CHAPTER 13

Atomic Structure

EXERCISE I (JEE MAIN)

Fundamental Particles

1. Gases are bad conductors of electricity. Their conductivity may be increased by
   (a) increasing the pressure as well as potential difference between the electrodes.
   (b) decreasing the pressure as well as potential difference between the electrodes.
   (c) decreasing the pressure and/or increasing the potential difference between the electrodes.
   (d) increasing the pressure and/or decreasing the potential difference between the electrodes.

2. Which of the following is true for cathode ray?
   (a) It is not deflected by magnetic field.
   (b) It is an electromagnetic wave.
   (c) It emits X-ray, when strikes a metal.
   (d) It consist of all the negative particles present in the atoms.

3. The specific charge of cathode rays
   (a) depends on the nature of the gas.
   (b) depends on the material of the discharge tube.
   (c) depends on the potential difference between cathode and anode.
   (d) is a universal constant.

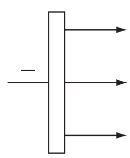
4. Which of the following is not a fundamental particle?
   (a) Electron (b) Proton
   (c) Neutron (d) X-rays

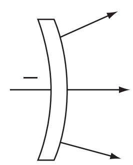
5. The presence of charge particles in the atoms was first confirmed by
   (a) Rutherford (b) Thomson
   (c) Faraday (d) Goldstein

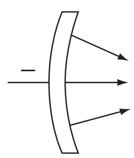
6. From the discharge tube experiment, it is concluded that
   (a) mass of proton is fractional.
   (b) matter contains electrons.
   (c) matter contains nucleus.
   (d) positive rays are heavier than protons.

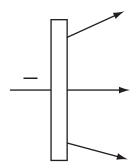
7. The cathode rays experiment demonstrated that
   (a) α-particles are the nuclei of He atoms.
   (b) the *e*/*m* ratio for the particles of the cathode rays varies gas to gas.
   (c) cathode rays are streams of negatively charged particles.
   (d) the mass of an atom is essentially all contained in its very small nucleus.

8. Which of the following is not the possible path of cathode rays ejecting from the surface of cathode?

   (a)


   (b)


   (c)


   (d)


9. Cathode rays are made up of electrons. Anode rays are made up of

(a) only protons.
(b) only nucleus of atoms.
(c) positive residue of atoms.
(d) only from all the positive particles present in the atoms.

10. Which of the following statement is incorrect

(a) Cathode rays are emitted out from the surface of cathode.
(b) Cathode rays travel in straight line.
(c) Anode rays are heavier than cathode rays.
(d) Anode rays are emitted out from the surface of anode.

11. The *e*/*m* ratio of anode rays produced in the discharge tube, depends on the

(a) nature of the gas filled in the tube.
(b) nature of anode material.
(c) nature of cathode material.
(d) all of these

12. When lithium vapours were filled in the discharge tube for anode rays experiment, the anode rays were found to contain only Li^+ ions ($A = 7, Z = 3$). Therefore, each particle of anode contains

(a) 1 proton only.
(b) 3 protons and 4 neutrons only.
(c) 3 protons, 4 neutrons and 2 electrons.
(d) 3 protons, 3 neutrons and 3 electrons.

13. In an oil drop experiment, the following charges (in arbitrary units) were found on a series of oil droplets 4.5×10^{-18}, 3.0×10^{-18}, 6.0×10^{-18}, 7.5×10^{-18}, 9.0×10^{-18}. The charge on electron (in the same unit) should be

(a) 3.0×10^{-18} (b) 9.0×10^{-18}
(c) 1.5×10^{-18} (d) 1.6×10^{-19}

14. In Wilson cloud chamber experiment, two particles were found to show equal deviations but in opposite directions. The names positron and negatron were given to these particles by Anderson. Hence, Negatron is

(a) neutron (b) neutrino
(c) proton (d) electron

15. Which of the following particle is not deflected in the magnetic field?

(a) Electron (b) Proton
(c) Neutron (d) Deuteron

16. Which of the following particle have non-zero *e*/*m* ratio?

(a) Neutron (b) Neutrino
(c) Positron (d) Neutral meson

17. The *e*/*m* ratio is maximum for

(a) Na^+ (b) Al^{3+}
(c) H^+ (d) Mg^{2+}

18. The potential difference between cathode and anode in a cathode ray tube is V. The speed acquired by the electrons is proportional to

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

19. The ratio of specific charges of α–particle and deuteron is

(a) 1 : 2 (b) 2 : 1
(c) 1 : 1 (d) 4 : 1

20. The *e*/*m* ratio of a particle of charge 2 unit and mass 4 amu is

(a) 4.8×10^7 C/kg
(b) 0.5 C/kg
(c) 4.8×10^4 C/kg
(d) 8×10^{-20} C/kg

Rutherford's Atomic Models

21. Atoms have void spaces. It was first suggested by

(a) Rutherford (b) Thomson
(c) Lenard (d) Dalton

22. Rutherford's experiment, which established the nuclear model of the atom, used a beam of

(a) β-particles, which impinged on a metal foil and got absorbed.
(b) γ-rays, which impinged on a metal foil and ejected electrons.
(c) helium atoms, which impinged on a metal foil and got scattered.
(d) helium nuclei, which impinged on a metal foil and got scattered.

23. Which of the following is not a conclusion of Rutherford's atomic model?

(a) Most of the part inside an atom is empty.
(b) Almost all mass of an atom is concentrated in the nucleus.
(c) The size of nucleus is very small in comparison to the size of atom.
(d) Electron revolves around the nucleus in definite orbits.

24. Which of the following is not a correct statement according to Rutherford's atomic model?

(a) 99% of mass of an atom is centred in the nucleus.
(b) Most of the part inside the atom is empty.
(c) The size of nucleus is very small in comparison to the atoms.
(d) Electrons revolve round the nucleus.

25. When β-particles are sent through a tin metal foil, most of them go straight through the foil as

(a) β-particles are much heavier than electron.
(b) most part of the atom is empty space.
(c) β-particles are positively charged.
(d) β-particles move with high velocity.

26. A proton and a deuteron are projected towards the stationary gold nucleus in different experiments with the same speed. The distance of closest approach will be

(a) same for both.
(b) greater for proton.
(c) greater for deuteron.
(d) depends on speed.

27. Two particles A and B having same *e*/*m* ratio are projected towards silver nucleus in different experiments with the same speed. The distance of closest approach will be

(a) same for both.
(b) greater for A.
(c) greater for B.
(d) depends on speed.

28. α-particles are projected towards the nucleus of following metals with the same kinetic energy. Towards which metal, the distance of closest approach will be minimum?

(a) Cu ($Z = 29$) (b) Ag ($Z = 47$)
(c) Au ($Z = 79$) (d) Ca ($Z = 20$)

29. In different experiments, α-particles, proton, deuteron and neutron are projected towards gold nucleus with the same kinetic energy. The distance of closest approach will be minimum for

(a) α-particle (b) proton
(c) deuteron (d) neutron

30. The following charged particles accelerated from rest through the same potential difference are projected towards gold nucleus in different experiments. The distance of closest approach will be maximum for

(a) α–particle (b) proton
(c) deuteron (d) same for all

31. In the Rutherford scattering experiment, the number of alpha particles scattered at an angle $\theta = 60^\circ$ is 36 per minute. The number of alpha particles per minute scattered at angles $\theta = 90^\circ$ is (Assume all other conditions to be identical)

(a) 144 (b) 9
(c) 36 (d) 16

32. If nucleus and atom are considered as perfect spheres with diameters 4×10^{-15} m and 2×10^{-10} m, respectively, then the ratio of the volumes of nucleus and atom should be

(a) $2 \times 10^{-5}:1$ (b) $8 \times 10^{-15}:1$
(c) $1.25 \times 10^{14}:1$ (d) $8 \times 10^{15}:1$

33. With what velocity should an α–particle travel towards the nucleus of copper atoms so as to arrive at a distance 10^{-12} m from the nucleus of the copper atom? ($4.8 \times \sqrt{29 \times 60} = 200$, $N_A = 6 \times 10^{23}$, $e = 1.6 \times 10^{-19}$ C)

(a) 2×10^3 ms^{-1} (b) 2×10^6 ms^{-1}
(c) 2×10^5 ms^{-1} (d) 2×10^7 ms^{-1}

34. An α-particle accelerated through V volt is fired towards a nucleus. The distance of closest approach is r. If a proton accelerated through the same potential is fired towards the same nucleus, the distance of closest approach of the proton will be

(a) r (b) $2r$
(c) $r/2$ (d) $r/4$

35. The distance of closest approach of an α-particle fired towards a nucleus with momentum 'P' is r. What will be the distance of closest approach when the momentum of the α-particle is 2P?

(a) $2r$ (b) $4r$
(c) $r/2$ (d) $r/4$

Planck's Quantum Theory, Photoelectric Effect and Moseley's Experiment

36. Small packets of light is called

(a) proton (b) quanta
(c) photon (d) spectrum

37. A radio station emits radiations of 400 kHz. The metre band of the station is

(a) 400 (b) 750
(c) 1333.33 (d) 7.5

38. Which of the following electromagnetic radiation have greater frequency?

(a) X–rays (b) Ultraviolet rays
(c) Radio waves (d) Visible rays

39. As its closest approach, the distance between the Mars and the Earth is found to be 60 million km. When the planets are at this closest distance, how long would it take to send a radio message from a space probe sent to Mars from Earth?

(a) 5 s (b) 200 s
(c) 0.2 s (d) 20 s

40. Two electromagnetic radiations have wave numbers in the ratio 2 : 3. Their energies per quanta will be in the ratio

(a) 3 : 2 (b) 9 : 4
(c) 4 : 9 (d) 2 : 3

41. A radio station is emitting the radiations of frequency 2×10^4 Hz. If its frequency is doubled,

(a) wavelength will be doubled.
(b) energy per quanta will be doubled.
(c) wave number will be halved.
(d) all of these

42. The eyes of a certain member of the reptile family pass a single visual single to the brain when the visual receptors are stuck by photons of wavelength 662.6 nm. If a total energy of 3.0×10^{-14} J is required to trap the signal, what is the minimum number of photons that must strike the receptor?

(a) 1.0×10^5 (b) 1.0×10^6
(c) 1000 (d) 1

43. A photon of 400 nm is absorbed by a gas molecule and then the molecule re-emits two photons. One re-emitted photon has wavelength 500 nm. Assuming that there is no change in the energy of molecule, the wavelength of second re-emitted photon is

(a) 100 nm (b) 2000 nm
(c) –100 nm (d) 900 nm

44. A green bulb and a red bulb are emitting the radiations with equal power. The correct relation between numbers of photons emitted by the bulbs per second is

(a) $n_g = n_r$ (b) $n_g < n_r$
(c) $n_g > n_r$ (d) unpredictable

45. A dye emits 50% of the absorbed energy as fluorescence. If the number of quanta absorbed and emitted out is in the ratio 1 : 2 and it absorbs the radiation of wavelength 'x' Å, then the wavelength of the emitted radiation will be

(a) x Å (b) $0.5x$ Å
(c) $4x$ Å (d) $0.25x$ Å

46. Wavelength of photon which have energy equal to average of energy of photons with $\lambda_1 = 4000$ Å and $\lambda_2 = 6000$ Å will be

(a) 5000 Å (b) 4800 Å
(c) 9600 Å (d) 2400 Å

47. Bond dissociation on energy of Br_2 is 200 kJ/mole. The longest wavelength of photon that can break this bond would be ($N_A \times hc = 0.12$ J)

(a) 6.0×10^{-5} m (b) 1.2×10^{-5} m
(c) 6.0×10^{-7} m (d) 1.2×10^{-7} m

48. Wavelength of photon having energy 1 eV would be

(a) 1.24×10^{-4} m (b) 1.24×10^{-6} m
(c) 1.24×10^{-5} m (d) 1.24×10^{4} m

49. In the emission of photoelectrons, the number of photoelectrons emitted per unit time depends upon

(a) energy of the incident radiation.
(b) intensity of the incident radiation.
(c) frequency of the incident radiation.
(d) wavelength of the incident radiation.

50. Radiations of frequency, (ν) are incident on a photosensitive metal. The maximum kinetic energy of photoelectrons is E. When the frequency of the incident radiations is doubled, then what is the maximum kinetic energy of the photoelectrons?

(a) $2E$ (b) $E/2$
(c) $E + h\nu$ (d) $E - h\nu$

51. A photo sensitive surface is receiving light of wavelength 5000 Å at the rate of 10^{-7} J/s. The number of photons received per second is

(a) 2.5×10^{11} (b) 3.0×10^{32}
(c) 2.5×10^{18} (d) 2.5×10^{9}

52. In order to increase the kinetic energy of ejected photoelectrons, there should be an increase in

(a) intensity of radiation.
(b) wavelength of radiation.
(c) frequency of radiation.
(d) both wavelength and intensity of radiation.

53. The threshold wavelength for ejection of electrons from a metal is 330 nm. The work function for the photoelectric emission from the metal is ($h = 6.6 \times 10^{-34}$ J-s)

(a) 1.2×10^{-18} J (b) 6.0×10^{-19} J
(c) 1.2×10^{-20} J (d) 6.0×10^{-12} J

54. The ratio of wavelengths of K_α-characteristic X-rays produced when iron ($Z = 26$) and scandium ($Z = 21$) are used as anticathode is

(a) 26 : 21 (b) 4 : 5
(c) 16 : 25 (d) 25 : 16

55. The wavelength of the K_α line for an element of atomic number 57 is λ. What is the wavelength of k_α line for the element of atomic number 29?

(a) λ (b) 2λ
(c) 4λ (d) $\lambda/4$

Bohr's Atomic Model

56. Bohr's model may be applied to

(a) Na^{10+} ion (b) He atom
(c) Be^{2+} ion (d) C^{6+} ion

57. If the radius of first orbit of H–atom is x Å, then the radius of the second orbit of Li^{2+} ion will be

(a) x Å (b) $\frac{4x}{3}$ Å
(c) $\frac{9x}{2}$ Å (d) $4x$ Å

58. According to Bohr's model, the radius of Ne^{9+} ion in ground state should be

(a) 0.529 Å (b) 0.0529 Å
(c) 5.29 Å (d) 52.9 Å

59. The ratio of spacing between the third and fourth orbit to the spacing between sixth and seventh orbit of H–atom is

(a) 7 : 13 (b) 13 : 7
(c) 16 : 49 (d) 1 : 1

60. What would be the approximate quantum number (n) for a circular orbit of hydrogen, 1×10^{-5} cm in diameter?

(a) 31 (b) 43
(c) 40 (d) 39

61. If the mass of electron is doubled, the radius of first orbit of H-atom becomes approximately

(a) 0.529 Å (b) 0.265 Å
(c) 1.058 Å (d) 0.32 Å

62. The ratio of circumference of third and second orbits of He^{+} ion is

(a) 3 : 2 (b) 2 : 3
(c) 9 : 4 (d) 4 : 9

63. If the mass of electron is doubled, the speed of electron revolving around Li^{2+} nucleus will

(a) remain same.
(b) be doubled.
(c) be halved.
(d) be quadrupled.

64. What is the orbit number of the He^{+} ion in which electron have speed $\frac{1}{205.67}$ times the speed of light?

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

65. The speed of electron revolving in the fourth orbit of a hydrogen-like atom or ion is 1094 km/s. The atom or ion is

(a) H (b) He^{+}
(c) Li^{2+} (d) Be^{3+}

66. The escape velocity for earth is 11.2 km/s. The orbit number for H-atom in which speed of electron is about 19.54 times the escape velocity is

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

67. The ratio of the speed of the electron in the ground state of hydrogen atom to the speed of light in vacuum is

(a) 1 : 1 (b) 1 : 100
(c) 1 : 137 (d) 2 : 3

68. An electron revolves round Li^{2+} nucleus at a distance of 1.587 Å. The speed of electron should be

(a) 2.188×10^6 m/s (b) 6.564×10^6 m/s
(c) 7.293×10^5 m/s (d) 7.293×10^6 m/s

69. How much distance an electron revolving in 3rd orbit of He^+ ion will travel in one second

(a) 1.458×10^6 m (b) 3.28×10^6 m
(c) 4.862×10^5 m (d) 2.917×10^6 m

70. The ratio of time taken by electron in revolution around the H-nucleus in the second and third orbits is

(a) 2 : 3 (b) 4 : 8
(c) 8 : 27 (d) 27 : 8

71. For hydrogen atom, the number of revolutions of the electron per second in the orbit of quantum number, n, is proportional to

(a) n^3 (b) $\sqrt{n}$
(c) n^{-3} (d) n^{-1}

72. Which of the following is not a permissible value of angular momentum of electron in H-atom?

(a) $1.5\ \frac{h}{\pi}$ (b) $0.5\ \frac{h}{\pi}$
(c) $1.25\ \frac{h}{\pi}$ (d) All of these

73. If an electron in H-atom jumps from one orbit to other, its angular momentum doubles. The distance of electron from nucleus becomes ____ times the initial distance.

(a) 2 (b) 4
(c) $\frac{1}{2}$ (d) $\frac{1}{4}$

74. The angular momentum of electron revolving in the second orbit of H-atom is 'x' J·s. The angular momentum of electron in the second orbit of He^+ ion should be

(a) x J·s (b) $2x$ J·s
(c) $0.5x$ J·s (d) $4x$ J·s

75. The angular momentum of electron revolving around the nucleus of H–atom is directly proportional to

(a) r (b) $r^{1/2}$
(c) $r^{-1/2}$ (d) r^{-1}

76. What is the angular speed of an electron revolving in the third orbit of He^+ ion?

(a) $6.12 \times 10^{15}\ s^{-1}$ (b) 1.63×10^{-16} s
(c) $1.92 \times 10^{16}\ s^{-1}$ (d) $1.95 \times 10^{15} s^{-1}$

77. The force of attraction on electron by the nucleus is directly proportional to

(a) $\frac{n^3}{Z^4}$ (b) $\frac{Z^3}{n^4}$
(c) $\frac{n^4}{Z^2}$ (d) $\frac{Z^2}{n^4}$

78. The K.E. of electron in He^+ will be maximum in

(a) third orbit (b) first orbit
(c) seventh orbit (d) infinite orbit

79. As the orbit number increases, the K.E. and P.E. for an electron

(a) both increases.
(b) both decreases.
(c) K.E. increases but P.E. decreases.
(d) P.E. increases but K.E. decreases.

80. The ratio of energies of first excited state of He^+ ion and ground state of H–atom is

(a) 1 : 1 (b) 4 : 1
(c) 1 : 4 (d) 16 : 1

81. For which atom or ion, the energy level of the second excited state is –13.6 eV?

(a) H (b) He^+
(c) Li^{2+} (d) Li

82. The orbit from which when electron will jump in other orbit, the energy may be absorbed but not emitted out, will be

(a) first orbit (b) second orbit
(c) seventh orbit (d) infinite orbit

83. In Bohr's model of the hydrogen atom, let r, v and E represent the orbit radius, speed of an electron and the total energy of the electron, respectively. Which of following relation is proportional to the orbit number n?

(a) $v \cdot r$ (b) r/E
(c) r/v (d) $r \cdot E$

84. The ratio of potential energy of electron in the third orbit of Li^{2+} ion to the kinetic energy of electron in the fourth orbit of He^+ ion should be

(a) 8 : 1 (b) –8 : 1
(c) –16 : 1 (d) 1 : 1

85. Which of the following quantity for an electron revolving around the H-nucleus is independent to the mass of electron?

(a) Distance from nucleus
(b) Kinetic energy
(c) Potential energy
(d) Speed

86. The potential energy of electron revolving in the ground state of H atom is

(a) –13.6 eV (b) –6.8 eV
(c) –27.2 eV (d) Zero

87. An electron is revolving around the nucleus of He^+ ion with a speed of 2.188×10^6 m/s. The potential energy of the electron is

(a) –13.6 eV (b) –6.8 eV
(c) –27.2 eV (d) Zero

88. As the orbit number increases, the difference in two consecutive energy levels

(a) remain constant (b) increases
(c) decreases (d) is unpredictable

89. The amount of energy released when an electron jumps from the seventh excited state to the first excited state in He^+ ion is

(a) 13.32 eV (b) 53.28 eV
(c) 12.75 eV (d) 26.08 eV

90. The energy difference will be minimum for which of the following energy levels of H-atom?

(a) $n = 2$ and $n = 3$ (b) $n = 3$ and $n = 4$
(c) $n = 1$ and $n = 2$ (d) $n = 1$ and $n = 4$

91. For which transition in H-atom, the amount of energy released will be maximum?

(a) $n = 4$ to $n = 2$ (b) $n = 5$ to $n = 2$
(c) $n = 2$ to $n = 1$ (d) $n = 7$ to $n = 2$

92. How much energy is needed for an electron revolving in the second orbit of He^+ ion in order to double its angular momentum?

(a) 40.8 eV (b) 2.55 eV
(c) 10.2 eV (d) 12.09 eV

93. The ionization energy of a hypothetical atom is 50 eV. If this atom obeys Bohr's atomic model, the energy of electron in its fifth orbit will be

(a) –1250 eV (b) + 2 eV
(c) –2 eV (d) +1250 eV

94. An electron revolving around H-nucleus in the ground state absorbs 10.2 eV energy. Its angular momentum increases by

(a) $\frac{h}{2\pi}$ (b) $\frac{h}{\pi}$
(c) $\frac{2h}{\pi}$ (d) $\frac{h}{4\pi}$

95. The ionization energy of He^+ ion is x eV. The ionization energy of Be^{3+} ion should be

(a) $4x$ eV (b) $2x$ eV
(c) $\frac{x}{4}$ eV (d) $\frac{x}{2}$ eV

96. The excitation energy of an electron from second orbit to third orbit of a hydrogen-like atom or ion with +Ze nuclear charge is 47.2 eV. If the energy of H-atom in the lowest energy state is –13.6 eV, then the value of Z is

(a) 4 (b) 5
(c) 6 (d) 7

97. Electromagnetic radiations of wavelength 240 nm are just sufficient to ionize sodium atom. The ionization energy of sodium (in kJ/mol) is

(a) 5.167 (b) 498.58
(c) 118.83 (d) 51.67

98. The ionization energy of He-atom in the ground state may be

(a) 13.6 eV (b) 54.4 eV
(c) 108.8 eV (d) 27.0 eV

99. The binding energy for the third electron in the ground state of Li-atom should be

(a) 108.8 eV (b) 122.4 eV
(c) 30.6 eV (d) 27.2 eV

100. Suppose that means were available for stripping 29 electrons from $_{30}Zn$ in vapours of this metal. The ionization energy for the last electron is

(a) 11.5 keV (b) 12.24 keV
(c) 13.6 eV (d) 408 eV

Spectrum

101. Suppose the mass of electron is decreased by 25%. How will it affect the Rydberg constant?

(a) It remains unchanged.
(b) It becomes one-fourth.
(c) It reduces to 75% of its original value.
(d) It is doubled.

102. The charge on the electron and proton is reduced to half. Let the present value of the Rydberg constant be R. What will be the new value of the Rydberg constant?

(a) $\frac{R}{2}$ (b) $\frac{R}{4}$
(c) $\frac{R}{8}$ (d) $\frac{R}{16}$

103. Rydberg is

(a) also called Rydberg constant and it is the universal constant.
(b) the unit of wavelength and one Rydberg equals 1.09×10^7 m.
(c) the unit of wave number and one Rydberg equals $1.09 \times 10^7\ m^{-1}$.
(d) the unit of energy and one Rydberg equals 13.6 eV.

