

139 **(b)**

ΔE_1 (for 4th to 3rd excited states)

$$= 13.6 \times 3^2 \left[\frac{1}{4^2} - \frac{1}{5^2}\right] = 2.75 \text{ eV}$$

ΔE_2 (for 3rd to 2nd excited states)

$$= 13.6 \times 3^2 \left[\frac{1}{3^2} - \frac{1}{4^2}\right] = 5.95 \text{ eV}$$

For shorter wavelength, i.e., for $\Delta E_2, V_{01} = 3.95$ volt

From $eV_{01} = hc - \phi$,

$3.95 = 5.95 - \phi$

$\therefore\ \phi = 2$ eV

For longer wavelength,

$eV_{02} = 2.75 - 2 = 0.75$ eV

So, $V_{02} = 0.75$ V

140 **(b)**

$v_n = \alpha\left(\frac{cZ}{n}\right)$, where $\alpha = \frac{e^2}{2h\varepsilon_0 c}$ is the fine structure constant $\left(\alpha = \frac{1}{137}\right)$

$$v_{He^+} = \alpha\frac{c(2)}{2} = \alpha c$$

and $v_H = \alpha\frac{c(1)}{1} = \alpha c = v_{He^+}$

141 **(b)**

$r_n \propto n^2$

$$\frac{n'^2}{n^2} = \frac{21.2 \times 10^{-11}}{5.3 \times 10^{-11}} \text{ or } \frac{n''^2}{n^2} = 4$$

or $\frac{n'^2}{1^2} = 4$ or $n' = 2$

142 **(c)**

The minimum energy to ionize an atom is the energy required to remove an outermost electron in the atom

143 **(c)**

$$\lambda_{\min} = \frac{hc}{eV_{\max}}$$

144 **(a)**

Shortest wavelength of Brackett series corresponds to the transition of electron between $n_1 = 4$ and $n_2 = \infty$ and the shortest wavelength of Balmer series corresponds to the transition of electron between $n_1 = 2$ and $n_2 = \infty$. So,

$$(z^2)\left(\frac{13.6}{16}\right) = \left(\frac{13.6}{4}\right)$$

$\therefore z^2 = 4$

or $z = 2$

145 **(c)**

Through filter, only those photons will pass through whose energy is less than $E = \frac{hc}{800 \text{ nm}} =$ 1.55 eV

From hydrogen's energy level diagram, we can easily identify that when electron jumps from 3rd excited state (4th energy level) to 2nd excited state (3rd energy level), then photons of 1.55 eV energy have been emitted. So, the required initial energy level is the 3rd excited state

146 **(c)**

First excitation energy is

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

$$\frac{3}{4}Rhc = V \text{ eV}$$

$$\therefore Rhc = \frac{4V}{3} \text{ eV}$$

147 **(d)**

$B = \frac{\mu_0 I}{2r}$ and $I = \frac{e}{T}$

$$B = \frac{\mu_0 e}{2rT} \quad [r \propto n^2, T \propto n^3]$$

$$B \propto \frac{1}{n^5}$$

148 **(b)**

Possible transitions are:

$4 \to 3, 4 \to 2, 4 \to 1,$

$3 \to 2, 3 \to 1,$ and

$2 \to 1$

149 **(a)**

$|F| = \left|\frac{-dU}{dr}\right| = \frac{mv^2}{r} \Rightarrow v = \sqrt{\frac{U_0}{m}}$, which is a constant

So, $mv_n r_n = \frac{nh}{2\pi} \Rightarrow r_n \propto n$

150 **(a)**

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

$$\therefore \frac{h}{mv} = \frac{(2\pi r)}{n}$$

$\frac{h}{mv}$ = de Broglie wavelength

151 **(d)**

$$\lambda_{\min} = \frac{hc}{eV_{\max}}$$

152 **(d)**

The energy of the K_α X-ray photon

$E_{K_\alpha} = E_i - E_f = (Z-1)^2(-3.4 \text{ eV} + 13.6 \text{ eV})$

$= (Z-1)^2(10.2 \text{ eV})$

Given $E_{K_\alpha} = 7.46$ keV

$\therefore 7.46 \times 10^3 \text{ eV} = (Z-1)^2(10.2 \text{ eV})$

or $(Z-1)^2 = \frac{7.46 \times 10^3}{10.2} = 731.4$

or $(Z-1) = 27 \Rightarrow Z = 28$

153 **(b)**

$$E_{\text{photon}} = E_3 - E_1 = -\frac{E_0}{3^2} - \left(-\frac{E_0}{1^2}\right) = \frac{8}{9}E_0$$

Therefore, (b) is the answer

154 **(d)**

Energy of n^{th} state in hydrogen is same as energy of $3n^{\text{th}}$ state in Li^{++}

$\therefore 3 \to 1$ transition in H would give same energy as the $3 \times 3 \to 1 \times 3$ i.e., $9 \to 3$ transition in Li^{++}

155 **(d)**

$$(r_m) = \left(\frac{m^2}{z}\right)(0.53\text{Å}) = (n \times 0.3)\text{Å}$$

$$\therefore \quad \frac{m^2}{z} = n$$

m=5 for $_{100}Fm^{257}$ (the outermost shell) and

$z = 100$

$$\therefore \quad n = \frac{(5)^2}{100} = \frac{1}{4}$$

156 **(a)**

$\frac{mv^2}{r} = \frac{3q^2}{4\pi\varepsilon_0 r^2} \Rightarrow mvr = \frac{3q^2}{4\pi\varepsilon_0 v}$ (i)

and $\frac{nh}{2\pi} = mvr$ (ii)

Using (i) and (ii) and putting $n = 1$

$$\frac{h}{2\pi} = \frac{3q^2}{4\pi\varepsilon_0 v} \Rightarrow v = \frac{3q^2}{2\varepsilon_0 h}$$

157 **(a)**

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

$$\frac{T_1}{T_2} = \left(\frac{n_1}{n_2}\right)^3 \Rightarrow 8 = \left(\frac{n_1}{n_2}\right)^3 \text{ or } \frac{n_1}{n_2} = 2$$

Only a. satisfies the above, hence this is right choice

158 **(c)**

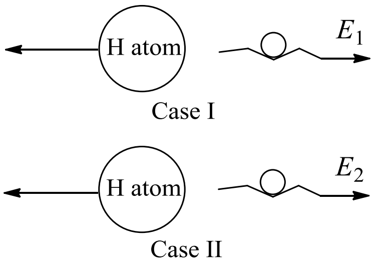
As the number of orbit increases, the velocity decreases. The potential energy becomes less negative, i.e., PE increases while KE decreases

159 **(d)**

$v = 2\pi r f$

$\Rightarrow f = \dfrac{v}{2\pi r}$

160 **(b)**



In the first case, KE of H atom increases due to recoil whereas in the second case KE decreases due to recoil

$\therefore E_2 > E_1$

161 **(d)**

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

For K_α line; $n_1 = 2, n_2 = 1$

For metal A; $\frac{1875R}{4} = R(z_1 - 1)^2 \left(\frac{3}{4}\right)$

$\Rightarrow z_1 = 26$

For metal B; $675R = R(z-1)^2 \left(\frac{3}{4}\right)$

$\Rightarrow z_2 = 31$

Therefore, 4 elements lie between A and B

162 **(a)**

$\dfrac{1}{\lambda} = 1.09 \times 10^7 \left[\dfrac{1}{2^2} - \dfrac{1}{3^2}\right]$

$\Rightarrow \ \lambda = 6.606 \times 10^{-7}\text{m} \Rightarrow 6606 \text{ Å}$

