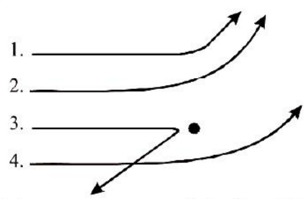
12 Atoms

Multiple Choice Questions (MCQs)

DIRECTIONS : *This section contains multiple choice questions. Each question has four choices (a), (b), (c) and (d) out of which only one is correct.*

1. 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

2. Rutherford's model could explain

I. Nucleus is positively charged.

II. There is a maximum empty space in an atom.

True/false statements are

(a) T, F (b) F, T
(c) T, T (d) F, F

3. When an α-particle of mass 'm' moving with velocity 'v' bombards on a heavy nucleus of charge 'Ze', its distance of closest approach from the nucleus depends on v as :

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

4. The observations of Geiger–Marsden experiment are

I. Many of α-particles pass straight through the gold foil.

II. Some of α-particles scattered through small angles.

III. Few α-particles (1 in 1000) is deflected more than $90°$.

IV. Very few particles are reflected back.

True/false statements are

(a) T, F, T, F (b) F, F, T, T
(c) T, T, F, F (d) T, T, T, T

5. 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

6. Bohr's atomic model concludes that

I. Orbits are elliptical

II. The radiation of energy occurs only when an electron jumps from one permitted orbit to another

True/false statements are

(a) F, T (b) T, F
(c) F, F (d) T, T

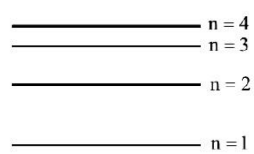
7. The angular momentum of electron n^{th} orbit is given by

(a) nh (b) $h/2\pi n$
(c) $\frac{nh}{2\pi}$ (d) $\frac{n^2h}{2\pi}$

8. The ionization energy of hydrogen atom is 13.6 eV. Following Bohr's theory, the energy corresponding to a transition between 3rd and 4th orbit is

(a) 3.40 eV (b) 1.51 eV
(c) 0.85 eV (d) 0.66 eV

9. 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

10. 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

11. Which of the following statements is ***not*** correct according to Rutherford model ? **[CBSE 2020]**

(a) Most of the space inside an atom is empty.

(b) The electrons revolve around the nucleus under the influence of coulomb force acting on them.

(c) Most part of the mass of the atom and its positive charge are concentrated at its centre.

(d) The stability of atom was established by the model.

12. The simple Bohr model cannot be directly applied to calculate the energy levels of an atom with many electrons. This is because

(a) of the electrons not being subject to a central force

(b) of the electrons colliding with each other

(c) of screening effects

(d) the force between the nucleus and an electron will no longer be given by Coulomb's law

13. For the ground state, the electron in the H – atom has an angular momentum = h, according to the simple Bohr model. Angular momentum is a vector and hence there will be infinitely many orbits with the vector pointing in all possible directions. In actuality, this is not true,

(a) because Bohr model gives in correct values of angular momentum

(b) because only one of these would have a minimum energy

(c) angular momentum must be in the direction of spin of electron

(d) because electrons go around only in horizontal orbits

14. Two H atoms in the ground state collide inelastically. The maximum amount by which their combined kinetic energy is reduced, is

(a) 10.20 eV (b) 20.40 eV

(c) 13.6 eV (d) 27.2 eV

15. 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

16. 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

17. 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

18. 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) $\frac{1}{n}, \frac{1}{n^2}, n^2$

