PRACTICE EXERCISES

SINGLE CORRECT CHOICE TYPE QUESTIONS

This section contains Single Correct Choice Type Questions. Each question has four choices (A), (B), (C) and (D), out of which ONLY ONE is correct.

1. Assume an imaginary world, where angular momentum is quantized to even multiple of $\hbar\left(=\dfrac{h}{2\pi}\right)$. The longest possible wavelength emitted by hydrogen in the visible spectrum, for this hypothetical assumption is

(A) 700 nm (B) 486 nm
(C) 600 nm (D) 584 nm

2. If first excitation potential of a hydrogen-like atom is V_0 electron volt, then the ionization energy of this atom will be

(A) V_0 electron volt
(B) $\dfrac{3V_0}{4}$ electron volt
(C) $\dfrac{4V_0}{3}$ electron volt
(D) cannot be calculated by given information

3. The magnetic field at the centre (at nucleus) of the hydrogen like atoms (atomic number $= z$) due to the motion of electron in nth orbit is proportional to

(A) $\dfrac{n^3}{z^5}$ (B) $\dfrac{n^4}{z}$
(C) $\dfrac{z^2}{n^3}$ (D) $\dfrac{z^3}{n^5}$

4. A hydrogen atom has electron in the fourth energy level. The number of different possible photons lie in which of following series

(A) 3 Lyman, 2 Balmer, 1 Paschen
(B) 2 Lyman, 1 Balmer, 1 Paschen
(C) 2 Lyman, 1 Paschen, 1 Brackett
(D) 1 Lyman, 1 Balmer, 1 Paschen

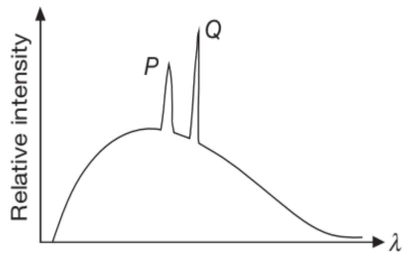
5. The angular momentum of an electron in an orbit is quantized because it is a necessary condition for the compatibility with

(A) the wave nature of electron.
(B) particle nature of electron.
(C) Pauli's exclusion behaviour.
(D) None of these.

6. A hydrogen atom is in fifth excited state. When the electron jumps to ground state, the velocity of recoiling hydrogen atom is

(A) $1.1\ \text{ms}^{-1}$ (B) $4.2\ \text{ms}^{-1}$
(C) $8.4\ \text{ms}^{-1}$ (D) $11.2\ \text{ms}^{-1}$

7. In a characteristic X-ray spectra of some atom superimposed on continuous X-ray spectra



(A) P represents K_α line
(B) Q represents K_β line
(C) Q and P represent K_α and K_β lines respectively
(D) Position of K_α and K_β depend on the particular atom

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

(A) $\Lambda_n \approx A + \dfrac{B}{\lambda_n^2}$ (B) $\Lambda_n \approx A + B\lambda_n$
(C) $\Lambda_n^2 \approx A + B\lambda_n^2$ (D) $\Lambda_n^2 \approx \lambda$

9. According to Bohr model, the magnetic field at centre (at the nucleus) of a hydrogen atom due to motion of electron in the n^{th} orbit is proportional to

(A) $\dfrac{1}{n^3}$ (B) $\dfrac{1}{n^5}$
(C) n^5 (D) n^3

10. A particle moving with a velocity $\dfrac{1}{10^{\text{th}}}$ of that of light will cross a nucleus in about

(A) 10^{-47} s (B) 10^{-22} s
(C) 10^{-12} s (D) 10^{-8} s

11. In X-ray tube when the accelerating voltage V is halved, the difference between the wavelengths 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

12. A H-atom moving with speed v makes a head on collision with a H-atom in rest. Both atoms are in ground state. The minimum value of velocity v for which one of atom may excite is
(A) $6.25\times10^4\ \text{ms}^{-1}$ (B) $8\times10^4\ \text{ms}^{-1}$
(C) $7.25\times10^4\ \text{ms}^{-1}$ (D) $13.6\times10^4\ \text{ms}^{-1}$

13. The minimum kinetic energy of an electron, hydrogen ion, helium ion required for ionization of a hydrogen atom is E_1 in case electron is collided with hydrogen atom. It is E_2 when 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) $E_1 > E_3 > E_2$ (D) $E_1 > E_2 > E_3$

14. An α-particle after passing through a potential difference of V volt collides with a nucleus. If the atomic number of the nucleus is Z then the distance of closest approach of α-particle to the nucleus will be
(A) $14.4\left(\frac{Z}{V_0}\right)$ Å (B) $14.4\left(\frac{Z}{V_0}\right)$ m
(C) $14.4\left(\frac{Z}{V_0}\right)$ cm (D) All of these

15. An electron is lying initially in the $n=4$ excited state. The electron de-excites itself to go to $n=1$ state directly emitting a photon of frequency ν_{41}. If the same electron first de-excites to $n=3$ state by emitting a photon of frequency ν_{43} and then goes from $n=3$ to $n=1$ state by emitting a photon of frequency ν_{31}, then
(A) $\nu_{41} = \nu_{43} + \nu_{31}$ (B) $\nu_{41} = \nu_{43} - \nu_{31}$
(C) $\nu_{43} = \nu_{41} + 2\nu_{31}$ (D) Data Insufficient

16. In Bohr's H atom, the graph of $\log\left(\frac{R}{R_0}\right)$ versus $\log n$ is
(A) a circle (B) an ellipse
(C) a parabola (D) a straight line

17. A diatomic molecule is made of two masses m_1 and m_2 which are separated by a distance r. If we calculate its rotational energy by applying Bohr's rule of angular momentum quantization, its energy will be given by (n is an integer)
(A) $\frac{n^2\hbar^2}{2(m_1+m_2)r^2}$ (B) $\frac{2n^2\hbar^2}{(m_1+m_2)r^2}$
(C) $\frac{(m_1+m_2)n^2\hbar^2}{2m_1m_2r^2}$ (D) $\frac{(m_1+m_2)^2n^2\hbar^2}{2m_1^2m_2^2r^2}$

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

19. When an electron has a transition from the state $(n+1)$ to state n where n is quite large, then the frequency of the emitted radiation (ν) will vary with n as
(A) $\nu\propto\frac{1}{n^3}$ (B) $\nu\propto\frac{1}{n^2}$
(C) $\nu\propto\frac{1}{n}$ (D) $\nu\propto n$

20. The ratio of the frequencies of the long wavelength limits of the Lyman series and the Balmer series of hydrogen is
(A) $27:5$ (B) $4:1$
(C) $5:27$ (D) $1:4$

21. The spin angular momentum of an electron is equal to
(A) $\frac{h}{\pi}$ (B) $\frac{h}{\sqrt{2}\pi}$
(C) $\frac{h}{2\pi}$ (D) $\frac{2h}{\sqrt{2}\pi}$

22. The energy levels of a certain atom for first, second and third levels are E, $\frac{4E}{3}$ and $2E$ respectively. A photon of wavelength λ is emitted for a transition $3\to1$, What will be the wavelength of emission for transition $2\to1$?

(A) $\frac{\lambda}{3}$ (B) $\frac{4\lambda}{3}$
(C) $\frac{3\lambda}{4}$ (D) 3λ

23. If R be the Rydberg's constant, the energy of an electron in the ground state of the H atom is given by
(A) $-\frac{Rh}{c}$ (B) $-\frac{1}{Rhc}$
(C) $-Rhc$ (D) $\frac{hc}{R}$

24. A nucleus of mass number A, originally at rest, emits an α-particle with speed v. The daughter nucleus recoils with a speed
(A) $\frac{2v}{(A+4)}$ (B) $\frac{4v}{(A+4)}$
(C) $\frac{4v}{(A-4)}$ (D) $\frac{2v}{(A-4)}$

25. The de-Broglie wavelength of electron in ground state of a hydrogen atom is
(A) 0.53 Å (B) 1.06 Å
(C) 1.52 Å (D) 3.33 Å

26. A hydrogen atom emits ultraviolet radiation of 102.5 nm. Then the quantum numbers of the states involved in the transition are
(A) $\infty \to 1$ (B) $5 \to 1$
(C) $3 \to 1$ (D) $4 \to 1$

27. The difference between nth and $(n+1)$th Bohr's radius of H atom is equal to it's $(n-1)$th Bohr's radius. The value of n is
(A) 1 (B) 2
(C) 3 (D) 4

28. The angular momentum of an electron in hydrogen atom is $\frac{2h}{\pi}$. Kinetic energy of this electron is
(A) 4.35 eV (B) 1.51 eV
(C) 0.85 eV (D) 13.6 eV

29. A particle of mass m moves in a circular orbit in a central potential field $U(r)=\frac{1}{2}kr^2$. If Bohr's quantization conditions are applied, radii of possible orbitals and energy levels vary with quantum number n as
(A) $r_n \propto n$, $E_n \propto n$ (B) $r_n \propto \sqrt{n}$, $E_n \propto n$
(C) $r_n \propto \sqrt{n}$, $E_n \propto \frac{1}{n}$ (D) $r_n \propto n^2$, $E_n \propto \frac{1}{n^2}$

30. The angular momentum of an electron in the hydrogen atoms is $\frac{3h}{2\pi}$, where, h is the Planck's constant. The kinetic energy of this electron is
(A) 1.51 eV (B) 3.4 eV
(C) 4.35 eV (D) 6.8 eV

31. K_α wavelength of an unknown element is 0.0709 nm. Identify the element.
(A) *Co* (B) *Cu*
(C) *Mn* (D) *Mo*

32. Stopping potentials of 24 kV, 100 kV, 110 kV, 110 kV are measured for photoelectrons emitted from a certain element when it is irradiated with monochromatic X-rays. If the element is used as a target in an X-ray tube. The energy of K_α line is
(A) 54 keV (B) 76 keV
(C) 88 keV (D) 32 keV

33. A potential difference of 20 kV is applied across an X-ray tube. The minimum wavelength of X-rays generated is
(A) 0.26 Å (B) 0.62 Å
(C) 0.16 Å (D) 0.50 Å

34. The target element in an X-ray tube must have a high
(A) atomic number only
(B) mass number only
(C) melting point only
(D) both atomic number and melting point

35. White X-rays are called 'white' due to the fact that
(A) they are electromagnetic radiations having nature same as that of white light.
(B) they are produced most abundantly in X-ray tubes.
(C) they have a continuous wavelength range.
(D) they can be converted to visible light using coated screens and photographic plates are affected by them just like light.

36. The atomic number (Z) of an element whose K_α wavelength is λ is 11. The atomic number of an element whose K_α wavelength is 4λ is
(A) 6 (B) 11
(C) 44 (D) 4

37. In Bohr's Model of hydrogen atom. The ratio between the period of revolution of an electron in orbit of $n=1$ to the period of revolution of the electron in the orbit $n=2$ is

(A) 1 : 2 (B) 2 : 1
(C) 1 : 4 (D) 1 : 8

38. According to Bohr correspondence principle when quantum number is very large
(A) frequency of revolution of electron in an orbit is equal to the frequency of photon emitted when electron jumps from that orbit to next lower orbit
(B) classical physics approaches quantum physics
(C) wavelength of electron de Broglie wavelength does not depend on kinetic energy of electron
(D) energy of electrons are not quantized

39. An electron with kinetic energy 5 eV is incident on a H-atom in its ground state. The collision
(A) must be elastic
(B) may be partially elastic
(C) must be completely inelastic
(D) may be partially inelastic

40. In a hydrogen atom, the binding energy of the electron in the ground state is E_1, then the frequency of revolution of the electron in the nth orbit is
(A) $\frac{E_1 n}{h}$ (B) $\frac{E_1}{nh}$
(C) $\frac{2E_1 n}{h}$ (D) $\frac{2E_1}{nh}$

41. The average life time of an excited state of hydrogen is of the order of 10^{-8} s. The number of orbits an electron makes, when it is in the state $n = 2$ (before it starts a transition to a lower state) will be (take T_0 to be time period of revolution in ground state in s.)
(A) $\left(\frac{8}{T_0}\right)\times 10^{-8}$ (B) $T_0 \times 10^{-8}$
(C) $\frac{10^{-8}}{8T_0}$ (D) $\frac{T_0}{8\times 10^{-8}}$

42. Magnetic moment due to the motion of the electron in n^{th} energy state of hydrogen atom is proportional to
(A) n^0 (B) n
(C) n^3 (D) n^5

43. The angular momentum of an electron in a hydrogen atom is proportional to
(A) $\frac{1}{\sqrt{r}}$ (B) $\frac{1}{r}$
(C) $\sqrt{r}$ (D) r^2

44. Which one of the following statements is wrong in the context of X-rays generated from an X-ray tube?
(A) Wavelength of characteristic X-rays decreases when the atomic number of the target increases
(B) Cut-off wavelength of the continuous X-rays depends on the atomic number of the target
(C) Intensity of the characteristic X-rays depends on the electrical power given to the X-ray tube
(D) Cut-off wavelength of the continuous X-rays depends on the energy of the electrons in the X-ray tube

45. In Bohr's Model, when an electron revolves around the nucleus in an orbit
(A) It radiates energy
(B) It absorbs energy
(C) Its total mechanical energy is conserved
(D) Its angular momentum changes continuously

46. If an electron has, orbital angular momentum quantum number $l = 7$, then it will have an orbital angular momentum equal to
(A) $7\left(\frac{h}{2\pi}\right)$ (B) $42\left(\frac{h}{2\pi}\right)$
(C) $\sqrt{7}\left(\frac{h}{2\pi}\right)$ (D) $\sqrt{56}\left(\frac{h}{2\pi}\right)$

47. 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

48. The radius of the first orbit of hydrogen is 0.528 Å. The radius of the second orbit of hydrogen is
(A) 4.752 Å (B) 2.112 Å
(C) 0.071 Å (D) 0.142 Å

49. Protons and singly ionized atoms of U^{235} and U^{238} are passed in turn (which means one after the other and not at the same time) through a velocity selector and then enter a uniform magnetic field. The protons describe semicircles of radius 10 mm. The separation between the ions of U^{235} and U^{238} after describing semicircle is given by
(A) 60 mm (B) 30 mm
(C) 2350 mm (D) 2380 mm

50. The speed of the electron in the first orbit (ground state) of the hydrogen atom in terms of velocity of light c is
(A) $\frac{c}{2}$ (B) $\frac{c}{11}$
(C) $\frac{c}{137}$ (D) $\frac{c}{274}$

51. Speed of electron in fourth orbit for He^+ is

(A) $\frac{e^2}{2h\varepsilon_0}$ (B) $\frac{e^2}{4h\varepsilon_0}$

(C) $\frac{e^2}{h\varepsilon_0}$ (D) $\frac{2e^2}{h\varepsilon_0}$

52. A hydrogen atom emits a photon corresponding to an electron transition from $n = 5$ to $n = 1$. The recoil speed of hydrogen atom is almost

(A) 10^{-4} ms^{-1} (B) 2×10^{-2} ms^{-1}

(C) 4 ms^{-1} (D) 8×10^{2} ms^{-1}

53. The radius of hydrogen atom in its ground state is 5.3×10^{-11} m. After collision with an electron it is found to have a radius of 21.2×10^{-11} m. What is the principal quantum number n of the final state of the atom?

