CHAPTER 27
ATOMS

FACT/DEFINITION TYPE QUESTIONS

1. The first model of atom was proposed by
   (a) Hans Geiger (b) Ernst Rutherford
   (c) J.J. Thomson (b) N.H.D Bohr
2. The empirical atom model was given by
   (a) J. J. Thomson (b) Rutherford
   (c) Niels Bohr (d) Sommerfeld
3. Which of the following statements is correct in case of Thomson's atomic model?
   (a) It explains the phenomenon of thermionic emission, photoelectric emission and ionisation.
   (b) It could not explain emission of line spectra by elements.
   (c) It could not explain scattering of α-particles
   (d) All of the above
4. Which one did Rutherford consider to be supported by the results of experiments in which α-particles were scattered by gold foil?
   (a) The nucleus of an atom is held together by forces which are much stronger than electrical or gravitational forces.
   (b) The force of repulsion between an atomic nucleus and an α-particle varies with distance according to inverse square law.
   (c) α-particles are nuclei of Helium atoms.
   (d) Atoms can exist with a series of discrete energy levels
5. According to the Rutherford's atomic model, the electrons inside the atom are
   (a) stationary (b) not stationary
   (c) centralized (d) None of these
6. According to classical theory, the circular path of an electron in Rutherford atom model is
   (a) spiral (b) circular
   (c) parabolic (d) straight line
7. Rutherford's α-particle experiment showed that the atoms have
   (a) Proton (b) Nucleus
   (c) Neutron (d) Electrons
8. Electrons in the atom are held to the nucleus by
   (a) coulomb's force (b) nuclear force
   (c) vander waal's force (d) gravitational force
9. The Rutherford α-particle experiment shows that most of the α-particles pass through almost unscattered while some are scattered through large angles. What information does it give about the structure of the atom?
   (a) Atom is hollow.
   (b) The whole mass of the atom is concentrated in a small centre called nucleus
   (c) Nucleus is positively charged
   (d) All of the above
10. In Rutherford's α -particle scattering experiment, what will be correct angle for α scattering for an impact parameter b = 0 ?
    (a) 90º (b) 270º (c) 0º (d) 180º
11. In the ground state in ...*A*... electrons are in stable equilibrium while in ...*B*... electrons always experiences a net force. Here, *A* and *B* refer to
    (a) Dalton's theory, Rutherford model
    (b) Rutherford's model, Bohr's model
    (c) Thomson's model, Rutherford's model
    (d) Rutherford's model, Thomson's model
12. The significant result deduced from the Rutherford's scattering experiment is that
    (a) whole of the positive charge is concentrated at the centre of atom
    (b) there are neutrons inside the nucleus
    (c) α-particles are helium nuclei
    (d) electrons are embedded in the atom
    (e) electrons are revolving around the nucleus
13. Electrons in the atom are held to the nucleus by
    (a) coulomb's force (b) nuclear force
    (c) vander waal's force (d) gravitational force
14. In a Rutherford scattering experiment when a projectile of charge Z_1 and mass M_1 approaches a target nucleus of charge Z_2 and mass M_2, the distance of closest approach is r_0. The energy of the projectile is
    (a) directly proportional to $Z_1 Z_2$
    (b) inversely proportional to Z_1
    (c) directly proportional to mass M_1
    (d) directly proportional to $M_1 \times M_2$
15. According to classical theory, Rutherford's atomic model is
    (a) stable (b) unstable
    (c) meta stable (d) both (a) and (b)
16. Rutherford's atomic model was unstable because
    (a) nuclei will break down
    (b) electrons do not remain in orbit
    (c) orbiting electrons radiate energy
    (d) electrons are repelled by the nucleus

17. The electrons of Rutherford's model would be expected to lose energy because, they
(a) move randomly
(b) jump on nucleus
(c) radiate electromagnetic waves
(d) escape from the atom

18. As one considers orbits with higher values of n in a hydrogen atom, the electric potential energy of the atom
(a) decreases (b) increases
(c) remains the same (d) does not increase

19. Which of the following parameters is the same for all hydrogen-like atoms and ions in their ground states?
(a) Radius of the orbit
(b) Speed of the electron
(c) Energy of the atom
(d) Orbital angular momentum of the electron

20. The angular speed of the electron in the n^{th} orbit of Bohr hydrogen atom is
(a) directly proportional to n
(b) inversely proportional to $\sqrt{n}$
(c) inversely proportional to n^2
(d) inversely proportional to n^3

21. According to Bohr's model of hydrogen atom
(a) the linear velocity of the electron is quantised.
(b) the angular velocity of the electron is quantised.
(c) the linear momentum of the electron is quantised.
(d) the angular momentum of the electron is quantised.

22. As the quantum number increases, the difference of energy between consecutive energy levels
(a) remain the same
(b) increases
(c) decreases
(d) sometimes increases and sometimes decreases.

23. Which of the following in a hydrogen atom is independent of the principal quantum number n? (The symbols have their usual meanings).
(a) νn (b) Er (c) En (d) νr

24. According to the Bohr theory of H-atom, the speed of the electron, its energy and the radius of its orbit varies with the principal quantum number n, respectively, as
(a) $\frac{1}{n}, n^2, \frac{1}{n^2}$ (b) $n, \frac{1}{n^2}, n^2$
(c) $n, \frac{1}{n^2}, \frac{1}{n^2}$ (d) $\frac{1}{n}, \frac{1}{n^2}, n^2$

25. In terms of Bohr radius r_0, the radius of the second Bohr orbit of a hydrogen atom is given by
(a) $4r_0$ (b) $8r_0$ (c) $\sqrt{2}r_0$ (d) $2r_0$

26. When hydrogen atom is in its first excited level, it's radius is
(a) four times, it ground state radius
(b) twice times, it ground state radius
(c) same times, it ground state radius
(d) half times, it ground state radius.

27. 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) $\frac{h}{4\pi}$

28. When an atomic gas or vapour is excited at low pressure, by passing an electric current through it then
(a) emission spectrum is observed
(b) absorption spectrucm is observed
(c) band spectrum is observed
(d) both (b) and (c)

29. The first spectral series was disscovered by
(a) Balmer (b) Lyman (c) Paschen (d) Pfund

30. When an electron jumps from the fourth orbit to the second orbit, one gets the
(a) second line of Paschen series
(b) second line of Balmer series
(c) first line of Pfund series
(d) second line of Lyman series

31. The Balmer series for the H-atom can be observed
(a) if we measure the frequencies of light emitted when an excited atom falls to the ground state
(b) if we measure the frequencies of light emitted due to transitions between excited states and the first excited state
(c) in any transition in a H-atom
(d) None of these

32. In Balmer series of emission spectrum of hydrogen, first four lines with different wavelength H_α H_β $H\gamma$ and H_δ are obtained. Which line has maximum frequency out of these?
(a) H_α (b) H_β (c) $H\gamma$ (d) H_δ

33. In which of the following series, does the 121.5 nm line of the spectrum of the hydrogen atom lie ?
(a) Lyman series (b) Balmer series
(c) Paschen series (d) Brackett series.