163 **(d)**

For Lyman series, $n_1 = 1$ and $n_2 = 2$ for first line

$\dfrac{1}{\lambda_1} = R\left[\dfrac{1}{1^2} - \dfrac{1}{2^2}\right] = R\left[\dfrac{1}{1} - \dfrac{1}{4}\right] = \dfrac{3R}{4}$

For Paschen series, $n_1 = 3$ and $n_2 = 4$ for firsts line

$\therefore \dfrac{1}{\lambda_2} = R\left[\dfrac{1}{3^2} - \dfrac{1}{4^2}\right] = R\left[\dfrac{1}{9} - \dfrac{1}{16}\right] = \dfrac{7R}{144}$

$\dfrac{\lambda_1}{\lambda_2} = \dfrac{4/3R}{144/7R} = \dfrac{7}{108}$

164 **(d)**

If the electron jumps from n_3 level to n_1 level, then photon of energy 12.1 eV is emitted. If the electron jumps from n_2 level to n_1 then 10.2 eV photon is emitted. Clearly, these transitions are possible in minimum two atoms and maximum three atoms

165 **(c)**

The electron is still in the state $n = 2$. It has to reach the ground state by emitting a photon

166 **(a)**

$\dfrac{1}{\lambda_\alpha} = \dfrac{3R}{4}(Z-1)^2$

$(Z-1) = \sqrt{\dfrac{4}{3R\lambda_\alpha}}$

$= \sqrt{\dfrac{4}{3 \times 1.1 \times 10^7 \times 1.8 \times 10^{-10}}}$

$= \dfrac{200}{3}\sqrt{\dfrac{5}{35}} = \dfrac{78}{3} = 26 \Rightarrow Z = 27$

167 **(c)**

As angular momentum of electron is $4h/2\pi$, it means electron is in the 4th orbit

TE of atom in 4th orbit is -0.85 eV

KE of electron = |TE| = 0.85 eV

168 **(a)**

$\dfrac{1}{\lambda} = R\left[\dfrac{1}{1^2} - \dfrac{1}{3^2}\right] \Rightarrow \lambda = \dfrac{9}{8R}$

Again, $\frac{1}{\lambda'} = R\left[\frac{1}{2^2} - \frac{1}{4^2}\right] \Rightarrow \lambda' = \frac{16}{3R}$

Now, $\frac{\lambda'}{\lambda} = \frac{16}{3R} \times \frac{8R}{9}$ or $\lambda' = \frac{128}{27}\lambda$

169 **(b)**

$\dfrac{1}{\lambda} = R\left[\dfrac{1}{2^2} - \dfrac{1}{3^2}\right] = \dfrac{5R}{36}; \lambda = \dfrac{36}{5R}$

170 **(b)**

$v = Z\left[\dfrac{1}{137}\dfrac{c}{n}\right]$

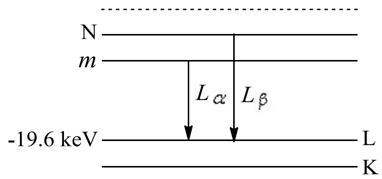
$\Rightarrow v = 4 \times \dfrac{1}{137} \times \dfrac{c}{2}$

or $v = \frac{2c}{137}$

171 **(a,b,c)**

$\lambda_{\text{min}} = \lambda_{\text{min}} = \dfrac{12400}{v_0} \text{Å}$

$= \dfrac{12400}{20{,}000} = 62 \text{ Å}$



172 **(a)**

We know that as the electron comes nearer to the nucleus, the potential energy decreases

$\left(\frac{-KZe^2}{r} = \text{PE and } r \text{ decreases}\right)$

The KE will increase $\left[\because KE = \frac{1}{2}|PE| = \frac{1}{2}\frac{kZe^2}{r}\right]$

The total energy decreases $\left[TE = \frac{1}{2}\frac{kZe^2}{r}\right]$

173 **(b,c)**

$v \propto \frac{1}{n}, E \propto \frac{1}{n^2}$, and $r \propto n^2$

174 **(b)**

Shortest wavelength or cut-off wavelength depends only upon the voltage applied in the Coolidge tube

175 **(a,c,d)**

a. $r_n = \frac{n^2h^2}{4\pi^2 mKe^2}$, i.e., $r_n \propto n^2$

c. Bohr's 2nd postulate, $mvr = \frac{nh}{2\pi}$

d. $K_n = \frac{KZe^2}{2r_n}, U_n = \frac{KZe^2}{r_n}$

176 **(a,c)**

Power loss increases the temperature

178 **(a,b)**

$|F| = \frac{dU}{dt} = \frac{Ke^2}{r^4}$ (i)

$\frac{Ke^2}{r^4} = \frac{mv^2}{r}$ (ii)

and $mvr = \frac{nh}{2\pi}$ (iii)

By (ii) and (iii),

$r = \frac{Ke^2 4\pi^2}{h^2}\frac{m}{n^2} = K_1\frac{m}{n^2}$ (iv)

Total energy $= \frac{1}{2}$ (potential energy)

$$\frac{Ke^2}{6r^3} = \frac{-Ke^2}{6\left(\frac{K_1 m}{n^2}\right)^3} = \frac{-Ke^2n^6}{6K_1^3m^3}$$

Total energy $\propto n^6$

Total energy $\propto$ m^{-3}

∴ (a) and (b) are correct

179 **(a,b,c)**

a. $U_1 = E$, then total energy in the orbit $= \frac{U_1}{2} = \frac{E}{2}$

b. IE $= (\text{TE})_{n=\infty} - (\text{TE})_{n=1} = 0 - (\text{TE})_{n=1} = -\left(\frac{E}{2}\right)$

c. $(\text{KE})_{n=1} = -(\text{TE})_{n=1} = -\left(\frac{E}{2}\right)$

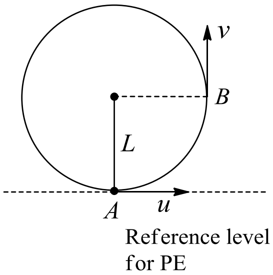
180 **(a,d)**

The time period of the electron in a Bohr orbit is given by $T = 2\pi r/V$

Since for the n^{th} Bohr orbit, $mvr = n(h/2\pi)$, the time period becomes

$$T = \frac{2\pi r}{nh/(2\pi mr)} = \left(\frac{4\pi^2 m}{nh}\right)r^2$$

Since the radius of the orbit r depends on n, we replace r



The expression of Bohr radius of a hydrogen atom is $r = n^2\left(\frac{h^2\varepsilon_0}{\pi me^2}\right)$

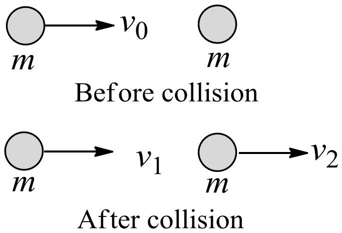
Hence, $T = \left(\frac{4\pi^2 m}{nh}\right)\left(\frac{n^4h^4\varepsilon_0^2}{\pi^2m^2e^4}\right) = n^3\left(\frac{4h^3\varepsilon_0^2}{me^4}\right)$

For two orbits, $\frac{T_1}{T_2} = \left(\frac{n_1}{n_2}\right)^3$

It is given that $T_1/T_2 = 8$. Hence, $n_1/n_2 = 2$

181 **(b,c,d)**

Let collision between two atoms be an inelastic one. From momentum conservation, $mv_0 = mv_1 + mv_2$



From energy conservation,

$$\frac{mv_1^2}{2} + \frac{mv_2^2}{2} - \frac{mv_0^2}{2} = -\Delta E$$

Where ΔE is the energy absorbed by the initially stationary atom to change its state

Solving above equations, we get

$$(v_1 - v_2)^2 = v_0^2 - \frac{4\Delta E}{m}$$

For collision to be inelastic, $(v_1 - v_2)^2 \geq 0$: a real quantity [equal to sign for perfect inelastic collision]