(A) $n = 4$ (B) $n = 2$

(C) $n = 16$ (D) $n = 3$

54. 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 in $n = 1$ orbit

(ii) The angular momentum of the electron in $n = 2$ orbit is more than in $n = 1$ orbit

(iii) The KE of the electron in $n = 2$ orbit is less than 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

55. The electronic transition in Li^{2+} ion that emits radiation of wavelength same as the wavelength of second Balmer line of H-atom is

(A) $4\to3$ (B) $6\to3$

(C) $12\to6$ (D) $12\to9$

56. A μ-meson is a particle which has charge same as that of the electron and mass 207 times the mass of electron. A μ-mesonic atom is formed when a μ-meason is captured by proton. The ionization energy of such an atom is

(A) 3.8 keV (B) 5 keV

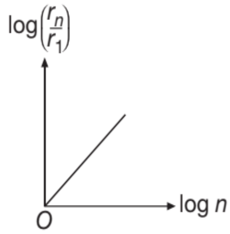
(C) 2.8 keV (D) 20 keV

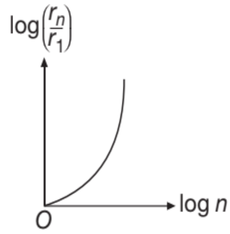
57. The ratio between total acceleration of the electron is singly ionized helium atom and hydrogen atom (both in ground state) is

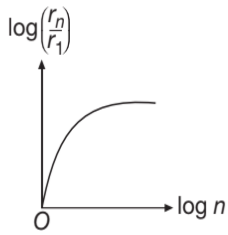
(A) 1 (B) 8

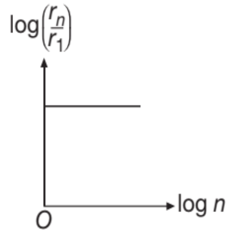
(C) 4 (D) 16

58. In hydrogen atom, the radius of n^{th} Bohr orbit is r_n. The graph between $\log\left(\frac{r_n}{r_1}\right)$ and $\log n$ will be

(A)


(B)


(C)


(D)


59. The ratio of the maximum wavelength of the Lyman series in hydrogen spectrum to the maximum wavelength in the Paschen series is

(A) $\frac{3}{105}$ (B) $\frac{6}{15}$

(C) $\frac{52}{7}$ (D) $\frac{7}{108}$

60. The Rydberg constant for hydrogen atom is R. The Rydberg constant for positronium (a bound system composed of a positron and an electron) is

(A) R (B) $2R$

(C) $\frac{R}{2}$ (D) $\frac{R}{4}$

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

(A) $2v$ (B) v

(C) $\frac{v}{2}$ (D) $\frac{v}{4}$

62. The radius of electron's second stationary orbit in Bohr's atom is a_0. The radius of the third orbit will be

(A) $3a_0$ (B) $2.25a_0$

(C) $9a_0$ (D) $\frac{a_0}{3}$

63. Electrons with de-Broglie wavelength λ fall on the target in an X-ray tube. The cut-off wavelength of the emitted X-rays is

(A) $\lambda_0 = \frac{2mc\lambda^2}{h}$ (B) $\lambda_0 = \frac{2h}{mc}$

(C) $\lambda_0 = \frac{2m^2c^2\lambda^3}{h^2}$ (D) $\lambda_0 = \lambda$

64. The shortest wavelength of the Paschen series of a hydrogen like atom (atomic number $= Z$) is the same as the shortest wavelength of the Lyman series of hydrogen atom. The value of Z

(A) 2 (B) 3
(C) 4 (D) 5

65. 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 X-ray beam is P.

(A) $P = 0.1\text{ W}$ (B) $P = 1\text{ W}$
(C) $P = 2\text{ W}$ (D) $P = 10\text{ W}$

66. When 24.8 KeV X-rays strike a material, the photoelectrons emitted from K shell are observed to move in a circle of radius 23 mm in a magnetic field of $2\times10^{-2}\text{ T}$. The binding energy of K-shell electrons is

(A) 6.2 keV (B) 5.4 keV
(C) 7.4 keV (D) 8.6 keV

67. For large principal quantum number n the frequency of revolution of electron is equal to the frequency of transition of the electron between two adjacent orbits. This frequency f is proportional to

(A) $\frac{1}{n^2}$ (B) $\frac{1}{n^3}$
(C) $\frac{1}{n}$ (D) $\frac{1}{n^0}$

68. An electron typically spends about 10^{-8} sec in an excited state before it drops to lower state by emitting a photon. The revolutions do an electron in an $n = 2$ Bohr orbit make in 10^{-8} sec is

(A) 8×10^6 rev (B) 8 rev
(C) 10×10^8 rev (D) 80 rev

69. A metal of atomic number Z is used as a target in a Coolidge tube. Let ν be the frequency of the K_α line. For a number of values of Z and ν which plot gives a straight line.

(A) ν vs Z (B) ν vs $\frac{1}{Z}$
(C) $\sqrt{\nu}$ vs Z (D) ν vs $\sqrt{Z}$

70. The shortest wavelength in the Lyman series of hydrogen spectrum is 912 Å corresponding to a photon energy of 13.6 eV. The shortest wavelength in the Balmer series is

(A) 3648 Å (B) 228 Å
(C) 6566 Å (D) 8208 Å

71. On transition to the ground state from the excited state of He^+ ion, two photons are emitted in succession with wavelengths 1026.7 Å and 304 Å. Assuming $R = 1.097\times10^7\text{ m}^{-1}$, then the quantum number n corresponding to the exciting state of He^+ ion is

(A) 4 (B) 6
(C) 2 (D) 1

72. An electron jumps from the fourth orbit to the 2nd orbit of the hydrogen atom. If $R = 10^7\text{ m}^{-1}$, the frequency of the emitted radiation will be

(A) $\frac{3}{16}\times10^5\text{ Hz}$ (B) $\frac{3}{16}\times10^{15}\text{ Hz}$
(C) $\frac{9}{16}\times10^{15}\text{ Hz}$ (D) $\frac{3}{4}\times10^{15}\text{ Hz}$

73. If E_n and J_n are the magnitude of total energy and angular momentum of electron in the n^{th} Bohr orbit respectively, then

(A) $E_n \propto J_n$ (B) $E_n \propto \frac{1}{J_n}$
(C) $E_n \propto J_n^2$ (D) $E_n \propto \frac{1}{J_n^2}$

74. 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}

75. An excited atom at rest emits a photon of frequency f. Now if the same excited atom is moving with a speed $v(\ll c)$ and emits a photon in the direction of its motion, then the frequency of the photon

(A) remains f
(B) increases by a fraction $\frac{\Delta f}{f} = \frac{v}{c}$
(C) decreases by a fraction $\frac{\Delta f}{f} = \frac{v}{c}$
(D) nothing can be predicted

76. A hydrogen atom emits a photon of energy 12.1 eV. Its orbital angular momentum changes by ΔL. Then ΔL equals

(A) $1.05\times10^{-34}\text{ Js}$ (B) $2.11\times10^{-34}\text{ Js}$
(C) $3.16\times10^{-34}\text{ Js}$ (D) $4.22\times10^{-34}\text{ Js}$

77. The ground state energy of hydrogen atom is –13.6 eV. The potential energy of the electron in this state is
(A) –27.2 eV (B) –13.6 eV
(C) +13.6 eV (D) 0 eV

78. When an electron makes transition from one energy level to the other in an atom then which of the following quantities is conserved?
(A) Angular momentum
(B) Linear momentum
(C) Mechanical energy
(D) None of the above

79. The Bohr radius of the fifth electron of phosphorus atom (atomic number 15) acting as a dopant in silicon (relative dielectric constant 12) is
(A) 380.9 pm (B) 390.8 pm
(C) 930.8 pm (D) 830.9 pm

80. How would the wavelength of the electromagnetic radiation absorbed change if the number of atoms undergoing the same electronic transition was increased?
(A) There would be no change
(B) It would shift to shorter wavelengths
(C) It would be shifted to longer wavelengths
(D) It would be depend on the magnitude of the increase in the number of atoms

81. When an electron revolves around the nucleus, then ratio of magnetic moment to angular momentum is
(A) $\frac{e}{2m}$ (B) $\frac{2e}{m}$
(C) $\frac{e}{m}$ (D) $\left(\frac{e}{m}\right)^2$

82. If an electron revolves around a proton in an orbit of radius r then its time period T is proportional to
(A) r^2 (B) $r^{\frac{3}{2}}$
(C) r^3 (D) r

83. The radius of second orbit of an electron in hydrogen atom is 2.116 Å. The de-Broglie wavelength associated with this electron in this orbit would be
(A) 1.058 Å (B) 2.116 Å
(C) 6.64 Å (D) 13.28 Å

84. Find the longest wavelength present in the radiation emitted when hydrogen atoms excited to $n = 3$ states return to their ground state.
(A) 103 nm (B) 122 nm
(C) 656 nm (D) 912 nm

85. The angular momentum (L) and radius (r) of a hydrogen atom are related to each other as
(A) $Lr = \text{constant}$ (B) $Lr^2 = \text{constant}$
(C) $Lr^4 = \text{constant}$ (D) $Lr^{-\frac{1}{2}} = \text{constant}$

86. 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

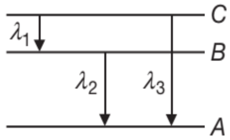
87. The total energy of the electron in the hydrogen atom in the ground state is -13.6 eV. The kinetic energy of the electron is
(A) 0 (B) 13.6 eV
(C) 6.8 eV (D) –13.6 eV

88. The energy of an electron in the n^{th} orbit of positronium (a bound system composed of positron and an electron) is
(A) $-\frac{13.6}{n^2}$ eV (B) $-\frac{27.2}{n^2}$ eV
(C) $-\frac{54.4}{n^2}$ eV (D) $-\frac{6.8}{n^2}$ eV

89. The binding energy of the electron with $n \to \infty$ in H atom is
(A) ZERO (B) infinite
(C) 13.6 eV (D) 10.2 eV

90. The wavelength of radiation emitted is λ_0 when an electron in hydrogen atom jumps from the third orbit to second. If in the hydrogen atom itself, the electron jumps from fourth orbit to second orbit, the wavelength of emitted radiation will be
(A) $\frac{16}{25}\lambda_0$ (B) $\frac{20}{27}\lambda_0$
(C) $\frac{27}{20}\lambda_0$ (D) $\frac{25}{16}\lambda_0$

91. Energy levels A, B, C of a certain atom correspond to increasing values of energy i.e., $E_A < E_B < E_C$. If $\lambda_1, \lambda_2, \lambda_3$ are the wavelengths of radiations corresponding to the transitions C to B, B to A and C to A respectively, which of the following statements is correct?



(A) $\lambda_3 = \lambda_1 + \lambda_2$ (B) $\lambda_3 = \dfrac{\lambda_1\lambda_2}{\lambda_1 + \lambda_2}$

(C) $\lambda_1 + \lambda_2 + \lambda_3 = 0$ (D) $\lambda_3^2 = \lambda_1^2 + \lambda_2^2$

92. Ionization potential of hydrogen atom is 13.6 eV. Hydrogen atoms in the ground state are excited by monochromatic radiation of photon energy 12.1 eV. According to Bohr's theory, the spectral lines emitted by hydrogen will be

(A) one (B) two
(C) three (D) four

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

94. The ionisation potential of mercury is 10.5 volt. To gain energy sufficient enough to ionise mercury, an electron must travel in an electric field of 1.5×10^6 Vm^{-1} a distance of

(A) 7 μm (B) 6 μm
(C) 14 μm (D) 12 μm

95. The absorption coefficient of X-rays for a given wavelength is larger for

(A) lithium (B) lead
(C) aluminium (D) copper

96. The maximum KE found in α particles of natural origin is 7.7 MeV. Then, if these are used in alpha scattering experiment, the distance of closest approach from gold nucleus is about

(A) 1.5×10^{-15} m (B) 3×10^{-14} m
(C) 41×10^{-15} m (D) 3×10^{-16} m

97. The speed of an electron in the fourth orbit of Be^{+++} atom is

(A) c (B) $\frac{c}{10}$

(C) $\frac{e^2}{2h\varepsilon_0 c}$ (D) $\frac{e^2}{2h\varepsilon_0}$

98. For X-rays the wavelength λ (in Å) in terms of energy E (in keV) is given by

(A) $\lambda = \frac{6.20}{E}$ (B) $\lambda = \frac{12.40}{E}$

(C) $\lambda = \frac{3.10}{E}$ (D) $\lambda = \frac{24.80}{E}$

99. The magnetic field at the centre of a hydrogen atom due to the motion of the electron in the first Bohr orbit is B. The magnetic field at the centre due to the motion of the electron in the second Bohr orbit will be

(A) $\frac{B}{4}$ (B) $\frac{B}{8}$

(C) $\frac{B}{32}$ (D) $\frac{B}{64}$

100. Suppose, the electron in a hydrogen atom makes transition from $n=3$ to $n=2$ in 10^{-8} s. The order of the torque acting on the electron in this period, using the relation between torque and angular momentum as discussed in the chapter on rotational dynamics is

(A) 10^{-34} Nm (B) 10^{-26} Nm
(C) 10^{-42} Nm (D) 10^{-8} Nm

101. When a hydrogen like atom in excited state makes a transition from excited state to ground state the most energetic photon has an energy of 52.224 eV and the least energetic photon has an energy of 1.224 eV. The atomic number of the hydrogen like atom is

(A) 4 (B) 6
(C) 2 (D) 8

102. The ionisation potential of hydrogen atom is 13.6 volts. The energy of the atom in $n=2$ state will be

(A) –10.2 eV (B) –6.4 eV
(C) –4.4 eV (D) –3.4 eV

103. In a transition to a state of excitation energy 10.2 eV, a hydrogen atom emits a 4960 Å photon. if $hc = 12400$ eVÅ, then the binding energy of the electron in the initial state is

(A) 1.51 eV (B) 3.4 eV
(C) 0.54 eV (D) 0.87 eV

104. Let ν_1 be the frequency of the series limit of the Lyman series, ν_2 be the frequency of the first line of the Lyman series, and ν_3 be the frequency of the series limit of the Balmer series.

(A) $\nu_1 - \nu_2 = \nu_3$ (B) $\nu_2 - \nu_1 = \nu_3$

(C) $\nu_3 = \frac{1}{2}(\nu_1 + \nu_2)$ (D) $\nu_1 + \nu_2 = \nu_3$

105. A hydrogen atom in ground 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

106. According to Bohr's theory of hydrogen atom, the product of the binding energy of the electron in the nth orbit and its radius in the nth orbit

(A) is inversely proportional to n^3

(B) is proportional to n^2

(C) has a constant value 7.2 eV Å

(D) has a constant value of 10.2 eV Å

107. Balmer gives an equation for wavelength of visible radiation of H-spectrum as $\lambda = \frac{kn^2}{n^2-4}$. The value of k in terms of Rydberg's constant R, is

(A) R (B) $4R$

(C) $\frac{R}{4}$ (D) $\frac{4}{R}$

108. 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

109. A hydrogen atom moving at speed v collides with another hydrogen atom kept at rest. Find the minimum value of v for which one of the atoms may get ionized. The mass of a H-atom $= 1.67\times10^{-27}$ kg

(A) 7.2×10^4 ms^{-1} (B) 5.1×10^4 ms^{-1}

(C) 8.8×10^4 ms^{-1} (D) 4×10^4 ms^{-1}

110. In an excited state of hydrogen like atom an electron has a total energy of -3.4 eV. If the kinetic energy of the electron is E and its de Broglie wavelength is λ, then

(A) $E = 6.8$ eV, $\lambda \sim 6.6\times10^{-10}$ m

(B) $E = 3.4$ eV, $\lambda \sim 6.6\times10^{-10}$ m

(C) $E = 3.4$ eV, $\lambda \sim 6.6\times10^{-11}$ m

(D) $E = 6.8$ eV, $\lambda \sim 6.6\times10^{-11}$ m

111. The order of energies of energy levels A, B and C is $E_A < E_B < E_C$. If the wavelength corresponding to transition $C \to B$, $B \to A$ and $C \to A$ are λ_1, λ_2 and λ_3 respectively, then which of the following relation is correct ?