34. Which of the following series in the spectrum of hydrogen atom lies in the visible region of the electromagnetic spectrum?
(a) Paschen series (b) Balmer series
(c) Lyman series (d) Brackett series

35. The shortest wavelength in Balmer's series for Hydrogen atom is ...*A*... and this is obtained by substituting ...*B* ... in Balmer's formula. Here, *A* and *B* refer to
(a) 656.3 nm, $n = 3$ (b) 486.1 nm, $n = 4$
(c) 410.2 nm, $n = 5$ (d) 364.6 nm, $n = \infty$

36. As an electron makes a transition from an excited state to the ground state of a hydrogen - like atom/ion
(a) kinetic energy decreases, potential energy increases but total energy remains same
(b) kinetic energy and total energy decrease but potential energy increases
(c) its kinetic energy increases but potential energy and total energy decrease
(d) kinetic energy, potential energy and total energy decrease

37. Which of the following series in the spectrum of hydrogen atom lies in the visible region of the electromagnetic spectrum?
(a) Paschen series (b) Balmer series
(c) Lyman series (d) Brackett series

38. In a hydrogen atom, which of the following electronic transitions would involve the maximum energy change
(a) n = 2 to n = 1 (b) n = 3 to n = 1
(c) n = 4 to n = 2 (d) n = 3 to n = 2

39. Hydrogen atom excites energy level from fundamental state to n = 3. Number of spectral lines according to Bohr, is
(a) 4 (b) 3 (c) 1 (d) 2

40. 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) $5 \to 4$

41. For a given value of n, the number of electrons in an orbit is
(a) n (b) n^2 (c) $2n^2$ (d) 2n

42. Bohr's atom model is the modification of Rutherford's atom model by the application of
(a) newton's theory (b) huygen's theory
(c) maxwell's theory (d) planck's quantum theory

43. In Bohr's model electrons are revolving in a circular orbits around the nucleus called as
(a) stationary orbits (b) non radiating orbits
(c) Bohr's orbits (d) all of these

44. According to Bohr's theory of H atom, an electron can revolve around a proton indefinitely, if its path is
(a) a perfect circle of any radius
(b) a circle of an allowed radius
(c) a circle of constantly decreasing radius
(d) an ellipse with fixed focus

45. According to Bohr the difference between the energies of the electron in the two orbits is equal to
(a) h ν (b) hc/λ
(c) both (a) and (b) (d) neither (a) nor (b)

46. The angular momentum of electrons in an atom produces
(a) magnetic moment (b) ZEEMAN effect
(c) light (d) nuclear fission

47. According to Planck's quantum theory any electromagnetic radiation is
(a) continuously emitted
(b) continuously absorbed
(c) emitted or absorbed in discrete units
(d) None of these

48. The radius of 'n'th Bohr's orbit of H atom is given by
(a) $\frac{\epsilon_0 n^2h^2}{\pi me^2}$ (b) $\frac{n^2h^2}{\epsilon_0 \pi me^2}$ (c) $\frac{\pi me^2}{\epsilon_0 n^2h^2}$ (d) n^2h^2

49. The linear speed of an electron, in Bohr's orbit is given by
(a) $\frac{e^2}{h}$ (b) $\frac{e^2}{2\epsilon_0 nh}$ (c) $\frac{2\epsilon_0 nh}{e}$ (d) $2\hat{I}_0 h$

50. Angular speed of an electron in a Bohr's orbit is given by
(a) $\omega = \frac{\pi me^4}{2\epsilon_0^2 n^3h^3}$ (b) $\omega = \frac{4\epsilon_0^2 n^3h^3}{me^4}$
(c) $\omega = \frac{me^4}{4\epsilon_0^2 n^3h^3}$ (d) all of these

51. Period of revolution of electron in the n^{th} Bohr's orbit is given by
(a) $T = \frac{4\epsilon_0^2 n^3h^3}{me^4}$ (b) $T = 4\epsilon_0^2 n^3h^3$
(c) $T = me^4 n$ (d) $T = 2\pi$

52. Frequency of revolution of electron in the n^{th} Bohr's orbit is given by
(a) $f = \frac{me^4}{4\epsilon_0^2 n^3h^3}$ (b) $f = 4\epsilon_0^2 n^3h^3$
(c) $f = \frac{me^4}{4\epsilon_0^2 h^2}$ (d) $f = \frac{me^4}{\epsilon_0 n}$

53. The total energy of the electron in the Bohr's orbit is given by
(a) $E = -\frac{me^4}{8\epsilon_0^2 n^2h^2}$ (b) $E = \frac{1}{8\pi\epsilon_0}\frac{e^2}{r}$
(c) both (a) and (b) (d) neither (a) nor (b)

54. If 'r' is the radius of the lowest orbit of Bohr's model of H-atom, then the radius of n^{th} orbit is
(a) $r n^2$ (b) 2r
(c) n^2/r (d) r n

55. The ratio of radii of the first three Bohr orbits is
(a) $1 : \frac{1}{2} : \frac{1}{3}$ (b) 1 : 2 : 3 (c) 1 : 4 : 9 (d) 1 : 8 : 27

56. The speed of an electron, in the orbit of a H-atom, in the ground state is
(a) c (b) $\frac{c}{2}$ (c) $\frac{c}{10}$ (d) $\frac{c}{137}$

57. The speed of electron in first Bohr orbit is c/137. The speed of electron in second Bohr orbit will be
(a) $\frac{2c}{137}$ (b) $\frac{4c}{137}$ (c) $\frac{c}{274}$ (d) $\frac{c}{548}$

58. If the angular momentum of an electron in an orbit is J then the K.E. of the electron in that orbit is
(a) $\frac{J^2}{2mr^2}$ (b) $\frac{Jv}{r}$ (c) $\frac{J^2}{2m}$ (d) $\frac{J^2}{2\pi}$

59. If the frequency of revolution of electron in an orbit in H atom is n then the equivalent current is
(a) $\frac{2\pi re}{n}$ (b) $\frac{en}{2\pi r}$ (c) $e^2 \pi n$ (d) en

60. In Bohr model of hydrogen atom, let P.E. represents potential energy and T.E. represents the total energy. In going to a higher level.
(a) P. E. decreases, T.E. increases
(b) P. E. increases, T.E. decreases
(c) P. E. decreases, T.E. decreases
(d) P. E. increases, T.E. increases

61. The wavelength of a spectral line emitted due to the transition of electron from outer stationary orbit to inner stationary orbit is given by
(a) $\frac{1}{\lambda} = R\left(\frac{1}{P^2} - \frac{1}{n^2}\right)$ (b) $\lambda = R\left(\frac{1}{P^2} - \frac{1}{n^2}\right)$
(c) $\lambda = R\left(\frac{1}{P^2}\right)$ (d) $\frac{1}{\lambda} = R\frac{1}{n^2}$

62. An electron makes a transition from outer orbit (n = 4) to the inner orbit (p = 2) of a hydrogen atom. The wave number of the emitted radiations is
(a) $\frac{2R}{16}$ (b) $\frac{3R}{16}$ (c) $\frac{4R}{16}$ (d) $\frac{5R}{16}$

63. Rydberg constant R is equal to

(a) $\frac{me^2}{8\epsilon_0^2 ch^3}$ (b) $\frac{me^4}{8\epsilon_0^2 ch^3}$

(c) $\frac{m^2e^4}{8\epsilon_0^2 ch^3}$ (d) $\frac{m^4e^4}{8\epsilon_0^2 ch^3}$

64. Which of the following are in the ascending order of wavelength?
(a) H_α, H_β and H_γ lines of Balmer series
(b) Lyman limit, Balmer limit
(c) Violet, blue, yellow, red colours in solar spectrum
(d) both (b) and (c)

65. Rydberg's constant is
(a) same for all elements
(b) different for different elements
(c) a universal constants
(d) is different for lighter elements but same for heavier elements

66. The Lyman transitions involve
(a) largest changes of energy
(b) smallest changes of energy
(c) largest changes of potential energy
(d) smallest changes of potential energy

67. The series limit wavelength of the Balmer series for the hydrogen atom is

(a) $\frac{1}{R}$ (b) $\frac{4}{R}$ (c) $\frac{9}{R}$ (d) $\frac{16}{R}$

68. If R is the Rydberg's constant, the energy of an electron in the ground state H atom is

(a) $\frac{Rc}{h}$ (b) $\frac{-1}{Rhc}$ (c) $-Rhc$ (d) $\frac{vc}{R}$

69. Balmer series lies in which spectrum?
(a) visible
(b) ultraviolet
(c) infrared
(d) partially visible, partially infrared