The minimum value of ΔE is 10.2 eV, so for collision to be inelastic, $E \geq 20.4$ eV

For perfectly inelastic collision, $v_1 = v_2$ and hence $E = 20.4$ eV

For $E = 18$ eV, the collision is elastic one and as masses are the same, velocities would be interchanged during collision

182 **(b,c)**

Any transition causing a photon to be emitted in the Balmer series must end at $n = 2$. This must be followed by the transition from $n = 2$ to $n = 1$, emitting a photon of energy 10.2 eV, which corresponds to a wavelength of about 122 nm. This belongs to the Lyman series

183 **(b,d)**

When potential difference between filament and target is increased, then KE of striking electrons gets increased. Since most energetic electrons now strike the target, therefore more energetic electrons are emitted. It means, frequency of X-ray photons increases. It means, penetration power of X-rays gets increased

To increase the photon flux, rate of collision of electrons with the target must be increased. This can be achieved only when rate of emission of electrons from the filament is increased. To achieve this, filament current must be increased. Therefore, options (b) and (d) are correct

184 **(c)**

We know that $\lambda \propto \frac{1}{m}$

For ordinary hydrogen atom,

$$\frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right] = \frac{5R}{36} \text{ or } \lambda = \frac{36}{5R}$$

With hypothetical particle, required wavelength

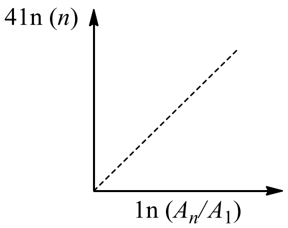
$$\lambda' = \frac{1}{2} \times \frac{36}{5R} = \frac{18}{5R}$$

185 **(a,b,c)**

$E_n^H = E_1^H + \Delta E = -13.6 \text{ eV} + 12.75 \text{ eV} = -0.85$ eV i.e., hydrogen atoms are excited to $n = 4$ level, i.e., transitions $4 \to 1, 3 \to 1, 2 \to 1$ are possible which correspond to Lyman series, then transitions $4 \to 2$ and $3 \to 2$ are possible which correspond to Balmer series, and then transition $4 \to 3$ is also possible which correspond to Paschen series

186 **(a,b)**

$r_n = n^2 r_1$



$$\text{In}\left(\frac{A_n}{A_1}\right) = \text{In}\left(\frac{\pi n_n^2}{\pi r_1^2}\right) = \text{In } n^4 = 41\text{n}(n)$$

187 **(b,c,d)**

Statement (a) is false. The shortest wavelength of the X-rays emitted depends on the energy of the electrons incident on the target. This, in turn, depends on the potential through which they have fallen. In fact,

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

Statement (b) is true. X-ray spectra of all heavy elements are similar in character.

Statement (c) is also true. The short wavelength of the X-rays (compared to the grating constant of optical grating) makes it difficult to observe X-ray diffraction with ordinary gratings.

Statement (d) is also true. The sharp limit on the short wavelength side is dependent on the voltage applied to the incident electrons and is give by:

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

188 **(b,c)**

Lyman series lies in the ultraviolet region, Balmer series in visible region, and Paschen series in infrared region

c. $\lambda_R > \lambda_Y > \lambda_B > \lambda_V$

189 **(d)**

Method 1: Memorisation

In Lyman series, we get energy in UV region

In Balmer series, we get energy in visible region

In Paschen/Brackett/Pfund series, we get energy in IR region

Method 2:

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

for e^- transition from $n_2 \to n_1$

For 4 to 3, $E \propto \frac{1}{\lambda} = R\left[\frac{1}{9} - \frac{1}{16}\right] = \frac{7}{9 \times 16} R$

For 2 to 1, 3 to 2, and 4 to 2, we get more value of $1/\lambda$, i.e., more energy than $4 \to 3$

IR radiation has less energy than UV radiation

Therefore, the correct option is (d)

190 **(d)**

For hydrogen and hydrogen-like atoms,

$$E_n = -13.6 \frac{(z)^2}{(n)^2} \text{eV}$$

Therefore, ground state energy of doubly ionized lithium atom ($z = 3, n = 1$) will be

$$E_1 = (-13.6)\frac{(3)^2}{(2)^2} = -122.4 \text{ eV}$$

∴ Ionization energy of an electron in ground state of doubly ionized lithium atom will be 122.4 eV

191 **(b,c)**

$$E_0 z^2\left(1 - \frac{1}{9}\right) - E_0 z^2\left(\frac{1}{4} - \frac{1}{9}\right) = 3E_0 \Rightarrow \frac{27}{36} E_0 Z^2 = 3E_0$$

$$\Rightarrow z = 2\frac{\lambda_1}{\lambda_2}; = 3$$

$$KE_1 = E_0\left(1 - \frac{1}{9}\right) - \phi;$$

$$KE_2 = E_0 z^2\left(1 - \frac{1}{4}\right) - \phi$$

$$KE \propto \frac{1}{\lambda^2} = 8.5 \text{ eV}$$

192 **(a,c)**

First line of Lyman series is obtained during transition of hydrogen atom from $n = 2$ to $n = 1$. Hence, its energy is equal to $E_2 - E_1 = (13.6)\text{eV} - (-3.4 \text{ eV}) = -1.2$ eV

∴ Wavelength of the first line of Lyman series is equal to

$$\frac{12375}{10.2} \text{Å} = 1215 \text{ Å}$$

Therefore, it lies in ultraviolet region
Since energy of all the other lines of Lyman series is greater than that of first line, therefore all the lines of Lyman series lie in ultraviolet region. Hence, option (a) is correct
First line of Balmer series is obtained during transition of hydrogen atom from $n = 3$ to $n = 2$. Hence, its energy is equal to $E_3 - E_2 = 1.89$ eV
∴ Wavelength of first line of Balmer series is equal to $12375/1.89$ Å $= 6563$ Å. It lies in visible region
Energy of last line of Balmer series is equal to 3.4 eV. Therefore, its wavelength is equal to $12375/3.4$ Å $= 3640$ Å
Since it is less than 4000 Å, therefore it lies in ultraviolet region. Hence, option (b) is wrong.
Energy of last line of Paschen series is equal to 1.51 eV. It lies in infrared region. Since energy of all the other lines of Paschen series is less than its energy, therefore all the lines of Paschen series will lie in infrared region. Hence, option (c) is also correct

193 **(a,b)**
For the third line of Balmer series, $n_1 = 2, n_2 = 5$
$$\therefore \frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = RZ^2\left(\frac{1}{2^2} - \frac{1}{5^2}\right) = \frac{21\,RZ^2}{100}$$
$E = -13.6$ eV
$$Z^2 \times \frac{21}{100} = \frac{hc}{\lambda} = \frac{1242 \text{ eVnm}}{108.5 \text{ nm}}$$
$$Z^2 = \frac{1242 \times 100}{108.5 \times 21 \times 13.6} = 4 \Rightarrow Z = 2$$
Binding energy of an electron in the ground state of hydrogen-like ion $= 13.6Z^2/n^2 = 54.4$ eV ($n = 1$)

195 **(a)**
The maximum number of electrons in an orbit is $2n^2$. Since $n > 4$ is not possible, therefore the maximum number of electrons that can be in the first four orbits are
$$2(1)^2 + 2(2)^2 + 2(3)^2 + 2(3)^2 + 2(4)$$
$$= 2 + 8 + 18 + 32 = 60$$
Therefore, possible elements are 60

196 **(a,c,d)**
a. As $v \propto 1/n$, so momentum $= mv \propto 1/n$
b. is not true as radius $r \propto n^2$
c. KE $= \frac{1}{2}mv^2$,
As $v \propto 1/n$, so KE $\propto \frac{1}{n^2}$
d. is true