(A) $\lambda_1+\lambda_2+\lambda_3 = 0$ (B) $\lambda_3^2 = \lambda_1^2+\lambda_2^2$

(C) $\lambda_3 = \lambda_1+\lambda_2$ (D) $\lambda_3 = \frac{\lambda_1\lambda_2}{\lambda_1+\lambda_2}$

112. The shortest wavelength of the Brackett series of a hydrogen like atom having 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

113. The difference in the angular momentum associated with the electron in the two successive orbits of the hydrogen atom is

(A) $\frac{h}{\pi}$ (B) $\frac{h}{2}$

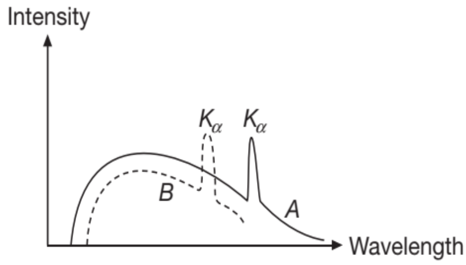
(C) $\frac{h}{2\pi}$ (D) $2h$

114. The shortest wavelength in the Lyman series is 912 Å. Then the longest wavelength in this series is

(A) 1216 Å (B) 1824 Å

(C) 2434 Å (D) 3648 Å

115. The figure represents the observed intensity of X-rays emitted by two different tubes A and B as a function of wavelength λ. For the tube A, the potential difference between the filament and target is V_A and atomic number of target is Z_A. For the tube B, corresponding potential difference is V_B and the atomic number is Z_B. The solid curve is for tube A and dotted curve for tube B, then



(A) $Z_A > Z_B$, $V_A > V_B$ (B) $Z_A = Z_B$, $V_A = V_B$

(C) $Z_A < Z_B$, $V_A > V_B$ (D) $Z_A < Z_B$, $V_A < V_B$

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

(A) n (B) n^0

(C) n^5 (D) n^3

117. The maximum angular speed of the electron of a hydrogen atom in a stationary orbit is

(A) 6.2×10^{5} rads^{-1} (B) 4.1×10^{16} rads^{-1}

(C) 2.4×10^{10} rads^{-1} (D) 9.2×10^{6} rads^{-1}

118. The ratio of the speed of the electron in the first Bohr orbit of He^{+} and the speed of light is equal to (where e, h and c have their usual meanings)

(A) $\frac{e^2}{2h\varepsilon_0}$ (B) $\frac{e^2}{4h\varepsilon_0 c}$

(C) $\frac{e^2}{h\varepsilon_0 c}$ (D) $\frac{e^2}{2h\varepsilon_0 c}$

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

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

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

120. In uranium $(Z=92)$ the K absorption edge is 0.107 Å and the K_α line is 0.126 Å the, wavelength of the L absorption edge is

(A) 0.7 Å (B) 1 Å

(C) 2 Å (D) 3.2 Å

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

(A) 1 Å (B) 2 Å

(C) 1.52 Å (D) 1.25 Å

122. The binding energy of an electron in the ground state of He is equal to 24.6 eV. The energy required to remove both the electrons is

(A) 24.6 eV (B) 38.2 eV

(C) 49.2 eV (D) 79 eV

123. The wavelengths of K_α X-rays of the metals A and B are $\frac{4}{1875R}$ and $\frac{1}{675R}$ respectively, where R is the 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

124. A material whose K absorption edge is 0.15 Å is irradiated with 0.1 Å X-rays. The maximum kinetic energy of photoelectrons that are emitted from K-shell is

(A) 41 keV (B) 51 keV

(C) 61 keV (D) 71 keV

125. In a hydrogen atom, the electron is in nth excited state. It comes down to first excited state by emitting ten different wavelengths. The value of n is

(A) 6 (B) 7

(C) 8 (D) 9

126. The element which has K_α X-ray line whose wavelength is 0.18 nm is

(A) Iron (B) Cobalt

(C) Nickel (D) Copper

127. The ratio of the energies of the hydrogen atom in the first to the second excited state

(A) 4 : 1 (B) 1 : 4

(C) 4 : 9 (D) 9 : 4

128. The wavelength of first line of Balmer series is 6563 Å. The wavelength of first line of Lyman series will be

(A) 1215.4 Å (B) 2500 Å

(C) 7500 Å (D) 600 Å

129. The ratio of the wavelength of first line of Lyman series to the first line of Balmer series is

(A) 1 : 4 (B) 5 : 27

(C) 27 : 20 (D) 20 : 27

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

(A) Sizes of two nuclei are different

(B) Nuclear forces are greater in case of deuterium

(C) Masses of the two nuclei are different

(D) Force of attraction between electron and nucleus is different in the two cases

131. The potential energy associated with an electron in the orbit

(A) increases with the increase in radii of the orbit

(B) decreases with the increase in the radii of the orbit

(C) remains the same with the change in the radii of the orbit

(D) None of the above

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

(A) $\frac{5}{9}$ (B) $\frac{5}{36}$

(C) $\frac{1}{4}$ (D) $\frac{3}{4}$

133. The wavelength K_α of X–rays produced by the X-ray tube is $0.76\ \text{Å}$. The atomic number of the anode material of the tube is

(A) 30 (B) 40

(C) 50 (D) 60

134. The graph of $\log\left(\frac{R}{R_0}\right)$ versus $\log A$ ($R=$ radius of a nucleus and $A=$ mass number) is

(A) a circle

(B) an ellipse

(C) a parabola

(D) a straight line

135. In Rutherford experiment the number of α-particles scattered at angle 90° is 25. How many particles are scattered at an angle 60°

(A) 100 (B) 85

(C) 70 (D) 55

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

(A) $X = \text{He}^+,\ n = 4$ (B) $X = \text{Li}^{++},\ n = 6$

(C) $X = \text{He}^+,\ n = 6$ (D) $X = \text{Li}^{++},\ n = 9$

137. The kinetic energy of an electron in the first orbit of H atom is $13.6\ \text{eV}$. The total energy of an electron in the second orbit of He^+ is

(A) 13.6 eV (B) 3.4 eV

(C) –13.6 eV (D) –3.4 eV

138. The ratio of the maximum wavelength of the Lyman series in hydrogen spectrum to the maximum wavelength in the Paschen series is

(A) $\frac{3}{105}$ (B) $\frac{6}{15}$

(C) $\frac{52}{7}$ (D) $\frac{7}{108}$

139. The ratio of areas between the electron orbits for the first excited state to the ground state for the hydrogen atom is

(A) 2 : 1 (B) 4 : 1

(C) 8 : 1 (D) 16 : 1

140. Electrons are accelerated through a potential difference of $V_0 = 10\ \text{kV}$. The minimum wavelength λ_{min} of the X-ray emitted is

(A) 1.24×10^{-10} m (B) 1.24×10^{-7} m

(C) 1240×10^{-10} m (D) 4000×10^{-10} m

141. The wavelength of the first line of the Balmer series in the hydrogen atom spectrum is

(A) 6563 Å (B) 6365 Å

(C) 6563 m (D) 6563 cm

142. In a Coolidge tube, the potential difference used to accelerate the electrons is increased from $12.4\ \text{kV}$ to $24.8\ \text{kV}$. As a result the difference between λ_{K_α} and λ_{min} increases three fold. The wavelength of K_α line is $\left(\frac{hc}{e} = 12.4\ \text{kV Å}\right)$

(A) 1 Å (B) 1.25 Å

(C) 1.5 Å (D) None of these

143. 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

144. When the number of electrons striking the target material in Coolidge's tube (i.e., X-ray tube) is increased keeping the potential difference same, then

(A) intensity of X-rays increase

(B) wavelength of X-rays photons increase

(C) frequency of X-rays photons increase

(D) energy of X-rays photons increase

145. Which of the following is true for X-rays

(A) wavelength of continuous X-rays does not depend on potential difference

(B) wavelength of discrete X-rays does not depend on potential difference

(C) discrete X-rays have energy of the order of MeV

(D) continuous X-rays have energy of the order of MeV

146. The angular momentum of the electron in hydrogen atom in the ground state is

(A) $2h$ (B) $\frac{h}{2}$

(C) $\frac{h}{2\pi}$ (D) $\frac{h}{4\pi}$

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

(A) $\frac{3q^2}{2\varepsilon_0 h}$ (B) $\frac{q^2}{\varepsilon_0 h}$

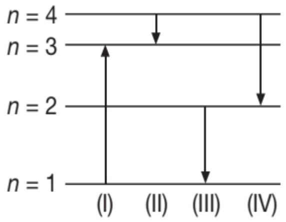
(C) $\frac{3q}{2\pi\varepsilon_0 h}$ (D) $\frac{3q}{4\pi\varepsilon_0 h}$

148. 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.

(A) $L_1 = L_2$ (B) $L_1 = 4L_2$

(C) $L_2 = 2L_1$ (D) $L_1 = 2L_2$

149. The diagram shows the energy levels for an electron in a certain atom. Which transition shown represents the emission of a photon with the most energy ?



(A) I (B) II

(C) III (D) IV

150. The longest wavelength present in the Balmer series of hydrogen, corresponding to H_α line is

(A) 656 nm (B) 565 nm

(C) 400 nm (D) 700 nm

151. The quantity $\frac{e^2}{2h\varepsilon_0 c}$ has a value

(A) $\frac{1}{137}\ \text{ms}^{-1}$ (B) $\frac{2}{137}\ \text{ms}^{-1}$

(C) $\frac{1}{137}$ (D) $\frac{2}{137}$

152. Which the following series fall in the visible range of electromagnetic spectrum ?

(A) Brackett series (B) Lyman series

(C) Balmer series (D) Paschen series

153. The largest wavelength in the ultraviolet region of the hydrogen spectrum is $122\ \text{nm}$. 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

154. An X-ray tube produces continuous X-rays of wavelength 0.1 Å and greater. Then potential difference applied to tube must be

(A) 1.24 kV (B) 12.4 kV

(C) 124 kV (D) 6.62 kV

155. The minimum energy in electron volt required to strip a ten times ionised sodium atom (i.e., $Z = 11$) of its last electron is

(A) 13.6 eV (B) 1.23 eV

(C) 150 eV (D) 1.65 keV

156. de-Broglie wavelength of an electron in the nth Bohr orbit is λ_n and the angular momentum is J_n, then

(A) $J_n \propto \lambda_n$ (B) $\lambda_n \propto \frac{1}{J_n}$

(C) $\lambda_n \propto J_n^2$ (D) $\lambda_n \propto \frac{1}{J_n^2}$

157. For a lead $^{208}_{82}\text{Pb}$ (μ-mesonic atom) the energy of the photon given off in the first Lyman transition

(A) 11 MeV (B) 14 meV

(C) 18 MeV (D) 20 MeV

158. When an electron in the hydrogen atom in ground state absorbs a photon of energy $12.1\ \text{eV}$, its angular momentum

(A) decreases by 2.11×10^{-34} Js

(B) decreases by 1.055×10^{-34} Js

(C) increases by 2.11×10^{-34} Js

(D) increases by 1.055×10^{-34} Js

159. In Rutherford experiment, α-particles are scattered by nucleus having charge $100e$. Initial kinetic energy of α-particles is 6 MeV. The size of the nucleus is

(A) 10^{-15} m (B) 5×10^{-14} m

(C) 10^{-13} m (D) 10^{-16} m

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

(A) 1 (B) 2

(C) 3 (D) 4

161. In hydrogen and hydrogen like atoms the ratio of difference of energies $E_{2n} - E_n$ and $E_{4n} - E_{2n}$ varies with atomic number z and principle quantum number n as

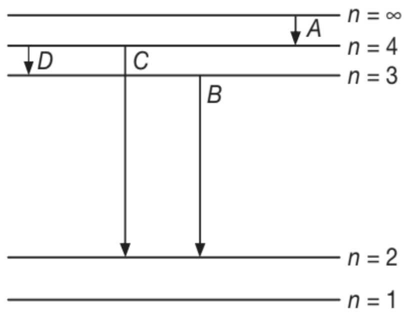
(A) $\frac{z^2}{n^2}$ (B) $\frac{z^4}{n^4}$

(C) $\frac{z}{n}$ (D) $\left(\frac{z}{n}\right)^0$

162. In Rutherford scattering experiment, the number of α-particles scattered at $60°$ is 9×10^6. The number of α-particles scattered at $120°$ will be

(A) 15×10^6
(B) $\frac{3}{5}\times10^6$
(C) 10^6
(D) $\frac{5}{9}\times10^6$

163. Consider the electronic energy level diagram of H-atom. The photons associated with shortest and longest wavelengths would be emitted from the atom by the transitions labelled



(A) D and C respectively
(B) C and A respectively
(C) C and D respectively
(D) A and C respectively

164. In a hypothetical atom like that of hydrogen, the mass of the electrons is doubled. The energy (in eV) and radius (in Å) of the first Bohr's orbit will be (Take Bohr's radius of Hydrogen to be 0.54 Å)

(A) –27.2 , 0.27
(B) –27.2 , 0.54
(C) –13.6 , 0.27
(D) –13.6 , 0.54

165. When a hydrogen atom emits a photon during the transition $n=5$ to $n=1$, its recoil speed is approximately

(A) $0.1\ \text{mms}^{-1}$
(B) $3\ \text{mms}^{-1}$
(C) $4\ \text{ms}^{-1}$
(D) $800\ \text{ms}^{-1}$

166. 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) $F\propto \frac{1}{n^4}$

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

(A) 1000
(B) 60
(C) 10000
(D) 31

168. The largest distance between the interatomic planes of a crystal is 10^{-7} cm. The upper limit for the wavelength of X-rays which can be usefully studied with this crystal is

(A) 1 Å
(B) 2 Å
(C) 10 Å
(D) 20 Å

169. Of the various series of the hydrogen spectrum, the one which lies wholly in the ultra violet region is

(A) Lyman series
(B) Balmer series
(C) Paschen series
(D) Brackett series

170. If the short series limit of the Balmer series for hydrogen is 3646 Å. Calculate the atomic number of the element which gives X-ray wavelength down to 1.0 Å. Identify the element

(A) $Z=21$
(B) $Z=31$
(C) $Z=11$
(D) $Z=5$

171. A potential difference of 10^3 V is applied across an X-ray tube. The ratio of the de-Broglie wavelength of the incident electrons to the shortest wavelength of X-rays produced is

$$\left(\frac{e}{m}=1.8\times10^{14}\ \text{Ckg}^{-1}\ \text{for an electron}\right)$$

(A) $\frac{1}{10^4}$
(B) $\frac{1}{100}$
(C) $\frac{1}{20}$
(D) 1

MULTIPLE CORRECT CHOICE TYPE QUESTIONS

This section contains Multiple Correct Choice Type Questions. Each question has four choices (A), (B), (C) and (D), out of which ONE OR MORE is/are correct.

1. The radius of the orbit of an electron in a Hydrogen like atom is $4.5a_0$, where a_0 is the Bohr radius. Its orbital angular momentum is $\frac{3h}{2\pi}$. It is given that h is Planck constant and R is Rydberg constant. The possible wavelength(s), when the atom de-excites, is (are)

(A) $\frac{9}{32R}$
(B) $\frac{9}{16R}$
(C) $\frac{9}{5R}$
(D) $\frac{4}{3R}$

2. H^+, He^+ and O^{++} all having the same kinetic energy pass through a region in which there is a uniform magnetic field perpendicular to their velocity. The masses of H^+, He^+ and O^{++} are 1 u, 4 u and 16 u respectively.
   (A) H^+ will be deflected the most.
   (B) O^{++} will be deflected the most.
   (C) He^+ and O^{++} will be deflected equally.
   (D) All will be deflected equally.