70. Maximum energy evolved during which of the following transition?
(a) n = 1 to n = 2 (b) n = 2 to n = 1
(c) n = 2 to n = 6 (d) n = 6 to n = 2

STATEMENT TYPE QUESTIONS

71. Rutherford's nuclear model could not explain
I. Why atoms emit light of only discrete wavelengths
II. How could an atom as simple as hydrogen consisting of a single electron and a single proton, emit a complex spectrum of specific wavelengths.
(a) I only (b) II only
(c) I and II (d) None of these

72. Rutherford's α-particle scattering experiment concludes that
I. there is a heavy mass at centre
II. electrons are revolving around the nucleus
(a) I only (b) II only
(c) I and II (d) None of these

73. The observations of Geiger–Marsden experiment are
I. many of α particles pass straight through the gold foil.
II. only about 0.14% of α-particles scatter by more than 1°
III. about 1 in 8000 of α-particles is deflected more than 90°.
IV. very few particles are reflected back.
(a) I, II and IV (b) I, II and III
(c) II, III and IV (d) I, II III and IV

74. Trajectroy of an α–particle in Geiger–Marsden experiment is explained by using
I. Coulomb's law II. Newton's law
III. Gauss's law IV. Faraday's law.
(a) I and II (b) I and III (c) I and IV (d) I, II and IV

75. Bohr's atomic model assume that
I. the nucleus is of infinite mass and is at rest.
II. electrons in a quantised orbit will not radiate the energy.
III. mass of electrons remains constant during revolution.
IV. emission or absorption of energy results to transition of electron from one orbit to another. Choose the correct option from the codes given below.
(a) Only I (b) I and II
(c) I, III and II (d) I, II, III and IV

76. Which of the following statements are true regarding Bohr's model of hydrogen atom?
I. Orbiting speed of electron decreases as it shifts to discrete orbits away from the nucleus
II. Radii of allowed orbits of electron are proportional to the principal quantum number
III. Frequency with which electrons orbit around the nucleus in discrete orbits is inversely proportional to the cube of principal quantum number
IV. Binding force with which the electron is bound to the nucleus increases as it shifts to outer orbits
(a) I and II (b) II and IV
(c) I, II and III (d) II, III and IV

MATCHING TYPE QUESTIONS

77. Match the Column-I and Column-II.

Column – I	Column – II
(A) J.J. Thomson	(1) Nuclear model of the atom
(B) E. Rutherford	(2) Plum pudding model of the atom
(C) Franck-Hertz	(3) Explanation of the hydrogen spectrum
(D) Nills Bohr	(4) Existence of discrete energy levels in an atom

(a) (A) → (4); (B) → (1); (C) → (3); (D) → (2)
(b) (A) → (4); (B) → (1); (C) → (2); (D) → (3)
(c) (A) → (2); (B) → (1); (C) → (4); (D) → (3)
(d) (A) → (3); (B) → (2); (C) → (4); (D) → (3)

78. Consider Bohr's model to be valid for a hydrogen like atom with atomic number Z. Match quantities given in Column -I to those given in Column II.

Column – I	Column – II
(A) $\frac{Z^3}{n^5}$	(1) Angular speed
(B) $\frac{Z^2}{n^2}$	(2) Magnetic field at the centre due to revolution of electron

(C) $\frac{Z^2}{n^3}$ (3) Potential energy of an electron in nth orbit

(D) $\frac{Z}{n}$ (4) Frequency of revolution of electron

(a) (A) → (1); (B) → (3); (C) → (2); (D) → (4)
(b) (A) → (4); (B) → (2); (C) → (1); (D) → (3)
(c) (A) → (3,4); (B) → (2,3); (C) → (1,2); (D) → (1)
(d) (A) → (1); (B) → (2); (C) → (3); (D) → (4)

79. Match the following Column II gives nature of image formed in various cases given in column I

Column – I	Column – II
(A) $n = 5$ to $n = 2$	(1) Lyman series
(B) $n = 8$ to $n = 4$	(2) Brackett series
(C) $n = 3$ to $n = 1$	(3) Paschen
(D) $n = 4$ to $n = 3$	(4) Balmer

(a) (A) → (2); (B) → (3); (C) → (1); (D) → (4)
(b) (A) → (4); (B) → (2); (C) → (1); (D) → (3)
(c) (A) → (3); (B) → (2); (C) → (4); (D) → (1,4)
(d) (A) → (1,3); (B) → (4); (C) → (3); (D) → (1)

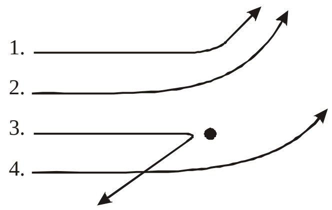
80. Match the Column-I and Column-II.

Column – I	Column – II
(A) Radius of nth orbit	(1) $\frac{2\pi kze^2}{nh}$
(B) Velocity of electron in nth orbit	(2) $\frac{-kze^2}{rh}$
(C) Potential energy in nth orbit	(3) $\frac{kze^2}{2rh}$
(D) Kinetic energy in nth orbit	(4) $\frac{n^2h^2}{4\pi kze^2 m}$

(a) (A) → (4); (B) → (1); (C) → (2); (D) → (3)
(b) (A) → (4); (B) → (3); (C) → (1); (D) → (2)
(c) (A) → (2); (B) → (1); (C) → (4); (D) → (3)
(d) (A) → (4); (B) → (2); (C) → (1); (D) → (3)

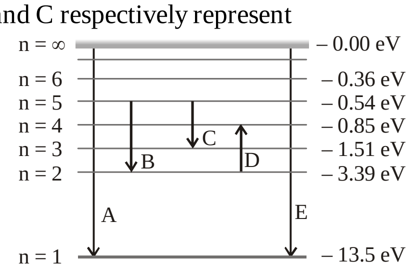
DIAGRAM TYPE QUESTIONS

81. The diagram shows the path of four α-particles of the same energy being scattered by the nucleus of an atom simulateneously which of those is not physically possible?



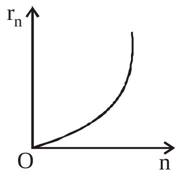
(a) 3 and 4 (b) 2 and 3 (c) 1 and 4 (d) 4 only

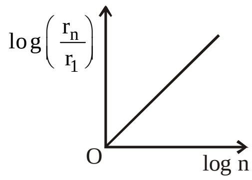
82. The energy levels of the hydrogen spectrum is shown in figure. There are some transitions A, B, C, D and E. Transition A, B and C respectively represent

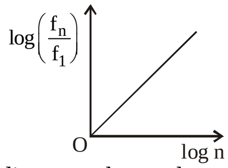


(a) first member of Lyman series, third spectral line of Balmer series and the second spectral line of Paschen series
(b) ionization potential of hydrogen, second spectral line of Balmer series, third spectral line of Paschen series
(c) series limit of Lyman series, third spectral line of Balmer series and second spectral line of Paschen series
(d) series limit of Lyman series, second spectral line of Balmer series and third spectral line of Paschen series

83. If in hydrogen atom, radius of nth Bohr orbit is r_n, frequency of revolution of electron in nth orbit is f_n, choose the correct option.

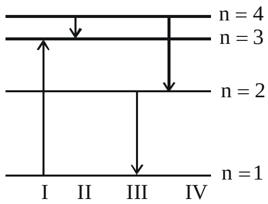
(a) 

(b) 

(c) 

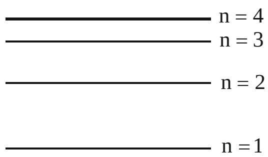
(d) Both (a) and (b)

84. 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) 4 (b) 3 (c) 2 (d) 1

85. Four lowest energy levels of H-atom are shown in the figure. The number of possible emission lines would be



(a) 3 (b) 4 (c) 5 (d) 6

ASSERTION- REASON TYPE QUESTIONS

Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

86. **Assertion :** The force of repulsion between atomic nucleus and α-particle varies with distance according to inverse square law.
Reason : Rutherford did α-particle scattering experiment.