197 **(a,b)**
The correct choices are (a) and (b). The last two statements are incorrect because they violate the principle of conservation of charge. We always have either an electron-positron 'pair production' or an electron-positron 'pair annihilation'. It is only then that the total charge remains zero both before and after reaction

198 **(a,c)**
Moseley's law: $\lambda \propto \frac{1}{(z-1)}2; \frac{\lambda_z}{\lambda_1} = \frac{(z_1-1)^2}{(z-1)^2}$
$z_1 - 1 = (z-1)2;$
$$z_1 = 2z - 1; \frac{\lambda_z}{\lambda_2} = \frac{1}{4} = \left(\frac{z_2 - 1}{z - 1}\right)^2$$

199 **(a,c,d)**
$p_n = mv_n, p_n = v_n \propto \frac{1}{n}, r_n \propto n^2$ and $K_n = \frac{Ke^2}{2r_n}$ i.e.,
$K_n \propto \frac{1}{n^2}$ and $L \propto n$

200 **(d)**
We know that
$$\frac{1}{\lambda} = Rz^2\left[\frac{1}{n_2^2} - \frac{1}{n_1^2}\right] \Rightarrow \frac{1}{\lambda} \propto z^2$$
λ is shortest when $1/\lambda$ is largest, i.e., when z is big.
z is highest for lithium

201 **(b,c,d)**
Ground state $n = 1$
First excited state $n = 2$
$$\text{KE} = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{2r}(z = 1)$$
$$\text{KE} = \frac{14.4 \times 10^{-10}}{2r}\text{eV}$$
Now $r = 0.53\,n^2$Å $(z = 1)$
$$(\text{KE})_1 = \frac{14.4 \times 10^{-10}}{2 \times 0.53 \times 10^{-10}}\text{eV} = 13.58 \text{ eV}$$
$$(\text{KE})_2 = \frac{14.4 \times 10^{-10}}{2 \times 0.53 \times 10^{-10} \times 4}\text{eV} = 3.39 \text{ eV}$$
KE decreases by 10.2 eV
Now, PE $= \frac{-1}{4\pi\varepsilon_0}\frac{e^2}{r} = \frac{-14.4\times10^{-10}}{r}$ eV
$$(\text{PE})_1 = \frac{-14.4 \times 10^{-10}}{0.53 \times 10^{-10}}\text{eV} = -27.1 \text{ eV}$$
$$(\text{PE})_2 = \frac{-14.4 \times 10^{-10}}{0.53 \times 10^{-10} \times 4} = -6.79 \text{ eV}$$
PE increases by 20.4 eV
Now, angular momentum, $L = mvr = \frac{nh}{2\pi}$
$$L_2 - L_1 = \frac{h}{2\pi} = \frac{6.6 \times 10^{-34}}{6.28} = 1.05 \times 10^{-34} \text{ Js}$$

202 **(c)**
$$E = \frac{hc}{\lambda} = \left[\frac{6.63 \times 10^{-34} \times 3 \times 10^8}{0.021 \times 10^{-9}}\right] \text{J}$$
$$= \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{0.021 \times 10^{-9} \times 1.6 \times 10^{-13}}\text{MeV}$$
$= 591.96 \times 10^{-4}$MeV $= 59.196$ keV
∴ (c) is the correct option

203 **(d)**

$$\lambda_{\min} = \frac{hc}{E} \Rightarrow \frac{12400}{80 \times 10^3} \text{Å} = 0.155$$

204 **(a,b,c)**

When a stationary hydrogen atom emits a photon, then energy of the emitted photon will be equal to the difference of the energy of the two levels involved in the transition. Hence, energy of emitted photon will be equal to $(E_m - E_n)$

If a hydrogen atom is moving and a photon is emitted by it along the same direction in which it is moving, due to momentum of the emitted photon, the momentum of hydrogen atom will get decreased. Therefore, energy of the emitted photon will be equal to ($E_m - E_n$ + loss of KE of the hydrogen atom)

But if the photon is emitted in a direction normal to the motion of the hydrogen atom, then the frequency of the emitted photon will be equal to f_0. Hence, option (a) is correct, obviously, option (d) is wrong

If the photon is emitted by the hydrogen atom in the direction opposite to its motion, then frequency of the emitted photon will be less than f_0. Hence, option (c) is correct

205 **(a,c,d)**

In Bohr model of hydrogen atom,

$R \propto n^2$

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

$T \propto n^3$ and $E \propto \frac{1}{n^2}$

$VR \propto n$

$TE \propto n$

$\frac{T}{R} \propto n$

$\therefore \frac{V}{E} \times n$

206 **(a,c)**

Statement (a) is correct. The angular momentum of the earth ($= mr^2\,\omega$) has to be equal to $nh/2\pi$. This gives, $n = 2\pi mr^2\,\omega/h$. Putting the numerical values of the Earth's mass, radius, and the angular velocity, we get the given value of n.

Statement (b) is incorrect. The maximum number of electrons allowed in an orbit being $2n^2$, the required number is $2(1^2 + 2^2 + 3^2 + 4^2) = 60$

Statement (c) is correct. The 'reduced mass' of the electron [$\mu = mM/(m + M)$] being dependent on the mass of the nucleus (M), the Rydberg constant also varies with the mass number of the given element

Statement (d) is incorrect. The ratio is not exactly equal to 4 but slightly different from 4 because of the dependence of the Rydberg constant on the mass number of the element concerned

207 **(a)**

In case of coolidge tube,

$\lambda_{\min} = \frac{hc}{eV} = \lambda_c$ (as given here)

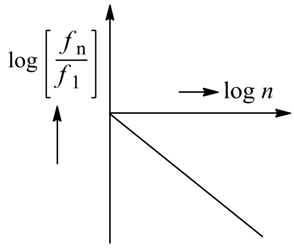
Thus, the cut-off wavelength is inversely proportional to acceleration voltage. As V increases, λ_c decreases

λ_k is the wavelength of K_∞line which is a characteristic of an atom and does not depend on acceleration voltage of bombarding electron since λ_k always refers to a photon wavelength of transition of e^- from the target element from $2 \to 1$

The above two facts lead to the conclusion that $\lambda_k - \lambda_c$ increases as accelerating voltage is increased

208 **(a,b,c)**

Since in hydrogen atom $r_n \propto n^2$, therefore graph between r_n and n will be a parabola through origin and having increasing slope. Therefore, option (a) is correct. Since, $r_n \propto n^2$, therefore $r_n/r_1 = n^2$ Hence, $\log(r_n/r_1) = 2\log n$



It means, graph between $\log(r_n/r_1)$ and $\log n$ will be a straight line passing through origin and having positive slope ($\tan\theta = 2$). Therefore, option (b) is also correct. It radius of an orbit is equal to r, then area enclosed by it will be equal to $A = \pi r^2$

Since $r_n \propto n^2$, therefore $A_n \propto n^4$

Hence, $\frac{A_n}{A_1} = n^4$ or $\log\left(\frac{A_n}{A_1}\right) = 4\log n$

It means, graph between $\log(A_n/A_1)$ and $\log n$ will be a straight line passing through origin and having positive slope ($\tan\theta = 4$). Therefore, option (c) is also correct.