3. An electron makes transition inside a hydrogen atom. The orbital angular momentum of the electron may change by
   (A) h (B) $\frac{h}{\pi}$
   (C) $\frac{h}{2\pi}$ (D) $\frac{h}{4\pi}$

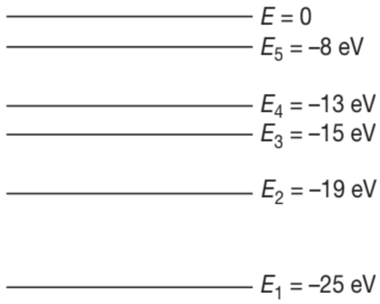
4. An electron is excited from a lower energy state to a higher energy state in a hydrogen atom. Which of the following decrease in the excitation?
   (A) potential energy
   (B) angular speed
   (C) kinetic energy
   (D) angular momentum

5. 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 of 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) $\frac{V}{E}$ (D) $\frac{T}{R}$

6. The wavelength of K_α X-rays for lead isotopes Pb^{208}, Pb^{206}, Pb^{204} are λ_1, λ_2 and λ_3 respectively. Then
   (A) $\lambda_1 = \lambda_2 = \lambda_3$ (B) $\lambda_1 > \lambda_2 > \lambda_3$
   (C) $\lambda_1 < \lambda_2 < \lambda_3$ (D) $\lambda_2 = \sqrt{\lambda_1 \lambda_3}$

7. Suppose the potential energy between electron and proton at a distance r is given by $-\frac{Ke^2}{3r^3}$. If m be the mass of electron, then application of Bohr's theory to hydrogen atom in this case shows that
   (A) energy in the nth orbit is proportional to n^6
   (B) energy is proportional to m^{-3}
   (C) energy the nth orbit is proportional to n^{-2}
   (D) energy is proportional to m^3

8. Consider an atom whose energy level diagram is shown in figure.



Suppose an atom starts at level 3 then
   (A) Shortest wavelength photon the atom can emit is 1.24×10^{-7} m
   (B) Longest wavelength photon that it can absorb is 6.2×10^{-7} m
   (C) Lowest frequency photon that can ionize the atom is 3.62×10^{15} Hz
   (D) The number of ways of de-excitation of atom to ground state is 3

9. A positronium atom consists of a positron and electron revolving around their common centre of mass. Then compared to hydrogen atom the positronium atom has
   (A) ground state energy half of hydrogen atom
   (B) Rydberg constant half of hydrogen atom
   (C) radius of first orbit of electron double that in case of hydrogen atom
   (D) velocity of electron in first orbit same as in case of hydrogen atom

10. The ground state and first excited state energies of hydrogen atom are -13.6 eV and -3.4 eV respectively. If potential energy in ground state is taken to be zero. Then
   (A) potential energy in the first excited state would be 20.4 eV
   (B) total energy in the first excited state would be 23.8 eV
   (C) kinetic energy in the first excited state would be 3.4 eV
   (D) total energy in the ground state would be 13.6 eV

11. When a hydrogen atom is excited from ground state to first excited state then
   (A) its kinetic energy increases by 10.2 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

12. An electron orbiting in a circular orbit around the nucleus of an atom
   (A) has a magnetic dipole moment
   (B) exerts an electric force on the nucleus equal to that on it by the nucleus

(C) does produces a magnetic induction at the nucleus
(D) has a net energy inversely proportional to its distance from the nucleus

13. The electron in a hydrogen atom makes a transition from 2^{nd} excited state to the ground state. Then
(A) it's K.E. increases and total energy decreases
(B) both its K.E. and total energy increases
(C) frequency of emitted photons may be 4.6×10^{14} Hz
(D) frequency of emitted photons must be 2.9×10^{15} Hz

14. The energy, the magnitude of linear momentum and orbital radius of an electron in a hydrogen atom corresponding to the quantum number n are E, P and r respectively. Then according to Bohr's theory of hydrogen atom
(A) PEr is proportional to $\frac{1}{n}$
(B) $\frac{P}{E}$ is proportional to n
(C) Er is constant for all orbits
(D) Pr is proportional to n

15. If potential energy in hydrogen atom with electron in ground state is taken to be 13.6 eV, then
(A) potential energy in the first excited state would be 34 eV
(B) total energy in the first excited state would be 37.4 eV
(C) kinetic energy in the first excited state would be 44.2 eV
(D) total energy in the ground state would be 27.2 eV

16. If electron of the hydrogen atom is replaced by another particle of same charge but of double the mass, then select the correct option(s).
(A) Bohr radius will increase to double value
(B) Ionisation energy of the atom will be doubled
(C) Speed of the new particle in a given state will be one fourth of what electron will possess in the same orbit
(D) Gap between energy levels will now be doubled

17. An electron in hydrogen atom first jumps from second excited state to ground state and then from first excited state to ground state. Let the ratio of wavelength, momentum and energy of photons emitted in these two cases be a, b and c respectively, then
(A) $c = \frac{1}{a}$
(B) $a = \frac{9}{4}$
(C) $b = \frac{5}{27}$
(D) $c = \frac{5}{27}$

18. A hydrogen like atom of atomic number Z is in an excited state of quantum number $2n$. It can emit a maximum energy photon of 204 eV. It makes a transition to quantum state n, a photon of energy 40.8 eV is emitted, then
(A) $Z = 2$
(B) $Z = 4$
(C) $n = 1$
(D) $n = 2$

19. Which of the following physical quantities in hydrogen atom are independent of the quantum number n. The symbols have their usual meanings.
(A) vr
(B) $\frac{E}{v^2}$
(C) Er
(D) v^2r

20. Select the correct statement(s).
(A) X-rays travel faster than ultraviolet rays in vacuum.
(B) Balmer series of H-spectrum is found in visible region.
(C) The characteristic X-rays are produced due to jumping of electrons from higher to lower shell.
(D) In photoelectric emission process, the maximum energy of the photoelectrons must increase with increasing intensity of incident light.

21. Total energy of electron in the first orbit of hydrogen atom is equal to the
(A) total energy of electron in 2nd orbit of He^+
(B) total energy of electron in 3rd orbit of He^+
(C) total energy of electron in 2nd orbit of Li^{++}
(D) total energy of electron in 3rd orbit to Li^{++}

22. Which of the following transitions in He^+ ion will give rise to a spectral line having the same wavelength as some spectral line in the hydrogen atom?
(A) $n = 4$ to $n = 2$
(B) $n = 6$ to $n = 2$
(C) $n = 6$ to $n = 3$
(D) $n = 8$ to $n = 4$

23. When atomic number Z is doubled in atoms, which of the following statements are consistent with Bohr's theory?
(A) Energy of a state is doubled.
(B) Radius of an orbit is doubled.
(C) Velocity of electrons in an orbit is doubled.
(D) Radius of an orbit is halved.

24. Let A_n be the area enclosed by the n^{th} orbit in a hydrogen atom. The graph of $\log_e\left(\frac{A_n}{A_1}\right)$ against $\log_e n$
(A) will pass through the origin.
(B) will have a slope of four units at all points.
(C) will be a monotonically increasing nonlinear curve.
(D) will be a straight line.

25. A particular hydrogen like atom has its ground state total energy -54.4 eV, then
(A) its atomic number is 2
(B) it can absorb a photon of 40.8 eV
(C) in its ground state it cannot emit photon
(D) for its ground state its potential energy is -108.8 eV and kinetic energy is $+54.4$ eV

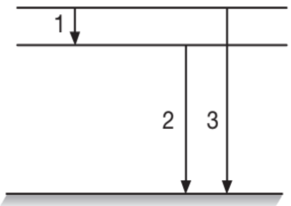
26. If the potential energy of the electron in the first allowed orbit in hydrogen atom is E then its
(A) ionisation potential is $-\frac{E}{2}$
(B) kinetic energy is $-\frac{E}{2}$
(C) total energy is $\frac{E}{2}$
(D) None of these

27. Hydrogen atoms absorb radiations of wavelength λ_0 and consequently emit radiations of 6 different wavelengths of which two wavelengths are shorter than λ_0. Choose the correct alternative(s).
(A) The final excited state of the atoms is $n = 4$
(B) The initial state of the atoms may be $n = 2$
(C) The initial state of the atoms may be $n = 3$
(D) There are three transitions belonging to Lyman series

28. For the electron in the n^{th} allowed orbit is
(A) the linear momentum is proportional to $\frac{1}{n}$
(B) the radius is proportional to n
(C) the kinetic energy is proportional to $\frac{1}{n^2}$
(D) the angular momentum is proportional to n

29. Whenever 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.

30. The wavelengths and frequencies of photons in transitions 1, 2 and 3 for hydrogen like atom are λ_1, λ_2, λ_3, ν_1, ν_2 and ν_3 respectively. Then



(A) $\nu_3 = \frac{\nu_1 \nu_2}{\nu_1 + \nu_2}$
(B) $\nu_3 = \nu_1 + \nu_2$
(C) $\lambda_3 = \frac{\lambda_1 \lambda_2}{\lambda_1 + \lambda_2}$
(D) $\lambda_3 = \lambda_1 + \lambda_2$

REASONING BASED QUESTIONS

This section contains Reasoning type questions, each having four choices (A), (B), (C) and (D) out of which ONLY ONE is correct. Each question contains STATEMENT 1 and STATEMENT 2. You have to mark your answer as

Bubble (A) If both statements are TRUE and STATEMENT 2 is the correct explanation of STATEMENT 1.
Bubble (B) If both statements are TRUE but STATEMENT 2 is not the correct explanation of STATEMENT 1.
Bubble (C) If STATEMENT 1 is TRUE and STATEMENT 2 is FALSE.
Bubble (D) If STATEMENT 1 is FALSE but STATEMENT 2 is TRUE.

1. **Statement-1:** If the accelerating potential in an *X*-ray tube is increased, the wavelengths of the characteristic *X*-rays do not change.
Statement-2: When an electron beam strikes the target in an *X*-ray tube, part of the kinetic energy is converted into *X*-ray energy.

2. **Statement-1:** According to classical theory, the proposed path of an electron in Rutherford atom model will be parabolic.
Statement-2: According to electromagnetic theory, an accelerated particle continuously emits radiation.

3. **Statement-1:** An electron in hydrogen atom passes from $n = 4$ to $n = 1$ level. The maximum number of photons that can be emitted is 6.
Statement-2: No. of photons emitted can never be more than 5.

4. **Statement-1:** The wavelength of first Balmer line of deuterium is slightly more than that of hydrogen.
Statement-2: In the centre of mass of an atom reference frame both nucleus and electron are non-stationary.

5. **Statement-1:** In a hydrogen atom energy of emitted photon corresponding to transition from $n=2$ to $n=1$ is much greater as compared to transition from $n \to \infty$ to $n=2$.
Statement-2: Wavelength of photon is directly proportional to the energy of emitted photon.

6. **Statement-1:** Magnetic moment of an atom is due to both, the orbital motion and spin motion of every electron.
Statement-2: A charged particle produces a magnetic field.

7. **Statement-1:** Total energy in an orbit is negative in an atom.
Statement-2: Electron is bounded by electrostatic attraction between electron and nucleus.

8. **Statement-1:** Between any two given energy levels, the number of absorption transition is always less than number of emission transition.
Statement-2: Absorption transition starts from the lowest energy level only and may end at any higher level. But emission transitions may starts from any higher energy level and end at any energy level below it.

9. **Statement-1:** Total energy of revolving electron in any stationary orbit is negative.
Statement-2: Energy is a scalar quantity and it can take positive and negative value.

10. **Statement-1:** In outermost stationary orbit, energy of electron is least negative.
Statement-2: In outermost orbit, electron is at maximum distance from nucleus.

11. **Statement-1:** Speed of electron in the n^{th} orbit of hydrogen atom is $v_H \propto \frac{1}{n}$.
Statement-2: Speed of electron in n^{th} orbit of hydrogen like atom is $v_{H\text{ Like}} \propto \frac{Z^2}{n}$

12. **Statement-1:** Atomic hydrogen gas excites to third excited state. The number of spectral lines in emission spectrum obtained is 6.
Statement-2: Number of spectral lines in emission spectrum can never be less than 6.

13. **Statement-1:** In a hydrogen atom energy of emitted photon corresponding to transition from $n=2$ to $n=1$ is much greater as compared to transition from $n \to \infty$ to $n=2$.
Statement-2: Wavelength of photon is directly proportional to the energy of emitted photon

14. **Statement-1:** The difference between the wavelengths of series limit of the Lyman series of spectral lines and that (the series limit) of the Paschen series is equal to the wavelength of a spectral line of the Lyman series (for the hydrogen atom).
Statement-2: The wave number of an atomic transition can be calculated from the formula $\bar{v} = R\left(\frac{1}{m^2} - \frac{1}{n^2}\right)$, where $\bar{v}$ is the wave number, R is the Rydberg's constant, m and n are the quantum numbers of the initial and final states.

15. **Statement-1:** If the current in the filament of electron gun in a X–ray tube is increased, the penetration power of X–rays is increased.
Statement-2: Increasing current increases the number of electrons emitted by the electron gun.

16. **Statement-1:** It is necessary to keep high vacuum in Coolidge tube to produce X–rays.
Statement-2: High vacuum is kept in Coolidge tube so that the electron emitting from the filament of the tube may not lose their energy in colliding with the atom of the gas in the tube.

17. **Statement-1:** If maximum frequency of Balmer and Paschen series is f_1 and f_2 respectively, then frequency of first line of Balmer series is $(f_1 - f_2)$.
Statement-2: Difference of energy level between two orbits is constant for an atom.

18. **Statement-1:** The wavelength of the K_α line from an element and that of the K_β line satisfy the relation $\lambda_{K_\alpha} > \lambda_{K_\beta}$
Statement-2: The energy separation between the K_α levels is smaller than that of the K_β levels

19. **Statement-1:** The wave number corresponding to the transition between the atomic levels $n=3$ and $n=2$ of a hydrogen atom i.e. $\bar{v}_{32}$, is related to the wavenumbers $\bar{v}_{21}$ and $\bar{v}_{31}$ for a hydrogen atom by the relation $\bar{v}_{31} = \bar{v}_{21} + \bar{v}_{32}$.
Statement-2: The wave-number $\bar{v}_{mn} = \frac{1}{\lambda_{mn}}$ for a transition is given by the expression $\frac{1}{\lambda_{mn}} = R\left(\frac{1}{n^2} - \frac{1}{m^2}\right)$, where R is the Rydberg constant and m, n are integers representing the initial and final principal quantum numbers.

20. **Statement-1:** When light is passed through a sample of hydrogen atoms in ground state, then wavelengths of absorption lines are same as wavelengths of lines of Lyman series in emission spectrum.
Statement-2: In ground state hydrogen atom will absorb only those radiation which will excite to higher energy level.

LINKED COMPREHENSION TYPE QUESTIONS

This section contains Linked Comprehension Type Questions or Paragraph based Questions. Each set consists of a Paragraph followed by questions. Each question has four choices (A), (B), (C) and (D), out of which only one is correct. (For the sake of competitiveness there may be a few questions that may have more than one correct options)

Comprehension 1

A beam of alpha particles is incident on a target made of lead. A particular alpha particle is incident head-on to a particular lead nucleus and stops 6.50×10^{-14} m away from the centre of the nucleus (This point lies well outside the nucleus). Assume that the lead nucleus which has 82 protons, remains at rest. The mass of alpha particle is 6.64×10^{-27} kg. Based on the information provided, answer the following questions.

1. The electric potential energy at the instant that alpha particle stops is

(A) 36.3 MeV (B) 45 MeV

(C) 3.63 MeV (D) None of these

2. The initial kinetic energy of the alpha particle is

(A) 36.3 MeV (B) 0.36 MeV

(C) 3.63 MeV (D) None of these

Comprehension 2

An energy of 68 eV is required to excite an electron in hydrogen like atom from its second Bohr orbit to third. The nuclear charge is Ze. Given that $hc = 12375$ eVÅ. Based on above information, answer the following questions.

3. The value of atomic number Z is given by

(A) 3 (B) 4

(C) 5 (D) 6

4. Kinetic energy of the electron in the first Bohr orbit is

(A) 4.896 eV (B) 48.96 eV

(C) 489.6 eV (D) 0.4896 eV

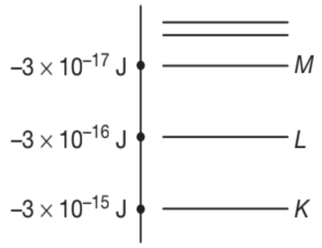
5. The wavelength of the electromagnetic radiation required to eject the electron from the first orbit to infinity is given by

(A) 2.528 Å (B) 25.28 Å

(C) 252.8 Å (D) 0.2528 Å

Comprehension 3

Simplified picture of electron energy levels in a certain atom bombarded with high energy electrons is shown in the figure.



The impact of one of these electrons has caused the complete removal of K-level and is filled by an electron from the L-level with a certain amount of energy being released during the transition. This energy may appear as X-ray or may all be used to eject an M-level electron from the atom. Based on above information, answer the following questions.

6. The minimum potential difference through which electron may be accelerated from rest to cause the ejection of K-level electron from the atom is

(A) 1.875×10^{4} V (B) 3×10^{-15} V

(C) 3.33×10^{14} V (D) 10 V

7. Energy released when L-level electron moves to fill the vacancy in the K-level is

(A) 3×10^{-15} J (B) 3×10^{-17} J

(C) 2.7×10^{-15} J (D) 2.7×10^{-16} J

8. Kinetic energy of the electron emitted from the M-level is

(A) 3×10^{-16} J (B) 3×10^{-17} J

(C) 2.7×10^{-15} J (D) 2.67×10^{-15} J

Comprehension 4

The surface temperature of Sun is estimated by finding the most probable energy E for photons emitted by a black body at temperature T. The intensity (I) of the radiation from sun is proportional to $E^5 e^{-\frac{E}{k_B T}}$. If n_E is the number of photons with energy E, then distribution of n_E is given by $P(n_E) \approx \frac{I(E)}{E}$. Also, we know that the Balmer lines of hydrogen span the visible frequency range and the human eye has evolved to be the most sensitive to sunlight and assuming that the visible light is the most probable frequency band of the light emitted by the sun, answer the following questions.