19. Electrons in the atom are held to the nucleus by

(a) electrostatic force (b) nuclear force

(c) vander waal's force (d) gravitational force

20. According to the Rutherford's atomic model, the electrons inside the atom are

(a) stationary (b) not stationary

(c) centralized (d) None of these

21. According to classical theory, the circular path of an electron in Rutherford atom is

(a) spiral (b) circular

(c) parabolic (d) straight line

22. 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

23. 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

24. Rutherford scattering experiment was explained by making following assumptions that

(a) the colllision is inelastic

(b) the nucleus can be treated as a point particle

(c) the nucleus is light

(d) None of these

25. 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

26. 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

27. 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

28. Value of Impact parameter will be zero, when scattering angle is

(a) $\pi/2$ (b) π (c) $2\pi/3$ (d) $3\pi/2$

29. The correct relation between scattering angle (θ), impact parameter (b) and distance of closest approach (D) is

(a) $\sin\theta = Db$ (b) $\tan\frac{\theta}{2} = \frac{D}{2b}$

(c) $\frac{\cos\theta}{b} = D$ (d) $\cot\frac{\theta}{2} = \frac{b}{2D}$

30. 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

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

(a) 10^{-12} cm (b) 10^{-10} cm

(c) 10^{-20} cm (d) 10^{-15} cm

32. 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

33. The spectrum obtained from a sodium vapour lamp is an example of

(a) band spectrum (b) continuous spectrum

(c) emission spectrum (d) absorption spectrum

34. The time period of an electron in n^{th} Bohr's orbit is proportional to

(a) n^3 (b) n^2 (c) n (d) 1/n

35. Current due to the orbital motion of an electron revolving in n^{th} Bohr's orbit is proportional to

(a) $1/n^3$ (b) n^3 (c) n^2 (d) n

36. 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

37. 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

38. Which of the following statements are true regarding Bohr's model of hydrogen atom?

(a) Orbiting speed of electron decreases as it shifts to discrete orbits away from the nucleus

(b) Radii of allowed orbits of electron are inversely proportional to the principal quantum number

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

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

39. When an electron jumps from the fourth orbit to the second orbit, one gets the

(a) second line of Lyman series

(b) second line of Paschen series

(c) second line of Balmer series

(d) first line of Pfund series

40. 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.

41. Line spectrum is obtained whenever the incandescent vapours at low pressure of the excited substance are in their

(a) atomic state (b) molecular state

(c) nuclear state (d) None of these

42. 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

43. 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

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

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

45. Energy of an electron in an excited hydrogen atom is –3.4 eV. Its angular momentum will be

(a) 3.72×10^{-34} Js (b) 2.10×10^{-34} Js

(c) 1.51×10^{-34} Js (d) 4.20×10^{-34} Js

46. 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 the galaxy with respect to earth is

(a) 2×10^8 m/s (b) 2×10^7 m/s

(c) 2×10^6 m/s (d) 2×10^5 m/s

47. What element has k_α line of wavelength 1.785 Å? $R = 109737$ cm^{-1}.

(a) Platinum (b) Zinc (c) Iron (d) Cobalt

48. The wavelength of K_α-line characteristic emitted by an element is 0.32 Å. The wavelength of k_β-line emitted by the same element will be

(a) 0.27 Å (b) 0.32 Å (c) 0.39 Å (d) 0.49 Å

49. 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

50. The ratio of the longest to shortest wavelengths in Brackett series of hydrogen spectra is

(a) 25/9 (b) 17/6 (c) 9/5 (d) 4/3

51. The kinetic energy of the electorn in an orbit of radius r in hydrogen atom is (e = electronic charge)

(a) $\frac{e^2}{r^2}$ (b) $\frac{e^2}{2r}$ (c) $\frac{e^2}{r}$ (d) $\frac{e^2}{2r^2}$

52. 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

53. The energy of electron in the nth orbit of hydrogen atom is expressed as $E_n = \frac{-13.6}{n^2}$ eV. The shortest wavelength of Lyman series will be

(a) 910 Å (b) 5463 Å
(c) 1315 Å (d) None of these

54. The ionisation potential of H-atom is 13.6 V. When it is excited from ground state by monochromatic radiations of 970.6 Å, the number of emission lines will be (according to Bohr's theory)

(a) 10 (b) 8 (c) 6 (d) 4

55. 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

Case/Passage Based Questions

DIRECTIONS : *Study the given Case/Passage and answer the following questions.*

Case/Passage-I

Rutherford gave the **nuclear model of the atom**. According to this model, "the entire positive charge and most of the mass of the atom is concentrated in a small volume called nucleus and electrons revolve around it."