If frequency of revolution of electron is f, then its angular velocity will be equal to $\omega = 2\pi f$. Hence, its angular momentum will be equal to $I\omega = mr^2\omega$. But according to Bohr's theory, it is equal to $nh/2\pi$, therefore,

$mr^2(2\pi f) = \frac{nh}{2\pi}$ or $f = \frac{nh}{4\pi^2 mr^2}$

Since $r \propto n^2$, therefore $f \propto \frac{1}{n^3}$

Hence, $\frac{f_n}{f_1} = \frac{1}{n^3}$ or $\log\left(\frac{f_n}{f_1}\right) = 3\log n$

It means, graph between $\log(f_n/f_1)$ and $\log n$ will be a straight line passing through origin and having negative slope, $\tan\theta = -3$. Hence, it will be as shown in figure. Hence, the option (d) is wrong

209 **(b,d)**

Line emission spectra can be obtained for atoms and molecules both. An atom or molecule in an excited state emits photons by making a transition from excited state to ground state thus constituting line emission spectra

The wavelengths emitted by the molecular energy levels which are generally grouped into several bunches are also grouped and each group is well separated from the other. The spectrum in this case looks like a band spectrum

210 **(a,b)**

Continuous spectrum is obtained from the bulk state of matter, it has no relation with the atomic or molecular state. It is produced by thermal vibrations of atoms in the macroscopic matter (not by the transition between the energy states of atoms). Every vibrating atom emits light of frequency of its vibrations. In a white hot matter, atoms vibrating with all frequencies within a definite range are present, so this matter emits frequencies of continuous range

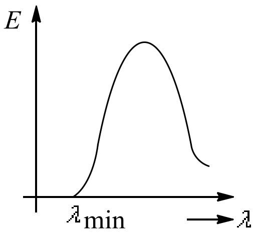
211 **(b)**

The continuous X-ray spectrum is shown in figure

All wavelengths $> \lambda_{\text{min}}$ are found where

$\lambda_{\text{min}} = \frac{12375}{V}$ Å

Here, V is the applied voltage



212 **(a,b,c)**

Energy of K absorption edge

$$E_K = \frac{1242\ \text{eVnm}}{0.0172\ \text{nm}} = 72.21 \times 10^3\ \text{eV} = 72.21\ \text{KeV}$$

Energy of K_α line is

$$E_{k_\alpha} = \frac{he}{e\lambda_\alpha} = \frac{1242\ \text{eVnm}}{0.021\ \text{nm}} = 59.14\ \text{KeV}$$

Similarly, $E_{k_\beta} = \frac{1242}{0.0192} = 64.69$ KeV

$$E_{k_\gamma} = \frac{1242}{0.0180} = 69\ \text{KeV}$$

Energy of K shell $= (E_{K_\alpha} - E_K)$

$= (59.14 - 72.21)\text{KeV} = -13.04$ keV

Energy of L shell $= E_{k_\beta} - 72.21$ keV

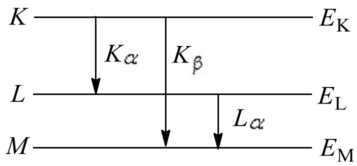
$= 64.69$ keV $- 72.21$ keV $= -7.52$ keV

Energy of M shell $= E_{k_\gamma} - E_k = \frac{1242\text{eVnm}}{0.018\ \text{nm}} -$ 72.21 keV

$= 69$ keV $- 72.21$ keV $= -3.21$ keV

214 **(a,c)**

$E_K - E_L = \frac{hc}{\lambda_\alpha}$ (i)



$E_K - E_M = \frac{hc}{\lambda_\beta}$ (ii)

$E_L - E_M = \frac{hc}{\lambda'_\alpha}$ (iii)

(ii)-(i) $\Rightarrow E_L - E_M = \frac{hc}{\lambda'_\alpha} = \frac{hc}{\lambda_\beta} - \frac{hc}{\lambda_\alpha}$

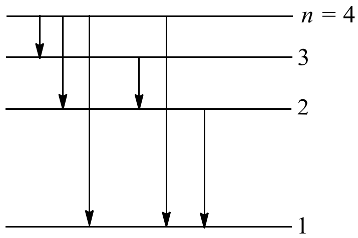
$$\frac{1}{\lambda_\beta} = \frac{1}{\lambda_\alpha} + \frac{1}{\lambda'_\alpha}$$

Also, $(E_K - E_M) > (E_K - E_L) > (E_L - E_M)$

$$\frac{hc}{\lambda_\beta} > \frac{hc}{\lambda_\alpha} > \frac{hc}{\lambda'_\alpha}$$

215 **(a,b,d)**

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



If the initial state were $n = 3$, in the emission spectrum, no wavelengths shorter than λ_0 would have occurred

This is possible if initial state were $n = 2$

216 **(c,d)**

$V = 6.6$ kV $= 6600$ V

Now, $v_{\text{max}} = \frac{eV}{h} = \frac{1.6\times10^{-19}\times6600}{6.6\times10^{-34}}$

$= 1.6 \times 10^{18}$ Hz

Thus, the frequency of the X-rays cannot exceed 1.6×10^{18} Hz. Hence, the correct choices are (c) and (d)

217 **(c,d)**

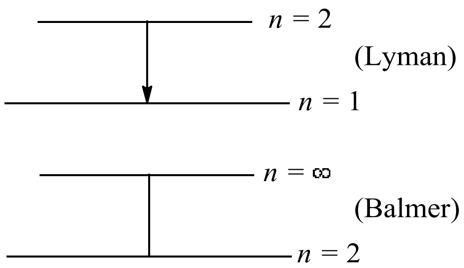
In the case of hydrogen,

Atomic number = mass number
In other atom, atomic number < mass number
Therefore, (c) and (d) are the correct options

218 **(b)**

1. If Assertion is True, Reason is True, Reason is correct explanation of 1
2. If Assertion is True, Reason is True, Reason is not correct explanation of 1
3. If Assertion is True, Reason is False
4. If Assertion is False, Reason is True

219 **(c)**
Lyman series: Its energy is in the ultraviolet region



Balmer series: Its energy is in visible region

Now, frequency of energy of ultraviolet photon is much greater than frequency of visible region. So, statement I is true. Statement II is false

220 **(a)**
A H atom that drops from $n = 2$ level to $n = 1$ level emits a photon of energy 10.2 eV and wavelength 122 nm. A He^+ ion emits a photon of the same energy and wavelength when it drops from $n = 4$ level to $n = 2$ level

222 **(b)**
An alpha particle carries 2 units of positive charge and 4 units of mass. It is made up of protons and 2 neutrons which make a nucleus of helium *ie*, helium atom is a deoid of 2 electrons *ie*, doubly ionized helium atom.

223 **(c)**
It is difficult to excite nucleus by usual methods employed for excitation for atoms because difference in energy of allowed energy states for nucleus is of the order of tens to hundreds of MeV.

225 **(d)**
As the energy of striking electron is increased, the wavelength of the characteristic X-ray does not change as characteristic X-rays are emitted when electrons are making transition from a higher energy level to a lower energy and energy of characteristic X-ray is given by

$$E = \frac{hc}{\lambda} = |E_f| - |E_i| = E_i - E_f$$

Which does not depend at all on the energy of the striking electron. The only dependence is that the striking electron should possess enough energy to knock out an electron from the inner shell

226 **(c)**
a. Moseley's law is about characteristic X-rays
b. In photoelectric effect, from electromagnetic radiation, electrons are ejected. In X-rays, the process is reverse; here, electromagnetic radiation (X-ray) is produced from fast moving electrons
Also X-rays are produced using high potential difference
c. Cut-off wavelength is related to potential difference applied in continuous X-rays
d. In continuous X-rays, electromagnetic radiations are emitted

227 **(d)**
a. KE of electrons striking the target: $\mathrm{KE} = eV$
So, if V increases, KE increases
Cut-off wavelength: $\lambda_{\min} = \frac{12400}{\mathrm{V}}$ Å
So, if V increases, $\lambda_{\min}$ decreases
b. If work function of target is increased in photoelectric effect, the KE of photoelectrons emitted decreases from: $\mathrm{KE} = hf - W_0$
Now, $hf_0 = W_0 \Rightarrow \frac{hc}{\lambda_0} = W_0 \Rightarrow \lambda_0 = \frac{hc}{W_0}$
It work function (W_0) increase, then cut-off wavelength (λ_0) decreases
c. $eV_0 = kE$, where V_0 is stopping potential. If V_0 decreases, then KE decreases
V_0 is also decreased by increasing W_0, hence λ_0 decreases as explained above
d. $f_{k_\alpha} = \frac{3}{4}Rc(z-1)^2$. If f_{k_α} increases, then f_{k_α} decreases and hence Z decreases

228 **(d)**
Burning candle gives continuous spectrum, sodium vapour gives line spectrum, Bunsen flame give band spectrum and dark lines in solar spectrum are due to absorption spectrum.