104. For the same electronic transition in the following atom or ion, the frequency of the emitted radiation will be maximum for

(a) H-atom (b) D-atom
(c) He^+ ion (d) Li^{2+} ion

105. An electron jumps from the fourth orbit to the first orbit in a H-atom. The number of photons liberated out will be

(a) 1 (b) 2
(c) 3 (d) 6

106. The wavelength of radiation emitted out in the transition $n = 4$ to $n = 1$ in Li^{2+} ion is

(a) $\frac{135R}{16}$ (b) $\frac{16}{135R}$
(c) $\frac{16R}{135}$ (d) $\frac{135}{16R}$

107. What is the frequency of the second line of the Paschen series in the spectrum of He^+ ion?

(a) $\frac{64\ R.C}{225}$ (b) $\frac{64\ R}{225}$
(c) $\frac{225}{64\ R}$ (d) $\frac{225\ C}{64\ R}$

108. What is the wave number of the radiation of lowest frequency in the Lyman series of the spectrum of Li^{2+} ion?

(a) $\frac{4}{27R}$ (b) $\frac{27R}{4}$
(c) $\frac{27RC}{4}$ (d) $\frac{4C}{27R}$

109. The wavelength of a spectral line obtained by an electronic transition is inversely proportional to

(a) the number of transit electrons.
(b) the nuclear charge of the atom.
(c) the energy difference of the related energy levels.
(d) Speed of the transit electron.

110. In H-atom, the wave number ratio is 108 : 7 is for

(a) first Lyman and first Balmer transition.
(b) first Lyman and first Brackett transition.
(c) first Lyman and first Paschen transition.
(d) first Lyman and second Balmer transition.

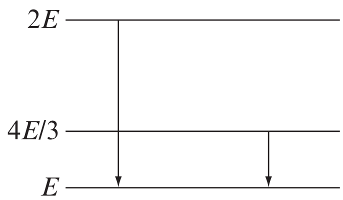
111. Wave number of the first line in the Balmer series of Be^{3+} is $2.5 \times 10^5\ cm^{-1}$. Wave number of the second line of the Paschen series of Li^{2+} is

(a) $7.2 \times 10^4\ cm^{-1}$ (b) $7.2 \times 10^5\ cm^{-1}$
(c) $7.2 \times 10^{-4}\ cm^{-1}$ (d) $1.8 \times 10^4\ cm^{-1}$

112. When an electron jumps from nth orbit to 1st orbit in an imaginary atom obeying Bohr's model, it emits two radiations of wavelengths 400 nm and 300 nm. The frequency of radiation emitted out in the transition $n = n$ to $n = 1$ will be

(a) 7.5×10^{14} Hz (b) 1.0×10^{15} Hz
(c) 8.75×10^{14} Hz (d) 1.75×10^{15} Hz

113. The given diagram indicates the energy levels of a certain atom. When the system moves from $2E$ level to E level, a photon of wavelength λ is emitted. The wavelength of the photon emitted during its transition from $4E/3$ level to E level is.



(a) $\lambda/3$ (b) $3\lambda/4$
(c) $4\lambda/3$ (d) 3λ

114. What transition in the hydrogen spectrum would have the same wavelength as the Balmer transition $n = 4$ to $n = 2$ of He^+ spectrum?

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

115. The number of possible spectral lines in the bracket series in hydrogen spectrum, when electrons present in the ninth excited state return to the ground state, is

(a) 36 (b) 45
(c) 5 (d) 6

Heisenberg's Uncertainty Principle

116. The uncertainty in measuring the speed of a particle is zero. Uncertainty in measuring its position will be

(a) zero (b) $\dfrac{h}{4\pi}$
(c) $\dfrac{h}{4\pi m}$ (d) infinite

117. Uncertainty in measuring the speed of a particle is numerically equal to the uncertainty in measuring its position. The value of these uncertainties will be

(a) equal to $\sqrt{\dfrac{h}{4\pi m}}$.

(b) less than $\sqrt{\dfrac{h}{4\pi m}}$.

(c) greater than $\sqrt{\dfrac{h}{4\pi m}}$.

(d) (a) or (c)

118. If uncertainty in position and momentum of a particle is numerically equal, then the minimum uncertainty in speed of the particle should be

(a) $\sqrt{\dfrac{h}{2\pi}}$ (b) $\dfrac{1}{2m}\sqrt{\dfrac{h}{\pi}}$

(c) $\sqrt{\dfrac{h}{\pi}}$ (d) $\dfrac{1}{m}\sqrt{\dfrac{h}{\pi}}$

119. The mass of a particle is 10^{-10} g and its diameter is 10^{-4} cm. If its speed is 10^{-6} cm/s with 0.0001% uncertainty in measurement, the minimum uncertainty in its position is

(a) 5.28×10^{-8} m (b) 5.28×10^{-7} m
(c) 5.28×10^{-6} m (d) 5.28×10^{-9} m

120. Uncertainty in the position of an electron (mass $= 9.1 \times 10^{-31}$ kg) moving with a velocity 300 m/s accurate up to 0.001% will be

(a) 5.76×10^{-3} m (b) 1.92×10^{-2} m
(c) 3.84×10^{-3} m (d) 19.2×10^{-4} m

De Broglie's Equation

121. The ratio of de Broglie wavelength of electron and proton moving with the same speed is about

(a) 1836 : 1 (b) 1 : 1836
(c) 1 : 1 (d) 1 : 2

122. An electron makes five crests during one revolution around H-nucleus. The electron belongs from the

(a) first orbit (b) fourth orbit
(c) fifth orbit (d) sixth orbit

123. The circumference of the third orbit of He^+ ion is x m. The de Broglie wavelength of electron revolving in this orbit will be

(a) $\frac{x}{3}$ m (b) $3x$ m
(c) $\frac{x}{9}$ m (d) $9x$ m

124. The momentum of a photon of wavelength 6626 nm will be

(a) 10^{-28} kg ms^{-1} (b) 10^{-25} kg ms^{-1}
(c) 10^{-31} kg m^{-1} (d) zero

125. If λ be the de Broglie wavelength of a thermal neutron at 27°C, then the wavelength of the same neutron at 927°C is

(a) λ (b) 0.5λ
(c) 2λ (d) 0.25λ

Quantum Numbers

126. The energy of different orbitals in an atom or ion having only one electron depends on

(a) n only (b) n and l only
(c) n, l and m only (d) n, l, m and s

127. The size of an orbital is given by

(a) principal quantum number.
(b) azimuthal quantum number.
(c) magnetic quantum number.
(d) spin quantum number.

128. The types and number of orbitals belonging from the fifth orbit are, respectively,

(a) 5, 25 (b) 25, 5
(c) 4, 16 (d) 5, 5

129. The electron in the same orbital may be identified with the quantum number

(a) n (b) l
(c) m (d) s

130. The orbital angular momentum of an electron is 2s orbital is

(a) $+\frac{1}{2}\cdot\frac{h}{2\pi}$ (b) 0
(c) $\frac{h}{2\pi}$ (d) $\sqrt{2}\,\frac{h}{2\pi}$

131. The orbital angular momentum of a 4p electron will be

(a) $4.\frac{h}{2\pi}$ (b) $\sqrt{2}.\frac{h}{2\pi}$
(c) $\sqrt{6}.\frac{h}{4\pi}$ (d) $\sqrt{2}.\frac{h}{4\pi}$

132. The probability of finding P_y electron is zero in

(a) XY-plane (b) YZ-plane
(c) XZ-plane (d) Y-axis

133. The quantum number which determines the shape of the orbital is

(a) magnetic quantum number.
(b) azimuthal quantum number.
(c) principal quantum number.
(d) spin quantum number.

134. Orbital with maximum symmetry is

(a) p-orbital (b) s-orbital
(c) d_{xy} -orbital (d) d_{z^2} -orbital

135. In the presence of external magnetic field, p-orbital is

(a) 3-fold degenerate (b) 5-fold degenerate
(c) 7-fold degenerate (d) non-degenerate

136. The number of orbitals of g-type

(a) 5 (b) 7
(c) 9 (d) 11

137. Which of the following orbital does not exist according to quantum theory?

(a) 5g (b) 4f
(c) 5h (d) 6h

138. Which of the following set of quantum numbers is permissible?

(a) 4, 1, +2, +1/2 (b) 4, 2, –1, +1/2
(c) 4, 0, 0, 1 (d) 4, 4, +2, –1/2

139. Number of orbitals represented by $n = 3$, $l = 2$ and $m = +2$ is

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

140. The quantum numbers +1/2 and –1/2 for the electron spin represent

(a) rotation of the electron in clockwise and anticlockwise direction, respectively.
(b) rotation of the electron in anticlockwise and clockwise direction, respectively.
(c) magnetic moment of the electron pointing up and down, respectively.
(d) two quantum mechanical spin states which have no classical analogue.

Schrodinger's Equation

141. The number of nodal planes in $2p_x$ orbital is

(a) zero (b) 1
(c) 2 (d) infinite

142. Which of the following orbital is represented by the complete wave function ψ_{410}?

(a) 4*s* (b) 3*p*
(c) 4*p* (d) 4*d*

143. Number of nodal surface in 5*s* orbital is

(a) 5 (b) 4
(c) 3 (d) 0

144. The orbital having two nodal surfaces is

(a) 1*s* (b) 2*s*
(c) 3*s* (d) 2*p*

145. The number of radial nodes of 3*s*, 3*p* and 3*d* electrons are, respectively,

(a) 0, 1, 2 (b) 2, 1, 0
(c) 2, 2, 2 (d) 1, 3, 5

Electronic Configuration

146. The process of successive addition of protons to the nucleus followed by an addition of the same number of electrons to the available orbitals in the sequence of increasing energy to obtain the electronic configuration of many electronic configuration of many electron atom is known as

(a) Pauli's exclusion principle
(b) Hund's rule
(c) Heisenberg's uncertainty principle
(d) Aufbau principle

147. When the value of azimuthal quantum number is 3, the maximum and minimum values of spin multiplicity are

(a) 1, 8 (b) 8, 1
(c) 6, 1 (d) 7, 0

148. A completely filled *d*-orbital (d^{10}) is of

(a) spherical symmetry
(b) octahedral symmetry
(c) tetrahedral symmetry
(d) unsymmetry

149. An atom has d^8 configuration. The maximum number of electrons in the same spin is

(a) 5 (b) 3
(c) 8 (d) 2

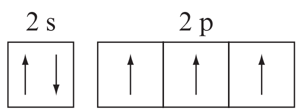
150. The number of orbitals having $(n + l) < 5$ is

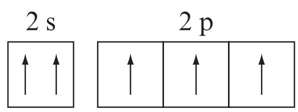
(a) 9 (b) 8
(c) 4 (d) 10

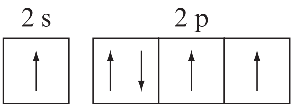
151. The total number of orbitals for $(n + l) = 4$ is

(a) 4 (b) 16
(c) 32 (d) 9

152. Which of the following configuration is violating Pauli's exclusion principle?

(a) 

(b) 

(c) 

(d) (b) and (c)

153. If there are three possible values (–1/2, 0, +1/2) for the spin quantum number, then the maximum capacity of second orbit will become

(a) 8 electrons (b) 6 electrons
(c) 12 electrons (d) 27 electrons

154. The electrons identified by quantum numbers n and l,

(i) $n = 4, l = 1$ (ii) $n = 4, l = 0$
(iii) $n = 3, l = 2$ (iv) $n = 3, l = 1$

can be placed in the order of increasing energy from the lowest to highest, as

(a) iv < ii < iii < i (b) ii < iv < i < iii
(c) i < iii < ii < iv (d) iii < i < iv < ii

155. If the numbers of orbitals of a particular type were $(3l + 1)$, but spin quantum numbers were only +1/2 and –1/2, then d-type orbitals will contain a maximum of ___ electrons.

(a) 10 (b) 14
(c) 7 (d) 5

156. If the nitrogen atom has electronic configuration $1s^7$, it would have energy lower than that of the normal ground state configuration $1s^2 2s^2 2p^3$, because the electrons would be closer to the nucleus. Yet $1s^7$ is not observed because it violates

(a) Heisenberg's uncertainty principle
(b) Hund's rule
(c) Pauli's exclusion principle
(d) Bohr postulate of stationary orbits

157. Which quantum number differs for the two electrons present in K-shell of an atom?

(a) Principal quantum number
(b) Azimuthal quantum number
(c) Magnetic quantum number
(d) Spin quantum number

158. The correct set of four quantum numbers for the unpaired electron of chloride atom is

(a) 3, 2, 0, +1/2 (b) 3, 1, 0, +1/2
(c) 3, 1, +1, 0 (d) 3, 0, –1, +1/2

159. The correct set of four quantum numbers for the valence electron of rubidium ($Z = 37$) is

(a) 5, 0, 0, +1/2 (b) 5, 1, 0, +1/2
(c) 5, 1, 1, +1/2 (d) 6, 0, 0, +1/2

160. The correct set of quantum numbers defining the highest energy electron in scandium (I) ion is

(a) $n = 3, l = 1, m = 0, s = -1/2$
(b) $n = 3, l = 0, m = 0, s = -1/2$
(c) $n = 4, l = 0, m = 0, s = +1/2$
(d) $n = 3, l = 2, m = 2, s = +1/2$

161. How many unpaired electrons are present in the ground state of chromium ($Z = 24$)?

(a) 1 (b) 5
(c) 6 (d) 0

162. The K and L shell of an element are completely filled and there are 16 electrons in M-shell and 2 electrons in N-shell. The atomic number of the element is

(a) 18 (b) 28
(c) 22 (d) 26

163. The penultimate and outermost orbit of an element contains 10 and 2 electrons, respectively. If the outermost orbit is fourth orbit, then the atomic number of the element should be

(a) 12 (b) 22
(c) 32 (d) 40

164. The number of unpaired electron in G. S., first E.S. and second E.S. of S ($Z = 16$) are, respectively,

(a) 0, 2 and 4 (b) 2, 4 and 6
(c) 0, 4 and 6 (d) 2, 4 and 4

165. The electronic structure of zinc ($Z = 30$) is 2, 8, 18, 2. The electronic structure of gallium ($Z = 31$) will be

(a) 2, 8, 18, 2, 1 (b) 2, 8, 19, 2
(c) 2, 8, 18, 3 (d) 2, 8, 19, 3

166. Which of the following ion have the same number of unpaired electrons as in Fe^{2+} ($Z = 26$)?

(a) Fe^{3+} ($Z = 26$) (b) Ni^{2+} ($Z = 28$)
(c) Co^{3+} ($Z = 27$) (d) Cr^{+} ($Z = 24$)

167. Which of the following will have magnetic moment about 4.9 BM?

(a) Cr^{+} ($Z = 24$) (b) Ti^{4+} ($Z = 22$)
(c) Fe^{2+} ($Z = 26$) (d) Cu^{2+} ($Z = 29$)

168. Which of the following ion is diamagnetic?

(a) Sc^{3+} ($Z = 21$) (b) Ti^{2+} ($Z = 22$)
(c) V^{3+} ($Z = 23$) (d) Fe^{2+} ($Z = 26$)

169. Which of the following ion will have maximum magnetic moment?

(a) Fe^{3+} ($Z = 26$) (b) Cr^{3+} ($Z = 24$)
(c) Ti^{4+} ($Z = 22$) (d) Co^{3+} ($Z = 27$)

170. For which of the following element, all of its existing ion M^{x+} will be diamagnetic?

(a) Cu (b) Fe
(c) Cr (d) Na

171. The magnetic moment of Ni^{x+} ion ($Z = 28$) is about 2.82 BM. The value of x is

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

172. A compound of vanadium has a magnetic moment of 1.73 BM. The electronic configuration of vanadium ion in the compound is

(a) $[Ar]3d^2$ (b) $[Ar]3d^1$
(c) $[Ar]3d^3$ (d) $[Ar]4s^1$

173. Which of the following is paramagnetic?

(a) Zn^{2+} ($Z = 30$) (b) Ni^{2+} ($Z = 28$)
(c) Sc^{3+} ($Z = 21$) (d) O^{2-} ($Z = 8$)

174. Which of the following ion is expected to be coloured?

(a) Zn^{2+} ($Z = 30$) (b) Ca^{2+} ($Z = 20$)
(c) Sn^{2+} ($Z = 50$) (d) V^{2+} ($Z = 23$)

175. Which of the following ion is expected to be colourless?

(a) Ni^{2+} ($Z = 28$) (b) Mn^{2+} ($Z = 25$)
(c) Zn^{2+} ($Z = 30$) (d) Cu^{2+} ($Z = 29$)

EXERCISE II (JEE ADVANCED)

Section A (Only one Correct)

1. The *e*/*m* ratio of cathode rays is *x* unit, when hydrogen is filled in the discharge tube. What will be its value, when deuterium (D_2) is filled in it?
   (a) *x* unit (b) *x*/2 unit
   (c) 2*x* unit (d) *x*/4 unit

2. The specific charges of two particles A and B are in the ratio 2 : 3. If the mass ratio $m_A : m_B$ is 2 : 3, then the ratio of their charges $e_A : e_B$, is
   (a) 1 : 1 (b) 4 : 9
   (c) 9 : 4 (d) 2 : 3

3. An electron at rest is accelerated through a potential difference of 200 V. If the specific charge of electron is 1.764×10^{11} C/kg, then the speed acquired by the electron is about
   (a) 8.4×10^6 cm/s (b) 8.4×10^6 m/s
   (c) 4.2×10^6 m/s (d) 4.2×10^6 cm/s

4. The mass of a negative meson is 208 time the mass of electron. If the *e*/*m* ratio of α-particle is *x* unit, then the *e*/*m* ratio of this meson will be
   (a) $\frac{x}{208}$ unit (b) $\frac{x}{52}$ unit
   (c) 17.65 *x* unit (d) 104 *x* unit

5. An electron and a proton are accelerated through a potential *V*. If P_e and P_p are their momentum, then $P_P : P_e$ ratio is approximately equal to
   (a) 1 : 1836 (b) 1 : 1
   (c) 1836 : 1 (d) 43 : 1

6. The frequency of an electromagnetic radiation which makes 2×10^6 waves per 50 cm is
   (a) 1.2×10^{15} Hz (b) 150 Hz
   (c) 6×10^{14} Hz (d) 1.2×10^{13} Hz

7. A certain laser transition emits 6.0×10^{15} quanta per second per square metre of λ = 662.6 nm. What is the power output in joule per second per square metre?
   (a) 1.8×10^{-3} (b) 6.626×10^{-4}
   (c) 1.8×10^3 (d) 6.626×10^{-12}

8. A bulb emits light of wavelength $\frac{1987.8}{7}$ nm. The bulb is rated as 200 W and 14% of the energy is emitted as light. How many photons are emitted by the bulb per second?
   (a) 1.2×10^{21} (b) 4×10^{10}
   (c) 1.33×10^{11} (d) 4×10^{19}

9. An amount of 1.75×10^{-4} mole of HI decomposes by the absorption of photons of wavelength 2500 Å. If one molecule is decomposed per absorbed photon, the total energy absorbed is ($N_A \times hc = 0.12$ J)
   (a) 42.0 J (b) 4.2 J
   (c) 8.4 J (d) 84 J

10. The dye acriflavine when dissolved in water has its maximum light absorption at 4530 Å and has maximum florescence emission at 5080 Å. The number of fluorescence quanta is about 53% of the number of quanta absorbed. What percentage of absorbed light energy is emitted as fluorescence?
    (a) 41% (b) 47%
    (c) 74% (d) 63%

11. The vapours of Hg absorb some electron accelerated by a potential difference of 5.0 V as a result of which light is emitted. If the full energy of single incident electron is supposed to be converted into light emitted by single Hg-atom, then the wavelength of the emitted light is
    (a) 2480 nm (b) 248 nm
    (c) 6200 nm (d) 620 nm

12. At one time the meter was defined as 1650763.73 wavelength of the orange light emitted by a light source containing Kr^{86} atoms. What is the corresponding photon energy of this radiation?
    (a) 3.28×10^{-19} J/quanta
    (b) 1.2×10^{-31} J/quanta
    (c) 1.09×10^{-27} J/quanta
    (d) 2.048 J/quanta

13. A ruby laser produces radiations of wavelength 662.6 nm in pulses whose duration are 1.0×10^{-9} s. If the laser produces 0.36 J of energy per pulse, then how many photons are produced in each pulse?

(a) 1.2×10^{9} (b) 1.2×10^{27}
(c) 1.2×10^{18} (d) 1.2×10^{15}

14. O_2 undergoes photochemical dissociation into one normal oxygen atom and one oxygen atom, 1.2 eV more energetic than normal. The dissociation of O_2 into two normal atoms of oxygen requires 482.5 kJ/mol. The maximum wavelength effective for photochemical dissociation of O_2 is (1 eV = 96.5 kJ/mol)

(a) 248 nm (b) 1033.3 nm
(c) 1236.2 nm (d) 200 nm

15. Photodissociation of water $H_2O(l) + h\nu \rightarrow H_2(g) + \frac{1}{2}O_2(g)$ has been suggested as a source of hydrogen. The heat absorbed in this reaction is 289.5 kJ/mole of water decomposed. The maximum wavelength that would provide the necessary energy assuming that one photon causes the dissociation of one water molecule is (1 eV = 96.5 kJ/mol)

(a) 413.33 nm (b) 826.67 nm
(c) 206.67 nm (d) 4.3 nm

16. The dissociation energy of H_2 is 429.0 kJ/mol. If H_2 is dissociated by illumination with radiation of wavelength 270.0 nm, then what percentage of radiant energy will be converted into kinetic energy? ($h = 6.6 \times 10^{-34}$ J·s, $N_A = 6 \times 10^{23}$)

(a) 1.25% (b) 2.5%
(c) 5.0% (d) 7.5%

17. In a measurement of the quantum efficiency of photosynthesis in green plants, it was found that 9 quanta of red light at 6900 Å were needed to evolve 1 molecule of O_2. The average energy storage in the photosynthesis process is 111.6 kcal/mol of O_2 evolved. What is the energy conversion efficiency in this experiment? ($\frac{h \cdot c}{e} = 1.24 \times 10^{-6}$ nm.eV, 1 eV = 23 kcal/mol)

(a) 70% (b) 50%
(c) 40% (d) 30%

18. For a photochemical reaction $A \rightarrow B$, 1×10^{-5} moles of 'B' were formed on absorption of 6.626×10^{7} erg at 360 nm. The quantum efficiency (molecules of 'B' formed per photon) is ($N_A = 6 \times 10^{23}$)

(a) 1.0 (b) 0.25
(c) 0.5 (d) 2.0

19. Light of wavelength λ, falls on a metal having work function hc/λ_0. Photoelectric effect will take place only if

(a) $\lambda \geq \lambda_0$ (b) $\lambda \geq 2\lambda_0$
(c) $\lambda \leq \lambda_0$ (d) $\lambda \leq \lambda_0/2$

20. Light of wavelength (λ) strikes a metal surface with intensity X and the metal emits Y electrons per second of maximum kinetic energy Z. What will happen to Y and Z if X is halved?

(a) Y will be halved and Z will be doubled.
(b) Y will be doubled and Z will be halved.
(c) Y will be halved and Z will remain the same.
(d) Y will remain the same and Z will be halved.