9. The most probable energy E for photons emitted by a black body of temperature T is
(A) KT (B) $2KT$
(C) $3KT$ (D) $4KT$

10. The maximum energy of the Balmer lines which fall in the visible range is
(A) 1.9 eV (B) 3.4 eV
(C) 5.2 eV (D) 6.4 eV

11. If the human eye is sensitive to sunlight, the maximum surface temperature of sun is
(A) 1×10^4 K (B) 2×10^4 K
(C) 3×10^4 K (D) 4×10^4 K

Comprehension 5

A dense collection of equal number of electrons and positive ions is called neutral plasma. Certain solids containing fixed positive ions surrounded by free electrons can be treated as neutral plasma. Let N be the number density of free electrons, each of mass m. When the electrons are subjected to an electric field, they are displaced relatively away from the heavy positive ions. If the electric field becomes zero, the electrons begin to oscillate about the positive ions with a natural angular frequency ω_p, which is called the plasma frequency. To sustain the oscillations, a time varying electric field needs to be applied that has an angular frequency ω, where a part of the energy is absorbed and a part of it is reflected. As ω approaches ω_p, all the free electrons are set to resonance together and all the energy is reflected. This is the explanation of high reflectivity of metals. Based on above information, answer the following questions.

12. Taking the electronic charge as e and the permittivity as ε_0, use dimensional analysis to determine the correct expression for ω_p
(A) $\sqrt{\frac{Ne}{m\varepsilon_0}}$ (B) $\sqrt{\frac{m\varepsilon_0}{Ne}}$
(C) $\sqrt{\frac{Ne^2}{m\varepsilon_0}}$ (D) $\sqrt{\frac{m\varepsilon_0}{Ne^2}}$

13. Estimate the wavelength at which plasma reflection will occur for a metal having the density of electrons $N \approx 4\times10^{27}\ \text{m}^{-3}$. Take $\varepsilon_0 \approx 10^{-11}$ and $m \approx 10^{-30}$, where these quantities are in proper SI units
(A) 800 nm (B) 600 nm
(C) 300 nm (D) 200 nm

Comprehension 6

A mixture of hydrogen atoms (in their ground state) and hydrogen like ions in their first excited state are being excited by electrons, which have been accelerated by same potential difference V. After excitation when they come into ground state, the wavelengths of emitted light are found in the ratio $1:5$, then

14. The minimum value of V for which both the atoms get excited after collision with electrons is
(A) 47.6 V (B) 13.6 V
(C) 10.2 V (D) 15 V

15. Atomic number of other ion is
(A) 2 (B) 1
(C) 3 (D) 4

16. The energy of light emitted by hydrogen atom is
(A) 47.6 eV (B) 13.6 eV
(C) 10.2 eV (D) 15 eV

17. Energy of light emitted by hydrogen ions is
(A) 47.6 eV (B) 13.6 eV
(C) 51 eV (D) 10.2 eV

Comprehension 7

The electric current in an X-ray tube (from the target to the filament) operating at 40 kV is 10 mA. Assume that on an average, 1% of the total kinetic energy of the electrons hitting the target is converted into X-rays. Based on above information, answer the following questions.

18. The total power emitted as X-rays is
(A) 40 W (B) 400 W
(C) 4 W (D) 0.4 W

19. The heat produced in the target every second is
(A) 29.6 J (B) 396 J
(C) 3600 J (D) 360 J

20. Minimum wavelength of X-ray produced is nearly
(A) 0.3 Å (B) 3 Å
(C) 30 Å (D) 300 Å

Comprehension 8

A sample of hydrogen atoms initially in its ground state are irradiated with light of different wavelengths and effects produced are observed.

21. If sample is irradiated with light of wavelength 85.5 nm, maximum kinetic energy of electrons leaving the gas is
(A) 0.9 eV
(B) 1.2 eV
(C) 10.2 eV
(D) Electrons cannot leave the gas

22. Least amount of energy that must be given to hydrogen atom initially in its ground level so that it can emit the H_α line in the Balmer series

(A) 12.09 eV (B) 10.2 eV
(C) 3.4 eV (D) 12.25 eV

23. For this least amount of energy given to the hydrogen atom, the maximum wavelength of photons emitted during de-excitation of atom will be

(A) 656 nm (B) 103 nm
(C) 240 nm (D) 346 nm

Comprehension 9

Consider a different atomic model in which electron revolves around the nucleus (proton) at a separation r under the action of force which is different from the electrostatic force of attraction. The potential energy between an electron and the proton due to this force is given by $U=-\frac{k}{r^4}$ where k is a constant. Based on above information, answer the following questions.

24. The radius of nth Bohr's orbit is

(A) $r=\frac{\pi}{nh}\sqrt{km}$ (B) $r=\frac{2\pi}{nh}\sqrt{km}$
(C) $r=\frac{4\pi}{nh}\sqrt{km}$ (D) $r=\frac{8\pi}{nh}\sqrt{km}$

25. The velocity in the nth orbit is given by

(A) $v=\frac{nh}{8\pi^2 m\sqrt{km}}$ (B) $v=\frac{n^2h}{8\pi^2 m\sqrt{km}}$
(C) $v=\frac{nh^2}{4\pi^2 m\sqrt{km}}$ (D) $v=\frac{n^2h^2}{8\pi^2 m\sqrt{km}}$

26. The kinetic energy of the electron in nth orbit is given by

(A) $KE=\frac{n^4h^4}{64\pi^4m^2k}$ (B) $KE=\frac{n^4h^4}{128\pi^4m^2k}$
(C) $KE=\frac{n^4h^4}{16\pi^4k^2}$ (D) $KE=-\frac{n^2h^2}{16k^2\pi^4m}$

27. The potential energy of the electron in the nth orbit is given by

(A) $PE=-\frac{n^4h^4}{64k\pi^4m^2}$ (B) $PE=-\frac{n^4h^4}{128k\pi^4m^2}$
(C) $PE=-\frac{n^2h^2}{128k\pi^4m^2}$ (D) $PE=-\frac{n^4h^4}{256k\pi^4m^2}$

28. The total energy of the electron in the nth orbit is given by

(A) $TE=-\frac{n^4h^4}{128\pi^4m^2k}$ (B) $TE=\frac{n^4h^4}{128\pi^4m^2k}$
(C) $TE=\frac{n^4h^4}{256k\pi^4m^2}$ (D) $TE=-\frac{n^4h^4}{256k\pi^4m^2}$

Comprehension 10

A 100 eV electron collides with a stationary helium ion (He^+) in its ground state and excites it to a higher level. After collision, He^+ ion emits two photons in succession with wavelength 1085 Å and 304 Å. Taking $hc = 12375$ eVÅ, answer the following questions.

29. The energy absorbed by He^+ during collision is

(A) 34.3 eV (B) 42.6 eV
(C) 52.1 eV (D) 47.9 eV

30. The principal quantum number of exited state is

(A) $n=2$ (B) $n=3$
(C) $n=4$ (D) $n=5$

31. The energy of electron after collision is

(A) 16.7 eV (B) 37.4 eV
(C) 47.9 eV (D) 52.1 eV

Comprehension 11

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 form the second Bohr orbit to third Bohr orbit. Based on above information, answer the following questions.

32. The value of z is

(A) 5 (B) 4
(C) 3 (D) 2

33. The radius of first Bohr orbit is

(A) 0.53 Å (B) 0.106 Å
(C) 0.318 Å (D) 0.53 nm

Comprehension 12

In quantum mechanics, some quantities are discrete and cannot be continuous. One of these quantities is the energy. Energy can only take certain values, like E_1, E_2, E_3, E_4, ..., which are called energy levels. The energy cannot take any values between E_1 and E_2 or E_2 and E_3 or E_3 and E_4, etc. Certain transitions from one energy level to another result in the emission of a photon of radiation, whereas others can only take place if a photon is absorbed. The energy levels in a newly discovered gas are expressed as

$$En = -\frac{E_1 z^2}{n^2}$$

where, $-E_1 z^2$ is the ground state energy. Taking $z=1$ for simplicity, but not assuming that the gas is hydrogen, an experiment is designed to measure the energy as a function of the level. The results obtained in the experiment are given in the table.

n	E_n(eV)
2	−144
3	−64
4	−36

Based on the information given, answer the following questions.

34. The ionization energy of the gas is

(A) 244 eV (B) 576 eV

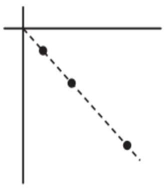
(C) 144 eV (D) +13.6 eV

35. The ground state energy is

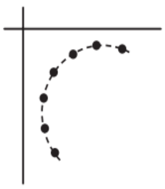
(A) −144 eV (B) +144 eV

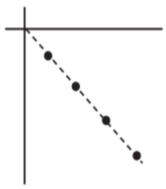
(C) −244 eV (D) None of these

36. The graph of E_n versus $\frac{1}{n^2}$ is best represented as

(A)


(B)


(C)


(D)


Comprehension 13

An electron is orbiting in a circular orbit of radius r under the influence of a constant magnetic field of strength B. Assuming that Bohr's postulate regarding the quantisation of angular momentum holds good for this electron of charge e and mass m, answer the following questions.

37. The radius of nth orbit of the electron will be

(A) $\sqrt{\frac{2nh}{\pi Be}}$ (B) $\sqrt{\frac{nh}{2\pi Be}}$

(C) $\sqrt{\frac{neh}{2\pi Be}}$ (D) $\sqrt{\frac{2neh}{\pi Be}}$

38. The kinetic energy of the electron in nth orbit is

(A) $nh\left(\frac{Be}{m}\right)$ (B) $2nh\left(\frac{Be}{m}\right)$

(C) $\frac{nh}{2}\left(\frac{Be}{m}\right)$ (D) $\frac{nh}{4}\left(\frac{Be}{m}\right)$

39. Potential energy of interaction between the magnetic moment of the orbital current due to the electron moving in its orbit and the magnetic field B is

(A) $\frac{nhBe}{2m}$ (B) $\frac{nhBe}{m}$

(C) $\frac{2nhBe}{m}$ (D) $\frac{nhBe}{4m}$

40. Total magnetic flux due to the magnetic field B passing through the nth orbit is

(A) $\frac{\pi}{2}\frac{nh}{e}$ (B) $\frac{\pi nh}{e}$

(C) $\frac{4\pi nh}{e}$ (D) $\frac{2\pi nh}{e}$

Comprehension 14

According to Bohr's theoretical model, the nucleus of the hydrogen atom is infinitely heavy when compared with electron and so it remains stationary while the electron revolves around it. However, practically, the nucleus has a finite mass, and both the electron and the nucleus revolve about their common centre of mass with a common angular velocity ω. Let us make correction in Bohr theory for the finite mass of the nucleus. Assuming m to be the mass of electron, M_H to be the mass of hydrogen nucleus and r the separation between them. Based on the information provided, answer the following questions.

41. The angular momentum of the atom will be constant about an axis passing through

(A) nucleus

(B) electron

(C) centre of mass of the atom

(D) any axis perpendicular to the line joining the electron and nucleus

42. The angular momentum of the atom about the centre of mass will be

(A) $mr^2\omega$ (B) $m(r-x)^2\omega$

(C) $\frac{(M_H+M)^2 r^2\omega}{M_H m^2}$ (D) $\left(\frac{M_H m}{H_H+m}\right)r^2\omega$

43. The new ground state energy of electron will be

(A) more than that found with Bohr's theoretical model.

(B) equal to that found with Bohr's theoretical model.

(C) smaller than that found with Bohr's theoretical model.
(D) data insufficient to arrive at a conclusion.

Comprehension 15

In atom X, a single electron orbits around a stationary nucleus of charge $+Ze$ where Z is a constant and e is the magnitude of the electronic charge. It requires 47.2 eV to excite the electron from the second Bohr orbit to the third Bohr orbit. Take ionization energy of the hydrogen atom 13.6 eV.

44. The value of Z is
(A) 3 (B) 4
(C) 5 (D) 6

45. Kinetic energy of electron in ground state of atom X is
(A) 122.4 eV (B) 170 eV
(C) 340 eV (D) 680 eV

46. The wavelength of electromagnetic radiation required to remove the electron from 3rd Bohr orbit to infinity is
(A) 329 Å (B) 428 Å
(C) 546 Å (D) 636 Å

Comprehension 16

A gas of identical hydrogen like atoms has some atoms in lowest (ground) energy level A and some atoms in particular upper (excited) energy level B and there are no atoms in any other energy level. The atoms of the gas make transition to a higher energy level by absorbing monochromatic light of photon energy 2.7 eV. Subsequently the atoms emit radiation of only six different photons energies. Some of emitted photons have energy 2.7 eV. Some have more and some have less than 2.7 eV. Based on the information given, answer the following questions.

47. The principal quantum number of initially excited level B is
(A) 1 (B) 2
(C) 3 (D) None of these

48. The magnitude of ionisation energy of gas atoms is
(A) 13.6 eV
(B) 12.7 eV
(C) 54.4 eV
(D) None of these

49. The maximum and minimum energies of the emitted photons
(A) 12.75 eV and 0.66 eV
(B) 13.6 eV and 12.75 eV
(C) 13.6 eV and 0.66 eV
(D) None of these

Comprehension 17

A sample of hydrogen atom gas contains 100 atoms. All the atoms are excited to the same n^{th} excited state. The total energy released by all the atoms as they come to the ground state through various types of transitions is $\frac{4800}{49}Rch$, where $Rch = 13.6$ eV. Based on the information provided, answer the following questions.

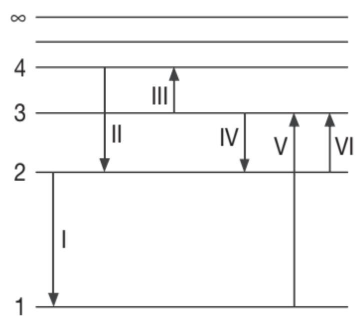
50. The value of n
(A) 5 (B) 6
(C) 7 (D) 8

51. The maximum energy of the emitted photon
(A) $\left(\frac{46}{49}\right)Rch$ (B) $\left(\frac{47}{49}\right)Rch$
(C) $\left(\frac{48}{49}\right)Rch$ (D) Rch

52. The maximum number of photons emitted is
(A) 300 (B) 600
(C) 1500 (D) 2100

Comprehension 18

The figure shown an energy level diagram for the hydrogen atom. Several transitions are marked as I, II, III, IV, V, & VI. The diagram is only indicative and not to scale. Based on the information given, answer the following questions.



53. A Balmer series photon is absorbed in
(A) II (B) III
(C) IV (D) VI

54. The wavelength of the radiation involved in transition II is
(A) 291 nm (B) 364 nm
(C) 487 nm (D) 652 nm

55. The transition that occur, when a hydrogen atom is irradiated with radiation of wavelength 1025 Å
(A) I (B) II
(C) IV (D) V

Comprehension 19

In the first orbit of hydrogen atom, energy is -13.6 eV, whereas in case of any other hydrogen like atom, the energy (in eV) in first orbit is $-(13.6)Z^2$, where Z is atomic number of atom. When the electron gets excited to a higher state then its energy increases. At infinity, it becomes zero, because electron becomes free from system. All other states other than the ground state are called as excited state. Based on the information provided, answer the following questions.

56. As number of orbit increases, kinetic energy of electron also increases

(A) yes
(B) no
(C) depends on atom
(D) depends on number of orbits

57. Energy of He^+ ion in its second excited state is approximately

(A) –13.6 eV (B) –27.2 eV
(C) –6 eV (D) –54.4 eV

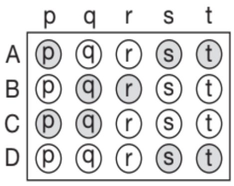
58. When a hydrogen nucleus joins an electron in the first excited state, then released energy is

(A) 13.6 eV (B) 3.4 eV
(C) 10.2 eV (D) None of these

MATRIX MATCH/COLUMN MATCH TYPE QUESTIONS

Each question in this section contains statements given in two columns, which have to be matched. The statements in **COLUMN-I** are labelled A, B, C and D, while the statements in **COLUMN-II** are labelled p, q, r, s (and t). Any given statement in **COLUMN-I** can have correct matching with **ONE OR MORE** statement(s) in **COLUMN-II**. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following examples:

If the correct matches are A → p, s and t; B → q and r; C → p and q; and D → s and t; then the correct darkening of bubbles will look like the following:



1. Match the quantities in **COLUMN-I** with their proportionality on Z (atomic number) in **COLUMN-II**.

COLUMN-I	COLUMN-II
(A) Radius of orbit	(p) is proportional to Z
(B) Current associated due to orbital motion of electron	(q) is inversely proportional to Z
(C) Magnetic field at the centre due to orbital motion of electron	(r) is proportional to Z^2
(D) Velocity of an electron	(s) is proportional to Z^3

2. Excitation energy of hydrogen atom is 13.6 eV. Match the following quantities in **COLUMN-I** with their values in **COLUMN-II**.