229 **(b)**

From Moseley's law: $f = \frac{1}{\lambda} = R(z-\sigma)^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

For Al, Z is highest and for $K_\beta, n_1 = 1$ and $n_2 = 3$; and for $K_\alpha, n_1 = 1$, and $n_2 = 2$

Hence, order of frequency:

$f_{k_\beta}(\text{Al}) > f_{k_\alpha}(\text{Al}) > f_{k_\alpha}(\text{Na}) > f_{k_\beta}(\text{Be}) > f_{k_\alpha}(\text{Li})$

Speed will be same (c) for all photons of any frequency

230 **(a)**

a. Emission spectra is discrete as only those wavelengths are emitted which correspond to energy difference of two energy levels

It is due to electronic transition, i.e., due to transition of electron from one energy level (higher) to the another energy level (lower). It is explained by quantum theory of light

b. For energies of incident light less than ionization energy, the absorption spectra is discrete. For energies of incident photon greater than ionization energy, the absorption spectra is continuous. It occurs due to electronic transition which is explained by quantum theory of light

c. Continuous X-rays constitute continuous spectra and characteristic X-rays arise due to electronic transition

d. Thermal radiation spectra is a continuous spectra and is explained by atomic transition and quantum theory

231 **(a)**

a. $f = \frac{mZ^2e^4}{4\varepsilon_0^2h^3n^3} \Rightarrow f \propto \frac{Z^2}{n^3}$

b. $L = \frac{nh}{2\pi} \Rightarrow L \propto n$

c. Magnetic moment: $M = IA = \frac{e}{2\pi r}v\pi r^2$

$= \frac{e}{2}vr = \frac{e}{2m}(mvr) = \frac{e}{2m}L$

$\Rightarrow M = \frac{e}{2m}\left(\frac{nh}{2\pi}\right) \Rightarrow \propto n$

d. $I = \frac{ev}{2\pi r} = \frac{e}{2\pi}\left(\frac{\pi mZe^2}{n^2h^2\varepsilon_0}\right)\frac{Ze^2}{2\varepsilon_0 nh} \Rightarrow I \propto \frac{Z^2}{n^3}$

232 **(c)**

$r_n = \frac{.529n^2}{Z}$ Å

So, (a) → (s)

Magnetic field, $B = \frac{12.5Z^3}{n^5}$ T

So, (b) → (t)

$B \propto \frac{1}{n^5}$

$V_n = \frac{2.2 \times 10^6\ Z}{n}$

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

$n \uparrow V_n \uparrow$

So, (c) → (q)

Total energy, $E_n = \frac{-13.6\ Z^2}{n^2}$ eV

$n \uparrow E_n \uparrow$

So, d. → p.

234 **(b)**

a. Photoelectrons can have KE anywhere from 0 to $KE_{\max} = hc/\lambda - \phi$

So, average KE is unpredictable

b. Minimum KE can be zero

c,d. In continuous X-rays, wavelength can vary from $\lambda_{\min} = hc/eV$ to ∞

235 **(a)**

$r_n = \frac{.529\ n^2}{Z}$ Å

So, (a) → (q)

$V_n = \frac{2.2 \times 10^6\ Z}{n}$ ms^{-1}

So, (d) → (p)

$I = \frac{1.06\ Z^2}{n^3}$ mA

So, (b) → (r)

Magnetic field, $B = \frac{12.5\ Z^3}{n^5}$ T

So, c. → s.

236 **(b)**

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

Wavelength range from 950 Å to 1350 Å corresponds to ultraviolet region of electromagnetic spectrum, i.e., Lyman series

For transition 4 → 1:

$\frac{1}{\lambda_1} = 1.1 \times 10^7\left(\frac{15}{16}\right)$

$\therefore\ \lambda_1 = \frac{16}{15 \times 1.1 \times 10^7} = 970$ Å

For transition 3 → 1:

$\lambda_2 = \frac{9}{8 \times 1.1 \times 10^7} = 1023$ Å

For transition 2 → 1:

$\lambda_3 = \frac{4}{3 \times 1.1 \times 10^7} = 1212$ Å

For Li^2 atom ($Z = 3$), for transition 2 → 1:

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

$\lambda' = \frac{1}{1.1 \times 10^7 \times 9 \times 0.75} = 134$ Å

For He^+ atom ($Z = 2$) for transition 2 → 1:

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

$\lambda' = \frac{1}{1.1 \times 10^7 \times 4 \times 0.75} = 303$ Å

237 **(b)**

On other planet: $mvr = 2n\frac{h}{2\pi} \Rightarrow v = \frac{nh}{\pi mr}$

$$\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2} \Rightarrow \frac{mn^2h^2}{n^2m^2r^3} = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2}$$

Putting $n = 1$, we get $r = \frac{4h^2\varepsilon_0}{m\pi e^2}$

238 **(c)**

$a_0 = \frac{h^2\varepsilon_0}{\pi me^2}$ and $r = \frac{n^2h^2\varepsilon_0}{\pi m_e e^2} = \frac{2^2h^2\varepsilon_0}{\pi(m/2)e^2} = 8a_0$

239 **(a)**

Internal forces act between electron and proton, then how can the atom get an acceleration

240 **(c)**

Given that $E_1 = -15.6$ eV, $E_\infty = 0$ eV

Ionization energy of the atom:

$E_\infty - E_1 = 0 - (-15.6 \text{ eV}) = 15.6$ eV

So, ionization potential = 15.6 eV

241 **(c)**

We can use the equation:

$$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_u^2}\right) = R\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = \frac{3R}{4}$$

$$\lambda = \frac{4}{3R} = \frac{4}{3(1.097 \times 10^7)}$$

$= 1.215 \times 10^{-7}$m $= 121.5$

The frequency of the photon is

$$f = \frac{c}{\lambda} = \frac{3.00 \times 10^8}{1.215 \times 10^{-7}} = 2.47 \times 10^{15} \text{ Hz}$$

The energy of the photon is $E = hf$

$= (4.136 \times 10^{-15})(2.47 \times 10^{15}) = 10.2$ eV

242 **(b)**

As we know, energy of a photon is given by $E = \frac{hc}{\lambda}$

From the given condition, $\lambda = \frac{1500p^2}{p^2-1}$

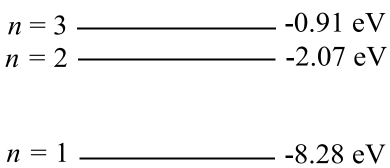
Hence, $E = \frac{hc}{\lambda} = \frac{hc}{1500}\left(1 - \frac{1}{p^2}\right) \times 10^{10}$ J

$$= \frac{hc}{(1500)(1.6 \times 10^{-19})}\left(1 - \frac{1}{p^2}\right) \times 10^{10} \text{eV}$$

$$= 8.28\left(1 - \frac{1}{p^2}\right) \text{eV}$$

Hence, energy of n^{th} state is given by

$$E_n = -\frac{8.28}{n^2} \text{eV}$$



Maximum energy is released for transition from $p = \infty$ to $p = 1$; hence, wavelength of most energetic photon is 1500 Å