21. Photoelectric emission is observed from a metal surface for frequencies v_1 and v_2 of the incident radiation ($v_1 > v_2$). If maximum kinetic energies of the photoelectrons in the two cases are in the ratio $1 : K$, then the threshold frequency for the metal is given by

(a) $\frac{\nu_2 - \nu_1}{K - 1}$ (b) $\frac{K\nu_2 - \nu_1}{K - 1}$
(c) $\frac{K\nu_1 - \nu_2}{K}$ (d) $\frac{K\nu_1 - \nu_2}{K - 1}$

22. Photons of frequency (ν) fall on metal surface for which the threshold of frequency is v_0. Which of the following statement is correct?

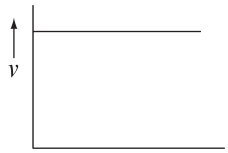
(a) All ejected electrons have the same kinetic energy $h(v - v_0)$.
(b) The ejected electrons have a distribution of kinetic energy from zero to $h(v - v_0)$.
(c) The most energetic electron has kinetic energy hv.
(d) The average kinetic energy of ejected electrons is $h(v - v_0)$.

23. If λ_0 is the threshold wavelength for photoelectric emission from a metal surface, λ is the wavelength of light falling on the surface of metal and m is the mass of electron, then the maximum speed of ejected electrons is given by

(a) $\left[\frac{2h}{m}(\lambda_0 - \lambda)\right]^{1/2}$ (b) $\left[\frac{2hc}{m}(\lambda_0 - \lambda)\right]^{1/2}$
(c) $\left[\frac{2hc}{m}\left(\frac{\lambda_0 - \lambda}{\lambda_0\lambda}\right)\right]^{1/2}$ (d) $\left[\frac{2h}{m}\left(\frac{1}{\lambda_0} - \frac{1}{\lambda}\right)\right]^{1/2}$

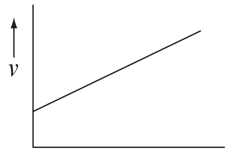
24. Which of the following graphs is correct for the photoelectric effect?

(a)



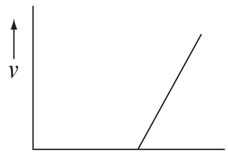
K.E. of emitted → electrons

(b)



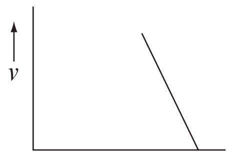
K.E. of emitted → electrons

(c)



K.E. of emitted → electrons

(d)



K.E. of emitted → electrons

25. The wavelength of K_α-characteristic X-rays produced is λ, when cathode rays strike on a metal of atomic number Z. What should be the atomic number of metal such that it can produce the K_α-characteristic X-rays of wavelength 4λ?

(a) $\frac{Z}{16}$ (b) $\frac{Z}{2}$

(c) $\frac{Z+1}{2}$ (d) $2Z - 1$

26. Two carbon discs, 1.0 g each are 1.0 cm apart have equal and opposite charges. If the force of attraction between them is 10^{-5} N, then the ratio of excess electrons to the total atoms on the negatively charged disc is ($N_A = 6 \times 10^{23}$, $e = 1.6 \times 10^{-19}$ C)

(a) $2.4 \times 10^{-12} : 1$ (b) $10^{-14} : 2.4$

(c) $10^{12} : 2.4$ (d) $2.4 : 10^{12}$

27. The radius of the 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 principal quantum number of final state of the atom is

(a) 2 (b) 3

(c) 4 (d) 16

28. For which orbit in He^+ ion, the circumference is 26.5 Å?

(a) 2 (b) 3

(c) 4 (d) 16

29. The radius of the second orbit of H-atom is equal to the radius of

(a) second orbit of He^+ ion.

(b) third orbit of Li^{2+} ion.

(c) fourth orbit of He^+ ion.

(d) fourth orbit of Be^{3+}ion.

30. As the orbit number increases, the distance between two consecutive orbits (r_1 = radius of first orbit)

(a) increases by $2r_1$.

(b) increases by $(2n - 1)r_1$, where n is the lower orbit number.

(c) increases by $(2n - 1)r_1$, where n is the higher orbit number.

(d) remains constant.

31. The ratio of the areas within 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

32. When an electron jumps from the second orbit to fourth orbit, its distance from nucleus increases by 2.116 Å. The atom or ion should be

(a) H atom (b) He^+ ion

(c) Li^{2+} ion (d) Be^{3+} ion

33. What is the distance travelled by an electron revolving in the second orbit of Be^{3+} ion in 100 revolutions?

(a) 3.32×10^{-8} m (b) 5.29×10^{-8} m

(c) 6.64×10^{-8} m (d) 1.16×10^{-8} m

34. Which of the following cannot be circumference of an orbit in H-atom? (r_0 = radius of the first orbit)

(a) $2\pi r_0$ (b) $4\pi r_0$

(c) $8\pi r_0$ (d) $18\pi r_0$

35. The speed of electron revolving around H-nucleus is 0.547×10^6 m/s. The distance of electron from the nucleus is

(a) 2.116 Å (b) 4.761 Å
(c) 8.464 Å (d) 0.529 Å

36. The speed of electron in H-atom is directly proportional to

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

37. The ratio of the speed of the electron in the first Bohr orbit of hydrogen and the speed of light is equal to (where e, h and c have their usual meanings)

(a) $2\pi hc/e^2$ (b) $e^2c/2\pi h$
(c) $e^2h/2\pi c$ (d) $e^2/2\in_0 hc$

38. In the Bohr's atomic model, the electrostatic force of attraction between nuclear charge (Ze) and electron of charge e is balanced by the centripetal force acting towards the centre of atom. If $\in_0$ be the permittivity of vacuum and r be the radius of orbit in which electron is revolving, the speed of electron is

(a) $\sqrt{\dfrac{Ze^2}{(4\pi\varepsilon_o)mr}}$ (b) $\sqrt{\dfrac{(4\pi\varepsilon_o)mr}{Ze^2}}$

(c) $\sqrt{(4\pi\varepsilon_o)mrZe^2}$ (d) $\dfrac{e}{\sqrt{(4\pi\varepsilon_o)mr}}$

39. If an electron is revolving around the nucleus of He^+ ion at a distance of 4.0 Å, the magnitude of centripetal force on electron by the nucleus is ($e = 1.6 \times 10^{-19}$ C)

(a) 2.88×10^{-9} N (b) 2.88×10^{-7} N
(c) 1.152×10^{-18} N (d) 1.44×10^{-9} N

40. The time period of revolution in the third orbit of Li^{2+} ion is x second. The time period of revolution in the second orbit of He^+ ion should be

(a) x s (b) $\frac{3}{2}x$ s
(c) $\frac{2}{3}x$ s (d) $\frac{8}{27}x$ s

41. In two hydrogen atoms A and B, the electrons are revolving around the nucleus in circular orbits of radius r and $4r$, respectively. The ratio of times taken by them to complete one revolution is

(a) 1 : 2 (b) 1 : 4
(c) 1 : 8 (d) 1 : 64

42. The time period of revolution of electron in H-atom is directly proportional to

(a) r (b) $r^{1/2}$
(c) $r^{3/2}$ (d) r^2

43. The average lifetime of an electron in an excited state of hydrogen atom is about 10^{-8} s. How many revolutions does an electron in the $n = 2$ state make before dropping to the $n = 1$ state?

(a) 10^8 (b) 8.33×10^6
(c) 6.67×10^7 (d) 1.04×10^6

44. According to Maxwell's theory of electrodynamics, an electron going in a circle should emit radiation of frequency equal to its frequency of revolution. What should be the wavelength of the radiation emitted by a hydrogen atom in the ground state if this rule is followed?

(a) 4500 nm (b) 450 nm
(c) 45 nm (d) 4.5 nm

45. The angular momentum of electron in Bohr's orbit is J. What will be the K.E. of electron in that Bohr's orbit?

(a) $\dfrac{1}{2}\dfrac{Jv}{r}$ (b) $\dfrac{Jv}{r}$

(c) $\dfrac{J^2}{2m}$ (d) $\dfrac{J^2}{2r}$

46. The kinetic energy of an electron in the second Bohr orbit of a hydrogen atom is (a_o is the Bohr radius)

(a) $\dfrac{h^2}{4\pi^2 ma_o^2}$ (b) $\dfrac{h^2}{16\pi^2 ma_o^2}$

(c) $\dfrac{h^2}{32\pi^2 ma_o^2}$ (d) $\dfrac{h^2}{64\pi^2 ma_o^2}$

47. The ionization energy of a hydrogen-like atom is 14.4 eV. The amount of energy released when electron jumps from the fourth orbit to the first orbit in this atom is

(a) 13.5 eV (b) 10.8 eV
(c) 0.9 eV (d) 12.75 eV

48. The radius of first orbit of H-atoms is 0.529 Å. The radius of first orbit of D-atoms should be

(a) exactly 0.529 Å.
(b) slightly less than 0.529 Å.
(c) slightly greater than 0.529 Å.
(d) 1.058 Å.

49. The ionization energy of H-atoms is 13.6 eV. The ionization energy of deuterium atom should be

(a) exactly 13.6 eV.
(b) slightly less than 13.6 eV.
(c) slightly greater than 13.6 eV.
(d) 27.2 eV.

50. An antiproton has the mass of a proton but a charge of $-e$. If a proton and an antiproton orbited each other, then how far apart would they be in ground state of such a system? Mass of a proton is 1836 times the mass of an electron.

(a) 0.058 pm (b) 0.029 pm
(c) 0.014 pm (d) 194.25 nm

51. A lithium atom has three electrons. Assume the following simple picture of the atom. Two electrons move close to the nucleus making up a spherical cloud around it and the third moves outside this cloud in a circular orbit. Bohr's model can be used for the motion of this third electron but $n = 1$ state is not available to it. The ionization energy of lithium in ground state, using the above picture, is

(a) 13.6 eV (b) 10.2 eV
(c) 3.4 eV (d) 1.51 eV

52. An electron in a hydrogen atom in its ground state absorbs 1.5 times as much energy as the minimum required for it to escape from the atom. What is the speed of the emitted electron?

(a) 1.55×10^6 m/s (b) 2.68×10^6 m/s
(c) 2.19×10^6 m/s (d) 1.02×10^6 m/s

53. Sodium atoms emit a spectral line with a wavelength in the yellow, 589.6 nm. What is the approximate difference in energy between the two energy levels involved in the emission of this spectral line?

(a) 3.37×10^{-19} J (b) 2.1 eV
(c) 48.35 kcal/mol (d) All of these

54. A certain molecule has an energy level diagram for its vibrational energy in which two levels are 0.0141 eV apart. The wavelength of the emitted line for the molecule as it falls from one of these levels to the other is about

(a) 88 μm (b) 88 mm
(c) 174.84 m (d) 88 nm

55. In a discharge tube, there are only two hydrogen atoms. If the electrons in both atoms are de-exciting from 4th orbit, the minimum and maximum number of spectral lines should, respectively, be

(a) 1, 4 (b) 4, 1
(c) 3, 4 (d) 1, 6

56. Electrons are de-exciting from the fifth orbit in hydrogen atoms but the first orbit is not available for them. The maximum number of spectral lines should be

(a) 10 (b) 6
(c) 15 (d) 3

57. From a hydrogen discharge tube, only three photons are picked up. The energies of these three photons were 10.2, 12.1 and 1.9 eV. These photons are coming from

(a) only one atoms. (b) two atoms.
(c) three atoms. (d) two or more atoms.

58. When electron jumps from the fourth orbit to the second orbit in He^+ ion, the radiation emitted out will fall in

(a) ultraviolet region (b) visible region
(c) infrared region (d) radio wave region

59. When electrons are de-exciting to the ground state from nth orbit of hydrogen atoms, 15 spectral lines are formed. The shortest wavelength among these will be

(a) $\frac{11}{900}R$ (b) $\frac{900}{11R}$
(c) $\frac{35}{36}R$ (d) $\frac{36}{35R}$

60. Rydberg given the equation for all visible radiation in the hydrogen spectrum as $\lambda = \frac{kn^2}{n^2 - 4}$. The value of k in terms of Rydberg constant is

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

61. The wavelengths of the first Lyman lines of hydrogen, He^+ and Li^{2+} ions are λ_1, λ_2, λ_3. The ratio of these wavelengths is

(a) 1 : 4 : 9 (b) 9 : 4 : 1
(c) 36 : 9 : 4 (d) 6 : 3 : 2

62. An excited hydrogen atom emits a photon of wavelength λ in returning to the ground state. If R is the Rydberg constant, then the quantum number n of the excited state is

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

(c) $\sqrt{\dfrac{\lambda R}{\lambda R - 1}}$ (d) $\sqrt{\lambda R(\lambda R - 1)}$

63. Suppose that in any Bohr atom or ion, orbits are only in even numbers like 2, 4, 6, …. The maximum wavelength of radiation emitted in the visible region of H-spectrum should be

(a) $\dfrac{4}{R}$ (b) $\dfrac{R}{4}$

(c) $\dfrac{36}{5R}$ (d) $\dfrac{16}{3R}$

64. The wavelength of first line of Lyman series of H-atom is 1216 Å. What will be the wavelength of first line of Lyman series in 10 time ionized sodium atom ($Z = 11$)?

(a) 1216 Å (b) 12.16 Å

(c) 10 Å (d) 110 Å

65. In a sample of hydrogen atoms, all the atoms are in a particular excited state. If the emission spectrum of this sample has only 4 spectral lines in the visible region, then the total number of spectral lines in IR region possible from that state is

(a) 6 (b) 5

(c) 7 (d) 15

66. Imagine an atom made up of a stationary proton and a hypothetical particle of double the mass of electron but having the same charge as the electron. Apply Bohr's atomic model and consider all possible transitions of this hypothetical particle directly to the first excited state. The longest wavelength photon that will be emitted has wavelength (given in terms of Rydberg constant R for the hydrogen atom) equal to

(a) $\dfrac{9}{5R}$ (b) $\dfrac{36}{5R}$

(c) $\dfrac{18}{5R}$ (d) $\dfrac{4}{R}$

67. Which of the following expression represent the wave number of spectral lines in Balmer series (if n is the principal quantum number of higher energy level)?

(a) $\dfrac{R(n^2-4)}{n^2}$ (b) $\dfrac{R(n-2)(n+2)}{n^2}$

(c) $\dfrac{R(n-2)(n+2)}{4n^2}$ (d) $\dfrac{R(n-1)(n+1)}{4n^2}$

68. The energy emitted when electron of 1.0 g atom of hydrogen undergoes transition giving the spectral lines of lowest energy in the visible region of its atomic spectra is

(a) 301.22 kJ (b) 328 kJ

(c) 984 kJ (d) 182.22 kJ

69. A series of lines in the spectrum of atomic hydrogen lines at wavelength 656.46, 486.27, 434.17, 410.29 nm. What is the wavelength of next line in this series?

(a) 397.12 nm (b) 407.83 nm

(c) 389.01 nm (d) 360.54 nm

70. To what series does the spectral line of atomic hydrogen belong if its wave number is equal to the difference between the wave numbers of the following two lines of the Balmer series: 486.1 and 410.2 nm?

(a) Lyman series (b) Balmer series

(c) Paschen series (d) Brackett series

71. The value of Rydberg constant R, if He^+ ions are known to have the wavelength difference between the first (of the longest wavelength) lines of the Balmer and Lyman series equal to 132 nm, is

(a) $2.07 \times 10^{16}\ m^{-1}$ (b) $1.11 \times 10^{7}\ m^{-1}$

(c) $9 \times 10^{-8}\ m^{-1}$ (d) $1.936 \times 10^{7}\ m^{-1}$

72. The wavelength of the first line of the He^+ ion spectral series whose interval between the extreme lines is $2.725 \times 10^6\ m^{-1}$ is ($R = 1.09 \times 10^7\ m^{-1}$)

(a) 471.82 nm (b) 4718.2 nm

(c) 1019.37 nm (d) 165.14 nm

73. The binding energy of an electron in the ground state of hydrogen-like ions in whose spectrum, the third line of the Balmer series is equal to 108.5 nm, is

(a) 13.6 eV (b) 54.4 eV

(c) 122.4 eV (d) 14.4 eV

74. A stationary He^+ ion emitted a photon corresponding to the first line of the Lyman series. That photon liberated a photoelectron from a stationary hydrogen atom in the ground state. The velocity of the photoelectron is

(a) 3.1×10^6 m/s (b) 3.1×10^5 m/s
(c) 9.56×10^{12} m/s (d) 9.56×10^6 m/s

75. A single electron species in energy level (orbit number n) with energy X was provided with excess of energy so that it jumps to higher energy level with energy Y. If it can emit radiations of six different wavelengths on de-excitement between these two energy levels, then the correct relation is

(a) $\frac{X}{Y} = (n-1)^2$ (b) $\frac{X}{Y} = 1 + \frac{3}{n}$

(c) $\sqrt{\frac{X}{Y}} = 1 + \frac{3}{n}$ (d) $\frac{X}{Y} = 1 + \frac{n}{3}$

76. When an electron de-excites from higher orbit in H-atom, two radiations are emitted out in Paschen and Lyman series. The wavelength of radiation emitted out in Lyman series is

(a) $\frac{8R}{9}$ (b) $\frac{3R}{4}$

(c) $\frac{4}{3R}$ (d) $\frac{9}{8R}$

77. If the radius of first Bohr orbit is x unit, then de Broglie wavelength of electron in the third orbit is

(a) $2\pi x$ unit (b) $6\pi x$ unit
(c) $9x$ unit (d) $18\pi x$ unit

78. If E_1, E_2 and E_3 are the kinetic energies of an electron, an α-particle and a proton with the same de Broglie wavelength, then

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

79. A proton and an α-particle are accelerated through the same potential difference. The ratio of their de Broglie wavelengths is

(a) 1 : 1 (b) 2 : 1

(c) $\sqrt{2}$: 1 (d) $2\sqrt{2}$: 1

80. The de Broglie wavelength of a vehicle moving with velocity v is λ. Its load is changed so that the velocity as well as kinetic energy is doubled. What will be the new de Broglie wavelength?

(a) λ (b) 2λ
(c) 4λ (d) $\lambda/2$

81. When accelerated electrons are directed against an anticathode in an X-ray tube, the radiation obtained has a continuous spectrum with a wavelength minimum, $\lambda_{min} = \frac{1.24 \times 10^{-6}}{V}$ m, where V is the voltage used for accelerating the electrons. λ_{min} for $V = 5 \times 10^4$ V is

(a) 0.124 nm (b) 24.8 nm
(c) 2.48 nm (d) 1.24 nm

82. The dynamic mass (in kg) of the photon with a wavelength corresponding to the series limit of the Balmer transitions of the He^+ ion is

(a) 4.22×10^{-36} (b) 2.24×10^{-34}
(c) 2.42×10^{-35} (d) 4.22×10^{-35}

83. An electron is continuously accelerated in a vacuum tube by the application of a potential difference. If its de Broglie wavelength decreases by 1% over a path length of l cm, then its kinetic energy

(a) increases by 1% (b) increases by 2%
(c) decreases by 2% (d) increases by 0.5%

84. Assume that the uncertainty in the position of a particle is equal to its de Broglie wavelength. The minimum uncertainly in its velocity is equal to

(a) 0.25 times its velocity.

(b) $\frac{\pi}{4}$ times its velocity.

(c) $\frac{1}{4\pi}$ times its velocity.

(d) $\frac{4}{\pi}$ times its velocity.

85. What should be the increase in kinetic energy of electron in order to decrease its de Broglie wavelength from 100 nm to 50 nm?

(a) 0.451 keV (b) 4.51×10^{-4} eV
(c) 4.51×10^{-3} eV (d) 0.0451 eV

86. An α–particle is accelerated from rest through a potential difference of 6.0V. Its de Broglie wavelength is

(a) 5 Å (b) 4.15 pm
(c) 414.6 Å (d) 5 nm

87. The de Broglie wavelength of electron of He^+ ion is 3.32 Å. If the photon emitted upon de-excitation of this He^+ ion is made to hit H-atom in its ground state so as to liberate electron from it, then what will be the de Broglie wavelength of photoelectron?

(a) 2.348 Å (b) 1.917 Å
(c) 3.329 Å (d) 1.66 Å

88. Photoelectrons are liberated by ultraviolet light of wavelength 3000 Å from a metallic surface for which the photoelectric threshold is 4000 Å. The de Broglie wavelength of electrons emitted with maximum kinetic energy is

(a) 1000 Å (b) 42.43 Å
(c) 12.05 Å (d) 3.54 Å

89. The minimum uncertainty in de Broglie wavelength of an electron accelerated from rest by a potential difference of 6.0V, if the uncertainty in measuring the position is $\frac{1}{\pi}$ nm, is

(a) 6.25 Å (b) 6.0 Å
(c) 0.625 Å (d) 0.3125 Å

90. A photon of 2.55 eV is emitted out by an electronic transition in hydrogen atom. The change in de Broglie wavelength of the electron is

(a) 3.32 Å (b) 4.98 Å
(c) 6.64 Å (d) 9.96 Å

91. The orbital angular momentum of 2*p* and 3*p*-orbitals

(a) are same.
(b) are different and more for 2*p*-orbital.
(c) are different and more for 3*p*-orbital.
(d) depends on the type of atom or ion.

92. Which of the following energy level may bring absorption of photon but never emission of photon?

(a) 3*d* (b) 2*p*
(c) 1*s* (d) 2*s*

93. An electron that has the quantum numbers $n = 3$ and $m = 2$

(a) must have spin quantum number value +1/2.
(b) must have $l = 2$, 3 or 4.
(c) must have $l = 0$, 1 or 2.
(d) must have $l = 2$.

94. If an electron has spin quantum number of + ½ and magnetic quantum number of –1, then it cannot be present in

(a) *s*-orbital (b) *p*-orbital
(c) *d*-orbital (d) *f*-orbital

95. In which of the following orbital, electron will be closer to the nucleus?

(a) 6*s* (b) 4*f*
(c) 5*d* (d) 6*p*

96. In the absence of external magnetic field, *d*-orbital is

(a) 3-fold degenerate (b) 5-fold degenerate
(c) 7-fold degenerate (d) non-degenerate

97. The following electronic transitions occur when Lithium atoms are sprayed into a hot flame;

$$2s \xrightarrow{\text{I}} 2p \xrightarrow{\text{II}} 3d \xrightarrow{\text{III}} 3p \xrightarrow{\text{IV}} 4s \xrightarrow{\text{V}} 3p,$$

which of these transition would result in the emission of light?

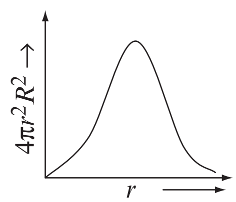
(a) I, II and IV (b) III and V
(c) III, IV and V (d) all of these steps

98. The possible set of quantum numbers for which $n = 4$, $l = 3$ and $s = +\frac{1}{2}$ is

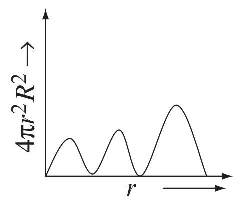
(a) 14 (b) 7
(c) 5 (d) 10

99. Which of the following graph represents the radial probability function of 3*d* electron?

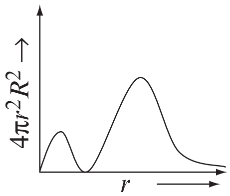
(a)



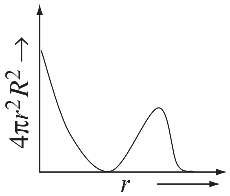
(b)



(c)



(d)



100. The wave function of 1*s* orbital of H-atom is $\psi = \frac{1}{\sqrt{\pi}}\left(\frac{1}{a_0}\right)^{3/2} e^{-r/a_0}$, where a_o = Bohr's radius. The probability of finding the electrons at a distance '*r*' from the nucleus is given by

(a) $\psi = \psi^2\, dr$ (b) $\int \psi^2 4\pi r^2 dr$

(c) $\psi^2 4\pi r^2 dr$ (d) $\psi \cdot dV$

101. For an electron in a hydrogen atom, the wave function is given by $\psi_{1s} = (\pi/\sqrt{2})\, e^{-r/a_0}$, where a_o is the radius of first Bohr's orbit and *r* is the distance from the nucleus with which the probability of finding electron varies. What will be the ratio of probabilities of finding electrons at the nucleus to first Bohr's orbit a_o?