In 1911 Geiger-Marsden performed the gold foil alpha particle scattering experiment which supported Rutherford's model.

56. Rutherford's α-particle experiment showed that the atoms have

(a) Proton (b) Nucleus
(c) Neutron (d) Electrons

57. 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

58. In Rutherford's α-particle scattering experiment, what will be correct angle for α scattering for an impact parameter b = 0?

(a) 90° (b) 270° (c) 0° (d) 180°

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

(a) 10^{-12} cm (b) 10^{-10} cm
(c) 10^{-20} cm (d) 10^{-15} cm

60. The distance of closest approach of a certain nucleus is 7.2 fm and it has a charge of 1.28×10^{-17} C. The number of neutrons inside the nucleus of an atom is

(a) 136 (b) 142 (c) 140 (d) 132

Case/Passage-II

The spacing between lines within certain sets of the hydrogen spectrum. Each of these sets is called a spectral series.
Balmer's empirical formula for the observed wavelength,

$$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right); \; R = \frac{me^4}{8\varepsilon_0^2 h^3 c}$$

where R = Rydberg constant = 1.097×10^7 m^{-1}; n_f = final orbital number and n_i = initial orbital number

61. 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

62. 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.

63. 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

64. 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

65. 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

Case/Passage-III

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

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

66. Find the ionization potential of the atom.

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

67. Find the short wavelength limit of the series terminating at $n = 2$.

(a) 3256 Å (b) 2339 Å
(c) 2509 Å (d) 3494 Å

68. Find the excitation potential for the state $n = 3$.

(a) 14.64 eV (b) 9.93 eV
(c) 12.52 eV (d) 10.04 eV

69. Find the wave number of the photon emitted for the transition $n = 3$ to $n = 1$.

(a) $2.23 \times 10^7 \text{ m}^{-1}$ (b) $1.009 \times 10^7 \text{ m}^{-1}$
(c) $3.005 \times 10^6 \text{ m}^{-1}$ (d) $0.432 \times 10^6 \text{ m}^{-1}$

70. If an electron with initial kinetic energy 6 eV is to interact with this hypothetical atom, what minimum energy will this electron carry after interaction ?

(a) 2 eV (b) 3 eV
(c) 6 eV (d) 0 eV

Assertion & Reason

DIRECTIONS : *Each of these questions contains an assertion followed by reason. Read them carefully and answer the question on the basis of following options. You have to select the one that best describes the two statements.*

(a) If both **Assertion** and **Reason** are **correct** and the Reason is the **correct explanation** of the Assertion.
(b) If both **Assertion** and **Reason** are correct but Reason is **not the correct explanation** of the Assertion.
(c) If the **Assertion** is **correct** but **Reason** is **incorrect.**
(d) If the **Assertion** is **incorrect** but the **Reason** is **correct**.

71. **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.

72. **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.

73. **Assertion :** Between any two given energy levels, the number of absorption transitions is always less than the number of emission transitions.
Reason : 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.

74. **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 $n = 3, 4, 5$.

Match the Following

DIRECTIONS : *Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in column-I have to be matched with statements (1, 2, 3, 4) in column-II.*

75. Match quantities given in Column -1 to those given in Column-II.

Column I		Column II
(A) Number of scattered particles proportional to	(1)	$\frac{1}{v^2}$
(B) Distance of closest approach is proportional to	(2)	$\frac{1}{\sin^4(\theta/2)}$
(C) Impact parameter is proportional to	(3)	$\frac{n^2}{Z}$
(D) Radius of orbit is proportional to	(4)	$\cot(\theta/2)$

(a) (A) → (2); (B) → (1); (C) → (4); (D) → (3)
(b) (A) → (1); (B) → (2); (C) → (3); (D) → (4)
(c) (A) → (3); (B) → (2); (C) → (1); (D) → (4)
(d) None of these

Fill in the Blanks

DIRECTIONS : *Complete the following statements with an appropriate word / term to be filled in the blank space(s).*

76. According to classical theory, the path of an electron in Rutherford atomic model is______.

77. When an electron jumps from the fourth orbit to the second orbit, one gets the_______series.

78. 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 _______ eV.