87. **Assertion :** According to classical theory the proposed path of an electron in Rutherford atom model will be parabolic.
Reason : According to electromagnetic theory an accelerated particle continuously emits radiation.

88. **Assertion :** Bohr had to postulate that the electrons in stationary orbits around the nucleus do not radiate.
Reason: According to classical physics all moving electrons radiate.

89. **Assertion :** Electrons in the atom are held due to coulomb forces.
Reason : The atom is stable only because the centripetal force due to Coulomb's law is balanced by the centrifugal force.

90. **Assertion :** Hydrogen atom consists of only one electron but its emission spectrum has many lines.
Reason : Only Lyman series is found in the absorption sepectrum of hydrogen atom whereas in the emission spectrum, all the series are found.

91. **Assertion :** Balmer series lies in the visible region of electromagnetic spectrum.
Reason : $\frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{n^2}\right]$ where n = 3, 4, 5.

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

93. **Assertion :** In Lyman series, the ratio of minimum and maximum wavelength is $\frac{3}{4}$.
Reason : Lyman series constitute spectral lines corresponding to transition from higher energy to ground state of hydrogen atom.

CRITICAL THINKING TYPE QUESTIONS

94. Ionization energy of a hydrogen-like ion A is greater than that of another hydrogen-like ion B. If r, u, E and L represent the radius of the orbit, speed of the electron, energy of the atom and orbital angular momentum of the electron respectively then in ground state
(a) $r_A > r_B$ (b) $u_A > u_B$
(c) $E_A > E_B$ (d) $L_A > L_B$

95. In the Bohr 's model of a hydrogen atom, the centripetal force is furnished by the coulomb attraction between the proton and the electron. If a_0 is the radius of the ground state orbit, m is the mass and e is charge on the electron and $\in_0$ is the vacuum permittivity, the speed of the electron is
(a) Zero (b) $\frac{e}{\sqrt{\in_0 a_0 m}}$
(c) $\frac{e}{\sqrt{4\pi\in_0 a_0 m}}$ (d) $\sqrt{\frac{4\pi\in_0 a_0 m}{e}}$

96. In a hydrogen atom following the Bohr's postulates the product of linear momentum and angular momentum is proportional to $(n)^x$ where 'n' is the orbit number. Then 'x' is
(a) 0 (b) 2 (c) –2 (d) 1

97. Doubly ionised helium atom and hydrogen ions are accelerated, from rest, through the same potential difference. The ratio of final velocities of helium and hydrogen is
(a) $1:\sqrt{2}$ (b) $\sqrt{2}:1$ (c) $1:2$ (d) $2:1$

98. The energy of a hydrogen atom in the ground state is – 13.6 eV. The energy of a He^+ ion in the first excited state will be
(a) –13.6 eV (b) – 27.2 eV (c) – 54.4 eV (d) – 6.8 eV

99. Out of the following which one is not a possible energy for a photon to be emitted by hydrogen atom according to Bohr's atomic model?
(a) 1.9 eV (b) 11.1 eV (c) 13.6 eV (d) 0.65 eV

100. Electron in hydrogen atom first jumps from third excited state to second excited state and then from second excited to the first excited state. The ratio of the wavelength $\lambda_1 : \lambda_2$ emitted in the two cases is
(a) 7/5 (b) 27/20 (c) 27/5 (d) 20/7

101. An electron of a stationary hydrogen atom passes from the fifth energy level to the ground level. The velocity that the atom acquired as a result of photon emission will be
(a) $\frac{24hR}{25m}$ (b) $\frac{25hR}{24m}$ (c) $\frac{25m}{24hR}$ (d) $\frac{24m}{25hR}$

102. If 13.6 eV energy is required to ionize the hydrogen atom, then the energy required to remove an electron from n = 2 is
(a) 10.2 eV (b) 0 eV (c) 3.4 eV (d) 6.8 eV.

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

104. K_α wavelength emitted by an atom λ is given 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

105. In an atom, the two electrons move round the nucleus in circular orbits of radii R and 4R. The ratio of the time taken by them to complete one revolution is
(a) 1/4 (b) 4/1 (c) 8/1 (d) 1/8

106. The ratio of the energies of the hydrogen atom in its first to second excited states is
(a) 1/4 (b) 4/9 (c) 9/4 (d) 4

107. In a hypothetical Bohr hydrogen atom, the mass of the electron is doubled. The energy E'_0 and radius r'_0 of the first orbit will be (r_0 is the Bohr radius)
(a) –11.2 eV (b) –6.8 eV (c) –13.6 eV (d) –27.2 eV

108. A 15.0 eV photon collides with and ionizes a hydrogen atom. If the atom was originally in the ground state (ionization potential =13.6 eV), what is the kinetic energy of the ejected electron?
(a) 1.4 eV (b) 13.6 eV (c) 15.0 eV (d) 28.6 eV

109. If the k_α radiation of Mo (Z = 42) has a wavelength of 0.71Å. Calculate the wavelength of the corresponding radiation of Cu (Z = 29).
(a) 1.52Å (b) 2.52Å (c) 0.52Å (d) 4.52Å

110. Excitation energy of a hydrogen like ion in its excitation state is 40.8 eV. Energy needed to remove the electron from the ion in ground state is
(a) 54.4 eV (b) 13.6 eV (c) 40.8 eV (d) 27.2 eV

111. A hydrogen atom in its ground state absorbs 10.2 eV of energy. The orbital angular momentum is increased by
(a) 1.05×10^{-34} J-s (b) 3.16×10^{-34} J-s
(c) 2.11×10^{-34} J-s (d) 4.22×10^{-34} J-s

112. If the atom ${}_{100}Fm^{257}$ follows the Bohr model and the radius of ${}_{100}Fm^{257}$ is *n* times the Bohr radius, then find *n*.
(a) 100 (b) 200 (c) 4 (d) 1/4

113. The ratio of longest wavelengths corresponding to Lyman and Blamer series in hydrogen spectrum is
(a) $\frac{3}{23}$ (b) $\frac{7}{29}$ (c) $\frac{9}{31}$ (d) $\frac{5}{27}$

114. 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) 2 (b) 3 (c) 5 (d) 6

115. The wavelength of the first spectral line in the Balmer series of hydrogen atom is 6561 A°. The wavelength of the second spectral line in the Balmer series of singly-ionized helium atom is
(a) 1215 A° (b) 1640 A° (c) 2430 A° (d) 4687 A°

116. The extreme wavelengths of Paschen series are
(a) 0.365 μm and 0.565 μm (b) 0.818 μm and 1.89 μm
(c) 1.45 μm and 4.04 μm (d) 2.27 μm and 7.43 μm

117. The third line of Balmer series of an ion equivalnet to hydrogen atom has wavelength of 108.5 nm. The ground state energy of an electron of this ion will be
(a) 3.4 eV (b) 13.6 eV (c) 54.4 eV (d) 122.4 eV

118. The first line of Balmer series has wavelength 6563 Å. What will be the wavelength of the first member of Lyman series
(a) 1215.4 Å (b) 2500 Å (c) 7500 Å (d) 600 Å

119. The energy of electron in the nth orbit of hydrogen atom is expressed as $E_n = \frac{-13.6}{n^2}$ eV. The shortest and longest wavelength of Lyman series will be
(a) 910 Å, 1213 Å (b) 5463 Å, 7858 Å
(c) 1315 Å, 1530 Å (d) None of these