(a) 0 (b) e

(c) e^2 (d) $\frac{1}{e^2}$

102. If *n* and *l* are, respectively, the principal and azimuthal quantum numbers, then the expression for calculating the total number of electrons in any energy level is

(a) $\sum_{l=1}^{l=n} 2(2l+1)$ (b) $\sum_{l=1}^{l=n-1} 2(2l+1)$

(c) $\sum_{l=0}^{l=n+1} 2(2l+1)$ (d) $\sum_{l=0}^{l=n-1} 2(2l+1)$

103. Which of the following element will have the same number of electrons in *s* and as well as *p*-type of orbitals?

(a) Fe ($Z = 26$) (b) Mg ($Z = 12$)

(c) Ne ($Z = 10$) (d) Ar ($Z = 18$)

104. Electronic configuration of an element is $1s^2$, $2s^1$, $2p^2$. It is

(a) ground state configuration of B ($Z = 5$).

(b) excited state configuration of B.

(c) ground state configuration of C^+ ion ($Z = 6$).

(d) impossible configuration.

105. The number of electrons having $m = 0$ for sodium atom is

(a) 2 (b) 5

(c) 7 (d) 3

106. The magnitude of the orbital angular momentum of an electron is given by $L = \sqrt{5}\ h/\pi$. How many orbitals of this kind are possible, belonging to an orbit?

(a) 4 (b) 5

(c) 11 (d) 9

107. What is the most probable distance of a 1*s* electron in a He^+ ion. The wave function for 1*s* orbital is given by $\psi = \sqrt{\left(\frac{Z^3}{\pi a_o^3}\right) e^{-Zr/a_o}}$, where a_o = radius of first Bohr's orbit in H-atom = 52.9 pm.

(a) 52.9 pm (b) 13.25 pm

(c) 6.61 pm (d) 26.45 pm

108. The average and the most probable distance from the nucleus for 1*s* electron in hydrogen atom are, respectively (a_o is the first Bohr radius.),

(a) a_o, a_o (b) a_o, $1.5a_o$

(c) $1.5a_o$, a_o (d) $1.5a_o$, $1.5a_o$

109. For an atom or ion having single electron, compare the energies of the following orbitals.

S_1 = A spherically symmetrical orbital having two spherical nodes.

S_2 = An orbital which is double dumb-bell and has no radial node.

S_3 = An orbital with orbital angular momentum zero and three radial nodes.

S_4 = An orbital having one planar and one radial node.

(a) $S_1 = S_2 = S_3 = S_4$ (b) $S_1 = S_2 = S_4 < S_3$

(c) $S_1 > S_2 > S_3 > S_4$ (d) $S_1 < S_4 < S_3 < S_2$

110. The orbital angular momentum of an electron is $\sqrt{3}\,\frac{h}{\pi}$. Which of the following may be the permissible value of angular momentum of this electron revolving in unknown Bohr's orbit?

(a) $\frac{h}{\pi}$ (b) $\frac{h}{2\pi}$

(c) $\frac{3h}{2\pi}$ (d) $\frac{2h}{\pi}$

Section B (One or More than one Correct)

1. An α-particle having kinetic energy 4.0 MeV is projected towards tin nucleus ($Z = 50$). Select the correct information(s) regarding the α-particle.

(a) Its distance of closest approach towards the nucleus is 3.6×10^{-14} m.

(b) Its potential energy at a distance of 9.0×10^{-14} m from the nucleus is 1.6 MeV.

(c) Its kinetic energy at a distance of 4.5×10^{-14} m from the nucleus is 0.8 MeV.

(d) At a moment, the distance between α-particle and the nucleus becomes 2.0×10^{-16} m.

2. The energy of an electron in the first Bohr's orbit of H-atom is –13.6 eV. The possible energy value(s) of the excited state(s) for electrons in Bohr's orbits to hydrogen is

(a) –3.4 eV (b) –10.2 eV

(c) –1.51 eV (d) –0.85 eV

3. According to Bohr's atomic theory, which of the following relations is/are correct?

(a) Kinetic energy of electron α $\frac{z^2}{n^2}$

(b) The product of speed of electron and the principal quantum number α z^2

(c) Frequency of revolution of the electron in an orbit α $\frac{z^2}{n^3}$

(d) Coloumbic force of attraction on the electron α $\frac{z^3}{n^4}$

4. As an electron jumps from the fourth orbit to the second orbit in Be^{3+} ion, its

(a) kinetic energy increases.

(b) speed increases.

(c) frequency of revolution increases.

(d) potential energy decreases.

5. Which of the following statement(s) is/are correct about the Bohr's model of hydrogen atom?

(a) The acceleration of the electron in the $n = 2$ orbit is more than that in the $n = 1$ orbit.

(b) The angular momentum of the electron in then $n = 2$ orbit is more than that in the $n = 1$ orbit.

(c) The kinetic energy of electron in the $n = 2$ orbit is less than that in the $n = 1$ orbit.

(d) The centripetal force of electron in the $n = 2$ orbit is more than that in the $n = 1$ orbit.

6. The frequency of certain line of the Lyman series ($n_2 = 4$ to $n_1 = 1$) of the atomic spectrum of hydrogen can satisfy the following conditions.

(a) It is the sum of the frequencies of a Lyman line and a Balmer line.

(b) It is the sum of the frequencies of a certain Lyman line, a Balmer line and a Brackett line.

(c) It is the sum of the frequencies of a Lyman line, a Balmer line and a Paschen line.

(d) It is the sum of the frequencies of a Lyman and a Paschen line.

7. A sample of hydrogen atoms in ground state is exposed to electromagnetic radiations of 1028 Å. The wavelengths of the induced radiation(s) is/are

(a) 1028 Å (b) 1218.4 Å

(c) 6579.2 Å (d) 190.4 Å

8. Some hydrogen-like atoms in ground state absorbs 'n' photons having same the energy and on de-excitement, it emits exactly 'n' photons. The energy of absorbed photon may be

(a) 91.8 eV (b) 40.8 eV

(c) 48.4 eV (d) 54.4 eV

9. Which of the following statement(s) is/are correct?

(a) The ratio of the radii of the first three Bohr orbits of hydrogen atom is 1 : 8 : 27.

(b) The ratio of magnitude of total energy : kinetic energy : potential energy for electron in any orbit of hydrogen atom is 1 : 1 : 2.

(c) The frequency of a green light is 6×10^{14} Hz, then its wavelength is 500 nm.

(d) The ratio of de Broglie wavelength of a H-atom, He-atom and CH_4-molecule moving with equal kinetic energy is 4 : 2 : 1.

10. When photons of energy 4.25 eV strikes the surface of a metal 'A', the ejected photoelectrons have maximum kinetic energy T_A (in eV) and de Broglie wavelength λ_A. The maximum kinetic energy of photoelectrons liberated from another metal 'B' by photons of energy 4.20 eV is T_B (= T_A – 1.50 eV). If the de Broglie wave length of these photoelectrons is λ_B (= $2\lambda_A$), then

(a) the work function of 'A' is 2.25 eV.

(b) the work function of 'B' is 3.70 eV.

(c) $T_A = 2.00$ eV

(d) $T_B = 2.75$ eV

11. Which of the following suggested that de Broglie wavelengths is not possible for the electron in a Bohr's orbit of the hydrogen atom?

(a) 3.20 Å (b) 4.98 Å

(c) 9.96 Å (d) 6.64 Å

12. The magnitude of spin angular momentum of an electron is given by

(a) $\left\{\sqrt{s(s+1)}\right\}\frac{h}{2\pi}$ (b) $\frac{sh}{2\pi}$

(c) $\frac{\sqrt{3}}{2}\frac{h}{2\pi}$ (d) $\frac{h}{4\pi}$

13. Which of the following information is true?

(a) 3*s* orbital is spherically symmetrical with two nodes.

(b) $d_{x^2-y^2}$ orbitals has lobes of electron density in *XY*-plane along *X* and *Y*-axis.

(c) The radial probability curve of 1*s*, 3*p* and 5*d* have one, two and three regions of maximum probability.

(d) $3d_{z^2}$ has zero electron density in *XY*-plane.

14. The correct statement(s) regarding $3p_y$ orbital is/are

(a) angular part of wave function is independent of angles θ and ϕ.

(b) number of maxima in $4\pi r^2 R^2(r)$ vs. *r* curve is 2.

(c) *XZ* plane is the nodal plane.

(d) magnetic quantum number must be −1.

15. The angular part of the wave function depends on the quantum numbers

(a) *n* (b) ℓ

(c) *m* (d) *s*

16. The electronic configuration of carbon atom in the excited state is $1s^2\ 2s^1\ 2p^3$. Which of the following is/are incorrect statement(s) about it?

(a) The number of unpaired electron is 4.

(b) There are five electrons in the same spin.

(c) There are only two unpaired electrons.

(d) The spin of all *p*-electrons are similar.

17. Which of the following statement(s) is (are) correct?

(a) The electronic configuration of Cr is [Ar] $3d^5 4s^1$ (Atomic number of Cr = 24).

(b) The magnetic quantum number may have a negative value.

(c) In silver atom, 23 electrons have a spin of one type and 24 of the opposite type.

(d) Azimuthal quantum number may have a negative value.

18. Which is/are correct for sodium atom in the ground state?

(a) There is only one unpaired electrons.

(b) There are five pairs of electrons.

(c) 6 electrons are in one spin and other 5 in opposite spin.

(d) There are ten electrons in the same spin.

19. Select the correct statement(s) among the following.

(a) Outside any orbital, the probability of finding the electron is zero.

(b) For single electronic atom or ion, the most probable distance of electron in an orbital having no radial node is $\frac{n^2 a_o}{Z}$ from the nucleus, where a_o is the first Bohr's radius.

(c) The average distance of electron (belonging from the same orbit) from the nucleus decreases with increase in the value of angular momentum quantum number for the orbital.

(d) The angular wave function of any s-orbital is independent from θ and ϕ.

20. Among the following, select the correct information(s).

(a) The opposite lobes in any *d*-orbital have the same sign of wave function.

(b) 1*s* orbital is the only orbital for which the sign of wave function does not have radial as well as angular dependency.

(c) The number of radial nodes is always greater than that of angular nodes.

(d) All the orbitals belonging from an orbit have the same number of total nodes.

Section C (Comprehensions)

Comprehension I

Three laser guns labelled as I, II and III have power 2, 3 and 5 W (not necessary in the same order) are used to produce photocurrent from metal plate. Number of photons emitted by laser guns are 4×10^{18}, 5×10^{18} and 9×10^{18} per second. Metal plate have threshold energy 4.5×10^{-19} J. Neither the power nor the number of photons emitted by a particular laser gun is known and it is known that all capable photons emit a photoelectron. ($N_A = 6 \times 10^{23}$, $e = 1.6 \times 10^{-19}$ C)

1. Minimum possible wavelength of emitted photoelectron is

(a) $\sqrt{680}$ Å (b) $\sqrt{30}$ Å

(c) $\sqrt{480}$ Å (d) $\sqrt{120}$ Å

2. Minimum photocurrent which must be passed through the circuit is

(a) 2.88 A (b) 1.44 A

(c) 2.08 A (d) 0.64 A

3. Ratio of maximum to minimum photocurrent which can be passed through the circuit is

(a) 5 : 4 (b) 9 : 5

(c) 9 : 4 (d) 9 : 2

Comprehension II

Let us assume 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 electrostatic force of attraction. The potential energy between an electron and the proton due to this force is given by $U = -k/r^4$, where *k* is a constant. This hypothetical atom is obeying Bohr's quantization condition.

4. The radius of *n*th 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) $r = \frac{8\pi}{nh}\sqrt{km}$

5. The speed of electron in the *n*th orbit is

(a) $V = \frac{nh}{8\pi^2 m\sqrt{km}}$ (b) $V = \frac{n^2 h}{8\pi^2 m\sqrt{km}}$

(c) $V = \frac{nh^2}{4\pi^2 m\sqrt{km}}$ (d) $V = \frac{n^2 h^2}{8\pi^2 m\sqrt{km}}$

6. The total energy of the electron in the *n*th orbit is

(a) $\text{T.E.} = \frac{-n^4 h^4}{128\pi^4 m^2 k}$ (b) $\text{T.E.} = \frac{n^4 h^4}{128\pi^4 m^2 k}$

(c) $\text{T.E.} = \frac{n^4 h^4}{256 k\pi^4 m^2}$ (d) $\text{T.E.} = \frac{-n^4 h^4}{256\pi^4 m^2}$

Comprehension III

A hydrogen-like atom (atomic number *Z*) is in a higher excited state of quantum number *n*. This excited atom can make a transition to the first excited state by successively emitting two photons of energies 10.20 and 17.00 eV, respectively. Alternatively, 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 and 5.95 eV, respectively.

7. The value of '*n*' is

(a) 4 (b) 5
(c) 6 (d) 7

8. The value of *Z* is

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

9. How much energy will be emitted when an electron in this atom moves from $(n + 1)$ to ground state?

(a) 114.75 eV (b) 117.5 eV
(c) 119.9 eV (d) 122.74 eV

Comprehension IV

A certain gas of identical hydrogen-like atoms has all its atoms in a particular upper energy level. The atoms make transition to a higher level when a monochromatic radiation having wavelength 1654 Å is incident on it. Subsequently, the atoms emit radiation of only three different photon energies.

10. The initial energy level of atoms was

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

11. The final energy level of atoms is

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

12. The atom/ion is

(a) H (b) D
(c) He^{+} (d) Li^{+2}

13. The energy of photon required to remove electron from higher energy level is

(a) 6.04 eV (b) 13.6 eV
(c) 27.2 eV (d) 36.8 eV

Comprehension V

A gas of identical H-like atom has some atoms in the lowest (ground) energy level 'A' and some atoms in a 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 the emitted photons have energy 2.7 eV. Some have more and some have less than 2.7 eV.

14. The principal quantum number of initially excited level 'B' is

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

15. The ionization energy for gas atoms is

(a) 3.4 eV (b) 12.8 eV
(c) 14.4 eV (d) 13.6 eV

16. The minimum energy of emitted photon is

(a) 0.2 eV (b) 13.5 eV
(c) 6.7 eV (d) 0.7 eV

Comprehension VI

A muon is an unstable elementary particle whose mass is 207m_e and whose charge is either +e or –e. A negative muon (μ^-) can be captured by a proton to form a muonic atom. This atom follows Bohr's quantization condition. Answer the following, neglecting reduced mass effect.

17. What is the radius of the first Bohr's orbit of this atom?

(a) 52.9 pm (b) 0.256 pm
(c) 0.256 nm (d) 10.9 nm

18. What is the ionization energy of the atom?

(a) 13.6 eV (b) 0.066 eV
(c) 0.583 MeV (d) 2.84 keV

19. What is the wavelength of the photon emitted when muon drops from second orbit to the ground state in this atom?

(a) 2.53×10^{-5} m
(b) 1.22×10^{-7} m
(c) 5.91×10^{-10} m
(d) 2.85×10^{-12} m

Comprehension VII

A sample of H-atoms contains all atoms in the ground state. If the atoms are irradiated by photons of x Å, the atoms get excited to a particular energy level. When these atoms de-excites, they emit radiations of six different photon energies.

20. What is the value of x?

(a) 978.6 (b) 0.098
(c) 1032 (d) 1223

21. What is the orbit number for the excited state?

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

22. What is the maximum wavelength among emitted radiations?

(a) 978.6 Å (b) 1223 Å
(c) 18,872.87 nm (d) 18,872.87 Å

23. What is the maximum frequency among emitted radiations?

(a) 2.453×10^{15} Hz (b) 3.066×10^{15} Hz
(c) 5.912×10^{16} Hz (d) 1.081×10^{18} Hz

24. What are the wavelengths of all infrared radiations coming out?

(a) 1887.3 nm, 4077.5 nm
(b) 1887.3 nm
(c) 122.3 nm, 103.2 nm, 97.9 nm
(d) 122.3 nm, 103.2 nm

25. What are the wavelengths of all visible radiations coming out?

(a) 660.5 nm, 489.3 nm
(b) 660.5 nm, 489.3 nm, 436.9 nm
(c) 660.5 nm, 489.3 nm, 436.9 nm, 412.8 nm
(d) 660.5 nm, 436.9 nm

Comprehension VIII

When a sample of hydrogen atoms is irradiated by electromagnetic radiations of suitable wavelength, all the electrons jump from the ground state to the fifth orbit. As the electrons cannot remain permanently in the fifth orbit, they de-excites to the ground state making one or more than one transitions. Each transition results in the emission of an electromagnetic radiation of a particular wavelength. When these radiations pass through a prism, they deviate with different angles resulting in the spectral lines.

26. What is the maximum number of spectral lines, if the sample is containing only one atom?

(a) 5 (b) 4
(c) 6 (d) 10

27. What is the maximum number of spectral lines, if the sample is containing only two atoms?

(a) 5 (b) 6
(c) 7 (d) 10

28. What is the maximum number of spectral lines, if the sample is containing only three atoms?

(a) 5 (b) 6
(c) 7 (d) 10

29. What is the maximum number of spectral lines, if the sample contains infinite number of atoms?

(a) 5 (b) 6
(c) 7 (d) 10

30. What should be the minimum number of hydrogen atoms in the sample to get a maximum of 10 spectral lines?

(a) 1 (b) 6
(c) 8 (d) 10

Comprehension IX

A hydrogen-like atom of atomic number *Z* is in an excited state of quantum number 2*n*. It can emit a maximum energy photon of 204 eV. If it makes a transition to quantum state *n*, a photon of energy 40.8 eV is emitted.

31. What is the initial excited state of the atom?

(a) 4 (b) 8
(c) 16 (d) 2

32. What is the value of Z?

(a) 2 (b) 4
(c) 8 (d) 16

33. What is the energy of ground state of this atom?

(a) −13.6 eV (b) −54.4 eV
(c) −217.6 eV (d) −870.4 eV

34. What is the minimum energy of the photons emitted by this atom during de-excitation?

(a) 204 eV (b) 4.16 eV
(c) 10.6 eV (d) 13.6 eV

Comprehension X

In stars, the Pickering series is found in the He^+ spectrum. It is emitted when the electron in He^+ jumps from higher levels to the level with $n = 4$.

35. The wavelengths of the lines in this series are given by $\lambda = \frac{Cn^2}{n^2 - 16}$, in which n = 5, 6, 7… and C is a constant. What is the value of C in nm?

(a) 366.97 (b) 91.74
(c) 22.93 (d) 1467.89

36. What is the wavelength of the series limit?

(a) 22.93 nm (b) 366.97 nm
(c) 1019.36 nm (d) 63.71 nm

37. In what region(s) of the spectrum does this series occur? Visible region is from 360 to 780 nm.

(a) Visible only.
(b) Infrared only.
(c) Visible and infrared.
(c) Visible and ultraviolet.

Comprehension XI

The hydrogen-like species Li^{2+} is in a spherically symmetric state S_1 with one radial node. Upon absorbing light, the ion undergoes transition to a state S_2. The state S_2 has one radial node and its energy is equal to the ground state energy of the hydrogen atom.

38. The state S_1 is

(a) 1*s* (b) 2*s*
(c) 2*p* (d) 3*s*

39. Energy of the state S_1 in units of the hydrogen atom ground state energy is

(a) 0.75 (b) 1.50
(c) 2.25 (d) 4.50

40. The orbital angular momentum quantum number of the state S_2 is

(a) 0 (b) 1
(c) 2 (d) 3

Comprehension XII

Suppose a particle has four quantum numbers such that the permitted values are

$n = 1, 2, 3......$

$l = (n - 1), (n - 3), (n - 5), ...,$ but no negative value

$j = \left(l + \frac{1}{2}\right)$ or $\left(l - \frac{1}{2}\right)$, the latter is not negative

$m = -j$ in integer step to $+j$.

41. The other permitted values for $n = 2$ is/are

(a) $l = 1, j = \frac{3}{2}, m = -\frac{3}{2}$

(b) $l = 0, j = \frac{1}{2}; m = -\frac{1}{2}$

(c) $l = 1, j = \frac{1}{2}; m = -\frac{3}{2}$

(d) All of these

42. For $n = 3$, the possible sets of (n, l, j, m) is

(a) 10 (b) 8

(c) 12 (d) 6

Comprehension XIII

The wave function for an atomic orbital of single electron atom or ion is

$$\psi(r, \theta, \phi) = \frac{2}{3}\left(\frac{Z}{3a_o}\right)^{3/2}(1 - \sigma)(12 - 8\sigma + \sigma^2) \cdot \sigma \cdot e^{-\sigma/2} \cdot \cos\theta$$

where $\sigma = \frac{2Zr}{na_o}$ and $a_o = 0.529$ Å. All other parameters have their usual meaning.

43. The number of radial and angular nodes for the orbital is, respectively,

(a) 3, 1 (b) 2, 1

(c) 3, 2 (d) 2, 2

44. The atomic orbital should be

(a) $4p$ (b) $5p$

(c) $5d$ (d) $5f$

45. If θ is the angle measured from Z-axis, then the orbital should be

(a) p_x (b) p_y

(c) p_z (d) d_{Z^2}

46. The maximum distance of radial node from the nucleus is

(a) $\frac{a_o}{Z}$ (b) $\frac{3a_o}{Z}$

(c) $\frac{6a_o}{Z}$ (d) $\frac{15a_o}{Z}$

Section D (Assertion – Reason)

The following questions consist of two statements. Mark the answer as follows.

(a) If both statements are CORRECT, and **Statement II** is the CORRECT explanation of **Statement I**.

(b) If both statements are CORRECT, and **Statement II** is NOT the CORRECT explanation of **Statement I**.

(c) If **Statement I** is CORRECT, but **Statement II** is INCORRECT.

(d) If **Statement I** is INCORRECT, but **Statement II** is CORRECT.

1. **Statement I:** The orbital angular momentum of an electron in any *s*-atomic orbital is zero.

Statement II: For any *s*-electron, $l = 0$.

2. **Statement I:** The kinetic energy of the photoelectron ejected increases with increase in frequency of incident light.

Statement II: Increase in intensity of incident light increases the photoelectric current.

3. **Statement I:** Threshold frequency is the maximum frequency required for the ejection of electron from the metal surface.

Statement II: Threshold frequency is the characteristic of a metal.

4. **Statement I:** Spin quantum number can have two values $+\frac{1}{2}$ and $-\frac{1}{2}$.

Statement II: +ve and –ve signs signify the positive and negative wave functions.

5. **Statement I:** For He^+ ion, the energy of electron in 3*p*-orbital is greater than that in 3*s*-orbital.

Statement II: Energy of an electron in single electron system depends only on principal quantum number.

6. **Statement I:** Helium and beryllium have similar outer electronic configuration ns^2.