79. As one considers orbits with higher values of n in a hydrogen atom, the potential energy of the atom _______.

80. Taking the Bohr radius as $a_0 = 53$ pm, the radius of Li^{++} ion in its ground state, on the basis of Bohr's model, will be about _______ pm.

81. According to Bohr's atomic model, the circumference of the electron orbit is always an ________ multiple of de Broglie wavelength. **[CBSE 2020]**

True / False

DIRECTIONS : *Read the following statements and write your answer as true or false.*

82. Bohr had to postulate that the electrons in stationary orbits around the nucleus radiate energy.

83 According to classical electromagnetic theory, an accelerated charged particle, should continueously radiate energy.

84. The force of repulsion between atomic nucleus and α-particle varies with distance according to inverse square law.

85. Rutherford did α-particle scattering experiment.

ANSWER KEY & SOLUTIONS

1. **(d)** α-particle cannot be attracted by the nucleus.
2. **(c)**
3. **(c)** At closest distance of approach, the kinetic energy of the particle will convert completely into electrostatic potential energy.

   Kinetic energy K.E. $= \frac{1}{2}mv^2$

   Potential energy P.E. $= \frac{KQq}{r}$

   $\frac{1}{2}mv^2 = \frac{KQq}{r} \quad \Rightarrow \quad r \propto \frac{1}{v^2}$
4. **(d)** Geiger and Marsden (students of Rutherford) studied the scattering of α-particles by gold foil on the advice of Rutherford and all those observations.
5. **(a)** $r_n = r_o.n^2$, where r_o is radius of ground-state and r_n is radius of n^{th} state. (For first excited state n = 2).
6. **(a)** Bohr postulated that an electron in an atom can more around the nucleus in certain circular stable orbits without emitting radiations.
7. **(c)** According to Bohr's second postulate.
8. **(d)** $E = E_4 - E_3$

   $$= -\frac{13.6}{4^2} - \left(-\frac{13.6}{3^2}\right) = -0.85 + 1.51 = 0.66\,\text{eV}$$
9. **(d)** Number of possible emission lines $= \frac{n(n-1)}{2}$
10. **(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.
11. **(d)**
12. **(a)** The simple Bohr model cannot be directly applied to calculate the energy levels of an atom with many electrons. So the nuclear the electrons not being subject to a central force.
13. **(a)** Accroding Bohr's second postulate states that the electron evolves around the nucleus only in those orbits for which the angular momentum is some integral multiple of $\frac{h}{2\pi}$ where h is the Planck's constant ($= 6.6 \times 10^{-34}$ J-s). So, the magnitude of angular momentum is kept equal to some integral multiple of $\frac{h}{2\pi}$, where, h is Planck's constant and thus, the Bohr model does not gives correct value of angular momentum.
14. **(a)** We know that,

    Electron on the lowest state of the atom, called the ground state have the lowest energy and the electron revolving in the orbit of smallest radius, the Bohr radius, r. The energy of this state (n = 1), E_1 is – 13.6 eV.

    Total energy of two H – atoms in the ground state collide in elastically $= 2 \times (-13.6\text{ eV}) = -27.2$ eV.

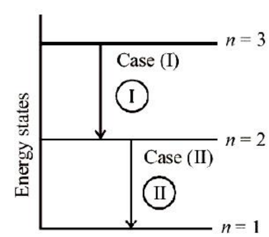
    The maximum amount by which their combined kinetic energy is reduced when any one H–atom goes into first excited state after the inelastic collision. So that the total energy of the two H – atoms after the inelastic collision

    $$= \left(\frac{13.6}{2^2}\right) + (13.6) = 17.0\text{eV} \left[\because \text{for excited state } (n = 2)\right].$$

    So, maximum loss of their combined kinetic energy.