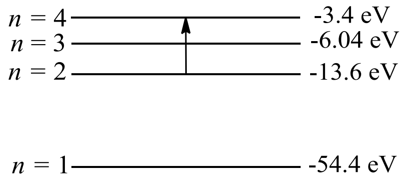
243 **(b)**

Consider energy level diagram of hydrogen atom. After absorbing photons of energy 10.2 eV, it would reach the first excited state of −3.4 eV, since energy difference corresponding to $n = 1$ and $n = 2$ is 10.2 eV. When this excited hydrogen atom de-excites, it would release 10.2 eV energy, which is absorbed by He^+ and Li^{2+}

Energy of the n^{th} state of a hydrogen-like atom with atomic number Z is given by

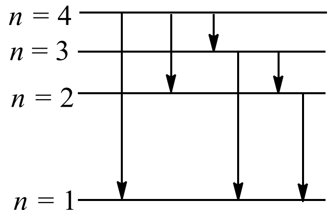
$$E_n = \frac{13.6Z^2}{n^2} \text{eV}$$

After absorbing 10.2 eV, He^+ electron moves from $n = 2$ to $n = 4$ and Li^{2+} electron moves from $n = 3$ to $n = 6$



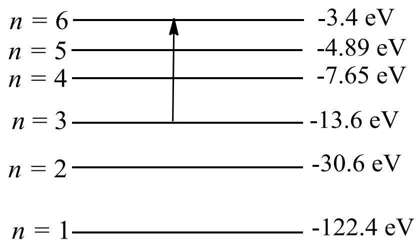
Energy levels of He^+

In the spectrum of He^+, there would be ${}^4C_2 = 6$ lines



Transition in He^+

$$n = 4 \to n = 1 \quad \lambda_{\text{min}} = \frac{hc}{\Delta E} = \frac{1242}{13.6\left[4 - \frac{4}{16}\right]} = 24.4 \text{ nm}$$



Similarly, in spectrum of Li^{2+} there will be ${}^6C_2 = 15$ lines

$$n = 6 \to n = 1 \quad \lambda_{\text{min}} = \frac{1242}{13.6\left[9 - \frac{9}{36}\right]} = 10.4 \text{ nm}$$

244 **(b)**

Let the final speeds of neutron and singly ionized helium atom be v_1 and v_2, respectively. From conservation of momentum, we have

Along x-axis: $mu = 4\,mv_2\cos\theta$ (i)

Along y-axis: $mv_1 = 4\,mv_2\sin\theta$ (ii)

On squaring and adding equations (i) and (ii), we get

$u^2 + v_1^2 = 16v_2^2$

$\frac{1}{2}mu^2 + \frac{1}{2}mv_1^2 = \frac{1}{2}16\,mv_2^2$ (iii)

The initial kinetic energy of neutron = 65 eV
Let kinetic energies of neutron and helium atom be
$K_n = \frac{1}{2}mv_1^2, K_{\text{He}} = \frac{1}{2}(4m)v_2^2$
So, Eq. (iii) reduces to $65 + K_n = 4K_{\text{He}}$
$4K_{\text{He}} - K_n = 65$ (iv)
a. Energy required to excite an electron from ground state of singly ionized helium atom (He^+) to n^{th} energy level is $u^2 + v_1^2 = 16v_2^2$
If the neutron has sufficient energy to excite the helium atom, then from conservation of energy, the energy of neutron must be equal to the sum of kinetic energy of neutron, helium atom, and excitation energy. So, we have
$$65 = K_n + K_{\text{He}} + 54.4\left(1 = \frac{1}{n^2}\right)$$
$K_{\text{He}} + K_n = 10.6 + \frac{54.4}{n^2}$ (v)
On solving Eqs. (iv) and (v), we get
$K_{\text{He}} = \left[15.52 + \frac{10.88}{n^2}\right]$ eV (vi)
$K_n = \left[\frac{43.52}{n^2} - 4.52\right]$ eV (vii)
The kinetic energy is always positive, so from equation (vii) we have
$\frac{43.52}{n^2} > 4.52, n < 3.1$
So, the only possible values of n are 2 and 3
Possible values of n
2, 3
Allowed values of neutron energy
K_{N}
6.36 eV, 0.32 eV
Allowed values of He atom energy
K_{He}
17.84 eV, 16.33 eV
b. When the atom de-excites,
$$v = \frac{(13.6)2^2 \times 1.6 \times 10^{-19}}{6.63 \times 10^{-34}}\left[\frac{1}{n_l^2} - \frac{1}{n_u^2}\right]$$
$$= 13.3\left[\frac{1}{n_l^2} - \frac{1}{n_u^2}\right] \times 10^{15} \text{ Hz}$$
The electron excited to $n = 3$ can make three transitions:
$n = 3$ to $n = 1$, $v_1 = 11.67 \times 10^{15}$ Hz
$n = 3$ to $n = 2$, $v_2 = 9.84 \times 10^{15}$ Hz
$n = 2$ to $n = 1$, $v_3 = 1.83 \times 10^{15}$ Hz

245 **(c)**
For a conservative force field,
$$-\frac{dU}{dr} = F$$
Since $U = k \log r$,
This force $F = -k/r$ provides the centripetal force for circular motion of electron
$\frac{mv^2}{r} = \frac{k}{r}$ (i)
Applying Bohr's quantization rule,
$mvr = \frac{nh}{2\pi}$ (ii)
From Eqs. (i) and (ii), we get
$$r = \frac{nh}{2\pi\sqrt{mk}}$$
From Eq.(i),
KE of electron $= \frac{1}{2}mv^2 = \frac{1}{2}k$
Total energy of electron = KE + PE
PE of electron $= k \log r$
$$= \frac{1}{2}k + k \log r$$
$$E = \frac{K}{2}\left[1 + \log\frac{n^2h^2}{4\pi^2mk}\right]$$

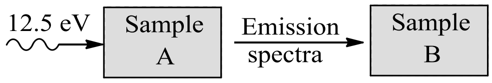
246 **(d)**
For Balmer series, $n_1 = 2; n_2 = 3, 4, \ldots$
(lower) (higher)
Therefore, in transition (VI), proton of Balmer series is absorbed

247 **(c)**
Let n be the lower energy level of the given series of lines, then maximum wavelength is given by
$$\frac{hc}{\lambda_{\text{max}}} = 13.6 \times Z^2\left[\frac{1}{n^2} - \frac{1}{(n+1)^2}\right]$$
$$\frac{hc}{\lambda_{\text{min}}} = 136 \times Z^2\left[\frac{1}{n^2} - \frac{1}{\infty^2}\right]$$
Where $\lambda_{\text{max}} = 41.02$ nm and $\lambda_{\text{min}} = 22.79$ nm
Solving above equations, we get $n = 2$, which corresponds to Balmer series
$Z = 4$
For next to longest wavelength, transition takes place from $n_1 = 4$ to $n_2 = 2$
So, $\frac{hc}{\lambda} = 13.6 \times 4^2\left[\frac{1}{4} - \frac{1}{16}\right]$
$\therefore \lambda = 30.47$ nm

248 **(a)**
The minimum energy required to remove the electron from K-level is 3×10^{-15} J
Let V be the potential difference required, then
eV $= 3 \times 10^{-15}$ J
$$V = \frac{3 \times 10^{-15}}{1.6 \times 10^{-19}} = 18750 \text{ V}$$