Statement II: Both are chemically inert.

7. **Statement I:** Sum of the radial and angular nodes of all the occupied orbitals in ground state of oxygen atom is 4.

Statement II: The electronic configuration of oxygen atom is $1s^2\ 2s^2\ 2p^4$. The number of radial and angular nodes for an orbital is $(n - l - 1)$ and l, respectively.

8. **Statement I:** The *XY*-plane is the nodal plane for d_{z^2} orbital.

Statement II: For a *d*-orbital, the number of angular nodes is 2.

9. **Statement I:** The radial wave functions for $3p_x$ and $3p_y$ orbitals are different.

Statement II: The radial function depends on n and l while the angular function depends on l and m.

10. **Statement I:** In multi-electron system (atom or ion), 4*s* orbital is filled first then 3*d* orbital is filled.

Statement II: 4*s* orbital is closer to the nucleus than 3*d* orbital.

Section E (Column Match)

1. Match the columns.

Column I (Orbitals)	Column II (Nodal properties)
(A) 2*s*	(P) Angular node = 1
(B) 1*s*	(Q) Radial node = 0
(C) 2*p*	(R) Radial node = 1
(D) 3*p*	(S) Angular node = 0

2. Match Column I with Column II in hydrogen atom spectrum.

Column I	Column II
(A) Lyman series	(P) Visible region
(B) Balmer series	(Q) Infrared region
(C) Paschen series	(R) Absorption spectrum
(D) Brackett series	(S) Ultraviolet region

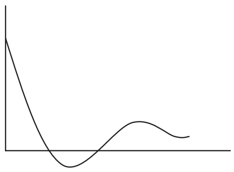
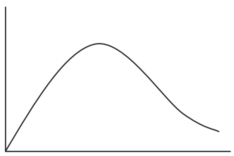
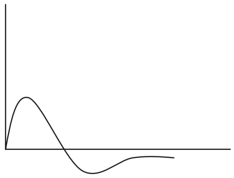
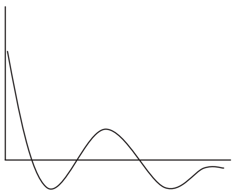
3. According to Bohr's theory, E_n = Total energy, K_n = Kinetic energy, V_n = Potential energy, r_n = Radius of *n*th orbit. Match the columns.

Column I	Column II
(A) V_n/K_n =?	(P) 0
(B) If radius of *n*th orbit $\propto E_n^x$; x = ?	(Q) –1
(C) Orbital angular momentum in lowest energy	(R) –2
(D) $\frac{1}{r^n} \propto Z^y$; y = ?	(S) 1

4. Match list I with list II.

List I	List II
(A) Number of values of l for an energy level.	(P) 0, 1, 2, ……, $(n - 1)$
(B) Actual values of l for an energy level.	(Q) $+l$, ……, 0,……., $-l$
(C) Number of m values for a particular type of orbital.	(R) $2l + 1$
(D) Actual value of 'm' for a particular type of orbital.	(S) n

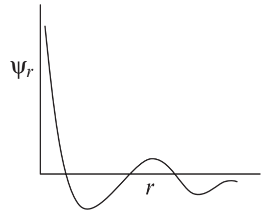
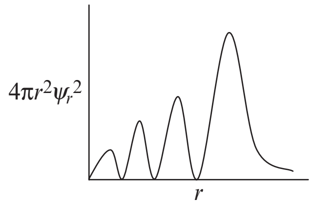
5. Match the columns.

Column I (Orbital)	**Column II (*R* vs. *r* Graph)**
(A) 3*s*	(P) 
(B) 4*s*	(Q) 
(C) 2*p*	(R) 
(D) 3*p*	(S) 

6. Match the columns.

Column I (Parameters for H-like atoms)	**Column II (Dependence on *n* and *Z*)**
(A) Radius of orbit.	(P) n^2
(B) Speed of electron.	(Q) $1/n$
(C) Centripetal force between electron and nucleus.	(R) $1/n^3$
(D) Frequency of revolution of electron.	(S) $1/n^4$
	(T) Z
	(U) 1/Z
	(V) Z^2
	(W) Z^3

7. Match the columns.

Column I	**Column II**
(A) 	(P) 4*s*
(B) 	(Q) Any of the 5*p* orbital.
(C) Angular wave function independent from θ and ϕ.	(R) 3*s*
(D) At least one angular node.	(S) any of the 6*d* orbital.

8. Match the entries in Column I with the correctly related quantum number(s) in Column II.

Column I	**Column II**
(A) Orbital angular momentum of the electron in a hydrogen-like atomic orbital.	(P) Principle quantum number
(B) A hydrogen-like one-electron wave function obeying Pauli's principle.	(Q) Azimuthal quantum number
(C) Shape, size and orientation of hydrogen-like atomic orbital.	(R) Magnetic quantum number
(D) Probability density of electron at the nucleus in hydrogen-like atom.	(S) Electron spin quantum number

9. Match the columns.

Column I	**Column II**
(A) Orbital with equal number of radial and angular nodes.	(P) $3d_{x^2-y^2}$
(B) Orbitals with number of radial nodes less than the number of angular nodes.	(Q) $2p_z$
(C) Orbitals with zero radial nodes but two angular nodes.	(R) $3p_x$
	(S) $5d_{xy}$

10. Match the columns.

Column I	Column II
(A) Ratio of speed of electron in the fifth and third excited state of H-atom.	(P) $\frac{4}{1}$
(B) Ratio of wavelength of series limit of Balmer and Lyman series of H-spectrum.	(Q) $\frac{2}{3}$
(C) Ratio of wavelength of photon corresponding to β-line of Lyman series and γ-line of Paschen series of H-spectrum.	(R) $\frac{1}{4}$
(D) Ratio of energy difference between 3rd and 1st orbits of H-atom and He^+ ion.	(S) $\frac{3}{32}$

Section F (Subjective)

Single-digit Integer Type

1. The work function (ϕ) of some metals is listed below. The number of metals which will show photoelectric effect when light of 300 nm wavelength falls on the metal is

Metal	Li	Na	K	Mg	Cu	Ag	Fe	Pt	W
ϕ (eV)	2.4	2.3	2.2	3.7	4.8	4.3	4.7	6.3	4.75

2. The average life time for then $n = 3$ excited state of a hydrogen-like atom is 4.8×10^{-8} s and that for the $n = 2$ state is 1.28×10^{-7} s. Ratio of the average number of revolutions made in the $n = 3$ state to the average number of revolutions made in the $n = 2$ state before any transitions can take place from these states is $1 : x$. The value of x is

3. The quantum number n corresponding to the excited state of He^+ ion if on transition to the ground state that ion emits two photons in succession with wavelengths 108.5 and 30.4 nm is

4. The atomic number of hydrogen-like ion has the wavelength difference between the first line of Balmer and Lyman series equal to 59.3 nm.

5. A sample of hydrogen atoms containing all the atoms in a particular excited state absorb radiations of a particular wavelength by which the atoms get excited to another excited state. When the atoms finally de-excite to the ground state, they emit the radiations of 10 different wavelengths. Out of these 10 radiations, 7 have wavelengths shorter than the absorbed radiation and 2 have wavelength longer than the absorbed radiation. The orbit number for the initial excited state of atoms is

6. Photons of same energy were allowed to strike on two different samples of hydrogen atoms, one having each atom in ground state and other in a particular excited state of orbit number n. The photonic beams ionize the hydrogen atoms in both the samples. If the difference in maximum kinetic energy of emitted photoelectron from both the samples is 12.75 eV, then the value of n is

7. The diameter of a dust particle of mass 10^{-3} g is 2 Å. The speed of this dust particle is measured with the uncertainty of $\frac{3.313}{\pi} \times 10^{-3}$ m/s. The minimum uncertainty in measuring the position of the duct particle (in order of 10^{-26} m) is

8. The uncertainty in position and velocity of a particle are 10^{-11} m and 5.27×10^{-24} m·s^{-1}, respectively. The minimum mass of the particle (in kg) is

9. The circumference of the second orbit of an atom or ion having single electron is 4 nm. The de Broglie wavelength of electron (in nm) revolving in this orbit is

10. The Schrodinger wave equation for hydrogen atom is $\Psi_{2s} = \frac{1}{4\sqrt{2\pi}}\left(\frac{1}{a_0}\right)^{3/2}\left(2 - \frac{r_0}{a_0}\right)e^{-\frac{r_0}{a_0}}$, where a_0 is Bohr's radius. If the radial node is $2s$ be at r_0, then the value of $\frac{r_o}{a_o}$ is

Four-digit Integer Type

1. An α-particle of momentum 3.2×10^{-20} kg ms^{-1} is projected towards the nucleus of an atom of an element. If the distance of closest approach of α-particle is 1.5×10^{-13} m, then the atomic number of element is (Mass of α-particle = 4 amu, charge on electron = 1.6×10^{-19} coulomb, $N_A = 6 \times 10^{23}$)

2. Suppose a satellite is in geostationary orbit at an average distance of 12600 km from the earth surface. This satellite is telecasting a cricket match between Indian and Pakistan. The radiowaves from the stadium are first received by the satellite and then from satellite to our TV sets. If a batsman hits a ball, then after what time (approximate, in milliseconds), we will see this action in our TV sets?

3. A cobalt target is bombarded with electrons and the wavelength of its characteristic spectrum is measured. A second fainter characteristic spectrum is also found due to an impurity in the target. The wavelengths of the K_α lines are 180.0 pm (cobalt, $Z = 27$) and 144.0 pm (impurity). The atomic number of impurity is

4. How many moles of photon would contain sufficient energy to raise the temperature of 245 g of water from 19.5°C to 99.5°C? The specific heat of water is 4.2 J/°C-g and frequency of light radiation used is 2.45×10^{10} per second. ($6.626 \times 5.04 = 33.6$, $N_A = 6 \times 10^{23}$)

5. A quantity of 1.0 g hydrogen atoms are excited to radiations. The study of spectra indicates that 45% of the atoms are in third energy level and 40% of atoms in second energy level and the rest in ground state. The total energy (in kJ) evolved, when all the atoms return to ground state is (Ionization energy of hydrogen atom is 1310 kJ/mol)

6. A proton and an electron, both at rest initially, combines to form a hydrogen atom in the ground state. A single photon is emitted in this process. The wavelength (in nm) of emitted photon is

7. The energy (in kJ) required to excite 1 L of hydrogen gas at 1 atm and 300 K to the first excited state of atomic hydrogen is (The energy for the dissociation of H–H bond is 436 kJ mol^{-1} and the ionization energy of hydrogen is 1312 kJ mol^{-1}). $R = 0.08$ L-atm/K-mol

8. In the hydrogen spectrum, the longest wavelength in the Lyman series is 120 nm and the shortest wavelength in the Balmer series is 360 nm. From this data, the longest wavelength (in nm) of light that could ionize hydrogen atom is

9. An electron beam can undergo diffraction by crystals. Through what potential (in Volt) should a beam of electron be accelerated so that its wavelength becomes equal to 0.25 nm?

10. The atomic masses of He and Ne are 4 and 20 amu, respectively. The value of the de Broglie wavelength of He gas at −73°C is M times that of the de Broglie wavelength of Ne at 727°C. The value of M is

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Answer Keys — Exercise I

Fundamental Particles

1. (c) 2. (c) 3. (d) 4. (d) 5. (c) 6. (b) 7. (c) 8. (d) 9. (c) 10. (d)
11. (a) 12. (c) 13. (c) 14. (d) 15. (c) 16. (c) 17. (c) 18. (b) 19. (c) 20. (a)

Rutherford's Atomic Models

21. (c) 22. (d) 23. (d) 24. (a) 25. (b) 26. (b) 27. (a) 28. (d) 29. (d) 30. (d)
31. (b) 32. (b) 33. (b) 34. (a) 35. (d)

Planck's Quantum Theory, Photoelectric Effect and Moseley's Experiment

36. (c) 37. (b) 38. (a) 39. (b) 40. (d) 41. (b) 42. (a) 43. (b) 44. (b) 45. (c)
46. (b) 47. (c) 48. (b) 49. (b) 50. (c) 51. (a) 52. (c) 53. (b) 54. (c) 55. (c)

Bohr's Atomic Mode

56. (a)	57. (b)	58. (b)	59. (a)	60. (a)	61. (b)	62. (c)	63. (a)	64. (c)	65. (b)
66. (c)	67. (c)	68. (a)	69. (a)	70. (c)	71. (c)	72. (c)	73. (b)	74. (a)	75. (b)
76. (a)	77. (b)	78. (b)	79. (d)	80. (a)	81. (c)	82. (a)	83. (a)	84. (b)	85. (d)
86. (c)	87. (c)	88. (c)	89. (c)	90. (b)	91. (c)	92. (c)	93. (c)	94. (a)	95. (a)
96. (b)	97. (b)	98. (d)	99. (b)	100. (b)					

Spectrum

101. (c)	102. (d)	103. (d)	104. (d)	105. (a)	106. (b)	107. (a)	108. (b)	109. (c)	110. (c)
111. (a)	112. (d)	113. (d)	114. (c)	115. (d)					

Heisenberg's Uncertainty Principle

116. (d)	117. (d)	118. (b)	119. (a)	120. (b)

De Broglie's Equation

121. (a)	122. (c)	123. (a)	124. (a)	125. (b)

Quantum Numbers

126. (a)	127. (a)	128. (a)	129. (d)	130. (b)	131. (b)	132. (c)	133. (b)	134. (b)	135. (d)
136. (c)	137. (c)	138. (b)	139. (a)	140. (d)					

Schrodinger's Equation

141. (b)	142. (c)	143. (b)	144. (c)	145. (b)

Electronic Configuration

146. (d)	147. (b)	148. (a)	149. (a)	150. (d)	151. (a)	152. (b)	153. (c)	154. (a)	155. (b)
156. (c)	157. (d)	158. (b)	159. (a)	160. (c)	161. (c)	162. (b)	163. (b)	164. (b)	165. (c)
166. (c)	167. (c)	168. (a)	169. (a)	170. (d)	171. (a)	172. (b)	173. (b)	174. (d)	175. (c)

Answer Keys — Exercise II

Section A (Only one Correct)

1. (a)	2. (b)	3. (b)	4. (c)	5. (d)	6. (a)	7. (a)	8. (d)	9. (d)	10. (b)
11. (b)	12. (a)	13. (c)	14. (d)	15. (a)	16. (b)	17. (d)	18. (c)	19. (c)	20. (c)
21. (d)	22. (b)	23. (c)	24. (b)	25. (c)	26. (b)	27. (a)	28. (c)	29. (d)	30. (c)
31. (d)	32. (c)	33. (a)	34. (b)	35. (c)	36. (d)	37. (d)	38. (a)	39. (a)	40. (c)
41. (c)	42. (c)	43. (b)	44. (c)	45. (a)	46. (c)	47. (a)	48. (b)	49. (c)	50. (a)
51. (c)	52. (a)	53. (d)	54. (a)	55. (a)	56. (b)	57. (d)	58. (a)	59. (d)	60. (c)
61. (c)	62. (c)	63. (d)	64. (b)	65. (a)	66. (c)	67. (c)	68. (d)	69. (a)	70. (d)
71. (b)	72. (a)	73. (b)	74. (a)	75. (c)	76. (d)	77. (b)	78. (a)	79. (d)	80. (a)
81. (b)	82. (c)	83. (b)	84. (c)	85. (b)	86. (b)	87. (a)	88. (c)	89. (c)	90. (c)
91. (a)	92. (c)	93. (d)	94. (a)	95. (b)	96. (b)	97. (b)	98. (b)	99. (a)	100. (a)
101. (a)	102. (d)	103. (b)	104. (b)	105. (c)	106. (d)	107. (d)	108. (c)	109. (b)	110. (d)

Section B (One or More than one Correct)

1. (a), (b), (c)	2. (a), (c), (d)	3. (a), (c), (d)	4. (a), (b), (c), (d)
5. (b), (c)	6. (a), (c), (d)	7. (a), (b), (c)	8. (a), (b)
9. (b), (c), (d)	10. (a), (b), (c)	11. (a), (b)	12. (a), (c)
13. (a), (b), (c)	14. (b), (c)	15. (b), (c)	16. (c)
17. (a), (b), (c)	18. (a), (b), (c)	19. (b), (c), (d)	20. (a), (b), (d)

Section C

Comprehension I

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

Comprehension II

4. (c) 5. (d) 6. (c)

Comprehension III

7. (c) 8. (b) 9. (c)

Comprehension IV

10. (b) 11. (c) 12. (c) 13. (a)

Comprehension V

14. (b) 15. (c) 16. (d)

Comprehension VI

17. (b) 18. (d) 19. (c)

Comprehension VII

20. (a) 21. (c) 22. (d) 23. (a)
24. (b) 25. (a)

Comprehension VIII

26. (b) 27. (b) 28. (c)
29. (d) 30 (b)

Comprehension IX

31. (a) 32. (b) 33. (c) 34. (c)

Comprehension X

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

Comprehension XI

38. (b) 39. (c) 40. (b)

Comprehension XII

41. (a) 42. (c)

Comprehension XIII

43. (a) 44. (b) 45. (c) 46. (d)

Section D (Assertion – Reason)

1. (a) 2. (b) 3. (d) 4. (c) 5. (d) 6. (c) 7. (a) 8. (d) 9. (d) 10. (c)

Section E (Column Match)

1. A $\rightarrow$ R, S; B $\rightarrow$ Q, S; C $\rightarrow$ P, Q; D $\rightarrow$ P, R
2. A $\rightarrow$ R, S; B $\rightarrow$ P, S; C $\rightarrow$ Q; D $\rightarrow$ Q
3. A $\rightarrow$ R; B $\rightarrow$ Q; C $\rightarrow$ P; D $\rightarrow$ S
4. A $\rightarrow$ S; B $\rightarrow$ P; C $\rightarrow$ R; D $\rightarrow$ Q
5. A $\rightarrow$ P; B $\rightarrow$ S; C $\rightarrow$ Q; D $\rightarrow$ R
6. A $\rightarrow$ P, U; B $\rightarrow$ Q, T; C $\rightarrow$ S, W; D $\rightarrow$ R, V
7. A $\rightarrow$ P; B $\rightarrow$ P, Q, S; C $\rightarrow$ P, R; D $\rightarrow$ Q, S
8. A $\rightarrow$ Q, R; B $\rightarrow$ P, Q, R, S; C $\rightarrow$ P, Q, R; D $\rightarrow$ P, Q
9. A $\rightarrow$ R, S; B $\rightarrow$ Q, P; C $\rightarrow$ P
10. A $\rightarrow$ Q; B $\rightarrow$ P; C $\rightarrow$ S; D $\rightarrow$ R

Section F (Subjective)

Single-digit Integer Type

1. (4)	2. (6)	3. (5)	4. (3)	5. (3)
6. (4)	7. (5)	8. (1)	9. (2)	10. (2)

Four-digit Integer Type

1. (0025)	2. (0084)	3. (0030)	4. (8400)	5. (0917)
6. (0091)	7. (0100)	8. (0090)	9. (0024)	10. (0005)

HINTS AND EXPLANATIONS

EXERCISE I (JEE MAIN)

Fundamental Particles

1. Theory based
2. Theory based
3. Specific charge is $\left(\frac{e}{m}\right)$ ratio
4. x-rays = electromagnetic radiation
5. Faraday, by his experiments of electrolysis.
6. Informative
7. Theoretical
8. Cathode rays comes out normal to the surface of cathode.
9. $X(g) \rightleftharpoons X^{+}(g) + e^{-}$
   anode rays
10. Anode rays do not come out from the surface of anode.
11. Theoretical
12. Number of protons = $Z = 3$
    Number of electrons = $3 - 1 = 2$
    Number of neutrons = $A - Z = 4$
13. Charge on electron = HCF of charges in oil droplets = 1.5×10^{-18} unit
14. $\left(\frac{e}{m}\right)$ ratio of positron and electron are same.
15. Neutron is electrically neutral.
16. Except positron, all are chargeless.
17. $H^{+} > Al^{3+} > Mg^{2+} > Na^{+} \left(\equiv 1 > \frac{1}{9} > \frac{1}{12} > \frac{1}{23}\right)$
18. $e \cdot V = \frac{1}{2} m v^2 \Rightarrow v = \sqrt{2 \times \left(\frac{e}{m}\right) \times V} \alpha \sqrt{V}$
19. $\frac{(e/m)_{\alpha}}{(e/m)_{\alpha}} \approx \frac{2/4}{1/2} = \frac{1}{1}$
20. $\frac{e}{m} = \frac{2 \times 1.602 \times 10^{-19}\ C}{4 \times 1.67 \times 10^{-27}\ Kg} \simeq 4.8 \times 10^{7}\ C/Kg$

Rutherford's Atomic Models

21. Informative.
22. α-particles are He^{2+} ions or Helium nucleus.
23. The concept of definite paths was not the part of Rutherford's model.
24. Almost all (not 99%) mass of an atom is concentrated in the nucleus.
25. Theoretical
26. Distance of closest approach, $r = \frac{K \cdot q_1 q_2}{\left(\frac{1}{2} m v^2\right)}$

    From question: $r \alpha \frac{1}{m}$

    $\therefore \frac{r_p}{r_d} = \frac{m_d}{m_p} = \frac{2}{1}$
27. $r = \frac{K \cdot q_1 q_2}{\left(\frac{1}{2} m v^2\right)}$

    As $\left(\frac{q_1}{m}\right)$, q_2 and v, all are same, r is same.
28. For r_{min}, q_2 = nuclear charge and hence, z should be minimum.
29. Neutron is chargeless.
30. $r = \frac{K \cdot q_1 q_2}{q_1 \cdot V} = \frac{K \cdot q_2}{V} = \text{Constant}$

31. $N_\alpha \alpha \dfrac{1}{\sin^4\left(\dfrac{\theta}{2}\right)}$

$\therefore \dfrac{N_1}{N_2} = \left[\dfrac{\sin\left(\dfrac{90}{2}\right)}{\sin\left(\dfrac{60}{2}\right)}\right]^4 \Rightarrow \dfrac{36}{N_2} = \dfrac{4}{1} \Rightarrow N_2 = 9$

32. $\dfrac{V_{\text{nucleus}}}{V_{\text{atom}}} = \left(\dfrac{4\times10^{-15}}{2\times10^{-10}}\right) = \dfrac{8\times10^{-15}}{1}$

33. $\dfrac{1}{2}\text{m v}^2 = K\cdot\dfrac{q_1q_2}{r}$

or, $\dfrac{1}{2}\times\left(\dfrac{4\times10^{-3}}{6\times10^{23}}\right)\times V^2$

$= 9\times10^9\times\dfrac{(2\times1.6\times10^{-19})\times(29\times1.6\times10^{-19})}{10^{-12}}$

$\therefore v = 2\times10^6$ m/s

34. $r = K\cdot\dfrac{q_1q_2}{q_1\cdot V} = \text{Constant}$

35. $r = K\cdot\dfrac{q_1q_2}{(P^2/2\,\text{m})} \Rightarrow r \;\alpha \dfrac{1}{P^2}$

Planck's Quantum Theory, Photoelectric Effect and Moseley's Experiment

36. Informative

37. $\lambda = \dfrac{c}{\upsilon} = \dfrac{3\times10^8}{400\times10^3} = 750$ m

38. Informative

39. $\text{Time} = \dfrac{\text{Distance}}{\text{Speed}}$

$= \dfrac{60\times10^6\times10^3}{3\times10^8} = 200$ sec

40. $E = n\cdot h\bar{\upsilon} \Rightarrow E_1 : E_2 = \bar{\upsilon_1} : \bar{\upsilon_2} = 2:3$

