Chapter 2

Structure of Atom

1. Calculate the wavelength (in nanometer) associated with a proton moving at 1.0×10^3 ms^{-1}

   (Mass of proton = 1.67×10^{-27} kg and h = 6.63×10^{-34} Js) **[AIEEE-2009]**

   (1) 0.40 nm (2) 2.5 nm
   (3) 14.0 nm (4) 0.032 nm

2. In an atom, an electron is moving with a speed of 600 m/s with an accuracy of 0.005%. Certainty with which the position of the electron can be located is ($h = 6.6 \times 10^{-34}$ kg m^2s^{-1}, mass of electron, $e_m = 9.1 \times 10^{-31}$ kg) **[AIEEE-2009]**

   (1) 5.10×10^{-3} m (2) 1.92×10^{-3} m
   (3) 3.84×10^{-3} m (4) 1.52×10^{-4} m

3. The energy required to break one mole of Cl – Cl bonds in Cl_2 is 242 kJ mol^{-1}. The longest wavelength of light capable of breaking a single Cl – Cl bond is

   ($c = 3 \times 10^8$ ms^{-1} and $N_A = 6.02 \times 10^{23}$ mol^{-1}) **[AIEEE-2010]**

   (1) 494 nm (2) 594 nm
   (3) 640 nm (4) 700 nm

4. Ionisation energy of He^+ is 19.6×10^{-18} $atom^{-1}$. The energy of the first stationary state (n = 1) of Li^{2+} is **[AIEEE-2010]**

   (1) 8.82×10^{-17} J $atom^{-1}$
   (2) 4.41×10^{-16} J $atom^{-1}$
   (3) -4.41×10^{-17} J $atom^{-1}$
   (4) -2.2×10^{-15} J $atom^{-1}$

5. The frequency of light emitted for the transition n = 4 to n = 2 of He^+ is equal to the transition in H atom corresponding to which of the following **[AIEEE-2011]**

   (1) n = 4 to n = 3
   (2) n = 3 to n = 1
   (3) n = 2 to n = 1
   (4) n = 3 to n = 2

6. The electrons identified by quantum numbers n and l

   (a) n = 4, l = 1 (b) n = 4, l = 0
   (c) n = 3, l = 2 (d) n = 3, l = 1

   can be placed in order of increasing energy as **[AIEEE-2012]**

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

7. Energy of an electron is given by $E = -2.178 \times 10^{-18} J\left(\frac{Z^2}{n^2}\right)$. Wavelength of light required to excite an electron in an hydrogen atom form level n = 1 to n = 2 will be

   ($h = 6.62 \times 10^{-34}$ Js and $c = 3.0 \times 10^8$ ms^{-1}) **[JEE (Main)-2013]**

   (1) 1.214×10^{-7} m (2) 2.816×10^{-7} m
   (3) 6.500×10^{-7} m (4) 8.500×10^{-7} m

8. The first ionisation potential of Na is 5.1 eV. The value of electron gain enthalpy of Na^+ will be **[JEE (Main)-2013]**

   (1) –2.55 eV (2) –5.1 eV
   (3) –10.2 eV (4) +2.55 eV

9. The correct set of four quantum numbers for the valence electrons of rubidium atom (Z = 37) is **[JEE (Main)-2014]**

   (1) $5, 0, 0, +\frac{1}{2}$ (2) $5, 1, 0, +\frac{1}{2}$
   (3) $5, 1, 1, +\frac{1}{2}$ (4) $5, 0, 1, +\frac{1}{2}$

10. Which of the following is the energy of a possible excited state of hydrogen? **[JEE (Main)-2015]**

    (1) +13.6 eV (2) –6.8 eV
    (3) –3.4 eV (4) +6.8 eV

11. A stream of electrons from a heated filament was passed between two charged plates kept at a potential difference V esu. If e and m are charge and mass of an electron, respectively, then the value of $\frac{h}{\lambda}$ (where λ is wavelength associated with electron wave) is given by **[JEE (Main)-2016]**

(1) 2meV

(2) $\sqrt{meV}$

(3) $\sqrt{2meV}$

(4) meV

12. The radius of the second Bohr orbit for hydrogen atom is

(Planck's Const. $h = 6.6262 \times 10^{-34}$ Js;

mass of electron $= 9.1091 \times 10^{-31}$ kg;

charge of electron $e = 1.60210 \times 10^{-19}$ C;

permittivity of vacuum

$\varepsilon_0 = 8.854185 \times 10^{-12}\ kg^{-1}\ m^{-3}\ A^2$)

[JEE (Main)-2017]

(1) 0.529 Å (2) 2.12 Å

(3) 1.65 Å (4) 4.76 Å

13. For emission line of atomic hydrogen from $n_i = 8$ to $n_f = n$, the plot of wave number ($\bar{\nu}$) against $\left(\frac{1}{n^2}\right)$ will be (The Rydberg constant, R_H is in wave number unit) **[JEE (Main)-2019]**

(1) Linear with slope R_H

(2) Linear with intercept $-R_H$

(3) Non-linear

(4) Linear with slope $-R_H$

14. Which of the following combination of statements is true regarding the interpretation of the atomic orbitals?

(a) An electron in an orbital of high angular momentum stays away from the nucleus than an electron in the orbital of lower angular momentum

(b) For a given value of the principal quantum number, the size of the orbit is inversely proportional to the azimuthal quantum number.