    Due to inelastic collision

    $= 27.2 - 17.0 = 10.2$ eV
15. **(b)**
16. **(d)** Since out of the given four lines H_δ line has smallest wavelength. Hence the frequency of this line will be maximum.
17. **(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) $n_1 = 3, n_2 = 2$

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

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

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

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

    $$\frac{\lambda_1}{\lambda_2} = \frac{27}{5}$$
18. **(d)**

19. **(a)** In an atom, electrons held to the nucleus by electrostatic force.

20. **(b)** 21. **(a)** 22. **(c)** 23. **(b)** 24. **(b)**

25. **(b)**

26. **(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.

27. **(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.

28. **(b)** 29. **(b)**

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

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

31. **(a)** Distance of closest approach $r_0 = \frac{Ze(2e)}{4\pi\varepsilon_0\left(\frac{1}{2}mv^2\right)}$

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

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

$\Rightarrow r = 5.2\times10^{-14} m = 5.3\times10^{-12}$ cm.

32. **(d)** According to Bohr's model, $mvr = \frac{nh}{2\pi}$ where n is an integer.

33. **(c)** A spectrum is observed, when light coming directly from a source is examined with a spectroscope. Therefore spectrum obtained from a sodium vapour lamp is emission spectrum.

34. **(a)** 35. **(a)** 36. **(b)** 37. **(c)**

38. **(a)** Orbital speed varies inversely as the radius $v \propto \frac{1}{n}$

39. **(c)** When the electron drops from any orbit to second orbit, then wavelength of line obtained belongs to Balmer series.

40. **(c)** 41. **(a)** 42. **(d)** 43. **(a)**

44. **(d)** $\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

For Balmer series n = 2

$$\frac{1}{\lambda_{max}} = RZ^2\left(\frac{1}{2^2} - \frac{1}{\infty^2}\right) \text{ and}$$

$$\frac{1}{\lambda_{min}} = RZ^2\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$$

or $\frac{1/\lambda_{min}}{1/\lambda_{max}} = \frac{(1/2^2 - 1/3^2)}{(1/2^2)} \Rightarrow \frac{\lambda_{max}}{\lambda_{min}} = \frac{5}{9}$

45. **(b)** $E = -3.4$ eV and $r = \frac{kze^2}{2E}$

angular momentum = mvr

$\Rightarrow \frac{1}{2}mv^2 = E = 3.4\times(10^{-19}\times1.6)$

$\Rightarrow m^2v^2 = (9.1\times10^{-31})2\times3.4\times1.6\times10^{-19}$

$= 99.008\times10^{-50}$

$mv = 9.95028\times10^{-25}$

$\therefore L = (9.95028\times10^{-25})\left(\frac{9\times10^9\times1\times(1.6\times10^{-19})^2}{2\times(3.4)}\right)$

$= 2.10\times10^{-34}$ Js.

46. **(b)** $\frac{1}{\lambda'} = \frac{1}{\lambda}\sqrt{\frac{c-v}{c+v}}$

Here, $\lambda' = 706$ nm, $\lambda = 656$ nm

$\therefore \frac{c-v}{c+v} = \left(\frac{\lambda}{\lambda'}\right)^2 = \left(\frac{656}{706}\right)^2 = 0.86 \Rightarrow \frac{v}{c} = \frac{0.14}{1.86}$

$\Rightarrow v = 0.075\times3\times10^8 = 2.25\times10^7$ m/s

47. **(d)** For k_α line $\frac{1}{\lambda_{k_\alpha}} = R(Z-1)^2\left[\frac{1}{1^2} - \frac{1}{2^2}\right]$

$$(Z-1)^2 = \frac{4}{3}\frac{1}{\lambda_{k_\alpha}}\frac{1}{R} = \frac{4}{3}\times\frac{1}{1.785\times10^{-8}}\times\frac{1}{109737}$$

$\Rightarrow (Z-1)^2 = 680.6 \Rightarrow Z-1 = 26 \Rightarrow Z = 27$

Thus, the element is cobalt.