41. $E = n\cdot h\upsilon$

42. $E = n\cdot\dfrac{hc}{\lambda}$

$\Rightarrow n = \dfrac{E\cdot\lambda}{hc} = \dfrac{(3\times10^{-14})\times(662.6\times10^{-9})}{(6.626\times10^{-34})\times(3\times10^8)} = 10^5$

43. $E = E_1 + E_2 \Rightarrow \dfrac{hc}{\lambda} = \dfrac{hc}{\lambda_1} + \dfrac{hc}{\lambda_2}$

or, $\dfrac{1}{400} = \dfrac{1}{500} + \dfrac{1}{\lambda_2} \Rightarrow \lambda_2 = 2000$ nm

44. $\text{E}_\text{g} = \text{E}_\text{r} \Rightarrow n_g\cdot\dfrac{h_c}{\lambda_g} = n_r\cdot\dfrac{hc}{\lambda_r} \Rightarrow \dfrac{n_g}{n_r} = \dfrac{\lambda_g}{\lambda_r} < 1$

45. $E_{\text{emitted}} = \dfrac{50}{100}\times E_{\text{absorbed}}$

or, $n_1\cdot\dfrac{hc}{\lambda_1} = \dfrac{1}{2}\times n_2\times\dfrac{hc}{\lambda_2}$

or $\dfrac{\lambda_1}{\lambda_2} = \dfrac{2}{1}\times\dfrac{n_1}{n_2} = \dfrac{2}{1}\times\dfrac{2}{1} \Rightarrow \dfrac{\lambda_1}{x\text{Å}} = \dfrac{4}{1} \Rightarrow \lambda_1 = 4x\text{Å}$

46. $E = \dfrac{1}{2}(E_1 + E_2) \Rightarrow \dfrac{1}{\lambda} = \dfrac{1}{2}\left(\dfrac{1}{4000} + \dfrac{1}{6000}\right)$

$\therefore \lambda = 4800$ Å

47. $E = n\cdot\dfrac{hc}{\lambda} \Rightarrow 200\times10^3 = \dfrac{N_A\times hc}{\lambda} = \dfrac{0.12}{\lambda}$

$\therefore \lambda = 6\times10^{-7}$ m

48. $\lambda = \dfrac{12400}{E}\text{Å} - \text{eV} = \dfrac{12400}{1} = 12400\text{Å}$

$= 12400\times10^{-10} = 1.24\times10^{-6}$ m

49. Theoretical

50. $(\text{K.E.})_{\max} : E = h\upsilon - \phi$

and $E' = h\cdot2\upsilon - \phi$

$\therefore E' = E + h\upsilon$

51. $E = n\cdot\dfrac{hc}{\lambda}$

$\Rightarrow \dfrac{E\cdot\lambda}{hc} = \dfrac{10^{-7}\times5000\times10^{-10}}{6.626\times10^{-34}\times3\times10^8} = 2.5\times10^{11}$

51. Theoretical

53. $\phi = \dfrac{hc}{\lambda} = \dfrac{6.6\times10^{-34}\times3\times10^8}{330\times10^{-9}} = 6\times10^{-19}$ J

54. $\sqrt{\frac{c}{\lambda}} = a(z-b)$

$\therefore \frac{\lambda_{\text{iron}}}{\lambda_{\text{scandium}}} = \frac{(21-1)^2}{(26-1)^2} = \frac{16}{25}$

55. $\frac{\lambda_2}{\lambda_1} = \left(\frac{z_1-b}{z_2-b}\right)^2 \Rightarrow \frac{\lambda_2}{\lambda} = \left(\frac{57-1}{29-1}\right)^2 \Rightarrow \lambda_2 = 4\lambda$

Bohr's Atomic Model

56. Na^{10+} ion has single electron

57. $r_{n,z} = 0.529 \times \frac{n^2}{z}$ Å

$\therefore \frac{r_{2,Li^{2+}}}{r_{1,H}} = \frac{0.529 \times \frac{2^2}{3}}{0.529 \times \frac{1^2}{1}} \Rightarrow \frac{r_{2,Li^{2+}}}{x\text{Å}} = \frac{4}{3}$

$\Rightarrow r_{2,Li^{2+}} = \frac{4}{3} x\text{Å}$

58. $r_{1,Ne^{9+}} = 0.529 \times \frac{1^2}{10} = 0.0529\text{Å}$

59. $\frac{r_4 - r_3}{r_7 - r_6} = \frac{r_1 \times 4^2 - r_1 \times 3^2}{r_1 \times 7^2 - r_1 \times 6^2} = \frac{7}{13}$

60. $r_{n,z} = 0.529 \times \frac{n^2}{z}\text{Å} \Rightarrow \frac{10^{-5}}{2} = 0.529 \times \frac{n^2}{1} \times 10^{-8}$

$\Rightarrow n \approx 31$

61. $r_{n,z} = \frac{(4\pi\varepsilon_0)n^2h^2}{4\pi^2 mze^2} \Rightarrow r_{n,z} \alpha \frac{1}{m}$

$\therefore$ Radius of 1st orbit of H-atom $= \frac{0.529}{2} = 0.2645$ Å

62. $\frac{(2\pi r)_3}{(2\pi r)_2} = \frac{3^2}{2^2} = \frac{9}{4}$

63. Speed is independent of mass.

64. $V_{n,z} = 2.188 \times 10^6 \frac{z}{n}$ m/s

$\frac{1}{205.67} \times 3 \times 10^8 = 2.188 \times 10^6 \times \frac{2}{n} \Rightarrow n = 3$

65. $V_{n,z} = 2.188 \times 10^6 \frac{z}{n}$ m/s

or, $1094 \times 10^3 = 2.188 \times 10^6 \times \frac{z}{4} \Rightarrow z = 2$

$\Rightarrow He^+$ ion

66. $V_{n,z} = 2.188 \times 10^6 \frac{z}{n}$ m/s

$19.54 \times 11.2 \times 10^3 = 2.188 \times 10^6 \times \frac{1}{n} \Rightarrow n \approx 10$

67. $\frac{V}{c} = \frac{2.188 \times 10^6}{3 \times 10^8} \approx \frac{1}{137}$

68. $r_{n,z} = 0.529 \times \frac{n^2}{z} \Rightarrow 1.587 = 0.529 \times \frac{n^2}{3} \Rightarrow n = 3$

$\therefore V_{n,z} = 2.188 \times 10^6 \times \frac{z}{n} = 2.188 \times 10^6 \times \frac{3}{3}$
$= 2.188 \times 10^6$ m/s

69. $V_{n,z} = 2.188 \times 10^6 \times \frac{z}{n} = 2.188 \times 10^6 \times \frac{2}{3}$
$= 1.459 \times 10^6$ m/s

$\therefore$ Distance travelled by electron in 1 second $= 1.459 \times 10^6$ m

70. $T_{n,z} = 1.5 \times 10^{-16} \times \frac{n^3}{z^2}$ sec

$\therefore \frac{T_{2,M}}{T_{3,M}} = \frac{2^3}{3^3} = \frac{8}{27}$

71. $f_{n,z} = \frac{1}{T_{n,z}} \alpha \frac{1}{n^3}$

72. Angular momentum $= n \cdot \frac{h}{2\pi}$ and n must be an integer.

73. $n_2 = 2 \times n_1$

$\therefore \frac{r_2}{r_1} = \frac{n_2^2}{n_1^2} = \frac{4}{1}$

74. Angular momentum is independent from atomic number.

75. Angular momentum $\alpha\, n\, \alpha \sqrt{r}$

76. $w = \frac{V}{r} = \frac{2.188 \times 10^6 \times \frac{2}{3}}{0.529 \times 10^{-10} \times \frac{3^2}{2}} = 6.13 \times 10^{15}\ s^{-1}$

77. $F=\frac{mv^2}{r}\alpha\frac{\left(\frac{z}{n}\right)^2}{\left(\frac{n^2}{z}\right)}=\frac{z^3}{n^4}$

78. $\text{K.E.}=\frac{1}{2}\text{mv}^2=\frac{1}{2}m\left(2.188\times10^6\times\frac{z}{n}\right)^2\alpha\frac{1}{n^2}$

$\therefore$ For maximum K.E., $n = 1$ (minimum)

79. $\text{K.E.}=\frac{1}{2}\text{mv}^2$, $\text{P.E.}=-\text{mv}^2$ and $V\alpha\frac{1}{n}$

Therefore, with increase in orbit number, K.E. decreased but P.E. increases.

80. $E_{n,z}=-13.6\times\frac{z^2}{n^2}\text{ eV}$

$\therefore\ \frac{E_{2,\text{He}^+}}{E_{1,\text{H}}}=\frac{-13.6\times\frac{2^2}{2^2}}{-13.6\times\frac{1^2}{1^2}}=\frac{1}{1}$

81. $E_{n,z}=-13.6\frac{z^2}{n^2}\text{ eV}\Rightarrow-13.6=-13.6\times\frac{z^2}{n^2}\Rightarrow z=3$

82. First orbit has lowest energy.

83. (a) $v\cdot r\,\alpha\frac{z}{n}\times\frac{n^2}{z}=n$

84. $\frac{(\text{P.E.})_{3,\text{Li}^{2+}}}{(\text{K.E.})_{4,\text{He}^+}}=\frac{-27.2\times\frac{3^2}{3^2}}{13.6\times\frac{2^2}{4^2}}=-\frac{8}{1}$

85. Speed, $V_{n,z}=\frac{2\pi ze^2}{(4\pi\varepsilon_0)nh}$

86. $\text{P.E.}=-27.2\times\frac{z^2}{n^2}=-27.2\text{ eV}$

87. $V_{n,z}=2.188\times10^6\frac{z}{n}\text{m/s}$

$\Rightarrow 2.188\times10^6=2.188\times10^6\times\frac{2}{n}\Rightarrow n=2$

Now, $\text{P.E.}=-27.2\times\frac{z^2}{n^2}=-27.2\times\frac{2^2}{2^2}=-27.2\text{ eV}$

88. Theoretical

89. $\Delta E=13.6z^2\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)\text{eV}=13.6\times2^2\left(\frac{1}{2^2}-\frac{1}{8^2}\right)$

$=12.75\text{ eV}$

90. Energy difference decreases on increasing the orbit number.

91. $\Delta E_{2\to1}$ is even greater that $\Delta E_{\infty\to2}$.

92. The required transition is $n = 2$ to $n = 4$.

93. $E_1=-\text{I. E.}=-50\text{ eV}$

Now, $E_n=\frac{E_1}{n^2}\Rightarrow E_5=\frac{-50}{5^2}=-2\text{ eV}$

94. $\Delta E=13.6z^2\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)\text{eV}$

$\therefore\ 10.2=13.6\times1^2\left(\frac{1}{1^2}-\frac{1}{n_2^2}\right)$

$\Rightarrow n_2=2$

Now, change in angular momentum $=\frac{2\times h}{2\pi}-\frac{1\times h}{2\pi}$

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

95. $\text{I. E. }\alpha\, z^2$

$\therefore\ \frac{(\text{I.E.})_{\text{Be}^{3+}}}{(\text{I.E.})_{\text{He}^+}}=\left(\frac{z_{\text{Be}^{2+}}}{z_{\text{He}^+}}\right)\Rightarrow\frac{(\text{I.E.})_{\text{Be}^{3+}}}{x}=\left(\frac{9}{2}\right)^2$

$\therefore\ (\text{I.E.})_{\text{Be}^{3+}}=4x\text{ eV}$

96. $\Delta E=13.6z^2\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)\text{eV}$

or $47.2=13.6\times z^2\left(\frac{1}{2^2}-\frac{1}{3^2}\right)\Rightarrow z\approx5$

97. $\text{I.E.}=\frac{hc}{\lambda}=\frac{6.626\times10^{-34}\times3\times10^8}{240\times10^{-9}}\times6.022\times10^{23}$

$=4.98\times10^5\text{ J/mol}$

98. Second I.E. of He is $13.6\times2^2=54.4$ eV. Hence, I.E. of He-atom must be greater than 13.6 eV but less than 54.4 eV.

99. Required B.E. $=13.6\times3^2=122.4$ eV

100. Required I.E. $=13.6\times30^2=12240$ eV

Spectrum

101. $R = \dfrac{2\pi^2 me^4}{(4\pi\varepsilon_0)^2 h^3 c}$

$\Rightarrow R \,\alpha\, m$

Here, m becomes $\left(m - \dfrac{m}{4} = \dfrac{3m}{4}\right)$, then R becomes $\dfrac{3}{4}R$.

102. $R \,\alpha\, e^4$

$\therefore \dfrac{R_2}{R_1} = \left(\dfrac{e_2}{e_1}\right)^4 \Rightarrow \dfrac{R_2}{R} = \left(\dfrac{e/2}{e}\right)^4 \Rightarrow R_2 = \dfrac{R}{16}$

103. Informative

104. For maximum υ, z should be maximum.

105. Only one photon is involved in one electronic transition.

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

$= R \times 3^2\left(\dfrac{1}{1^2} - \dfrac{1}{4^2}\right) = \dfrac{135\,R}{16}$

$\therefore \lambda = \dfrac{16}{135\,R}$

107. Second line of Panchen series is $5 \to 3$.

Now, $\upsilon = \dfrac{c}{\lambda} = CRz^2\left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right)$

$= CR \times 2^2\left(\dfrac{1}{3^2} - \dfrac{1}{5^2}\right)$

$= \dfrac{64CR}{225}$

108. For lowest frequency in Lyman series, the transition is $2 \to 1$.

Now, $\bar{\upsilon} = Rz^2\left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right) = R \times 3^2\left(\dfrac{1}{1^2} - \dfrac{1}{2^2}\right)$

$= \dfrac{27R}{4}$

109. $\Delta E = \dfrac{hc}{\lambda}$

110. $\dfrac{\lambda_2}{\lambda_1} = \dfrac{\left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right)_1}{\left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right)_2} = \dfrac{\left(\dfrac{1}{1^2} - \dfrac{1}{2^2}\right)}{\left(\dfrac{1}{3^2} - \dfrac{1}{4^2}\right)} = \dfrac{108}{7}$

111. $\dfrac{\overline{\upsilon_2}}{\overline{\upsilon_1}} = \dfrac{z_2^2\left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right)_1}{z_1^2\left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right)_2}$

$\Rightarrow \dfrac{\overline{\upsilon_2}}{2.5 \times 10^5} = \dfrac{3^2\left(\dfrac{1}{3^2} - \dfrac{1}{5^2}\right)}{4^2\left(\dfrac{1}{2^2} - \dfrac{1}{3^2}\right)}$

$\therefore \overline{\upsilon_2} = 7.2 \times 10^4 \text{ cm}^{-1}$

112. $\upsilon = \dfrac{c}{\lambda} = c\left(\dfrac{1}{\lambda_1} + \dfrac{1}{\lambda_2}\right)$

$= 3 \times 10^8\left(\dfrac{1}{400 \times 10^{-9}} + \dfrac{1}{300 \times 10^{-9}}\right)$

$= 1.75 \times 10^{15}$ Hz

113. $\Delta E = \dfrac{hc}{\lambda} \Rightarrow \Delta E \alpha \dfrac{1}{\lambda}$

Now, $\dfrac{\lambda_2}{\lambda 1} = \dfrac{\Delta E_1}{\Delta E_2} \Rightarrow \dfrac{\lambda_2}{\lambda} = \dfrac{2E - E}{\dfrac{4E}{3} - E} \Rightarrow \lambda_2 = 3\lambda$

114. $\bar{\upsilon}_{H} = \bar{\upsilon}_{He^+}$

or, $R \times 1^2\left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right) = R \times 2^2\left(\dfrac{1}{2^2} - \dfrac{1}{4^2}\right)$

$\therefore n_1 = 1$ and $n_2 = 2$

115. $10 \to 4, 9 \to 4, 8 \to 4, 7 \to 4, 6 \to 4, 5 \to 4$

Heisenberg's Uncertainty Principle

116. $\Delta x = \dfrac{h}{4\pi m \cdot \Delta V_{\min}}$

117. $\Delta x \cdot m\Delta v \geq \dfrac{h}{4\pi}$

If the numerical values of Δx and Δv is x, then

$x \geq \sqrt{\dfrac{h}{4\pi m}}$

118. If the numerical values of Δx and Δp is x, then

$$x \geq \sqrt{\frac{h}{4\pi}}$$

$$\therefore \ \Delta v_{\min} = \frac{1}{m} \cdot \sqrt{\frac{h}{4\pi}}$$

119. $\Delta x_{\min} = \dfrac{h}{4\pi m \cdot \Delta v} = \dfrac{6.626\times10^{-34}}{4\pi\times10^{-13}\times\dfrac{0.001}{100}\times10^{-8}}$

$= 5.28 \times 10^{-8}$ m

120. $\Delta x_{\min} = \dfrac{h}{4\pi m \cdot \Delta v}$

$$= \frac{6.626\times10^{-34}}{4\pi\times(9.1\times10^{-31})\times\left(300\times\dfrac{0.0001}{100}\right)}$$

$= 1.93 \times 10^{-2}$ m

De-Broglie's Equation

121. $\lambda = \dfrac{h}{mv} \Rightarrow \dfrac{\lambda_e}{\lambda_p} = \dfrac{m_p}{m_e} = \dfrac{1836}{1}$

122. Number of orbit = Number of waves.

123. $2\pi r = n\lambda \Rightarrow x = 3 \times \lambda \Rightarrow \lambda = \dfrac{x}{3}$ m

124. $p = \dfrac{h}{\lambda} = \dfrac{6.626\times10^{-34}}{6626\times10^{-9}} = 10^{-28}$ Kg m s^{-1}

125. $\lambda \,\alpha\, \dfrac{1}{v} \,\alpha\, \dfrac{1}{\sqrt{T}} \Rightarrow \dfrac{\lambda_2}{\lambda_1} = \sqrt{\dfrac{T_1}{T_2}} \Rightarrow \dfrac{\lambda_2}{\lambda_1} = \sqrt{\dfrac{300}{1200}}$

$\therefore \ \lambda_2 = \dfrac{\lambda}{2}$

Quantum Numbers

126. Theoretical

127. Theoretical

128. Type of orbitals = n

Number of orbitals = n^2

129. Theoretical

130. Orbital angular momentum = $\sqrt{l(l+1)} \cdot \dfrac{h}{2\pi}$ and for s-orbital, $l = 0$.

131. For p-orbital, $l = 1$

$\therefore$ Orbital angular momentum = $\sqrt{l(l+1)} \cdot \dfrac{h}{2\pi}$

$= \sqrt{1(1+1)} \cdot \dfrac{h}{2\pi} = \sqrt{2} \cdot \dfrac{h}{2\pi}$

132. xz plane is the nodal plane for p_y-orbital.

133. The shape is given by l.

134. The s-orbital is symmetrical in all directions.

135. Theoretical

136. Number of orbitals of a particular type = $2l + 1$ and for g-orbital, $l = 4$

137. For $5h$, $n = 5$ and $l = 5$, which is not permissible.

138. Theoretical

139. A set of n, l, m represent a single orbital.

140. Informative

Schrodinger's Equation

141. The p-orbital has only one nodal plane.

142. $n = 4$, $l = 1$, $m = 0 \Rightarrow$ orbital = $4p$

143. Number of nodal surface of s-orbital = $n - 1$

144. Theoretical

145. Number of radial nodes = $n - l - 1$

Electronic Configuration

146. Informative

147. Spin multiplicity = $2s + 1$, where s = magnitude of total spin quantum number.

$l = 3 \Rightarrow$ Number of orbitals $= 2 \times 3 + 1 = 7$

$\therefore$ Maximum spin multiplicity $= 2 \times \frac{7}{2} + 1 = 8$

(When each orbital has single electron in same spin)

148. Informative

149. d-orbitals are five in number.

150. Orbitals are 1s, 2s, 2p, 3s, 3p, 4s.

No. of orbitals = 1 + 1 + 3 + 1 + 3 + 1 = 10

151. Orbitals are 3p, 4s. Number = 3 + 1 = 4.

152. Two electrons in the same orbital cannot have same spin.

153. $3n^2 = 3 \times 2^2 = 12$

154. $3p < 4s < 3d < 4p$

155. $(3 \times 2 + 1) \times 2 = 14$

156. Pauli's exclusion principle limits the maximum capacity of electrons in an orbital equal to 2.

157. K-shell $\Rightarrow n = 1$

158. 3p-orbital $\Rightarrow n = 3, l = 1$

159. Valence electron $\Rightarrow n = 3, l = 1$

160. Orbital is 4s.

161. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ \underbrace{3d^5\ 4s^1}_{\text{6 unpaired electrons}}$

162. 2 + 8 + 16 + 2 = 28

163. 2 + 8 + 10 + 2 = 22

164.

	33	3 p	3 d	Unpaired electron
G.S.	↑↓	↑↓ ↑ ↑	□ □ □ □ □	2
1st E.S.	↑↓	↑ ↑ ↑	↑ □ □ □ □	4
2nd E.S.	↑	↑ ↑ ↑	↑ ↑ □ □ □	6

165. Outermost shell can have a maximum of 8 electrons.

166. Number of unpaired electron in Fe^{2+} is 4.

167. Number of unpaired electron should be 4.

168. Number of unpaired electron should be zero.

169. Number of unpaired electron should be maximum.

170. Na^+ is diamagnetic.

171. Number of unpaired electron is 2. Hence, the ion is Ni^{2+} (d^8 configuration).

172. Number of unpaired electron is 1.

173. Ni^{2+} has unpaired electron is 1.

174. Ions having d^{1-9} configuration are expected to be coloured.

175. Ions having d^0 or d^{10} configuration are expected to be colourless.

EXERCISE II (JEE ADVANCE)

Section A (Only one Correct)

1. $\frac{e}{m}$ ratio of cathode rays is independent to the nature of gas.

2. $\frac{\left(\frac{e}{m}\right)_A}{\left(\frac{e}{m}\right)_B} = \frac{e_A}{e_B} \times \frac{m_B}{mA}$

$\Rightarrow \frac{2}{3} = \frac{e_A}{e_B} \times \frac{3}{2}$

$\Rightarrow \frac{eA}{e_B} = \frac{4}{9}$

3. $eV = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{2 \times \frac{e}{m} \times V}$

$= \sqrt{2 \times 1.764 \times 10^{11} \times 200} = 8.2 \times 10^6 \text{ m/s}$

4. $\frac{\left(\frac{e}{m}\right)_{\text{mesor}}}{\left(\frac{e}{m}\right)_{\alpha\text{-particle}}} = \frac{\frac{1}{\left(\frac{1}{1836} \times 208\right)}}{\frac{2}{4}} = \frac{17.65}{1}$

5. $eV = \frac{1}{2}mv^2 = \frac{p^2}{2m} \Rightarrow p = \sqrt{2meV}$

$\therefore \frac{p_p}{p_e} = \sqrt{\frac{1836}{1}} = \frac{42.85}{1}$

6. $\upsilon = c\bar{\upsilon} = \left(3 \times 10^{10} \frac{\text{cm}}{s}\right) \times \left(\frac{2 \times 10^6}{50} \text{cm}^{-1}\right)$

$= 1.2 \times 10^{15} H_z$

7. $p = \frac{E}{t} = \frac{n \cdot hc}{t \cdot \lambda} = \frac{6 \times 10^{15} \times 6.626 \times 10^{-34} \times 3 \times 10^8}{1 \times 662.6 \times 10^{-9}}$

$= 1.8 \times 10^{-3}$ J/s – m^2

8. $p = \frac{E}{t} = \frac{n \cdot hc}{t \cdot \lambda}$

$\Rightarrow \frac{14}{100} \times 200 = \frac{n \times 6.626 \times 10^{-34} \times 3 \times 10^8}{1 \times \frac{1987.8}{7} \times 10^{-9}}$

$\therefore n = 4 \times 10^{19}\ s^{-1}$

9. $E = n \cdot \frac{hc}{\lambda} = (1.75 \times 10^{-4} \times N_A) \times \frac{hc}{2500 \times 10^{-10}}$

$= 84\,J$

10. $E_{abs} \times \frac{x}{100} = E_{\text{emit}} \Rightarrow n_1 \cdot \frac{hc}{\lambda_1} \cdot \frac{x}{100} = n_2 \cdot \frac{hc}{\lambda_2}$

$\therefore x = \frac{n_2}{n_1} \times \frac{\lambda_1}{\lambda_2} = \frac{53}{100} \times \frac{4530}{5080} = 47.3$

11. $\lambda = \frac{1240}{5} = 248$ nm

12. $E = n \cdot hc\bar{\upsilon} = 1 \times 6.626 \times 10^{-34} \times 3 \times 10^8 \times 1650763.73$

$= 3.28 \times 10^{-19}$ J/quanta.