120. Taking Rydberg's constant $R_H = 1.097 \times 10^7$m, first and second wavelength of Balmer series in hydrogen spectrum is
(a) 2000 Å, 3000 Å (b) 1575 Å, 2960 Å
(c) 6529 Å, 4280 Å (d) 6563 Å, 4861 Å

121. If υ_1 is the frequency of the series limit of Lyman series, υ_2 is the frequency of the first line of Lyman series and υ_3 is the frequency of the series limit of the Balmer series then
(a) $\upsilon_1 - \upsilon_2 = \upsilon_3$ (b) $\upsilon_1 = \upsilon_2 - \upsilon_3$
(c) $\frac{1}{\upsilon_2} = \frac{1}{\upsilon_1} + \frac{1}{\upsilon_3}$ (d) $\frac{1}{\upsilon_1} = \frac{1}{\upsilon_2} + \frac{1}{\upsilon_3}$

122. The wavelength of the first line of Lyman series for hydrogen atom is equal to that of the second line of Balmer series for a hydrogen like ion. The atomic number Z of hydrogen like ion is
(a) 3 (b) 4 (c) 1 (d) 2

123. According to Bohr's theory, the wave number of last line of Balmer series is (Given $R = 1.1 \times 10^7\ m^{-1}$)
(a) $5.5 \times 10^5\ m^{-1}$ (b) $4.4 \times 10^7\ m^{-1}$
(c) $2.75 \times 10^6\ m^{-1}$ (d) $2.75 \times 10^8\ m^{-1}$

124. The first line of the Lyman series in a hydrogen spectrum has a wavelength of 1210 Å. The corresponding line of a hydrogen-like atom of Z = 11 is equal to
(a) 4000 Å (b) 100 Å (c) 40 Å (d) 10 Å

125. What is the ratio of the shortest wavelength of the Balmer series to the shortest wavelength to the Lyman series ?
(a) 4 : 1 (b) 4 : 3 (c) 4 : 9 (d) 5 : 9

126. If the wavelength of the first line of the Balmer series of hydrogen is 6561 Å, the wavelength of the second line of the series should be
(a) 13122 Å (b) 3280 Å (c) 4860 Å (d) 2187 Å

127. The radiation corresponding to $3 \rightarrow 2$ transition of hydrogen atom falls on a metal surface to produce photoelectrons. These electrons are made to enter a magnetic field of 3×10^{-4} T. If the radius of the largest circular path followed by these electrons is 10.0 mm, the work function of the metal is close to:
(a) 1.8 eV (b) 1.1 eV (c) 0.8 eV (d) 1.6 eV

128. Hydrogen $\left({}_1H^1\right)$, Deuterium $\left({}_1H^2\right)$, singly ionised Helium $\left({}_2He^4\right)^+$ and doubly ionised lithium $\left({}_3Li^6\right)^{++}$ all have one electron around the nucleus. Consider an electron transition from n = 2 to n = 1. If the wavelengths of emitted radiation are $\lambda_1, \lambda_2, \lambda_3$ and λ_4 respectively then approximately which one of the following is correct?
(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) $\lambda_1 = 2\lambda_2 = 3\lambda_3 = 4\lambda_4$

129. The energy of an excited state of H atom is –0.85 eV. What will be the quantum number of the orbit, if the ground state energy for hydrogen is –13.6 eV?
(a) 4 (b) 3 (c) 2 (d) 1

130. An electron jumps from the 4th orbit to the 2nd orbit of hydrogen atom. Given the Rydberg's constant $R = 10^5 cm^{-1}$. The frequency in Hz of the emitted radiation is
(a) $\frac{3}{16} \times 10^5$ (b) $\frac{3}{16} \times 10^{15}$
(c) $\frac{9}{16} \times 10^{15}$ (d) $\frac{3}{4} \times 10^{15}$

131. The longest wavelength of the Balmer series is 6563 Å. The Rydberg's constant is
(a) $1.09 \times 10^5\ m^{-1}$ (b) $1.09 \times 10^6\ m^{-1}$
(c) $1.09 \times 10^7\ m^{-1}$ (d) $1.09 \times 10^8\ m^{-1}$

132. If 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. The principle quantum number of the final orbit is
(a) n = 4 (b) n = 3 (c) n = 2 (d) n = 16

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

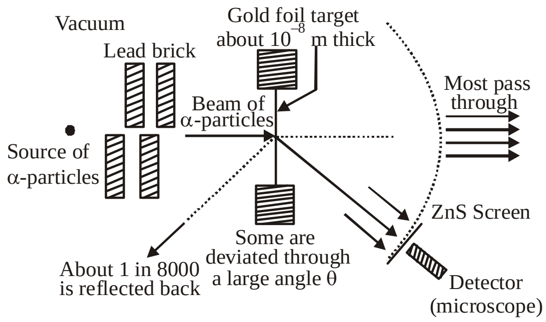
1. (c) 2. (a) 3. (c) 4. (b) 5. (b) 6. (a)
7. (b) 8. (a) 9. (d)
10. (d) When b = 0, scattering angle, $\theta = 180^o$
11. (c) In Thomson's modle, electrons are in stable equilibrium i.e., no force or no net force, while, in Rutherford's model, there is always a centripetal force acting on electron towards nucleus.
12. (a) The significant result deduced from the Rutherford's scattering is that whole of the positive charge is concentrated at the centre of atom i.e. nucleus.
13. (a)
14. (a) The kinetic energy of the projectile is given by
$$\frac{1}{2}mv^2 = \frac{Ze(2e)}{4\pi\varepsilon_0 r_0} = \frac{Z_1 Z_2}{4\pi\varepsilon_0 r_0}$$
Thus energy of the projectile is directly proportional to Z_1, Z_2
15. (d) 16. (b) 17. (c) 18. (b)
19. (d) The orbital angular momentum of electron is independent of mass of orbiting particle & mass of nuclei.
20. (d) 21. (d) 22. (c)
23. (b) $v = \frac{ke^2}{n\hbar}, r = \frac{n^2\hbar^2}{mke^2}, \nu = \frac{1}{T} = \frac{v}{2\pi r}, E = \frac{me^4}{8\varepsilon_0 n^2 h^2}$
24. (d)
25. (a) As $r \propto n^2$, therefore, radius of 2nd Bohr's orbit = $4\,r_0$
26. (a) $r_n = r_o.n^2$, where r_o is radius of ground-state & r_n is radius of n^{th} state. (For first excited state n = 2).
27. (c) According to Bohr's theory,
Angular momentum, $mvr = \frac{nh}{2\pi}$
So in ground state, angular momentum = $\frac{h}{2\pi}$.
28. (a)
29. (a) In 1885, the first spectral series were observed by a Swedish school teacher Johann Jakob Balmer, This series is called the Balmer series.
30. (b) Jump to second orbit leads to Balmer series. When an electron Jumps from 4^{th} orbit to 2^{nd} orbit shall give rise to second line of Balmer series.
31. (b)
32. (d) Since out of the given four lines H_δ line has smallest wavelength. Hence the frequency of this line will be maximum.
33. (a) Since 121.5 nm line of spectrum of hydrogen atom lies in ultraviolet region, therefore it is Lyman series.
34. (b) Transition from higher states to n = 2 lead to emission of radiation with wavelengths 656.3 nm and 365.0 nm. These wavelengths fall in the visible region and constitute the Balmer series.
35. (d) The shortest wavelength occurs when an electron makes a transitions from $n = \infty$ to $n = 2$ state.
$$\therefore \quad \frac{1}{\lambda_{min}} = R\left(\frac{1}{2^2} - \frac{1}{\infty}\right) = \frac{R}{4}$$
36. (c) $U = -K\frac{ze^2}{r}$; $T.E = -\frac{k}{2}\frac{ze^2}{r}$
K.E = $\frac{k}{2}\frac{ze^2}{r}$. Here r decreases
37. (b) Transition from higher states to n = 2 lead to emission of radiation with wavelengths 656.3 nm and 365.0 nm. These wavelengths fall in the visible region and constitute the Balmer series.
38. (b)
39. (b) No. of lines $N_E = \frac{n(n-1)}{2} = \frac{3(3-1)}{2} = 3$
40. (d) $\lambda_{IR} > \lambda_{UV}$ also wavelength of emitted radiation $\lambda \propto \frac{1}{\Delta E}$.
41. (c) 42. (d) 43. (d) 44. (b) 45. (c) 46. (a)
47. (c) 48 (a) 49. (b) 50. (a) 51. (a) 52. (a)
53. (c) 54. (a) 55. (c) 56. (d)
57. (c) $v_n = \frac{v_1}{n}$
$$\therefore\ v_2 = \frac{c}{137\times 2} = \frac{c}{274}$$
58. (a) Angular momentum = mrv = J
$$\therefore\ v = \frac{J}{mr}$$
K. E. of electron = $\frac{1}{2}mv^2 = \frac{1}{2}m\left(\frac{J}{mr}\right)^2 = \frac{J^2}{2mr^2}$
59. (d) $I = \frac{q}{t} = qn = en \qquad \left(\because \frac{1}{t} = n\ \&\ q = e\right)$
60. (d) 61. (a) 62. (b) 63. (b) 64. (d) 65. (b)
66. (a)
67. (b) For series limit of Balmer series, p = 2 and n = ∞.
$$\frac{1}{\lambda} = R\left(\frac{1}{p^2} - \frac{1}{n^2}\right) = R\left(\frac{1}{4} - \frac{1}{\infty}\right)$$
$$\therefore \quad \lambda = \frac{4}{R}$$
68. (c) 69. (a) 70. (b)