48. **(a)** $\frac{1}{\lambda_\alpha} = R(Z-b)^2\left[\frac{1}{1^2} - \frac{1}{2^2}\right]$

$\Rightarrow \frac{1}{\lambda_\beta} = R(Z-b)^2\left[\frac{1}{1^2} - \frac{1}{3^2}\right]$

$\therefore \frac{\lambda_\beta}{\lambda_\alpha} = \frac{\left(1-\frac{1}{4}\right)}{\left(1-\frac{1}{9}\right)} \Rightarrow \lambda_\beta = \frac{27}{32}\times0.32 \Rightarrow \lambda_\beta = 0.27$ Å

49. **(a)** $\frac{(Z_{MO}-1)^2}{(Z_{Cu}-1)^2} = \frac{\lambda_{Cu}}{\lambda_{MO}}$ or $\left(\frac{41}{28}\right)^2 = \frac{\lambda_{Cu}}{0.71}$

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

50. **(a)** For Brackett series

$$\frac{1}{\lambda_{max}} = R\left[\frac{1}{4^2} - \frac{1}{5^2}\right] = \frac{9}{25\times16}R$$

and $\frac{1}{\lambda_{min}} = R\left[\frac{1}{4^2} - \frac{1}{\infty^2}\right] = \frac{R}{16} \Rightarrow \frac{\lambda_{max}}{\lambda_{min}} = \frac{25}{9}$

51. **(b)** Potential energy of electron in n^{th} orbit of radius r in H-atom $U = -\frac{e^2}{r}$ (in CGS)

$\because$ K.E. $= \frac{1}{2}|$P.E.$| \Rightarrow K = \frac{e^2}{2r}$

52. **(b)** The smallest frequency and largest wavelength in ultraviolet region will be for transition of electron from orbit 2 to orbit 1.

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

$\Rightarrow \frac{1}{122 \times 10^{-9} m} = R\left[\frac{1}{1^2} - \frac{1}{2^2}\right] = R\left[1 - \frac{1}{4}\right] = \frac{3R}{4}$

$\Rightarrow R = \frac{4}{3 \times 122 \times 10^{-9}} m^{-1}$

The highest frequency and smallest wavelength for infrared region will be for transition of electron from ∞ to 3rd orbit.

$\therefore \frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \Rightarrow \frac{1}{\lambda} = \frac{4}{3 \times 122 \times 10^{-9}}\left(\frac{1}{3^2} - \frac{1}{\infty}\right)$

$\therefore \lambda = \frac{3 \times 122 \times 9 \times 10^{-9}}{4} = 823.5\text{nm}$

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

54. **(c)** $\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$\Rightarrow \frac{1}{970.6 \times 10^{-10}} = 1.097 \times 10^7 \left[\frac{1}{1^2} - \frac{1}{n_2^2}\right] \Rightarrow n_2 = 4$

$\therefore$ Number of emission line $N = \frac{n(n-1)}{2} = \frac{4 \times 3}{2} = 6$

55. **(d)** $r \propto n^2 \Rightarrow \pi r^2 \propto n^4$

56. **(b)**

57. **(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.

58. **(d)** When b = 0, scattering angle, $\theta = 180°$

59. **(a)** Distance of closest approach $r_0 = \frac{Ze(2e)}{4\pi\varepsilon_0\left(\frac{1}{2}mv^2\right)}$

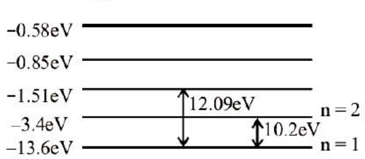
Energy, $E = 5 \times 10^6 \times 1.6 \times 10^{-19}$ J

$\therefore r_0 = \frac{9 \times 10^9 \times (92 \times 1.6 \times 10^{-19})(2 \times 1.6 \times 10^{-19})}{5 \times 10^6 \times 1.6 \times 10^{-19}}$

$\Rightarrow r = 5.2 \times 10^{-14} m = 5.3 \times 10^{-12}$ cm.

60. **(a)**

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



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

63. **(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.