COLUMN-I	COLUMN-II
(A) Energy of second excited state of hydrogen	(p) –3.4 eV
(B) Energy of fourth state of He^+	(q) –13.6 eV
(C) Potential energy of first excited state of Li^{++}	(r) –1.5 eV
(D) Kinetic energy of electron in second excited state of Li^{++}	(s) –61.2 eV

3. Some laws/processes are given in **COLUMN-I**. Match these with the physical phenomena given in **COLUMN-II**.

COLUMN-I	COLUMN-II
(A) Transition between two atomic energy levels	(p) Characteristic X-rays

(Continued)

COLUMN-I	COLUMN-II
(B) Electron emission from a material	(q) Photoelectric effect
(C) Mosley's Law	(r) Hydrogen spectrum
(D) Change of photon energy into kinetic energy of electrons	(s) β-decay

4. Match the energies in **COLUMN-I** with their respective values in **COLUMN-II**.

COLUMN-I	COLUMN-II
(A) Binding energy of electron in triply ionised Lithium atom	(p) 340 eV
(B) Energy that can remove electron from first excited state of triply ionised Beryllium atom	(q) 3.4 eV
(C) Ionisation energy of tetra-ionised Boron	(r) 122.4 eV
(D) Energy obtained in assembling singly ionised Helium atom so that the atom can be in ground state or other excited states	(s) 54.4 eV

5. Regarding transition of electrons match the transitions in **COLUMN-I** to the corresponding series in **COLUMN-II**.

COLUMN-I	COLUMN-II
(A) $n = 5$ to $n = 2$	(p) Lyman series
(B) $n = 8$ to $n = 4$	(q) Brackett series
(C) $n = 3$ to $n = 1$	(r) Paschen series
(D) $n = 4$ to $n = 3$	(s) Balmer series

6. Match the quantities in **COLUMN-I** with their dependence on the principal quantum number n and the atomic number Z in **COLUMN-II**.

COLUMN-I	COLUMN-II
(A) Angular speed	(p) $\frac{n^3}{Z^2}$
(B) Time period	(q) n
(C) Angular momentum	(r) $\frac{Z^2}{n^3}$
(D) Magnetic moment	(s) $\frac{Z^3}{n^5}$
(E) Magnetic Field	

7. Match the properties in **COLUMN-I** with their corresponding transitions in **COLUMN-II**.

COLUMN-I	COLUMN-II
(A) Ultraviolet light	(p) $n = 6 \to n = 3$
(B) Visible light	(q) $n = 3 \to n = 1$
(C) Infrared radiation	(r) $n = 4 \to n = 2$
(D) Micro wave	(s) $n = 7 \to n = 6$

8. For transition of electrons match the following

COLUMN-I	COLUMN-II
(A) $n = 5$ to $n = 2$	(p) Lyman series
(B) $n = 8$ to $n = 4$	(q) Brackett series
(C) $n = 3$ to $n = 1$	(r) Paschen series
(D) $n = 4$ to $n = 3$	(s) Balmer series

9. Match the quantities in **COLUMN-I** with their respective values in **COLUMN-II** for He^+ atom.

COLUMN-I	COLUMN-II
(A) Angular momentum	(p) $\frac{2h}{\pi}$
(B) Total energy of electron in ground state (in eV)	(q) 54.4
(C) Potential energy of electron in ground state (in eV)	(r) −108.8

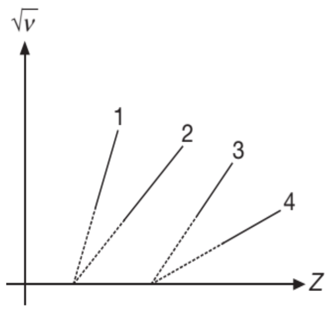
(Continued)

COLUMN-I	COLUMN-II
(D) Kinetic energy of electron in first excited state (in eV)	(s) $\frac{h}{2\pi}$
	(t) 13.6
	(u) –54.4

10. Match the entries of **COLUMN-I** with the respective entries in **COLUMN-II**.

COLUMN-I	COLUMN-II
(A) Characteristic X-ray	(p) Inverse process of photoelectric effect
(B) X-ray production	(q) Potential difference
(C) Cut-off wavelength	(r) Moseley's law
(D) Continuous X-ray	(s) None of these

11. Square root of frequency $\sqrt{v}$, versus atomic number Z graph for characteristic X-rays is as shown in figure. Match the following



COLUMN-I	COLUMN-II
(A) Line-1	(p) L_α
(B) Line-2	(q) L_β
(C) Line-3	(r) K_α
(D) Line-4	(s) K_β

12. The energy, the magnitude of linear momentum, magnitude of angular momentum and orbital radius of an electron in a hydrogen atom corresponding to the quantum number n are E, p, L and r respectively. Then according to Bohr's theory of hydrogen atom match the expressions in **COLUMN-I** with statement in **COLUMN-II.**

COLUMN-I	COLUMN-II
(A) Epr	(p) is independent of n
(B) $\frac{p}{E}$	(q) is directly proportional to n
(C) Er	(r) is inversely proportional to n
(D) pr	(s) is directly proportional to L

13. **COLUMN-I** is a physical quantity related to orbiting electron in a hydrogen like atom, the term Z and n given in **COLUMN- II** have usual meaning in Bohr's theory.

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
	(t) is different for different hydrogen like atom

14. Match the series in **COLUMN-I** with the type of emission in **COLUMN-II** for hydrogen spectrum.

COLUMN-I	COLUMN-II
(A) Lyman series	(p) infrared region
(B) Balmer series	(q) visible region
(C) Paschen series	(r) ultraviolet region
(D) Brackett series	(s) X-rays

15. In **COLUMN-I**, maximum wavelengths of spectral series are given and in **COLUMN-II** minimum wavelengths are given. Match the **COLUMN-I** with **COLUMN-II** and mark the correct the correct option from the codes given below

COLUMN-I (λ_{max})	COLUMN-II (λ_{min})
(A) $\frac{4}{3R}$	(p) $\frac{9}{R}$
(B) $\frac{36}{5R}$	(q) $\frac{16}{R}$
(C) $\frac{144}{7R}$	(r) $\frac{25}{R}$
(D) $\frac{400}{9R}$	(s) $\frac{1}{R}$
(E) $\frac{900}{11R}$	(t) $\frac{4}{R}$

16. In Bohr's atomic model for hydrogen atom, match the contents of **COLUMN-I** with contents of **COLUMN-II**.

COLUMN-I	COLUMN-II
(A) If electron jumps from $n = 2$ to $n = 1$	(p) speed of electron will become 2 times
(B) If electron jumps from $n = 1$ to $n = 4$	(q) kinetic energy of electron will become 4 times
(C) If electron jumps from $n = 3$ to $n = 1$	(r) angular momentum of electron will become 4 times
(D) If electron jumps from $n = 6$ to $n = 3$	(s) angular velocity of electron becomes 27 times
	(t) current due to electron becomes 8 times

17. Match the entries in **COLUMN-I** with their respective entries in **COLUMN-II**.

COLUMN-I	COLUMN-II
(A) Atomic excitation	(p) Absorption spectrum
(B) Lyman series	(q) Independent of mass of electron
(C) Rydberg constant	(r) Inelastic collision
(D) Bohr's atomic model	(s) Dependent on mass of electron
(E) Speed of electron	(t) Stationary orbit

18. If f_1 is the maximum frequency of emitted photon of Lyman series, f_2 is minimum frequency of the emitted photon of Lyman series and f_3 is maximum frequency of the emitted photon of Balmer series, then match the relations in given in **COLUMN-I** with the corresponding relations in **COLUMN-II**.

COLUMN-I	COLUMN-II
(A) f_1	(p) greater than f_3
(B) f_2	(q) is negative
(C) $(f_2 - f_1)$	(r) less than f_2
(D) $(f_1 - f_2)$	(s) is equal to f_3

19. In hydrogen atom wavelength of second line of Balmer series is λ, Match the following two columns corresponding to the wavelength.

COLUMN-I	COLUMN-II
(A) First line of Balmer series	(p) $\left(\frac{27}{20}\right)\lambda$
(B) Third line of Balmer series	(q) $\left(\frac{\lambda}{4}\right)$
(C) First line of Lyman series	(r) $\left(\frac{25}{12}\right)\lambda$
(D) Second line of Lyman series	(s) None of these

20. Match the energies in **COLUMN-I** with the respective values in **COLUMN-II**.

COLUMN-I	COLUMN-II
(A) Energy of second excited state of hydrogen	(p) −3.4 eV
(B) Energy of fourth state of He^+	(q) +13.6 eV
(C) Energy of first excited state of Li^{++}	(r) −1.5 eV
(D) Excitation energy of hydrogen atom	(s) −30.6 eV
	(t) −13.6 eV

21. Ionization energy of electron from first excited state of hydrogen atom is E. Match the following two columns for He^+ atom.

COLUMN-I	COLUMN-II
(A) Ionization energy from ground state	(p) $4E$
(B) Electrostatic potential energy in first excited state	(q) $-16E$
(C) Kinetic energy of electron in ground state	(r) $-8E$
(D) Ionization energy from first excited state	(s) $16E$

INTEGER/NUMERICAL ANSWER TYPE QUESTIONS

In this section, the answer to each question is a numerical value obtained after doing series of calculations based on the data given in the question(s).

1. Calculate the ratio between total acceleration of the electron in singly ionized helium atom and hydrogen atom when both the atoms are in ground state.

2. The binding energy of an electron in the ground state of He atom is equal to $E_0 = 24.6$ eV. Find the energy required, in eV, to remove both electrons from the atom.

3. An X-ray tube is operating at 18 kV. The speed of electrons striking the target is $x \times 10^7$ ms^{-1}. Calculate x. Take mass of electron to be 9×10^{-31} kg.

4. Find the quantum number n corresponding to nth excited state of He^+ ion if on transition to the ground state the ion emits two photons in succession with wavelengths 108.5 nm and 30.4 nm. The ionization energy of the hydrogen atom is 13.6 eV.

5. The half-value thickness of an absorber is defined as the thickness that will reduce exponentially the intensity of a beam of particles by a factor of 2. Calculate the half-value thickness for lead, in micrometre, assuming that the X-ray beam has a wavelength of 20 pm, absorption coefficient of lead to be $\mu = 50$ cm^{-1}.

6. From what material (Z value) is the anode of an X-ray tube made, if the K_α line wavelength of the characteristic spectrum is 0.76 Å?

7. Calculate the voltage of X-ray tube in kilovolt, so that an electron emitted from the cathode may give an X-ray of wavelength 3.1 Å after striking the target. Take $hc = 12400$ eVÅ.

8. A stream of α-particles is incident on a sample of hydrogen gas. What should be the minimum kinetic energy of α-particles, in eV, to ionize the hydrogen atoms.

9. The potential difference across Coolidge tube is 20 kV and a 10 mA current flows through the voltage supply. Only 0.5% of the energy carried by electrons striking the target is converted into X-rays. Calculate the power carried by X-ray beam in watt.

10. Hydrogen gas in the atomic state is excited to an energy level such that the electrostatic potential energy of hydrogen atom becomes −1.7 eV. Now a photoelectric plate having work function 2.3 eV is exposed to the emission spectra of this gas. Assuming all the transitions to be possible, find the minimum de-Broglie wavelength of the ejected photoelectrons in Å to the nearest integer.

11. The shortest wavelength of the Brackett series of a hydrogen like atom of atomic number Z is same as the shortest wavelength of the Balmer series of hydrogen atom, then calculate Z.

12. A hydrogen like atom (described by the Bohr model) is observed to emit six wavelengths, originating from all possible transitions between a group of levels. These levels have energies between -0.85 eV and -0.544 eV (including both these values).
   (a) Find the atomic number of the atom.
   (b) Calculate the smallest wavelength emitted in these transitions, in Å.
   (Take ground state energy of hydrogen atom to be -13.6 eV).

13. Emission spectrum of hydrogen atom has two lines of Balmer series with wavelength 4102 Å and 4861 Å. To what series does a spectral line belong if its wave number is equal to the difference of wave numbers of the above two lines? What is the wavelength of this line in Å? Given, $R = 1.097 \times 10^7\ \text{m}^{-1}$.

14. Calculate the quantum number n corresponding to the excited state of singly ionised helium, if on transition to ground state, the ionised helium emits two photons in succession having wavelengths 1026.7 Å and 304 Å. Given that the Rydberg's constant has a value $1.09 \times 10^7\ \text{m}^{-1}$.

15. A hydrogen like atom (atomic number Z) is in a higher excited state of quantum number n. The excited atom can make a transition to the first excited state by successively emitting two photons of energy 10.2 eV and 17 eV respectively. Alternately, the atom from the same excited state can make a transition to the second excited state by successively emitting two photons of energies 4.25 eV and 5.95 eV respectively.
   Determine the values of n and Z.
   (Ionization energy of hydrogen atom is 13.6 eV)

16. Assuming that the binding energy of an electron in the ground state of helium atom is 25.6 eV. If the ionisation energy of hydrogen is 13.6 eV, then the energy required to remove both the electrons from the helium atom is $10N$ eV. Calculate N.

17. The ionization energy of a hydrogen like Bohr atom is 4 rydberg.
   (a) What is the wavelength of the radiation emitted, in Å, when the electron jumps from the first excited state to the ground state?
   (b) What is the atomic number Z of the atom?
   (c) Also, the radius of the first orbit for this atom as a multiple of the Bohr's radius a_0 is $\frac{a_0}{*}$, where $*$ is not readable. Find $*$.

18. Calculate the wavelength of K_α line (in picometer) for copper $(Z = 29)$ if the wavelength of K_α line for iron $(Z = 26)$ is known to be equal to 193 pm.

19. A doubly ionized lithium atom is hydrogen like with atomic number 3. Find the wavelength of the radiation to the nearest three digit integer, in Å, required to excite the electron in Li^{++} from the first to the third Bohr orbit. The ionization energy of the hydrogen atom is 13.6 eV.

20. The electric current in an X-ray tube operating at 40 kV is 10 mA. Assume that on an average 1% of the total kinetic energy of the electrons hitting the target are converted into X-rays.
   (a) What is the total power emitted as X-rays, in watt?
   (b) How much heat, in joule is produced in the target every second?

21. In a certain element, the K electron energy is -18.525 keV and the L electron energy is -3 keV. When electron jumps from L to K shell, the wavelength of X-ray emitted is $x \times 10^{-11}$ m. Calculate x. Take $hc = 12375$ eVÅ.

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1. **[Online April 2019]**
   Radiation coming from transitions $n = 2$ to $n = 1$ of hydrogen atoms fall on He^+ ions in $n = 1$ and $n = 2$ states. The possible transition of helium ions as they absorb energy from the radiation is
   (A) $n = 2 \rightarrow n = 4$ (B) $n = 2 \rightarrow n = 5$
   (C) $n = 2 \rightarrow n = 3$ (D) $n = 1 \rightarrow n = 4$

2. **[Online April 2019]**
   Taking the wavelength of first Balmer line in hydrogen spectrum $(n = 3 \text{ to } n = 2)$ as 660 nm, the wavelength of the 2nd Balmer line $(n = 4 \text{ to } n = 2)$ will be
   (A) 889.2 nm (B) 488.9 nm
   (C) 388.9 nm (D) 642.7 nm

3. **[Online April 2019]**
   A He^+ ion is in its first excited state. Its ionization energy is
   (A) 13.60 eV (B) 6.04 eV
   (C) 48.36 eV (D) 54.40 eV

4. **[Online April 2019]**
   In Li^{++}, electron in first Bohr orbit is excited to a level by a radiation of wavelength λ. When the ion gets deexcited to the ground state in all possible ways

(including intermediate emissions), a total of six spectral lines are observed. What is the value of λ ?