STATEMENT TYPE QUESTIONS

71. (c)

72. (a) Heavy mass at the centre of atom is responsible for large angle scattering of alpha particles

73. (d) Many of the α-particles pass through the foil. It means that they do not suffer any collisions.



Schematic arrangement of the Geiger-Marsden experiment

Only about 0.14% of the incident α-particles scatter by more than 1° and about 1 in 8000 deflected by more than 90°.32.

74. (a) Trajectory of α-particle can be experienced by using Coulomb's law and Newton's II^{nd} law of motion.

75. (d) All assumptions are necessary for Bohr's model.

76. (a) Orbital speed varies inversely as the radius of the orbit.

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

MATCHING TYPE QUESTIONS

77. (c) (A) $\to$ (2); (B) $\to$ (1); (C) $\to$ (4); (D) $\to$ (3)

78. (a) (A) $\to$ (1); (B) $\to$ (3); (C) $\to$ (2); (D) $\to$ (4)

79. (b) (A) $\to$ (4); (B) $\to$ (2); (C) $\to$ (1); (D) $\to$ (3)

80. (a) (A) $\to$ (4); (B) $\to$ (1); (C) $\to$ (2); (D) $\to$ (3)

DIAGRAM TYPE QUESTIONS

81. (d) α-particle cannot be attracted by the nucleus.

82. (c) Transition A ($n = \infty$ to 1) : Series lime of Lyman series
Transition B ($n = 5$ to $n = 2$) : Third spectral lien of Balmer series
Transition C ($n = 5$ to $n = 3$) : Second spectral line of Paschen series

83. (d) Radius of n^{th} orbit $r_n \propto n^2$, graph between r_n and n is a parabola. Also, $\frac{r_n}{r_1} = \left(\frac{n}{1}\right)^2 \Rightarrow \log_e\left(\frac{r_n}{r_1}\right) = 2\log_e(n)$

Comparing this equation with $y = mx + c$,

Graph between $\log_e\left(\frac{r_n}{r_1}\right)$ and $\log_e(n)$ will be a straight line, passing from origin.

Similarly it can be proved that graph between $\log_e\left(\frac{f_n}{f_1}\right)$ and $\log_e n$ is a straight line. But with negative slops.

84. (b)

85. (d) Number of possible emission lines $= \frac{n(n-1)}{2}$

ASSERTION- REASON TYPE QUESTIONS

86. (b) Rutherford confirmed that the repulsive force of α–particle due to nucleus varies with distance according to inverse square law and that the positive charges are concentrated at the centre and not distributed throughout the atom.

87. (d) According to classical electromagnetic theory, an accelerated charged particle continuously emits radiation. As electrons revolving in circular paths are constantly experiencing centripetal acceleration, hence they will be losing their energy continuously and the orbital radius will go on decreasing, form spiral and finally the electron will fall in the nucleus.

88. (b) Bohr postulated that electrons in stationary orbits around the nucleus do not radiate.
This is the one of Bohr's postulate, According to this the moving electrons radiates only when they go from one orbit to the next lower orbit.

89. (c) According to postulates of Bohr's atom model the electron revolves around the nucleus in fixed orbit of definite radii. As long as the electron is in a certain orbit it does not radiate any energy.

90. (b) When the atom gets appropriate energy from outside, then this electron rises to some higher energy level. Now it can return either directly to the lower energy level or come to the lowest energy level after passing through other lower energy levels hence all possible transitions take place in the source and many lines are seen in the spectrum.

91. (a) The wavelength in Balmer series is given by

$$\frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{n^2}\right], \quad n = 3, 4, 5, ...$$

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

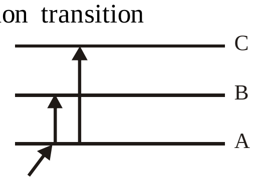
$$\lambda_{max} = \frac{36}{5R} = \frac{36}{5 \times 1.097 \times 10^7} = 6563 \text{ Å}$$

and $\frac{1}{\lambda_{min}} = R\left[\frac{1}{2^2} - \frac{1}{\infty^2}\right]$

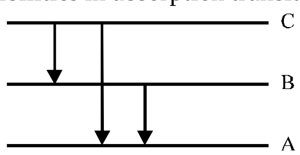
$$\lambda_{min} = \frac{4}{R} = \frac{36}{1.097 \times 10^7} = 3646 \text{ Å}$$

The wavelength 6563 Å and 3646 Å lie in visible region. Therefore, Balmer series lies in visible region.

92. (a) Absorption transition



Two possibilities in absorption transition.



Three possibilities in emission transition.
Therefore, absorption transition < emission.

93. **(b)**

CRITICAL THINKING TYPE QUESTIONS

94. **(b)**

95. **(c)** Centripetal force = force of attraction of nucleus on electron

$$\frac{mv^2}{a_0} = \frac{1}{4\pi\varepsilon_o}\frac{e^2}{a_0^2} \qquad v = \frac{e}{\sqrt{4\pi\varepsilon_o\, m a_0}}$$

96. **(a)**

97. **(a)** $qV = \frac{1}{2}mv^2$ or $v = \sqrt{\frac{2qV}{m}}$ i.e. $v \propto \sqrt{\frac{q}{m}}$

$$\therefore \frac{v_{He}}{v_H} = \sqrt{\frac{q_{He}}{q_H}\times\frac{m_H}{m_{He}}} = \sqrt{\frac{2e}{e}\times\frac{m}{4m}} = \frac{1}{\sqrt{2}}$$

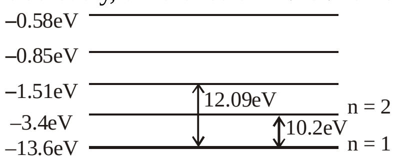
98. **(a)** Energy of a H-like atom in it's n^{th} state is given by

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

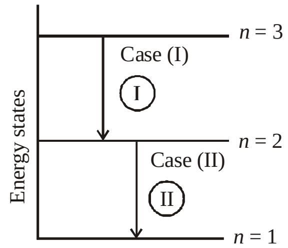
For, first excited state of He^+, n = 2, Z = 2

$$\therefore E_{He^+} = -\frac{4}{2^2}\times 13.6 = -13.6\,eV$$

99. **(b)** Obviously, difference of 11.1eV is not possible.