64. **(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 $= \frac{h}{2\pi}$

$= \frac{6.6 \times 10^{-34}}{6.28} = 1.05 \times 10^{-34}$ J-s.

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

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

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

66. **(c)** Given that $E_1 = -15.6$ eV, $E_\infty = 0$ eV.

Ionization energy of the atom :

$E_\infty - E_1 = 0 - (-15.6\text{ eV}) = 15.6$ eV

So, ionization potential = 15.6 V

67. **(b)** For short wavelength limit of the series terminating at $n = 2$, a transition must take place from $n = \infty$ state to $n = 2$ state. For this, $\Delta E = 5.30$ eV

$\lambda = \frac{12400}{\Delta E(eV)}\text{Å} = \frac{12400}{5.30}\text{Å} = 2339\text{Å}$

68. **(c)** The excitation energy for the $n = 3$ state is

$\Delta E = E_3 - E_1 = 15.6 - 3.08 = 12.52$ eV

Excitation potential = 12.52 V

69. **(b)** $\lambda = \frac{12400}{E_3^z - E_1^z} = \frac{12400}{12.52}\text{Å} = 990\text{Å}$

Wave number

$= \frac{1}{\lambda} = \frac{1}{990 \times 10^{-10} m} = 1.009 \times 10^7 m^{-1}$

70. **(c)** Because excitation energy for the second shell is more than 6 eV, hence electron having initial kinetic energy of 6 eV will not interact with the atom. Because it cannot transfer its energy to the electron in the atom.

71. **(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.

72. **(b)** For Lyman series,

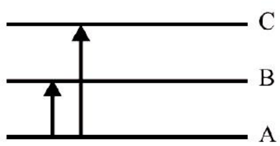
$\lambda_{max} = 4/3R$

$\lambda_{min} = 1/R$

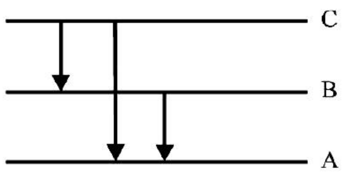
so $\frac{\lambda_{min}}{\lambda_{max}} = \frac{1}{R} \times \frac{3R}{4}$

$\frac{\lambda_{min}}{\lambda_{max}} = \frac{3}{4}$

73. **(a)** Absorption transition



Two possibilities in absorption transition.



Three possibilities in emission transition.

Therefore, absorption transition < emission.

74. **(a)** The wavelength in Balmer series is given by,

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

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

$$\Rightarrow \frac{1}{\lambda_{max}} = \frac{36}{5R} = \frac{36}{5 \times 1.097 \times 10^7} = 6563Å$$

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

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

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

75. **(a)** Number of scattered particle, $N \propto \frac{1}{\sin^4(\theta/2)}$

Distance of closest approach,

$$r_0 = \frac{Ze^2}{mv^2\pi\varepsilon_0} \Rightarrow r_0 \propto \frac{1}{v^2}$$

Impact parameter, $b \propto \cot(\theta/2)$

Radius of orbit, $r_n = \frac{n^2h^2\varepsilon_0}{\pi mZe^2} \Rightarrow r_n \propto \frac{n^2}{Z}$

76. (Spiral) According to classical theory, the path on an electron in Rutherford atomic model is spiral.

77. (Balmer) 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.

78. (54.4) 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.

79. (Increases) The potentical energy of the atom increases in higher values of n.

80. (18) According to Bohr's model of atom rading of an atom in ground stateme is $r = \frac{r_0}{z}$ where r_0 is Bohr's radius and z is a atomic number. Given $r_0 = 53$ pm

The atomic number of lithium is 3, therefore, the radius of Li^{++} ion in its ground state, on the basis of Bohr's model, will be about $\frac{1}{3}$ times to that of Bohr radius.

So, the radius of lithim ion is $= \frac{r_0}{z} = \frac{53}{3} \approx 18$ pm.

81. (Integral multiple)

82. (False) Bohr's postulated that electrons in stationary orbits around the nucleus do not radiate.

83. (True)

84. (True)

85. (True)