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

(A) 11.4 nm (B) 12.3 nm
(C) 9.4 nm (D) 10.8 nm

5. [Online April 2019]
An excited He^+ ion emits two photons in succession, with wavelengths 108.5 nm and 30.4 nm , in making a transition to ground state. The quantum number n , corresponding to its initial excited state is (for photon of wavelength λ , energy $E = \frac{1240 \text{ eV}}{\lambda(\text{in nm})}$)

(A) $n = 5$ (B) $n = 7$
(C) $n = 4$ (D) $n = 6$

6. [Online April 2019]
The electron in a hydrogen atom first jumps from the third excited state to the second excited state and subsequently to the first excited state. The ratio of the respective wavelengths, $\frac{\lambda_1}{\lambda_2}$, of the photons emitted in this process is

(A) $\frac{7}{5}$ (B) $\frac{27}{5}$
(C) $\frac{9}{7}$ (D) $\frac{20}{7}$

7. [Online January 2019]
A hydrogen atom, initially in the ground state is excited by absorbing a photon of wavelength 980 Å. The radius of the atom in the excited state, in terms of Bohr radius a_0 , will be $(hc = 12500 \text{ eVÅ})$

(A) $4a_0$ (B) $9a_0$
(C) $25a_0$ (D) $16a_0$

8. [Online January 2019]
In a hydrogen like atom, when an electron jumps from the M-shell to the L-shell , the wavelength of emitted radiation is λ . If an electron jumps from N-shell to the L-shell , the wavelength of emitted radiation will be

(A) $\frac{25}{16}\lambda$ (B) $\frac{16}{25}\lambda$
(C) $\frac{20}{27}\lambda$ (D) $\frac{27}{20}\lambda$

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

(A) $r_n \propto n$, $E_n \propto n$ (B) $r_n \propto \sqrt{n}$, $E_n \propto n$
(C) $r_n \propto \sqrt{n}$, $E_n \propto \frac{1}{n}$ (D) $r_n \propto n^2$, $E_n \propto \frac{1}{n^2}$

10. [2018]
An electron from various excited states of hydrogen atom emit radiation to come to the ground state. Let λ_n , λ_g be the de Broglie wavelength of the electron in the n^{th} state and the ground state respectively. Let Λ_n be the wavelength of the emitted photon in the transition from the n^{th} state to the ground state. For large n , (A , B are constants)

(A) $\Lambda_n \approx A + \frac{B}{\lambda_n^2}$ (B) $\Lambda_n \approx A + B\lambda_n$
(C) $\Lambda_n^2 \approx A + B\lambda_n^2$ (D) $\Lambda_n^2 \approx \lambda$

11. [2018]
If the series limit frequency of the Lyman series is ν_L , then the series limit frequency of the Pfund series is

(A) $25\nu_L$ (B) $16\nu_L$
(C) $\frac{\nu_L}{16}$ (D) $\frac{\nu_L}{25}$

12. [Online 2018]
The energy required to remove the electron from a singly ionized Helium atom is 2.2 times the energy required to remove an electron from Helium atom. The total energy required to ionize the Helium atom completely is

(A) 34 eV (B) 79 eV
(C) 20 eV (D) 109 eV

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

I. Radius of the muonic orbit is 200 times smaller than that of the electron.
II. The speed of the μ^- in the n^{th} orbit is $\frac{1}{200}$ times that of the electron in the n^{th} orbit.
III. The ionization energy of muonic atom is 200 times more than that of an hydrogen atom.
IV. The momentum of the muon in the n^{th} orbit is 200 times more than that of the electron.

(A) I, II, IV (B) II, IV
(C) I, III, IV (D) III, IV

14. [Online 2018]

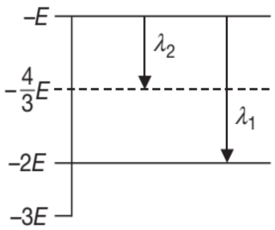
Both the nucleus and the atom of some element are in their respective first excited states. They get de-excited by emitting photons of wavelengths λ_N, λ_A respectively. The ratio is $\frac{\lambda_N}{\lambda_A}$ closest to

(A) 10 (B) 10^{-6}

(C) 10^{-10} (D) 10^{-1}

15. [2017]

Some energy levels of a molecule are shown in the figure. The ratio of the wavelengths $r = \frac{\lambda_1}{\lambda_2}$ is given by



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

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

16. [Online 2017]

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

(A) n^{-2} (B) n^{-3}

(C) n^{-4} (D) n^{-5}

17. [Online 2017]

The acceleration of an electron in the first orbit of hydrogen atom $(n = 1)$ is

(A) $\frac{h^2}{\pi^2 m^2 r^3}$ (B) $\frac{h^2}{4\pi^2 m^2 r^3}$

(C) $\frac{h^2}{4\pi m^2 r^3}$ (D) $\frac{h^2}{8\pi^2 m^2 r^3}$

18. [Online 2016]

A hydrogen atom makes a transition from $n = 2$ to $n = 1$ and emits a photon. This photon strikes a doubly ionized lithium atom $(Z = 3)$ in excited state and completely removes the orbiting electron. The least quantum number for the excited state of the ion for the process is

(A) 2 (B) 4

(C) 5 (D) 3

19. [2015]

As an electron makes a transition from an excited state to the ground state of a hydrogen – like atom/ion

(A) its kinetic energy increases but potential energy and total energy decrease

(B) kinetic energy, potential energy and total energy decrease

(C) kinetic energy decreases, potential energy increases but total energy remains same

(D) kinetic energy and total energy decrease but potential energy increases

20. [Online 2015]

If one were to apply Bohr model to a particle of mass m and charge q moving in a plane under the influence of a magnetic field B, the energy of the charged particle in the n^{th} level will be

(A) $n\left(\frac{hqB}{2\pi m}\right)$ (B) $n\left(\frac{hqB}{4\pi m}\right)$

(C) $n\left(\frac{hqB}{8\pi m}\right)$ (D) $n\left(\frac{hqB}{\pi m}\right)$

21. [2014]

Hydrogen $\left({}_1\mathrm{H}^1\right)$, Deuterium $\left({}_1\mathrm{H}^2\right)$, singly ionised Helium $\left({}_2\mathrm{He}^4\right)^+$ and doubly ionised lithium $\left({}_3\mathrm{Li}^6\right)^{++}$ all have one electron around the nucleus. Consider an electron transition from $n = 2$ to $n = 1$. If the wavelengths of emitted radiation are λ_1, λ_2, λ_3 and λ_4 respectively then approximately which one of the following is correct?

(A) $4\lambda_1 = 2\lambda_2 = 2\lambda_3 = \lambda_4$ (B) $\lambda_1 = 2\lambda_2 = 2\lambda_3 = \lambda_4$

(C) $\lambda_1 = \lambda_2 = 4\lambda_3 = 9\lambda_4$ (D) $\lambda_1 = 2\lambda_2 = 3\lambda_3 = 4\lambda_4$

22. [2013]

In a hydrogen like atom electron makes transition from an energy level with quantum number n to another with quantum number $(n-1)$. If $n \gg 1$, the frequency of radiation emitted is proportional to

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

(C) $\frac{1}{n^{3/2}}$ (D) $\frac{1}{n^3}$

23. [2012]

Hydrogen atom is excited from ground state to another state with principal quantum number equal to 4. Then the number of spectral lines in the emission spectra will be

(A) 3 (B) 5

(C) 6 (D) 2

24. [2012]

A diatomic molecule is made of two masses m_1 and m_2 which are separated by a distance r. If we calculate its rotational energy by applying Bohr's rule of angular momentum quantization, its energy will be given by (n is an integer)

(A) $\dfrac{n^2\hbar^2}{2(m_1+m_2)r^2}$ (B) $\dfrac{2n^2\hbar^2}{(m_1+m_2)r^2}$

(C) $\dfrac{(m_1+m_2)n^2\hbar^2}{2m_1m_2r^2}$ (D) $\dfrac{(m_1+m_2)^2n^2\hbar^2}{2m_1^2m_2^2r^2}$

25. [2011]

Energy required for the electron excitation in Li^{++} from the first to the third Bohr orbit is

(A) 12.1 eV (B) 36.3 eV

(C) 108.8 eV (D) 122.4 eV

26. [2009]

The transition from the state $n=4$ to $n=3$ in a hydrogen like atom results in ultraviolet radiation. Infrared radiation will be obtained in the transition from

(A) $2 \to 1$ (B) $3 \to 2$

(C) $4 \to 2$ (D) $5 \to 4$

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Single Correct Choice Type Problems

(In this section each question has four choices (A), (B), (C) and (D), out of which ONLY ONE is correct)

1. [JEE (Advanced) 2014]

If λ_{Cu} is the wavelength of K_α, X-ray line of copper (atomic number 29) and λ_{mo} is the wavelength of the K_α, X-ray line of molybdenum (atomic number 42), then the ratio $\dfrac{\lambda_{Cu}}{\lambda_{mo}}$ is close to

(A) 1.99 (B) 2.14

(C) 0.50 (D) 0.48

2. [IIT-JEE 2011]

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

3. [IIT-JEE 2008]

Which one of the following statements is wrong in the context of X-rays generated from an X-ray tube?

(A) Wavelength of characteristic X-rays decreases when the atomic number of the target increases

(B) Cut-off wavelength of the continuous X-rays depends on the atomic number of the target

(C) Intensity of the characteristic X-rays depends on the electrical power given to the X-ray tube

(D) Cut-off wavelength of the continuous X-rays depends on the energy of the electrons in the X-ray tube

4. [IIT-JEE 2007]

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

5. [IIT-JEE 2005]

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

(A) $Z=6$ (B) $Z=4$

(C) $Z=11$ (D) $Z=44$

6. [IIT-JEE 2005]

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 mocro second another photon collides with same hydrogen atom inelastically with an energy of 15 eV. What will be observed by the detector?

(A) 2 photon of energy 10.2 eV

(B) 2 photon of energy 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

7. [IIT-JEE 2003]

The electric potential between a proton and an electron is given by $V = V_0 \log_e\left(\dfrac{r}{r_0}\right)$, 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.

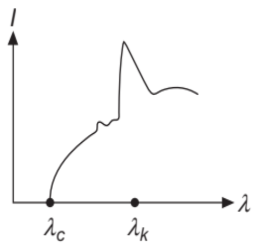
(A) $r_n \propto n$ (B) $r_n \propto \dfrac{1}{n}$

(C) $r_n \propto n^2$ (D) $r_n \propto \dfrac{1}{n^2}$

8. **[IIT-JEE 2002]**
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) $L_H > L_{Li}$ and $|E_H| > |E_{Li}|$
(B) $L_H = L_{Li}$ and $|E_H| < |E_{Li}|$
(C) $L_H = L_{Li}$ and $|E_H| > |E_{Li}|$
(D) $L_H < L_{Li}$ and $|E_H| < |E_{Li}|$

9. **[IIT-JEE 2002]**
The potential difference applied to an X-ray tube is 5 kV and the current through it is 3.2 mA. The number of electrons striking the target per second is
(A) 2×10^{16} (B) 5×10^{6}
(C) 1×10^{17} (D) 4×10^{15}

10. **[IIT-JEE 2001]**
The intensity of X-rays from a Coolidge tube is plotted against wavelength λ as shown. 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

11. **[IIT-JEE 2001]**
The transition from the state $n=4$ to $n=3$ in a hydrogen like atom results in ultraviolet radiation. Infrared radiation will be obtained in the transition
(A) $2\rightarrow1$ (B) $3\rightarrow2$
(C) $4\rightarrow2$ (D) $5\rightarrow4$

12. **[IIT-JEE 2000]**
The electron in a hydrogen atom makes a transition from an exited 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

13. **[IIT-JEE 2000]**
Imagine an atom made up of a proton and a hypothetical particle of double the mass of 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 (given in terms of 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. **[IIT-JEE 2000]**
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 $\sim 0.155\text{ Å}$.
(B) a 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 $\sim 0.155\text{ Å}$ and the characteristic X-ray spectrum of tungsten.

15. **[IIT-JEE 1999]**
In Hydrogen spectrum the wavelength of H_α line is 656 nm, whereas in the spectrum of a distant galaxy, H_α line wavelength is 706 nm. Estimated speed of galaxy with respect to earth is
(A) $2\times10^{8}\text{ ms}^{-1}$ (B) $2\times10^{7}\text{ ms}^{-1}$
(C) $2\times10^{6}\text{ ms}^{-1}$ (D) $2\times10^{5}\text{ ms}^{-1}$

16. **[IIT-JEE 1998]**
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 to ∞
(B) λ_{min} to ∞ where $\lambda_{min} > 0$
(C) 0 to λ_{max} where $\lambda_{max} < \infty$
(D) λ_{min} to λ_{max} where $0 < \lambda_{min} < \lambda_{max} < \infty$

17. **[IIT-JEE 1997]**
As per Bohr Model, the minimum energy (in eV) required to remove an electron from the ground state of doubly ionised Li atom $(Z=3)$ is
(A) 1.51 (B) 13.6
(C) 40.8 (D) 122.4

18. **[IIT-JEE 1997]**
The K_α X-ray emission line of tungsten occurs at $\lambda = 0.021$ nm. The energy difference between K and L levels in this atom is about
(A) 0.51 MeV (B) 1.2 MeV
(C) 59 keV (D) 13.6 eV

19. **[IIT-JEE 1985]**
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

20. **[IIT-JEE 1983]**
If the elements with principal quantum number $n > 4$ were not allowed in nature, the possible number of elements would be
(A) 4 (B) 32
(C) 60 (D) 64

21. **[IIT-JEE 1982]**
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 tube
(D) the atomic number of the target material

Multiple Correct Choice Type Problems

(In this section each question has four choices (A), (B), (C) and (D), out of which ONE OR MORE is/are correct)

1. **[JEE (Advanced) 2019]**
A free hydrogen atom after absorbing a photon of wavelength λ_a gets excited from the state $n = 1$ to the state $n = 4$. Immediately after that the electron jumps to $n = m$ state by emitting a photon of wavelength λ_e. Let the change in momentum of atom due to the absorption and the emission are Δp_a and Δp_e, respectively. If $\frac{\lambda_a}{\lambda_e} = \frac{1}{5}$, which of the option(s) is/are correct?

(Use $hc = 1242$ eV nm; $1\text{ nm} = 10^{-9}$ m, h and c are Planck's constant and speed of light, respectively)
(A) $\lambda_e = 418$ nm
(B) $\frac{\Delta p_a}{\Delta p_e} = \frac{1}{2}$
(C) The ratio of kinetic energy of the electron in the state $n = m$ to the state $n = 1$ is $\frac{1}{4}$
(D) $m = 2$

2. **[JEE (Advanced) 2016]**
Highly excited states for hydrogen-like atoms (also called Rydberg states) with nuclear charge Ze are defined by their principal quantum number n, where $n \gg 1$. Which of the following statement(s) is(are) true?
(A) Relative change in the radii of two consecutive orbitals does not depend on Z
(B) Relative change in the radii of two consecutive orbitals varies as $\frac{1}{n}$
(C) Relative change in the energy of two consecutive orbitals varies as $\frac{1}{n^3}$
(D) Relative change in the angular momenta of two consecutive orbitals varies as $\frac{1}{n}$

3. **[JEE (Advanced) 2013]**
The radius of the orbit of an electron in a Hydrogen like atom is $4.5a_0$, where a_0 is the Bohr radius. Its orbital angular momentum is $\frac{3h}{2\pi}$. It is given that h is Planck constant and R is Rydberg constant. The possible wavelength(s), when the atom de-excites, is (are)
(A) $\frac{9}{32R}$ (B) $\frac{9}{16R}$
(C) $\frac{9}{5R}$ (D) $\frac{4}{3R}$

4. **[IIT-JEE 1998]**
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 the Bohr Model to be valid. The time period of the electron in 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) $n_1 = 6$, $n_2 = 3$

5. **[IIT-JEE 1988]**
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

6. **[IIT-JEE 1984]**
In the Bohr model of the hydrogen atom
(A) the radius of the nth orbit is proportional to n^2
(B) the total energy of the electron in the nth orbit is inversely proportional to n
(C) the angular momentum of the electron in an orbit is an integral multiple of $\frac{h}{\pi}$
(D) the magnitude of the potential energy of the electron in any orbit is greater than its kinetic energy

Reasoning Based Questions

This section contains Reasoning type questions, each having four choices (A), (B), (C) and (D) out of which ONLY ONE is correct. Each question contains STATEMENT 1 and STATEMENT 2. You have to mark your answer as

Bubble (A) If both statements are TRUE and STATEMENT 2 is the correct explanation of STATEMENT 1.
Bubble (B) If both statements are TRUE but STATEMENT 2 is not the correct explanation of STATEMENT 1.
Bubble (C) If STATEMENT 1 is TRUE and STATEMENT 2 is FALSE.
Bubble (D) If STATEMENT 1 is FALSE but STATEMENT 2 is TRUE.