100. **(c)**



The wave number $(\bar{v})$ of the radiation $= \frac{1}{\lambda}$

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

Now for case (I) $n_1 = 3, n_2 = 2$

$$\frac{1}{\lambda_1} = R_\infty\left[\frac{1}{9}\frac{-1}{4}\right], R_\infty = \text{ Rydberg constant}$$

$$\frac{1}{\lambda_1} = R_\infty\left[\frac{4-9}{36}\right] = \frac{-5R_\infty}{36} \Rightarrow \lambda_1 = \frac{-36}{5R_\infty}$$

$$\frac{1}{\lambda_2} = R_\infty\left[\frac{1}{4}-\frac{1}{1}\right] = \frac{-3R_\infty}{4}$$

$$\lambda_2 = \frac{-4}{3R_\infty} \Rightarrow \frac{\lambda_1}{\lambda_2} = \frac{-36}{5R_\infty}\times\frac{3R_\infty}{-4}$$

$$\frac{\lambda_1}{\lambda_2} = \frac{27}{5}$$

101. **(a)** For emission, the wave number of the radiation is given as

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

R = Rydberg constant, Z = atomic number

$$= R\left(\frac{1}{1^2}-\frac{1}{5^2}\right) = R\left(1-\frac{1}{25}\right) \Rightarrow \frac{1}{\lambda} = R\frac{24}{25}$$

linear momentum

$$P = \frac{h}{\lambda} = h\times R\times\frac{24}{25} \text{ (de-Broglie hypothesis)}$$

$$\Rightarrow mv = \frac{24hR}{25} \Rightarrow V = \frac{24hR}{25m}$$

102. **(c)** $E_n = -\frac{13.6}{n^2} \Rightarrow E_2 = -\frac{13.6}{2^2} = -3.4\,eV.$

103. **(b)** Energy of excitation,

$$\Delta E = 13.6\,\pi^2\left(\frac{1}{\eta_1}-\frac{1}{\eta_2}\right)eV$$

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

104. **(a)** According the Moseley's law

$$\sqrt{f} = a(z-b) \Rightarrow f = a^2(z-b)^2$$

$$\Rightarrow \frac{c}{\lambda} = a^2(z-b)^2 \qquad \ldots(i)$$

for k_α line, b = 1

From (i), $\frac{\lambda_2}{\lambda_1} = \frac{(z_1-1)^2}{(z_2-1)^2} \Rightarrow \frac{4\lambda}{\lambda} = \frac{(11-1)^2}{(z_2-1)^2}$

$$\Rightarrow z_2 - 1 = \frac{10}{2} \Rightarrow z_2 = 6$$

105. **(d)** $\frac{R_1}{R_2} = \frac{n_1^2}{n_2^2} = \frac{1}{4} \quad \therefore \frac{n_1}{n_2} = \frac{1}{2}$

$$\frac{T_1}{T_2} = \left(\frac{n_1}{n_2}\right)^3 = \left(\frac{1}{2}\right)^3 = \frac{1}{8}$$

106. **(c)** Ist excited state corresponds to n = 2
2nd excited state corresponds to n = 3

$$\therefore \frac{E_1}{E_2} = \frac{n_2^2}{n_1^2} = \frac{3^2}{2^2} = \frac{9}{4}$$

107. **(d)** As $r \propto \frac{1}{m}$ $\quad \therefore r_0' = \frac{1}{2}r_0$

As $E \propto m$ $\quad \therefore E_0' = 2(-13.6) = -27.2\,eV$

108. **(a)** Conservation of energy requires that the 15.0 eV photon energy first provides the ionization energy to unbind the electron, and then allows any excess energy to become the electron's kinetic energy. The kinetic energy in this case is 15.0 eV – 13.6 eV = 1.4 eV.

109. **(a)** From Mosley's law, we have,

$$(Z-1)^2 \propto \nu \therefore (Z-1)^2 = A\frac{c}{\lambda_{k_\alpha}}$$

where A is some constant,

$$\therefore \frac{(Z_{MO}-1)^2}{(Z_{Cu}-1)^2} = \frac{\lambda_{Cu}}{\lambda_{MO}} \text{ or } \left(\frac{41}{28}\right)^2 = \frac{\lambda_{Cu}}{0.71}$$

$$\therefore \lambda_{Cu} = 0.71\times\left(\frac{41}{28}\right)^2 = 1.52\text{Å}$$

110. (a) Excitation energy $\Delta E = E_2 - E_1 = 13.6\,Z^2\left[\frac{1}{1^2}-\frac{1}{2^2}\right]$

$\Rightarrow 40.8 = 13.6 \times \frac{3}{4} \times Z^2 \Rightarrow Z = 2.$

Now required energy to remove the electron from ground state $= \frac{+13.6Z^2}{(1)^2} = 13.6(Z)^2 = 54.4$ eV.

111. (a) Electron after absorbing 10.2 eV energy goes to its first excited state (n = 2) from ground state (n = 1).

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

$= \frac{6.6\times10^{-34}}{6.28} = 1.05\times10^{-34}$ J-s.

112. (d) For an atom following Bohr's model, the radius is given by $r_m = \frac{r_0 m^2}{Z}$ where r_0 = Bohr's radius and m = orbit number.

For Fm, m = 5 (Fifth orbit in which the outermost electron is present)

$\therefore\ r_m = \frac{r_0 5^2}{100} = nr_0$ (given) $\Rightarrow n = \frac{1}{4}$

113. (d) For Lyman series $(2 \to 1)$

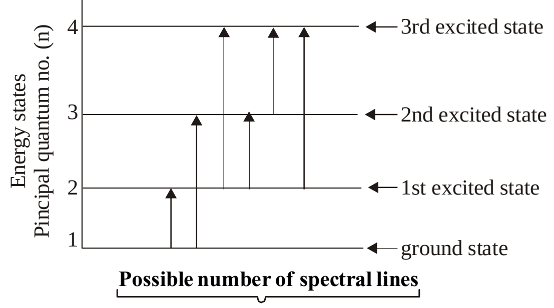
$\frac{1}{\lambda_L} = R\left[1-\frac{1}{2^2}\right] = \frac{3R}{4}$

For Balmer series $(3 \to 2)$

$\frac{1}{\lambda_B} = R\left[\frac{1}{4}-\frac{1}{9}\right] = \frac{5R}{36}$

$\Rightarrow \frac{\lambda_L}{\lambda_B} = \frac{\frac{4}{3R}}{\frac{36}{5R}} = \frac{4}{36}\left(\frac{5}{3}\right) = \frac{5}{27}$

114. (d) For ground state, the principal quantum no $(n) = 1$. There is a 3rd excited state for principal quantum number.