249 **(d)**
As photon energy of incident light is not equal to energy difference between two energy states, that is why sample A does not absorb any photon and therefore remains in ground state, and hence, no emission spectra. Thus, sample B remains as it is, but it will de-excite itself to ground state by

emitting radiations of energy 10.2 eV



When photon energy is replaced by electron beam, then atom of sample A can absorb either 10.2 eV (to reach 1st excited state) or 12.1 eV (to reach 2nd excited state). In emission spectra of A, we will have 3 lines corresponding to $n = 2$ to 1, $n = 3$ to 2 and $n = 3$ to 1, having energies equal to 10.2 eV, 1.9 eV and 12.1 eV, respectively

As least energy of this emission spectra is corresponding to transition from $n = 2$ to 3 and sample B is in 1st excited state, so B can be excited to some higher energy level and if B absorbs energy corresponding to $n = 1$ to 2 and $n = 1$ to 3, then it may ionize

250 **(a)**

$\Delta E = -13.6z^2\left[\frac{1}{2^2} - \frac{1}{3^2}\right]$

$47.2 = 13.6\, z^2\left[\frac{1}{4} - \frac{1}{9}\right] \Rightarrow z = 5$

251 **(c)**

Characteristic X-ray arises due to transition of electrons

252 **(a)**

In photoelectric effect

$E = W + K_{\max}$

$= 0.73 + 1.82$

$= 2.55$ eV

253 **(a)**

Least intensity $2 \to 1 \Rightarrow K_\alpha, X$-rays

254 **(b)**

$\Delta E = \left\{13.6\, Z_B^2\left(\frac{1}{1^2} - \frac{1}{2^2}\right) - 13.6\, Z_A^2\left(\frac{1}{1^2} - \frac{1}{2^2}\right)\right\}$eV

$81.6 \text{ eV} = \frac{1.36 \times 3}{4}(Z_B^2 - Z_A^2)$eV

$Z_B^2 - Z_A^2 = 8$ (i)

Using conservation of momentum,

For $A, m_A u = MV_1 - m_A \frac{u}{2}$

$\frac{3}{2} m_A u = MV_1$

For $B, \frac{3}{2} m_B u = MV_2$

But, $MV_2 = 3MV_1$

$m_B - 3m_A$

Since both A and B carry same number of protons and neutrons, we have

$Z_B = 3Z_A$ (ii)

But $Z_B^2 - Z_A^2 = 8$

$9Z_A^2, Z_{BN}^2 = 8$

$Z_A = 1, Z_B = 3$

Hence, A is $_1^2$H and B is $_4^6$Li

Now, the difference in energy between the first Balmer lines emitted by A and B

$\Delta E = 13.6\left(\frac{1}{2^2} - \frac{1}{3^2}\right)Z_B^2 - 13.6\left(\frac{1}{2^2} - \frac{1}{3^2}\right)Z_A^2$

$= 13.6 \times \frac{5}{36} \times (Z_B^2 - Z_A^2)$

$= \frac{13.6 \times 5 \times 8}{36} = 15.1$ eV

255 **(c)**

Number of atoms in the second excited state

$N_2 = \frac{N_{av}}{M} \times m \times \frac{15}{100}$

$= \frac{6.023 \times 10^{23}}{1.008} \times 1.8 \times \frac{15}{100} = 1.61 \times 10^{23}$

In the first excited state,

$N_1 = \frac{N_{av}}{M} m \times \frac{27}{100} = 2.9 \times 10^{23}$

256 **(d)**

$E_2 - E_1 = \left(\frac{E_1}{2^2} - E_1\right)$

$\frac{hc}{\lambda_{2\to1}} = \frac{1242 \text{ eV. nm}}{94.54 \text{ nm}} = 13.14$ eV

$E_1 = -17.52 \text{ eV} = Z^2 E_{01}$

$E_3 - E_1 = \frac{hc}{\lambda_{3\to1}} = \frac{1242 \text{ eV nm}}{79.76 \text{ nm}} = 15.57$ eV

$E_3 = -1.95$ eV

$E_4 - E_1 = \frac{hc}{\lambda_{4\to1}} = \frac{1242 \text{ eV nm}}{75.63 \text{ nm}} = 16.42$ eV

257 **(4)**

$E_{\text{photon}} = 13.6\left(1 - \frac{1}{25}\right)\text{eV} = 13.0$ eV

$E/c = $ mv (momentum conserved)

$v = \frac{E}{mc} = \frac{(13)(1.6 \times 10^{-19})}{(1.67)(10^{-27})(3)(10^8)} = 4$ m/s

258 **(2)**

The shortest wavelength of Brackett series is corresponding to transition of electron between $n_1 = 4$ and $n_2 = \infty$

Similarly, the shortest wavelength of Balmer series is corresponding to transition of electron between $n_1 = 2$ and $n_2 = \infty$

$(Z)^2\left(\frac{13.6}{16}\right) = \left(\frac{13.6}{4}\right)$ or $Z = 2$

259 **(6)**

When electron jumps from n^{th} state to ground state, number of possible emission lines $= n(n-1)/2$. But here transition takes place from n^{th} state to state $n_1 = 2$

Here, number of possible emission lines

$= n(n-1)(n-2)/2 = 10$ (given)

On solving, $n = 6$

260 **(9)**

Number of revolutions before transition = frequency × time

Also, frequency $\propto \frac{1}{n^3}$

So required ratio = $\frac{(1/2)^3 12.8\times10^{-8}}{(1/3)^3 4.8\times10^{-8}} = 9$

261 **(1)**

Heat produced/sec = 200 W

$\Rightarrow i = \frac{200}{V} = \frac{200}{20\times10^3} = 10$ mA

262 **(5)**

$E_n = -\frac{mZ^2e^4}{8\varepsilon_0^2 n^2h^2}$, so $hf = +\frac{mZ^2e^4}{8\varepsilon_0^2h^2}\left[\frac{1}{16}-\frac{1}{25}\right]$

$\therefore f = \frac{mZ^2e^4}{8\varepsilon_0^2h^3}\left[\frac{9}{16\times25}\right]$ (i)

and frequency $f_4 = \frac{Z^2e^4m}{4\varepsilon_0^2n^3h^3} = \frac{Z^2e^4m}{4\varepsilon_0^2(4)^3h^3}$ (ii)

$\therefore f/f_4 = 18/25$, so $m = 5$

263 **(2)**

$$\frac{T_1}{T_2} = \frac{n_1^3}{n_1^3} \Rightarrow \frac{8_1}{8_2} = \frac{n_1^3}{n_1^3} \Rightarrow \frac{n_1}{n_2} = \frac{2}{1}$$

264 **(6)**

$$\frac{\lambda_1}{\lambda_2} = \frac{(Z_2-1)^2}{(Z_1-1)^2}\left(\text{since}, \frac{1}{\lambda} \propto (Z-1)^2\right)$$

$\frac{1}{4} = \frac{(Z_2-1)^2}{(11-1)^2}$; on solving, $Z_2 = 6$

265 **(8)**

Change in angular momentum = $I\omega$

$$\Rightarrow \frac{mh}{2\pi} - \frac{nh}{2\pi} = I\omega \Rightarrow \omega = \frac{(m-n)h}{6.28\, I}$$

266 **(4)**

For the first line of Balmer series of hydrogen

$$\frac{1}{\lambda} = R\left(\frac{1}{2^2}-\frac{1}{3^2}\right) = \frac{5R}{36} \Rightarrow \lambda = \frac{36}{5R}$$

For singly ionized helium $Z = 2$

$$\frac{1}{\lambda'} = 4R\left(\frac{1}{n_2^2}-\frac{1}{n_1^2}\right)$$

Given $\lambda' = \lambda \Rightarrow 4R\left(\frac{1}{n_2^2}-\frac{1}{n_1^2}\right) = \frac{5R}{36}$

$\Rightarrow n_2 = 4$

DCAM classes

Dynamic Classes for Academic Mastery