13. $E = \frac{nhc}{\lambda} \Rightarrow 0.36 = \frac{n \times 6.626 \times 10^{-34} \times 3 \times 10^8}{662.6 \times 10^{-9}}$

$\therefore n = 1.2 \times 10^{18}$

14. Energy needed for photochemical dissociation

$= 482.5 \frac{\text{KJ}}{\text{mol}} + 1.2\,\text{eV} = \left(\frac{482.5}{96.5} + 1.2\right)\text{eV} = 6.2\text{ eV}$

$\therefore \lambda \approx \frac{1240}{6.2} = 200\,\text{nm}$

15. $\lambda \approx \frac{1240}{\left(\frac{289.5}{96.5}\right)} = 413.33$ nm

16. Energy absorbed per mole of H_2

$= 6 \times 10^{23} \times \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{270 \times 10^{-9}} \times 10^{-3} = 440$ KJ

$\therefore$ Percentage of absorbed energy corrected into

K.E. $= \frac{440 - 429}{440} \times 100$

$= 2.5\ \%$

17. $E = 9 \times \frac{12400}{6900} \times 23 = 372$ kcal/mole

$\therefore$ Energy conversion efficiency

$= \frac{111.6}{372} \times 100 = 30\,\%$

18. $E = n \cdot \frac{hc}{\lambda} \Rightarrow 6.626 = n \times \frac{6.626 \times 10^{-34} \times 3 \times 10^{8}}{360 \times 10^{-9}}$

$\therefore$ Mole of photons absorbed

$= \frac{n}{\sim_A} = \frac{1.2 \times 10^{19}}{6 \times 10^{23}} = 2 \times 10^{-5}$

$\therefore$ Quantum efficiency $= \frac{1 \times 10^{-5}}{2 \times 10^{-5}} 0.5$

19. Theoretical

20. Theoretical

21. $h\upsilon_1 = h\upsilon_0 + E$ and $h\upsilon_2 = h\upsilon_0 + \text{E} \cdot \text{K}$

$\therefore \ \upsilon_0 = \frac{K\,\upsilon_1 - \upsilon_2}{K - 1}$

22. Theoretical

23. $\frac{1}{2} m v_{\max}^2 = \frac{hc}{\lambda} - \frac{hc}{\lambda_0} \Rightarrow v_{\max} = \left[\frac{2hc}{m}\left(\frac{\lambda_0 - \lambda}{\lambda_0 \lambda}\right)\right]^{\frac{1}{2}}$

24. $h\upsilon = \text{K.E.} + h\upsilon_0 \Rightarrow \upsilon = \frac{1}{h} \cdot (\text{K.E.}) + \upsilon_0$

25. $\sqrt{\frac{c}{\lambda}} = a(z-1)$ and $\sqrt{\frac{c}{4\lambda}} = a(z'-1)$

$\therefore \ z' = \frac{z+1}{z}$

26. Number of atoms in the disc

$= \frac{1}{12} \times 6 \times 10^{23} = 5 \times 10^{22}$

Now, $F = K \cdot \frac{q_1 q_2}{r^2} \Rightarrow 10^{-5} = 9 \times 10^{9} \times \frac{q^2}{(10^{-2})^2}$

$\Rightarrow q = \frac{10^{-10}}{3}\text{C}$

$\therefore$ Number of excess electron on negatively charged disc $= \frac{10^{-10}/3}{1.6 \times 10^{-19}} = \frac{10^{9}}{4.8}$

Hence, $\frac{\text{Number of excess electron}}{\text{Number of atoms}} = \frac{10^{9}/4.8}{5 \times 10^{22}}$

$= \frac{10^{-14}}{2.4}$

27. $r_n = r_1 \times n^2 \Rightarrow 21.2 \times 10^{-11} = 5.3 \times 10^{-11} \times n^2$
$\Rightarrow n = 2$

28. $2\pi\, r_n = 26.5\ \text{Å} \Rightarrow 2\pi \times 0.529 \times \frac{n^2}{2} = 26.5 \Rightarrow n = 4$

29. $r_n = 0.529 \times \frac{n^2}{z}$ Å

30. $r_n = r_1 \times n^2$

$\therefore\ r_n - r_{n-1} = r_1 \times n^2 - r_1 \times (n-1)^2 = (2n-1) \cdot r_1$

Where n is the higher orbit.

31. $\frac{A_2}{A_1} = \frac{(\pi r^2)_2}{(\pi r^2)_1} = \left(\frac{r_2}{r_1}\right)^2 = \left(\frac{r_1 \times 2^2}{r_1}\right)^2 = \frac{16}{1}$

32. $r_4 - r_2 = 2.116$ Å $\Rightarrow 0.529 \times \frac{4^2}{z} - 0.529 \times \frac{2^2}{z}$
$= 2.116$

$\therefore\ z = 3 \Rightarrow Li^{2+}$ ion

33. $d = 2\pi r \times 100 = 2\pi \times \left(0.529 \times \frac{2^2}{4} \times 10^{-10}\ \text{m}\right) \times 100$

$= 3.32 \times 10^{-8}$ m

34. Circumference $= Z\pi r = 2\pi \cdot r_0 \times \frac{n^2}{1} = 2\pi r_0 n^2$ and
$n = 1, 2, 3, \ldots.$

35. $V_n = 2.188 \times 10^6\ \frac{z}{n}$ m/s

$\Rightarrow 0.547 \times 10^6 = 2.188 \times 10^6 \times \frac{1}{n}$

$\therefore\ n = 4$

Now, $r_n = 0.529 \times \frac{n^2}{z} = 0.529 \times \frac{4^2}{1} = 8.464$ Å

36. $\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{ze^2}{r^2} \Rightarrow v = \sqrt{\frac{ze^2}{(4\pi\varepsilon_0)mr}}$

37. $\frac{v}{c} = \frac{2\pi z e^2}{(4\pi\varepsilon_0) nh \cdot c}$

38. Solution of Q.36

39. $F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{ze^2}{r^2} = 9 \times 10^9 \times \frac{2 \times (1.6 \times 10^{-19})^2}{(4 \times 10^{-10})^2}$

$= 2.88 \times 10^{-9}$ N

40. $T_{n,z} = 1.5 \times 10^{-16} \frac{n^3}{z^2}$ sec

$\frac{T_{2,\text{H}_\text{e}^+}}{T_{3,\text{Li}^{2+}}} = \frac{2^3/2^2}{3^3/3^2} \Rightarrow T_{2,\text{H}_\text{e}^+} = \frac{2}{3} x$ sec

41. $\frac{r_1}{r_2}=\frac{n_1^2}{n_2^2} \Rightarrow \frac{r}{4r}=\frac{n_2^1}{n_2^2} \Rightarrow \frac{n_1}{n_2}=\frac{1}{2}$

$\therefore \frac{T_1}{T_2}=\frac{n_1^3}{n_2^3}=\frac{1}{8}$

42. $T_n \,\alpha\, n^3$ and $n \,\alpha\, \sqrt{r_n} \Rightarrow T_n \,\alpha\, r_n^{3/2}$

43. $N=\frac{10^{-8\text{sec}}}{T_{n,z}}=\frac{10^{-8}}{1.5\times10^{-16}\times\frac{2^3}{1^2}}=8.33\times10^6$

44. $\lambda=\frac{c}{v}=c\cdot T_{n,z}=3\times10^8\times1.5\times10^{-16}\times\frac{1^3}{1^2}$

$=4.5\times10^{-8}\,\text{m}$

45. $\text{K.E.}=\frac{1}{2}mv^2=\frac{1}{2}\cdot\frac{(mvr)\cdot v}{r}=\frac{\text{J}\cdot\text{V}}{2r}$

46. $\text{K.E.}=\frac{1}{2}mv^2=\frac{1}{2}m\left(\frac{nh}{2\pi\cdot mr}\right)^2=\frac{n^2h^2}{8\pi^2mr^2}$

$=\frac{n^2h^2}{8\pi^2m\cdot(a_0^2\cdot n^4)}=\frac{h^2}{8\pi^2ma_0^2\cdot n^2}$

47. $\Delta E=(\text{I.E.})\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)=14.4\times\left(\frac{1}{1^2}-\frac{1}{4^2}\right)=13.5\text{ eV}$

48. Reduced mass effect: $r'=r\cdot\left(1+\frac{m_e}{m_n}\right)$

On increasing the nuclear mass, radius decreases.

49. Reduced mass effect:

$(\text{I.E.})'=(\text{I.E.})\cdot\frac{1}{\left(1+\frac{m_e}{m_n}\right)}$

On increasing the nuclear mass, ionisation energy increases.

50. $u=\frac{m_1m_2}{m_1+m_2}=\frac{m_p\cdot m_p}{m_p+m_p}=\frac{m_p}{2}=\frac{1836\times m_e}{2}$

$\therefore\ r=\frac{0.529}{918}\,\text{Å}=0.058\,pm$

51. $n=2$ but $z=3-2=1$

$\therefore\ E_2=-13.6\times\frac{1^2}{2^2}=-3.4\text{ eV}$

and I.E. = 3.4 eV

52. K.E. of emitted electron = 0.5 × 13.6 eV

Now, $\text{K.E.}=\frac{1}{2}\text{mV}^2$

or, $6.8\times1.6\times10^{-19}=\frac{1}{2}\times9.1\times10^{-31}\times v^2$

$\Rightarrow v=1.55\times10^6$ m/s

53. $\Delta E=\frac{1240}{589.6}=2.1\,\text{eV}=3.37\times10^{-19}\text{J}$

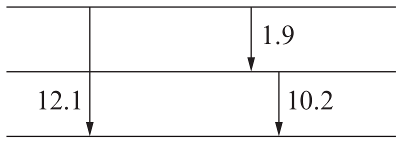
$=48.5$ kcal/mol

54. $\lambda=\frac{1240}{0.0141}=8.8\times10^4\,\text{nm}=8.8\times10^{-5}\,\text{m}=88\text{ nm}$

55. Minimum is 1 ($4\rightarrow1$ transition in both atoms) and maximum is 4 ($4\rightarrow3\rightarrow2\rightarrow1$ in one atom and any other transition in other atom).

56. Number of available orbits is only 4. Hence, maximum number of spectral lines $=4_{C_2}=6$.

57.



At least two atoms are needed for these three transitions.

58. $\frac{1}{\lambda}=Rz^2\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)=R\times2^2\left(\frac{1}{2^2}-\frac{1}{4^2}\right)$

$\Rightarrow\lambda=1223$ Å

$\therefore$ UV region.

59. $\frac{n(n-1)}{2}=15 \Rightarrow n=6$

Now, for shortest wavelength, required transition is $6\rightarrow1$.

$\therefore\ \frac{1}{\lambda}=R\times1^2\left(\frac{1}{1^2}-\frac{1}{6^2}\right)=\frac{35}{36}R \Rightarrow \lambda=\frac{36}{35R}$

60. $\frac{1}{\lambda}=R\times1^2\left(\frac{1}{2^2}-\frac{1}{n^2}\right)=\frac{R\cdot(n^2-4)}{4n^2}$

$\therefore\ \lambda=\frac{4n^2}{R(n^2-4)}=\frac{K\cdot n^2}{n^2-4} \Rightarrow K=\frac{4}{R}$

61. $\lambda\alpha\frac{1}{z^2} \Rightarrow \lambda_{\text{H}}:\lambda_{\text{He}^+}:\lambda_{\text{Li}^{2+}}=\frac{1}{1^2}:\frac{1}{2^2}:\frac{1}{3^2}=36:9:4$

62. $\frac{1}{\lambda}=R\times1^2\times\left(\frac{1}{1^2}-\frac{1}{n^2}\right) \Rightarrow n=\sqrt{\frac{\lambda R}{\lambda R-1}}$

63. Required transition is $4 \to 2$

$$\frac{1}{\lambda} = R\times 1^2\left(\frac{1}{2^2}-\frac{1}{4^2}\right) = \frac{3R}{16} \Rightarrow \lambda = \frac{16}{3R}$$

64. $\lambda \alpha \frac{1}{z^2} \Rightarrow \frac{\lambda_{Na^{10+}}}{\lambda_H} = \frac{1^2}{10^2} \Rightarrow \lambda_{Na^{10+}} = 12.16$ Å

65. Excited state is $n = 6$ [$3 \to 2, 4 \to 2, 5 \to 2, 6 \to 2$]

$\therefore$ Number of spectral lines in $1R$ region = 6.

66. Required transition is $3 \to 2$.

Modified Rydberg constant is given by,

$$R' = R\times 2 \text{ as } R = \frac{2\pi^2 me^4}{(4\pi\varepsilon_0)^2 h^3 c}$$

Now, $\frac{1}{\lambda} = R'\times 1^2\left(\frac{1}{2^2}-\frac{1}{3^2}\right) = 2R\cdot\frac{5}{36}$

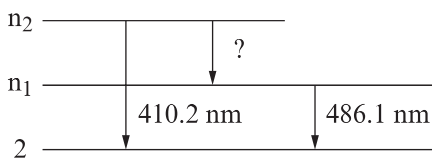
$\therefore \lambda = \frac{18}{5R}$

67. $\bar{\upsilon} = R\cdot\left(\frac{1}{2^2}-\frac{1}{n^2}\right) = \frac{R(n^2-4)}{4n^2}$

68. $\Delta E = 1312\times\left(\frac{1}{2^2}-\frac{1}{3^2}\right) = 182.22$ KJ

69. All are visible radiations. Next line is from transition $7 \to 2$.

70.



Both are visible radiations. For required series, we get only n_1.

Now, $\frac{1}{486.1\times 10^{-9}} = 1.09\times 10^7\times 1^2\left(\frac{1}{2^2}-\frac{1}{n_1^2}\right)$

$\Rightarrow n_1 = 4$.

Hence, the series is Brackett series.

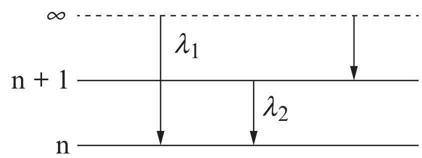
71. $\frac{1}{\lambda_1} = R\times 2^2\left(\frac{1}{2^2}-\frac{1}{3^2}\right) \Rightarrow \lambda_1 = \frac{9}{5R}$

$\frac{1}{\lambda_2} = R\times 2^2\left(\frac{1}{1^2}-\frac{1}{2^2}\right) \Rightarrow \lambda_2 = \frac{1}{5R}$

From question, $\lambda_1 - \lambda_2 = 132$ nm

or, $\frac{9}{5R}-\frac{1}{3R} = 132\times 10^{-9}$ m $\Rightarrow$ R = 1.11×10^9 m^{-1}

72.



$$\bar{\upsilon} = 2.725\times 10^6 = 1.09\times 10^7\times 1^2\left(\frac{1}{(n+1)^2}-\frac{1}{\infty^2}\right)$$

$\therefore n = 3$

Now, $\frac{1}{\lambda_{req}} = 1.09\times 10^7\times 2^2\left(\frac{1}{3^2}-\frac{1}{4^2}\right)$

$\Rightarrow \lambda_{req} = 471.8$ nm

73. $\frac{1240}{108.5} = \text{B.E.}\left(\frac{1}{2^2}-\frac{1}{5^2}\right) \Rightarrow \text{B.E.} = 54.4$ eV

74. K.E. of electron

$= 13.6\times 2^2\left(\frac{1}{1^2}-\frac{1}{2^2}\right) - 13.6 = 27.2$ eV

Now, $27.2\times 1.6\times 10^{-19} = \frac{1}{2}\times 9.1\times 10^{-31}\times v^2$

$\therefore$ v $\approx 3.1\times 10^6$ m/s

75. $X = \frac{E}{n^2}$ and $Y = \frac{E}{(n+3)^2}$

$\therefore \sqrt{\frac{X}{Y}} = 1+\frac{3}{n}$

76. $\frac{1}{\lambda} = R\times 1^2\times\left(\frac{1}{1^2}-\frac{1}{3^2}\right) \Rightarrow \lambda = \frac{9}{8R}$

77. $n\lambda = 2\pi r \Rightarrow \frac{2\pi\times x\times 3^2}{3} = 6\pi x$

78. $\lambda = \frac{h}{\sqrt{2m\text{E}}} \Rightarrow E\alpha\frac{1}{m}$ (for same λ)

79. $\lambda = \frac{h}{\sqrt{2m\text{E}}} \Rightarrow \frac{\lambda_p}{\lambda_\alpha} = \sqrt{\frac{4\times 2}{1\times 1}} = \frac{2\sqrt{2}}{1}$

80. $p = mv = \frac{\frac{1}{2}mv^2}{\frac{1}{2}v} = \text{const} \Rightarrow \lambda = \text{Constant}$

81. $\lambda_{min} = \frac{1.24\times 10^{-6}}{5\times 10^4} = 2.48\times 10^{-11}$ m

82. $m = \frac{h}{c\cdot\lambda} = \frac{h}{c}\times R\times 2^2\left(\frac{1}{2^2}-\frac{1}{\infty^2}\right) = 2.4\times 10^{-35}$ g

83. $\lambda = \frac{h}{\sqrt{2mE}} \Rightarrow \frac{E_2}{E_1} = \left(\frac{\lambda_1}{\lambda_2}\right)^2 = \left(\frac{100}{99}\right)^2 \approx 1.02$

$\therefore$ E_2 is about 2% greater than E_1.

84. $\Delta v_{min} = \frac{h}{4\pi m \cdot \Delta x} = \frac{h}{4\pi m \cdot \frac{h}{mv}} = \frac{v}{4\pi}$

85. $\lambda = \frac{h}{\sqrt{2mE}} \Rightarrow \Delta E = \frac{h^2}{2m}\left(\frac{1}{\lambda_2^2} - \frac{1}{\lambda_1^2}\right)$

$= \frac{(6.626\times 10^{-34})^2}{2\times 9.1\times 10^{-31}}\left(\frac{1}{(50\times 10^{-9})^2} - \frac{1}{(100\times 10^{-9})^2}\right)$

$= 7.24 \times 10^{-23}$ J $= 4.5 \times 10^{-4}$ eV

86. $\lambda = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{2m2V}}$

$= \frac{6.626\times 10^{-34}}{\sqrt{2\times 4\times 1.66\times 10^{-27}\times 2\times 1.6\times 10^{-19}\times 6}}$

$= 4.15 \times 10^{-12}$ m

87. $\lambda = 3.32\cdot\frac{n}{z}$Å $\Rightarrow 3.32 = 3.32\times\frac{n}{2} \Rightarrow n = 2$

Energy of photon liberated in 2 → 1 transition,

$\Delta E = 13.6\times 2^2 \times\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = 40.8$ eV

$\therefore$ K.E. of emitted electron from H-atom
$= 40.8 - 13.6 = 27.2$ eV

Hence, its de Broglie wavelength is given by,

$\lambda = \sqrt{\frac{150}{27.2}} = 2.348$Å

88. K.E. of electrons $= \frac{12400}{3000} - \frac{12400}{4000} = 1.03$ eV

$\therefore\ \lambda = \sqrt{\frac{150}{1.03}} = 12.05$ Å

89. $\Delta x \cdot \Delta\lambda \geq \frac{\lambda^2}{4\pi}$ and $\lambda = \sqrt{\frac{150}{6}} = 5$Å

$\therefore\ \Delta\lambda_{min} = \frac{\lambda^2}{4\pi\cdot\Delta x} = \frac{(5\times 10^{-10})^2}{4\pi\times\left(\frac{1}{\pi}\times 10^{-9}\right)}$

$= 6.25\times 10^{-11}$m

90. $\Delta E = 2.55$ eV $= 13.6\times 1^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$eV

$\therefore\ n_1 = 2$ and $n_2 = 4$

Now, $\Delta\lambda = 3.32\times\frac{4}{1} - 3.32\times\frac{2}{1} = 6.64$ Å

91. Orbital angular momentum $= \sqrt{l(l+1)}\cdot\frac{h}{2\pi}$

92. Electron of 1*s* level can never emit photon.

93. Maximum permissible value of $l = (n - 1)$

94. $m = -1 \Rightarrow l \geq 1 \Rightarrow$ can not be *s*-orbital.