The possible number of the spectral lines is given

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

115. (a) We know that $\frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]$

The wave length of first spectral line in the Balmer series of hydrogen atom is 6561Å. Here $n_2 = 3$ and $n_1 = 2$

$\therefore\ \frac{1}{6561} = R(1)^2\left(\frac{1}{4}-\frac{1}{9}\right) = \frac{5R}{36}$ ...(i)

For the second spectral line in the Balmer series of singly ionised helium ion $n_2 = 4$ and $n_1 = 2$; Z = 2

$\therefore\ \frac{1}{\lambda} = R(2)^2\left[\frac{1}{4}-\frac{1}{16}\right] = \frac{3R}{4}$ ...(ii)

Dividing equation (i) and equation (ii) we get

$\frac{\lambda}{6561} = \frac{5R}{36} \times \frac{4}{3R} = \frac{5}{27}$

$\therefore\ \lambda = 1215$ Å

116. (b) In Paschen series $\frac{1}{\lambda_{max}} = R\left[\frac{1}{(3)^2}-\frac{1}{(4)^2}\right]$

$\Rightarrow \lambda_{max} = \frac{144}{7R} = \frac{144}{7\times1.1\times10^7} = 1.89\times10^{-6}\,m = 1.89\,\mu m$

Similarly $\lambda_{min} = \frac{9}{R} = \frac{9}{1.1\times10^7} = 0.818\ \mu m$

117. (c) For third line of Balmer series $n_1 = 2, n_2 = 5$

$\therefore \frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]$ gives $Z^2 = \frac{n_1^2 n_2^2}{(n_2^2 - n_1^2)\lambda R}$

On putting values Z = 2

From $E = -\frac{13.6Z^2}{n^2} = \frac{-13.6(2)^2}{(1)^2} = -54.4$ eV

118. (a) $\frac{1}{\lambda_{Balmer}} = R\left[\frac{1}{2^2}-\frac{1}{3^2}\right] = \frac{5R}{36}, \frac{1}{\lambda_{Lyman}} = R\left[\frac{1}{1^2}-\frac{1}{2^2}\right] = \frac{3R}{4}$

$\therefore\ \lambda_{Lyman} = \lambda_{Balmer} \times \frac{5}{27} = 1215.4$Å

119. (a) $\frac{1}{\lambda_{max}} = R\left[\frac{1}{(1)^2}-\frac{1}{(2)^2}\right] \Rightarrow \lambda_{max} = \frac{4}{3R} \approx 1213$Å

and $\frac{1}{\lambda_{min}} = R\left[\frac{1}{(1)^2}-\frac{1}{\infty}\right] \Rightarrow \lambda_{min} = \frac{1}{R} \approx 910$Å.

120. (d) $\frac{1}{\lambda} = R\left[\frac{1}{n_1^2}-\frac{1}{n_2^2}\right]$. For first wavelength, $n_1 = 2, n_2 = 3$

$\Rightarrow \lambda_1 = 6563$ Å. For second wavelength, $n_1 = 2, n_2 = 4$

$\Rightarrow \lambda_2 = 4861$ Å

121. (a) For Lyman series

$\upsilon = R_C\left[\frac{1}{1^2}-\frac{1}{n^2}\right]$

where n = 2, 3, 4, ...

For the series limit of Lyman series, $n = \infty$

$\therefore\ \upsilon_1 = R_C\left[\frac{1}{1^2}-\frac{1}{\infty^2}\right] = R_C$ ...(i)

For the first line of Lyman series, n = 2

$\therefore\ \upsilon_2 = R_C\left[\frac{1}{1^2}-\frac{1}{2^2}\right] = \frac{3}{4}R_C$ ...(ii)

For Balmer series

$\upsilon = R_C\left[\frac{1}{2^2}-\frac{1}{n^2}\right]$

where n = 3, 4, 5 .....

For the series limit of Balmer series, $n = \infty$

$\therefore\ \upsilon_3 = R_C\left[\frac{1}{2^2}-\frac{1}{\infty^2}\right] = \frac{R_C}{4}$ ...(iii)

From equation (i), (ii) and (iii), we get

$\upsilon_1 = \upsilon_2 + \upsilon_3$ or $\upsilon_1 - \upsilon_2 = \upsilon_3$

122. (d) The wavelength of the first line of lyman series for hydrogen atom is

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

The wevelength of the second line of Balmer series for like ion is

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

According to question = $\lambda = \lambda'$

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

or $\frac{3}{4} = \frac{3Z^2}{16}$ or $Z^2 = 4$ or $Z = 2$

123. (c) For last line Balmer series, $n_1 = 2$ and $n_2 = \infty$

$$\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] = \frac{1.1\times10^7}{4}\ \text{m}^{-1}$$

$= 2.75 \times 10^6\ \text{m}^{-1}$

124. (d) : By Bohr's formula

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

For first line of Lyman series $n_1 = 1$, $n_2 = 2$

$$\therefore \quad \frac{1}{\lambda} = Z^2R\frac{3}{4}$$

In the case of hydrogen atom, Z = 1

$$\frac{1}{\lambda} = R\frac{3}{4}$$

For hydrogen like atom, Z = 11

$$\frac{1}{\lambda'} = 121R\frac{3}{4} \Rightarrow \frac{\lambda}{\lambda'} = \frac{3R}{4} \times \frac{4}{121R\times3} = \frac{1}{121}$$

$$\lambda' = \frac{\lambda}{121} = \frac{1210}{121} = 10\ \text{Å}$$

125. (a) **:** For a Balmer series

$$\frac{1}{\lambda_B} = R\left[\frac{1}{2^2} - \frac{1}{n^2}\right] \quad \text{... (i)}$$

where $n = 3, 4, ...$

By putting $n = \infty$ in eauaton (i), we obtain the series limit of the Balmer series. This is the shortest wavelength of the Balmer series.

$$\text{or} \quad \lambda_B = \frac{4}{R} \quad \text{... (ii)}$$

For a Lyman series

$$\frac{1}{\lambda_L} = R\left[\frac{1}{1^2} - \frac{1}{n^2}\right] \quad \text{... (iii)}$$

where $n = 2, 3, 4, ...$

By putting $n = \infty$ in equation (iii), we obtain the series limit of the Balmer series. This is the shortest wavelength of the Lyman series.

$$\text{or} \quad \lambda_L = \frac{1}{R} \quad \text{... (iv)}$$

Dividing (ii) by (iv), we get

$$\frac{\lambda_B}{\lambda_L} = \frac{4}{1}$$

126. (c) For Balmer series, $n_1 = 2$, $n_2 = 3$ for 1st line and $n_2 = 4$ for second line.

$$\frac{\lambda_1}{\lambda_2} = \frac{\left(\frac{1}{2^2} - \frac{1}{4^2}\right)}{\left(\frac{1}{2^2} - \frac{1}{3^2}\right)} = \frac{3/16}{5/36} = \frac{3}{16} \times \frac{36}{5} = \frac{27}{20}$$

$$\lambda_2 = \frac{20}{27}\lambda_1 = \frac{20}{27} \times 6561 = 4860\ \text{Å}$$

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

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

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

For transition between 3 to 2.

$$E = 13.6\left(\frac{1}{4} - \frac{1}{9}\right) = \frac{13.6\times5}{36} = 1.88eV$$

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

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

By question n = 1 and $n_1 = 2$

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

129. (a) $E_n = \frac{E_1}{n^2}$

$$\therefore\ n^2 = \frac{E_1}{E_n} = \frac{-13.6}{-0.85} = 16$$

130. (c) $\nu = \frac{c}{\lambda} = cR\left(\frac{1}{p^2} - \frac{1}{n^2}\right) = cR\left(\frac{1}{4} - \frac{1}{16}\right)$

$$= \frac{3\times10^8\times10^7\times12}{64} = \frac{9}{16}\times10^{15}\,\text{Hz}$$

131. (c) For longest wavelength of Balmer series, p = 2 and n = 3

$$\frac{1}{\lambda} = R\left(\frac{1}{p^2} - \frac{1}{n^2}\right) = R\left(\frac{1}{4} - \frac{1}{9}\right) = \frac{5R}{36}$$

$$\therefore\ R = \frac{36}{5\lambda} = \frac{36}{5\times6.563\times10^{-7}} = 1.09\times10^7\,\text{m}^{-1}$$

132. (c) $r_n = r_1 n^2$

$$\therefore\ n^2 = \frac{r_n}{r_1} = \frac{21.2\times10^{-11}}{5.3\times10^{-11}} = 4$$

$\therefore$ n = 2