1. **[IIT-JEE 2007]**
Statement-1: If the accelerating potential in an X-ray tube is increased, the wavelengths of the characteristic X-rays do not change.
Statement-2: When an electron beam strikes the target in an X-ray tube, part of the kinetic energy is converted into X-ray energy.
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

Comprehension Type Questions

This section contains Linked Comprehension Type Questions or Paragraph based Questions. Each set consists of a Paragraph followed by questions. Each question has four choices (A), (B), (C) and (D), out of which only one is correct. (For the sake of competitiveness there may be a few questions that may have more than one correct options)

Comprehension 1

The key feature of Bohr's theory of spectrum of hydrogen atom is the quantisation of angular momentum when an electron is revolving around a proton. We will extend this to a general rotational motion to find quantised rotational energy of a diatomic molecule assuming it to be rigid. The rule to be applied is Bohr's quantisation condition.

1. **[IIT-JEE 2010]**
A diatomic molecule has moment of inertia I. By Bohr's quantization condition its rotational energy in the n^{th} level ($n = 0$ is not allowed) is
(A) $\frac{1}{n^2}\left(\frac{h^2}{8\pi^2 I}\right)$
(B) $\frac{1}{n}\left(\frac{h^2}{8\pi^2 I}\right)$
(C) $n\left(\frac{h^2}{8\pi^2 I}\right)$
(D) $n^2\left(\frac{h^2}{8\pi^2 I}\right)$

2. **[IIT-JEE 2010]**
It is found that the excitation frequency from ground to the first excited state of rotation for the CO molecule is close to $\frac{4}{\pi}\times 10^{11}$ Hz. Then the moment of inertia of CO molecule about its centre of mass is close to (Take $h = 2\pi\times 10^{-34}$ Js)
(A) 2.76×10^{-46} kgm^2
(B) 1.87×10^{-46} kgm^2
(C) 4.67×10^{-47} kgm^2
(D) 1.17×10^{-47} kgm^2

3. **[IIT-JEE 2010]**
In a CO molecule, the distance between C(mass = 12 amu) and O(mass = 16 amu), where $1 \text{ amu} = \frac{5}{3}\times 10^{-27}$ kg, is close to
(A) 2.4×10^{-10} m
(B) 1.9×10^{-10} m
(C) 1.3×10^{-10} m
(D) 4.4×10^{-11} m

Comprehension 2

When a particle is restricted to move along x-axis between $x = 0$ and $x = a$, where a is of nanometer dimension, its energy can take only certain specific values. The allowed energies of the particle moving in such a restricted region, correspond to the formation of standing waves with nodes at its ends $x = 0$ and $x = a$. The wavelength of this standing wave is related to the linear momentum p of the particle according to the de-Broglie relation. The energy of the particle of mass m is related to its linear momentum as

$E=\frac{p^2}{2m}$. Thus, the energy of the particle can be denoted by a quantum number n taking values $1, 2, 3, \ldots$ ($n=1$, called the ground state) corresponding to the number of loops in the standing wave.

Use the model described above to answer the following three questions for a particle moving in the line $x=0$ to $x=a$. [Take $h=6.6\times10^{-34}$ Js and $e=1.6\times10^{-19}$ C].

4. **[IIT-JEE 2009]**
The allowed energy for the particle for a particular value of n is proportional to

(A) a^{-2} (B) $a^{-\frac{3}{2}}$
(C) a^{-1} (D) a^2

5. **[IIT-JEE 2009]**
If the mass of the particle is $m=1\times10^{-30}$ kg and $a=6.6$ the energy of the particle in its ground state is closest to
(A) 0.8 meV (B) 8 meV
(C) 80 meV (D) 800 meV

6. **[IIT-JEE 2009]**
The speed of the particle that can take discrete values is proportional to

(A) $n^{-\frac{3}{2}}$ (B) n^{-1}
(C) $n^{\frac{1}{2}}$ (D) n

Comprehension 3

In a mixture of $H-He^+$ gas (He^+ is singly ionized He atom), H atoms and He^+ ions are excited to their respective first excited states. Subsequently, H atoms transfer their total excitation energy to He^+ ions (by collisions). Assume that the Bohr model of atom is exactly valid. Based on above information, answer the following questions.

7. **[IIT-JEE 2008]**
The quantum number n of the state finally populated in He^+ ions is
(A) 2 (B) 3
(C) 4 (D) 5

8. **[IIT-JEE 2008]**
The wavelength of light emitted in the visible region by He^+ ions after collisions with H atoms is

(A) 6.5×10^{-7} m (B) 5.6×10^{-7} m
(C) 4.8×10^{-7} m (D) 4×10^{-7} m

9. **[IIT-JEE 2008]**
The ratio of the kinetic energy of the $n=2$ electron for the H atom to that of He^+ ion is

(A) $\frac{1}{4}$ (B) $\frac{1}{2}$
(C) 1 (D) 2

Integer/Numerical Answer Type Questions

(In this section, the answer to each question is a numerical value obtained after series of calculations based on the data provided in the question(s)).

1. **[JEE (Advanced) 2018]**
Consider a hydrogen-like ionized atom with atomic number Z with a single electron. In the emission spectrum of this atom, the photon emitted in the $n=2$ to $n=1$ transition has energy 74.8 eV higher than the photon emitted in the $n=3$ to $n=2$ transition. The ionization energy of the hydrogen atom is 13.6 eV. The value of Z is............

2. **[JEE (Advanced) 2013]**
A proton is fired from very far away towards a nucleus with charge $Q=120e$, where e is the electronic charge. It makes a closest approach of 10 fm to the nucleus. Find the de-Broglie wavelength (in units of fm) of the proton at its start.

Take the proton mass, $m_p=\left(\frac{5}{3}\right)\times10^{-27}$ kg,

$\frac{h}{e}=4.2\times10^{-15}$ JsC^{-1}, $\frac{1}{4\pi\varepsilon_0}=9\times10^9$ mF^{-1} and

1 fm $=10^{-15}$ m.

3. **[JEE (Advanced) 2017]**
An electron in a hydrogen atom undergoes a transition from an orbit with quantum number n_i to another with quantum number n_f. v_i and v_f are respectively the initial and final potential energies of the electron. If $\frac{v_i}{v_f}=6.25$, then the smallest possible n_f is

4. **[JEE (Advanced) 2016]**
A hydrogen atom in its ground state is irradiated by light of wavelength 970 Å. Taking $\frac{hc}{e}=1.237\times10^{-6}$ Vm and the ground state energy of hydrogen atom as -13.6 eV, the number of lines present in the emission spectrum is

5. **[JEE (Advanced) 2015]**
Consider a hydrogen atom with its electro in the n^{th} orbital. An electromagnetic radiation of wavelength 90 nm is used to ionize the atom. If the kinetic energy of the ejected electron is 10.4 eV, then the value of n is $(hc = 1242\text{ eVnm})$

6. **[JEE (Advanced) 2015]**
An electron in an excited state of Li^{2+} ion has angular momentum $\frac{3h}{2\pi}$. The de Broglie wavelength of the electron in this state is $p\pi a_0$ (where a_0 is the Bohr radius). The value of p is

7. **[JEE (Advanced) 2013]**
A proton is fired from very far away towards a nucleus with charge $Q = 120e$, where e is the electronic charge. It makes a closest approach of 10 fm to the nucleus. Find the de-Broglie wavelength (in units of fm) of the proton at its start.

Take the proton mass, $m_p = \left(\frac{5}{3}\right)\times 10^{-27}\text{ kg}$,

$\frac{h}{e} = 4.2\times 10^{-15}\text{ JsC}^{-1}$, $\frac{1}{4\pi\varepsilon_0} = 9\times 10^{9}\text{ mF}^{-1}$ and

$1\text{ fm} = 10^{-15}\text{ m}$.

ANSWER KEYS–TEST YOUR CONCEPTS AND PRACTICE EXERCISES

Test Your Concepts-I (Based on Atomic Structure and Properties)

1. (a) 113.74 Å (b) 3
2. 122.4 eV
3. 793.3 Å
4. 1.82×10^{-14} m
5. 8.2×10^{6} revolutions
6. 6.56×10^{15} rev/sec
7. $r_n=\dfrac{nh}{2\pi\sqrt{mk}}$, $E_n=\dfrac{k}{2}\left[1-\log_e\left(\dfrac{n^2h^2}{4\pi^2mk}\right)\right]$
8. (a) Helium atom, (b) 54.4 eV, (c) 10.2 eV
9. 12.1 eV
10. −26.9 eV, −12 eV
11. 10.2 V, 2, 10.2 eV, 51 eV
12. 3.1×10^{6} ms^{-1}
13. (a) 15.6 eV (b) 2335 Å
 (c) 12.52 eV (d) 1.01×10^{7} m^{-1}
 (e) (i) 6 eV, (ii) 0.7 eV
14. (a) 1.587 Å (b) 1.095×10^{6} ms^{-1}
15. $\mu=\dfrac{neh}{4\pi m}$, $B=\dfrac{\mu_0\pi m^2e^7}{8\varepsilon_0h^5n^5}$
16. $r=\left(\dfrac{n^2h^2}{8am\pi^2}\right)^{1/4}$
17. $(n_1,n_2)=(2,1),(4,2),(6,3),\ldots\ldots$
18.

Orbit	*K*(eV)	*U*(eV)	*E*(eV)
First	13.60	0	13.60
Second	3.40	20.40	23.80

19. 0.55 eV
20. $\sqrt{2}$
21. (a) 3.4 eV (b) 6.63 Å
22. 1.86×10^{6} ms^{-1}
23. 1216 Å, 1026 Å
24. $\dfrac{3}{4}$
25. 6.68×10^{-3} eV

Test Your Concepts-II (Based on X-rays and Properties)

1. 2×10^{-15} J
2. (a) 27.624 keV (b) 30 kV
3. $Z=31$, Gallium
4. 10 μs
5. 7.52×10^{18} Hz
6. 15865 volt
7. 0.31 Å
8. 8.4×10^{7} ms^{-1}
9. 0.192 Å
10. 21 keV
11. 42
12. 0.163 Å

Single Correct Choice Type Questions

1. B	2. C	3. D	4. A	5. A	6. B	7. C	8. A	9. B	10. B
11. D	12. A	13. B	14. A	15. A	16. D	17. C	18. D	19. A	20. C
21. C	22. D	23. A	24. C	25. D	26. C	27. D	28. C	29. B	30. A
31. D	32. B	33. B	34. D	35. C	36. A	37. D	38. A	39. A	40. D

41. C	42. B	43. C	44. B	45. C	46. D	47. B	48. B	49. A	50. C
51. B	52. C	53. B	54. C	55. C	56. C	57. B	58. A	59. D	60. C
61. B	62. B	63. A	64. B	65. B	66. A	67. B	68. A	69. C	70. A
71. B	72. C	73. D	74. C	75. B	76. B	77. A	78. D	79. A	80. A
81. A	82. B	83. C	84. C	85. D	86. B	87. B	88. D	89. A	90. B
91. B	92. C	93. D	94. A	95. B	96. B	97. D	98. B	99. C	100. B
101. C	102. D	103. D	104. A	105. A	106. C	107. D	108. C	109. A	110. B
111. D	112. A	113. C	114. A	115. C	116. A	117. B	118. C	119. B	120. A
121. C	122. D	123. D	124. A	125. A	126. B	127. D	128. A	129. B	130. C
131. A	132. A	133. B	134. D	135. A	136. D	137. C	138. D	139. D	140. A
141. A	142. B	143. B	144. A	145. B	146. C	147. A	148. C	149. C	150. A
151. C	152. C	153. B	154. C	155. D	156. A	157. B	158. C	159. B	160. D
161. D	162. C	163. C	164. A	165. C	166. D	167. D	168. D	169. A	170. B

Multiple Correct Choice Type Questions

1. A, C	2. A, C	3. B, C	4. B, C	5. A, C, D
6. A, D	7. A, B	8. A, B, C	9. A, B, C, D	10. A, B, C, D
11. B, C, D	12. A, B, C, D	13. A, C	14. A, B, C, D	15. A, B, D
16. B, D	17. A, C, D	18. B, D	19. B, C, D	20. B, C
21. A, D	22. A, D	23. C, D	24. A, B, D	25. B, C, D
26. A, B, C	27. A, B, D	28. A, C, D	29. B, C	30. B, C

Reasoning Based Questions

1. B	2. D	3. C	4. D	5. C	6. C	7. A	8. A	9. B	10. B
11. C	12. C	13. C	14. D	15. D	16. A	17. A	18. B	19. A	20. A

Linked Comprehension Type Questions

1. C	2. C	3. D	4. C	5. B	6. A	7. C	8. D	9. D	10. B
11. A	12. C	13. B	14. C	15. A	16. C	17. C	18. C	19. B	20. A
21. A	22. A	23. B	24. C	25. D	26. B	27. D	28. C	29. C	30. D
31. C	32. A	33. B	34. B	35. D	36. A	37. B	38. C	39. A	40. B
41. C	42. D	43. A	44. C	45. C	46. A	47. B	48. A	49. A	50. B
51. C	52. D	53. D	54. C	55. D	56. B	57. A	58. B		

Matrix Match/Column Match Type Questions

1. A → (q)	B → (r)	C → (s)	D → (p)
2. A → (r)	B → (p)	C → (s)	D → (t)
3. A → (p, r)	B → (p, q, s)	C → (p)	D → (q)
4. A → (r)	B → (s)	C → (p)	D → (q, s)
5. A → (s)	B → (q)	C → (p)	D → (r)

6. A → (r)	B → (p)	C → (q)	D → (q)	E → (s)
7. A → (q)	B → (r)	C → (p)	D → (s)	
8. A → (s)	B → (q)	C → (p)	D → (r)	
9. A → (p, s)	B → (u)	C → (r)	D → (t)	
10. A → (r)	B → (p)	C → (q)	D → (q)	
11. A → (s)	B → (r)	C → (q)	D → (p)	
12. A → (p, s)	B → (q, s)	C → (q, s)	D → (s)	
13. A → (p, r, t)	B → (q, s)	C → (q, s)	D → (p, r, t)	
14. A → (r)	B → (q)	C → (p)	D → (p)	
15. A → (s)	B → (t)	C → (p)	D → (q)	E → (r)
16. A → (p, q, t)	B → (r)	C → (s)	D → (t)	
17. A → (r)	B → (p)	C → (s)	D → (t)	E → (q)
18. A → (p)	B → (p)	C → (q)	D → (s)	
19. A → (p)	B → (s)	C → (q)	D → (s)	
20. A → (r)	B → (p)	C → (s)	D → (q)	
21. A → (s)	B → (r)	C → (s)	D → (p)	

Integer/Numerical Answer Type Questions

1. 8	**2.** 79	**3.** 8	**4.** 5	**5.** 139
6. 41	**7.** 4	**8.** 68	**9.** 1	**10.** 4
11. 2	**12.** (a) 4, (b) 40441	**13.** 26206	**14.** 6	**15.** 6
16. 8	**17.** (a) 300, (b) 2, (c) 2	**18.** 154	**19.** 114	**20.** (a) 4, (b) 396
21. 8				

ARCHIVE: JEE MAIN

1. A	**2.** B	**3.** A	**4.** D	**5.** A	**6.** D	**7.** D	**8.** C	**9.** B	**10.** A
11. D	**12.** B	**13.** C	**14.** B	**15.** D	**16.** D	**17.** B	**18.** B	**19.** A	**20.** B
21. C	**22.** D	**23.** C	**24.** C	**25.** C	**26.** D				

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Single Correct Choice Type Problems

1. B	**2.** A	**3.** B	**4.** B	**5.** A	**6.** C	**7.** A	**8.** B	**9.** A	**10.** A
11. D	**12.** A	**13.** C	**14.** D	**15.** B	**16.** B	**17.** D	**18.** C	**19.** C	**20.** C
21. B									

Multiple Correct Choice Type Problems

1. C, D	**2.** A, B, D	**3.** A, C	**4.** A, D	**5.** A, D
6. A, D				

Reasoning Based Questions

1. B

Comprehension Type Questions

1. D	**2.** B	**3.** C	**4.** A	**5.** B	**6.** D	**7.** C	**8.** C	**9.** A

Integer/Numerical Answer Type Questions

1. 3	**2.** 7	**3.** 5	**4.** 6	**5.** 2	**6.** 2	**7.** 7