95. Theoretical

96. Theoretical

97. Energy $2s < 2p < 3s < 3p < 4s < 3d$

98. $m = -3, -2, -1, 0, +1, +2, +3$

99. Number of radial nodes $= n - l - 1 = 3 - 2 - 1 = 0$

100. Theoretical

101. Probability of finding electron at the nucleus = 0

102. Theoretical

103. Mg(z = 12) $1s^2\ 2s^2\ 2p^6\ 3s^2$

104. Theoretical

105. 2(1*s*) + 2(2*s*) + 2(2*p*) + 1(3*s*) = 7

106. $L = \sqrt{l+(l+1)}\cdot\frac{h}{2\pi} = \sqrt{5}\cdot\frac{h}{\pi} \Rightarrow l = 4$

Number of orbitals $= 2l + 1 = 9$

107. $r_{mp} = \frac{a_0}{z} = 26.45$ pm

108. For $n - l - 1 = 0$, $r_{mp} = \frac{n^2 a_0}{z}$

and for all orbitals, $r_{av} = \frac{n^2 a_0}{z}\left[1 + \frac{1}{2}\left(1 - \frac{l(l+1)}{n^2}\right)\right]$

109. $S_1 = 3s$; $S_2 = 3d$; $S_3 = 4s$; $S_4 = 3p$

For single electron system $3s = 3p = 3d < 4s$

110. $\sqrt{l(l+1)}\cdot\frac{h}{2\pi} = \sqrt{3}\cdot\frac{h}{\pi} \Rightarrow l = 3 \Rightarrow n \geq 4$

Section B (One or More than one Correct)

1. (a) $(\text{K.E.})_{\text{Initial}} = (\text{P.E.})_{\text{at distance of closest approach}}$

or $4.0 \text{ MeV} = \text{K.} \dfrac{q_1 q_2}{r}$

or, $4 \times 10^6 \times 1.6 \times 10^{-19} = 9 \times 10^9 \times \dfrac{(2\times1.6\times10^{-19})\times(50\times1.6\times10^{-19})}{r}$

$\therefore$ Distance of closest approach, $r = 3.6 \times 10^{-14}$ m

(b) $\text{P.E.} = \text{K}\cdot\dfrac{q_1 q_2}{r} = 9 \times 10^9 \times \dfrac{(2\times1.6\times10^{-19})\times(50\times1.6\times10^{-19})}{9\times10^{-14}}$

$= 10^{25} \times (1.6 \times 10^{-19})^2 \text{ J} = \dfrac{10^{25}\times(1.6\times10^{-19})^2}{1.6\times10^{-19}} \text{e V}$

$= 1.6$ MeV

(c) $\text{P.E.} = K\cdot\dfrac{q_1 q_2}{r}$

$= \dfrac{9\times10^9\times(2\times1.6\times10^{-19})\times(50\times1.6\times10^{-19})}{4.5\times10^{-14}\times(1.6\times10^{-19}\times10^6)}$

$= 3.2$ MeV

$\therefore$ K.E. of α-particle at this distance

$= 4.0 - 3.2 = 0.8$ MeV

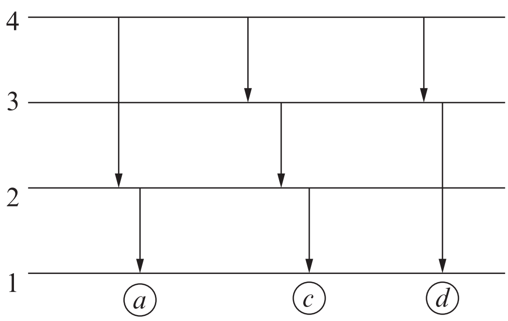
2. $\varepsilon_n = \dfrac{\varepsilon_1}{n^2}$

3. Theoretical

4. Theoretical

5. Theoretical

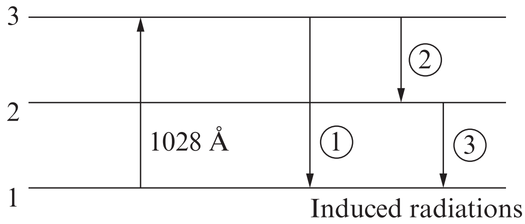
6.



7. $\dfrac{1}{\lambda} = RZ^2\left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right)$

$\Rightarrow \dfrac{1}{1028\times10^{-10}} = 1.09\times10^7\times1^2\left(\dfrac{1}{1^2} - \dfrac{1}{n^2}\right)$

$\therefore n = 3$



$\lambda_1 = 1028$ Å

$$\frac{\lambda_2}{\lambda_1} = \frac{\left(\frac{1}{1^2} - \frac{1}{3^2}\right)}{\left(\frac{1}{2^2} - \frac{1}{3^2}\right)} \Rightarrow \lambda_2 = 6579.2 \text{ Å}$$

$$\frac{\lambda 3}{\lambda_1} = \frac{\left(\frac{1}{1^2} - \frac{1}{3^2}\right)}{\left(\frac{1}{1^2} - \frac{1}{2^2}\right)} \Rightarrow \lambda_3 = 1218.4 \text{ Å}$$

8. Per atom only one photon is emitted out and hence, the concerned transition is $2 \to 1$.

$$\Delta E = 13.6\, Z^2\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = 10.2\, Z^2 \text{ eV}$$

9. (a) $r_1 : r_2 : r_3 = 1^2 : 2^2 : 3^2 = 1 : 4 : 9$

(c) $\lambda = \dfrac{c}{v} = \dfrac{3\times10^8}{6\times10^{14}} = 5\times10^{-7}\text{ m} = 500 \text{ nm}$

(d) $\lambda = \dfrac{h}{\sqrt{2mE}} \Rightarrow \lambda\, \alpha \dfrac{1}{\sqrt{m}}$

$\therefore \lambda_{\text{H}} : \lambda_{\text{H}_e} : \lambda_{cn_4} = \dfrac{1}{\sqrt{1}} : \dfrac{1}{\sqrt{4}} : \dfrac{1}{\sqrt{16}} = 4 : 2 : 1$

10. $h\nu = \phi + (\text{K.E.})_{\text{max}}$

For A: $4.25 = \phi_{\text{A}} + T_{\text{A}}$ and $\lambda_{\text{A}} = \dfrac{h}{\sqrt{2mT_{\text{A}}}}$

For B: $4.20 = \phi_{\text{B}} + T_{\text{B}}$ and $\lambda_{\text{B}} = \dfrac{h}{\sqrt{2mT_{\text{B}}}}$

As $T_{\text{B}} = T_{\text{A}} - 1.50$ and $\lambda_{\text{B}} = 2\,\lambda_{\text{A}}$

$\phi_{\text{A}} = 2.25$ eV; $\phi_{\text{B}} = 3.70$ eV; $T_{\text{A}} = 2.0$ eV; $T_{\text{B}} = 0.5$ eV

11. $l = 3.32\, \dfrac{n}{z}$ Å

12. Theoretical

13. Theoretical

14. Theoretical

15. Theoretical

16. 1*S*: ↑↓ 2*S*: ↑ 2*P*: ↑ ↑ ↑

17. Theoretical

18. Na (11) $1s^2\ 2s^2\ 2p^6\ 3s^1$

19. Theoretical

20. Total nodes = $n - 1$

Section C (Comprehensions)

Comprehension I

1. For minimum *l*, K.E. of photoelectron should be maximum. For it, the power should be maximum and number of photons is minimum.

E_{max} for photon = $\dfrac{5}{4\times10^{18}} = 1.25\times10^{-18}$ J

$\therefore$ (K.E.)$_{max}$ of photoelectron = $1.25 \times 10^{-18} - 4.5 \times 10^{-19}$

$= 8.0 \times 10^{-19}$ J = 5 eV

$$\therefore \lambda_{min} = \sqrt{\frac{150}{5}} = \sqrt{30}\ \text{Å}$$

2. $i_{min} = 4 \times 10^{18} \times 1.6 \times 10^{-19} = 0.64$ A

3. $\dfrac{i_{max}}{i_{min}} = \dfrac{9\times10^{18}\times1.6\times10^{-19}}{4\times10^{18}\times1.6\times10^{-19}} = \dfrac{9}{4}$

Comprehension II

4. $F = -\dfrac{du}{dr} = \dfrac{4K}{r^5} = \dfrac{MV^2}{r} \Rightarrow V^2 = \dfrac{4K}{mr^4}$ (1)

From Bohr's quantization, $V^2 = \dfrac{n^2h^2}{4\pi^2m^2r^2}$ (2)

$$\therefore \frac{4K}{mr^4} = \frac{n^2h^2}{4\pi^2m^2r^2} \Rightarrow r = \sqrt{\frac{16\pi^2mK}{n^2h^2}} = \frac{4\pi}{nh}.\sqrt{mK}$$

5. $V = \dfrac{nh}{2\pi mr} = \dfrac{nh}{2\pi m.\dfrac{4\pi}{nh}\sqrt{mK}} = \dfrac{n^2h^2}{8\pi^2m\sqrt{mK}}$

6. E = K.E. + P.E. = $\dfrac{1}{2}mv^2 + \left(-\dfrac{K}{r^4}\right)$

$$= \frac{1}{2}m\cdot\frac{4K}{mr^4} - \frac{K}{r^4} = \frac{K}{\left(\dfrac{4\pi}{nh}\cdot\sqrt{mK}\right)^4}$$

$$\therefore\ E = \frac{n^4h^4}{256\pi^4m^2K}$$

Comprehension III

$$\Delta E = 13.6z^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)\text{eV}$$

$10.2 + 17.0 = 13.6\ z^2\left(\dfrac{1}{2^2} - \dfrac{1}{n^2}\right)$ (1)

$4.25 + 5.95 = 13.6\ z^2\left(\dfrac{1}{3^2} - \dfrac{1}{n^2}\right)$ (2)

7. $n = 6$

8. $z = 3$

9. $\Delta E = 13.6\times3^2\left(\dfrac{1}{1^2} - \dfrac{1}{7^2}\right) = 119.9$ eV

Comprehension IV

10. After excitation, $n = 3$. Hence, initial excited state is $n = 2$.

11. $n = 3$

12. $\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \Rightarrow \frac{1}{1654 \times 10^{-10}}$

$= 1.09 \times 10^7 \times z^2\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$

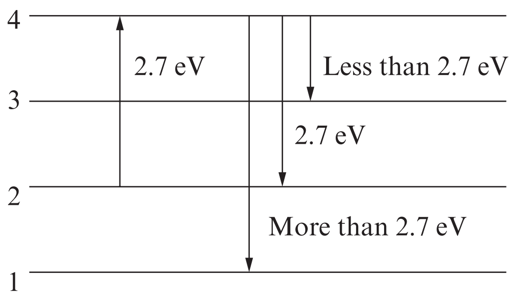
$\therefore z = 2$ Þ He^+ ion

13. $\Delta E = 13.6\, z^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = 13.6 \times 2^2\left(\frac{1}{3^2} - \frac{1}{\infty^2}\right)$

$= 6.04$ eV

Comprehension V

14. Final excited state, after absorption of 2.7 eV, is 4. On de-excitation, the sample emit radiations equal to less than or more than 2.7 eV and hence, the initial excited state must be 2.



15. $\Delta E = I.E.\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \Rightarrow 2.7 = I.E.\left(\frac{1}{2^2} - \frac{1}{4^2}\right)$

$\therefore I.E. = 14.4$ eV

16. $\Delta E_{min} = I.E.\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = 14.4 \times \left(\frac{1}{3^2} - \frac{1}{4^2}\right)$

$= 0.7$ eV

Comprehension VI

17. $r = \frac{(4\pi\varepsilon_0)n^2h^2}{4\pi^2 mze^2} = 0.529 \times \frac{n^2}{z}$ Å (for H-like atom)

For this system,

$r = \frac{0.529}{1 \times 207} = 2.56 \times 10^{-3}$ Å $= 0.256$ pm

18. $I.E. = \frac{2\pi^2 mz^2e^4}{(4\pi\varepsilon_0)^2 n^2h^2} = 13.6 \times \frac{z^2}{n^2}$ eV (for H-like atom)

For this system, $I.E. = 13.6 \times 207 = 2835.9$ eV

19. Rydberg constant for this system $= 1.09 \times 10^7 \times 207\ m^{-1}$

$\therefore \frac{1}{\lambda} = (1.09 \times 10^7 \times 207)\left(\frac{1}{1^2} - \frac{1}{2^2}\right)$

$\Rightarrow \lambda = 5.91 \times 10^{-10}$ m

Comprehension VII

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

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

$\Rightarrow \frac{1}{x \times 10^{-10}} = 1.09 \times 10^7 \times 1^2\left(\frac{1}{1^2} - \frac{1}{4^2}\right)$

$\therefore x = 978.6$

21. $n = 4$

22. For max λ, transition : $n = 4$ to $n = 3$

$\therefore \frac{1}{\lambda_{max}} = 1.09 \times 10^7 \times 1^2\left(\frac{1}{3^2} - \frac{1}{4^2}\right)$

$\Rightarrow \lambda_{max} = 1.887 \times 10^{-6}$ m

23. For max ν, transition : $n = 4$ to $n = 1$

$$\therefore \quad \nu_{max} = \frac{c}{\lambda} = \frac{3 \times 10^8}{978.6 \times 10^{-10}} = 3.066 \times 10^{15} \text{ Hz}$$

24. 1R radiations involve transition : $n = 4$ to $n = 3$ only.

25. Visible radiation involve transitions : $n = 4$ to $n = 2$ (489.3 nm)
and $n = 3$ to $n = 2$ (660.5 nm).

Comprehension VIII

26. $5 \xrightarrow{1} 4 \xrightarrow{2} 3 \xrightarrow{3} 2 \xrightarrow{4} 1$

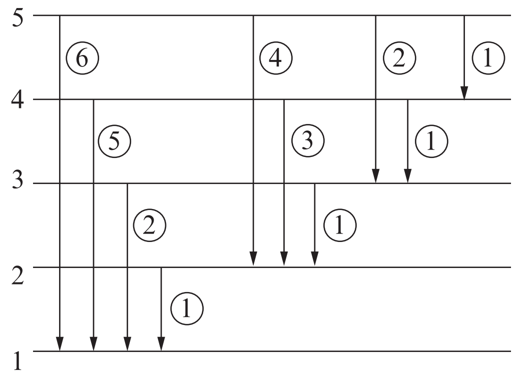
27. $5 \longrightarrow 3 \longrightarrow 2 \longrightarrow 1$ and

$5 \longrightarrow 4 \longrightarrow 3 \longrightarrow 1$

28. 6 + 1 (any possibility after than Q.27)

29. $\frac{5(5-1)}{2} = 10$

30.



Comprehension IX

$$\Delta E = 13.6 Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right) eV$$

$$204 = 13.6 Z^2 \left(\frac{1}{1^2} - \frac{1}{(2n)^2} \right) \qquad (1)$$

$$40.8 = 13.6 Z^2 \left(\frac{1}{n^2} - \frac{1}{(2n)^2} \right) \qquad (2)$$

31. $n = 2 \quad \Rightarrow \quad 2n = 4$

32. $Z = 4$

33. $E_1 = -13.6 \times \frac{4^2}{1^2} = -217.6$ eV

34. $\Delta E_{min} = 13.6 \times 4^2 \left(\frac{1}{3^2} - \frac{1}{4^2} \right) = 10.58$ eV

Comprehension X

35. $$\frac{1}{\lambda} = R Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right) = R \times 2^2 \left(\frac{1}{4^2} - \frac{1}{n^2} \right)$$

$$= \frac{4R(n^2 - 16)}{16 n^2}$$

$$\therefore \lambda = \frac{4n^2}{R(n^2 - 16)} = \frac{cn^2}{n^2 - 16} \Rightarrow C = \frac{4}{R} = 366.97 \text{ nm}$$

36. For series limit, $n = \infty$

$\therefore \lambda = C = 366.97$ nm

37. For $n = 5$, $\lambda = 1019.36$ nm

For $n = \infty$, $\lambda = 366.97$ nm

Comprehension XI

38. $S_1 = 2s$

39. $E_{S_1} = -13.6 \times \frac{3^2}{2^2} = E_H \times 2.25$

40. $S_2 = 3p \Rightarrow l = 1$

Comprehension XII

41. $n = 2$

$l = 1$ $\quad j = \frac{3}{2}$ or $\frac{1}{2}$

$m = = -\frac{3}{2}, -\frac{1}{2}, +-\frac{1}{2}, +-\frac{3}{2}$ for $j = \frac{3}{2}$

$= -\frac{1}{2}, +\frac{1}{2}$ for $j = \frac{1}{2}$

42. $n = 3$

$l = 0 \quad \Rightarrow j = \frac{1}{2} \quad \Rightarrow m = -\frac{1}{2}, +\frac{1}{2}$

$= 2 \quad \Rightarrow j = \frac{3}{2}$

$\Rightarrow m = -\frac{3}{2}, -\frac{1}{2}, +\frac{1}{2}, +\frac{3}{2}$

$= \frac{5}{2} \Rightarrow m = -\frac{5}{2}, -\frac{3}{2}, -\frac{1}{2}, +\frac{1}{2}, +\frac{3}{2}, +\frac{5}{2}$

Comprehension XIII

43. Radial nodes $= n - l - 1 = 3$

Angular nodes $= 1$

44. $n = 5, l = 1 \Rightarrow$ Orbital $= 5p$

45. p_z

46. For radial nodes, $\sigma = 1, 2, 6 = \frac{2zr}{5a_0}$

$\therefore r_{max} = \frac{15\, a_0}{Z}$

Section D (Assertion – Reason)

1. Orbital angular momentum $= \sqrt{l(l+1)} \cdot \frac{h}{2\pi}$
2. Theory based
3. Theory based
4. Spin quantum number is independent from wave function.
5. Theory based
6. Be is the reactive element.
7. $2p \Rightarrow 2p_x + 2p_y + 2p_z \Rightarrow$ Total 3 angular nodes.
8. dz^2 has two conical nodes.
9. $3p_x$ and $3p_y$ differs in angular function.
10. 4s energy level is lower than 3*d*.

Section E (Column Match)

1. Radial nodes $= n - l - 1$

   Angular nodes $= l$
2. Theory based
3. (A) $\frac{V_n}{K_n} = \frac{P.E.}{K.E.} = \frac{-mV^2}{\frac{1}{2}mV^2} = -2$

   (B) $\varepsilon_n \propto (-\frac{1}{r_n})$

   (C) Lowest energy level is 1*s*.

   (D) $r_n \propto \frac{1}{z}$
4. Theory based
5. Graph of *s*-orbital status with some value but for other orbitals, it starts from zero.

   Radial nodes: $3s = 2$, $4s = 3$, $2p = 0$, $3p = 1$
6. (A) $r \propto \frac{n^2}{z}$

   (B) $V \propto \frac{z}{n}$

   (C) $F = \frac{mv^2}{r} \propto \frac{z^3}{n^4}$

   (D) $f = \frac{v}{2\pi r} \propto \frac{z^2}{n^3}$

7. (A) 3 radial nodes $\Rightarrow$ 4s, 5p, 6d but graph does not start from origin and hence, only 4s.

(B) 3 radial nodes $\Rightarrow$ 4s, 5p, 6d

(C) Only s-orbital

(D) $l \geq 1$

8. Theory based

9.

Orbital	Radial nodes	Angular nodes
3d	0	2
2p	0	1
3p	1	1
5d	2	2

10. (A) $\frac{V_6}{V_4} = \frac{4}{6} = \frac{2}{3}$ $\quad\left(v \propto \frac{1}{n}\right)$

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

(C) $\frac{\lambda_c}{\lambda_p} = \frac{\left(\frac{1}{3^2} - \frac{1}{6^2}\right)}{\left(\frac{1}{1^2} - \frac{1}{3^2}\right)} = \frac{3}{3^2}$

(D) $\frac{\Delta E_n}{\Delta E_{H_e^+}} = \frac{1^2}{2^2} = \frac{1}{4}$

Section F (Subjective)

Single-digit Integer Type

1. $\varepsilon = \frac{1240}{300} = 4.13 \text{ eV}$

For photoelectric effect, $\varepsilon \geq \phi \Rightarrow N_0 = 4$

2. Frequency of reduction $\propto \frac{z^2}{n^3}$

$\therefore \frac{T_3}{T_2} = \frac{\frac{1^2}{3^3} \times 4.8 \times 10^{-8}}{\frac{1^2}{2^2} \times 1.28 \times 10^{-7}} = \frac{1}{6}$

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

$\Rightarrow \frac{1}{108.5 \times 10^{-7}} + \frac{1}{30.4 \times 10^{-7}}$

$= 1.09 \times 10^7 \times 2^2 \times \left(\frac{1}{1^2} - \frac{1}{n^2}\right)$

$\therefore n = 5$

4. $\lambda_3 - \lambda_2 = 59.3$ nm

or, $\frac{1}{RZ^2\left(\frac{1}{2^2} - \frac{1}{3^2}\right)} - \frac{1}{RZ^2\left(\frac{1}{1^2} - \frac{1}{2^2}\right)} = 59.3 \text{ nm}$

$\Rightarrow z = 3$

5. Final excited state = 5th orbit
As only the wavelengths are longer than absorbed radiation initial excited state = 3rd orbit

6. $\Delta E = 12.75 = 13.6 \times 1^2 \left(\frac{4nm}{2} - \frac{1}{n^2}\right) \Rightarrow n = 4$

7. $\Delta x_{\min} = \frac{h}{4\pi m \Delta V} = \frac{6.626 \times 10^{-34}}{4\pi \times 10^{-6} \times \frac{3.313}{\pi} \times 10^{-3}}$

$= 5 \times 10^{-26}$ m

8. $m_{\min} = \frac{h}{4\pi \cdot \Delta x \cdot \Delta v}$

$= \frac{6.626 \times 10^{-34}}{4\pi \times 10^{-11} \times 5.27 \times 10^{-24}} = 1 \text{ kg}$

9. $2\pi r = nl \quad \Rightarrow l = \frac{4 \text{ nm}}{2} = 2 \text{ nm}$

10. For radial node, $\psi_{23} = 0 \quad \Rightarrow r_0 = 2\, a_0$

Four-digit Integer Type

1. Initial K. E. = P. E. at distance of closest approach

or, $\frac{p^2}{2\text{m}} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_0}{r}$.

or

$$\frac{(3.2 \times 10^{-20})^2}{2 \times 4 \times \frac{10^{-3}}{6 \times 10^{23}}} = 9 \times 10^9 \times \frac{2 \times 1.6 \times 10^{-19} \times z \times 1.6 \times 10^{-19}}{1.5 \times 10^{-13}}$$

$\therefore z = 25$

2. $t = \dfrac{\text{Distance}}{\text{Speed}} = \dfrac{2\times 12600\times 10^3}{3\times 10^8} = 0.084 \text{ sec}$

3. $\sqrt{\dfrac{c}{\lambda}} = a(\text{z}-6)$

$\sqrt{\dfrac{c}{180}} = a(27-1)$

$\sqrt{\dfrac{c}{144}} = a(z-1) \Rightarrow z = 30$

4. $nh\nu = \text{ms}\cdot\Delta T$

or, $n \times 6.626 \times 10^{-34} \times 2.45 \times 10^{10} = 245 \times 4.2 \times (99.5 - 19.5)$

$\therefore$ Number of photons $= 5.04 \times 10^{27}$

$\therefore$ Moles of photon $= \dfrac{5.04\times 10^{27}}{6\times 10^{23}} = 8400$

5. $\Delta E = \Delta E_1 + \Delta E_2$

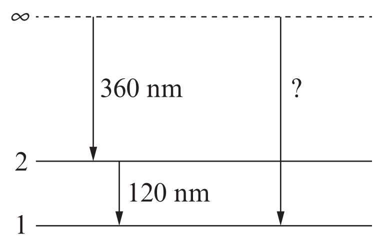
$= 1310\left(\dfrac{1}{1^2}-\dfrac{1}{3^2}\right)\times\dfrac{45}{100} + 1310\times\left(\dfrac{1}{1^2}-\dfrac{1}{2^2}\right)\times\dfrac{40}{100} = 917 \text{ kJ}$

6. $\lambda = \dfrac{1240}{13.6} = 91.17 \text{ nm}$

7. Moles of $H_2 = \dfrac{PV}{RT} = \dfrac{1\times 1}{0.08\times 300} = x$

$\Delta E = 436\times x + 1312\left(\dfrac{1}{1^2}-\dfrac{1}{2^2}\right)\times 2x = 100.16 \text{ kJ}$

8.



$\dfrac{1}{\lambda} = \dfrac{1}{120} + \dfrac{1}{360} \Rightarrow \lambda = 90 \text{ nm}$

9. $\lambda = \sqrt{\dfrac{150}{\text{V}}}\text{-}\ V^{\frac{1}{2}} \Rightarrow 2.5 = \sqrt{\dfrac{150}{\text{V}}} \Rightarrow V = 24$

10. $\lambda = \dfrac{h}{\sqrt{2\text{mE}}} = \dfrac{h}{\sqrt{2m\cdot\dfrac{3}{2}KT}} \Rightarrow \lambda\alpha\dfrac{1}{\sqrt{m\cdot T}}$

$\therefore \dfrac{\lambda_{\text{H}_\text{e}}}{\lambda_{\text{N}_\text{e}}} = \sqrt{\dfrac{20\times 1000}{4\times 200}} = 5$