(c) According to wave mechanics, the ground state angular momentum is equal to $\frac{h}{2\pi}$

(d) The plot of ψ Vs r for various azimuthul quantum numbers, shows peak shifting towards higher r value. **[JEE (Main)-2019]**

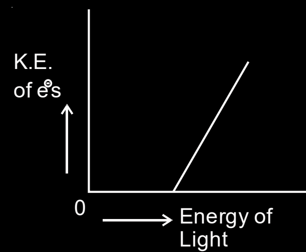
(1) (a), (d) (2) (b), (c)

(3) (a), (c) (4) (a), (b)

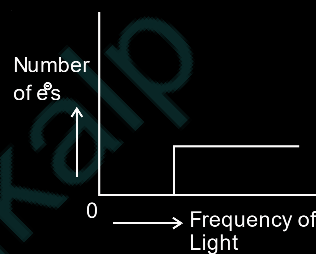
15. Which of the graphs shown below does not represent the relationship between incident light and the electron ejected from metal surface?

[JEE (Main)-2019]

(1)



(2)



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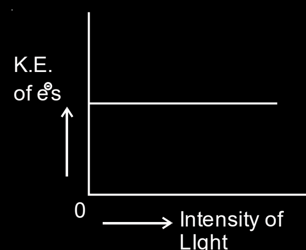

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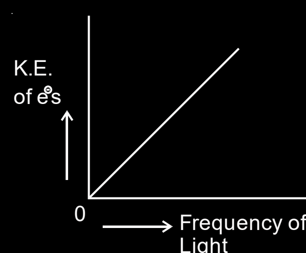


16. The ground state energy of hydrogen atom is –13.6 eV. The energy of second excited state of He^+ ion in eV is **[JEE (Main)-2019]**

(1) –27.2 (2) –6.04

(3) –54.4 (4) –3.4

17. Heat treatment of muscular pain involves radiation of wavelength of about 900 nm. Which spectral line of H-atom is suitable for this purpose?

[$R_H = 1 \times 10^5$ cm, $h = 6.6 \times 10^{-34}$ Js, $c = 3 \times 10^8\ ms^{-1}$]

[JEE (Main)-2019]

(1) Balmer, $\infty \rightarrow 2$ (2) Lyman, $\infty \rightarrow 1$

(3) Paschen, $5 \rightarrow 3$ (4) Paschen, $\infty \rightarrow 3$

18. The de Broglie wavelength (λ) associated with a photoelectron varies with the frequency (ν) of the incident radiation as, [ν_0 is threshold frequency]

[JEE (Main)-2019]

(1) $\lambda \propto \frac{1}{(\nu - \nu_0)}$ (2) $\lambda \propto \frac{1}{(\nu - \nu_0)^{\frac{1}{4}}}$

(3) $\lambda \propto \frac{1}{(\nu - \nu_0)^{\frac{1}{2}}}$ (4) $\lambda \propto \frac{1}{(\nu - \nu_0)^{\frac{3}{2}}}$

19. What is the work function of the metal if the light of wavelength 4000 Å generates photoelectrons of velocity 6×10^5 ms^{-1} from it?

(Mass of electron = 9×10^{-31} kg

Velocity of light = 3×10^8 ms^{-1}

Planck's constant = 6.626×10^{-34} Js

Charge of electron = 1.6×10^{-19} JeV^{-1})

[JEE (Main)-2019]

(1) 4.0 eV (2) 2.1 eV

(3) 3.1 eV (4) 0.9 eV

20. If the de Broglie wavelength of the electron in nth Bohr orbit in a hydrogenic atom is equal to 1.5 πa_0 (a_0 is Bohr radius), then the value of n/z is

[JEE (Main)-2019]

(1) 0.40 (2) 1.50

(3) 0.75 (4) 1.0

21. The quantum number of four electrons are given below

(I) n = 4, l = 2, m_l = –2, $m_s = -\frac{1}{2}$

(II) n = 3, l = 2, m_l = 1, $m_s = +\frac{1}{2}$

(III) n = 4, l = 1, m_l = 0, $m_s = +\frac{1}{2}$

(IV) n = 3, l = 1, m_l = 1, $m_s = -\frac{1}{2}$

The correct order of their increasing energies will be [JEE (Main)-2019]

(1) IV < II < III < I (2) I < III < II < IV

(3) IV < III < II < I (4) I < II < III < IV

22. If p is the momentum of the fastest electron ejected from a metal surface after the irradiation of light having wavelength λ, then for 1.5 p momentum of the photoelectron, the wavelength of the light should be

(Assume kinetic energy of ejected photoelectron to be very high in comparison to work function):

[JEE (Main)-2019]

(1) $\frac{3}{4}\lambda$ (2) $\frac{4}{9}\lambda$

(3) $\frac{2}{3}\lambda$ (4) $\frac{1}{2}\lambda$

23. For any given series of spectral lines of atomic hydrogen, let $\Delta\bar{\nu} = \bar{\nu}_{max} - \bar{\nu}_{min}$ be the difference in maximum and minimum frequencies in cm^{-1}. The ratio $\Delta\bar{\nu}_{Lyman} / \Delta\bar{\nu}_{Balmer}$ is [JEE (Main)-2019]

(1) 9 : 4 (2) 27 : 5

(3) 4 : 1 (4) 5 : 4

24. Which one of the following about an electron occupying the 1s orbital in a hydrogen atom is incorrect? (The Bohr radius is represented by a_0)

[JEE (Main)-2019]

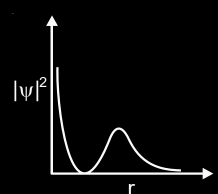
(1) The probability density of finding the electron is maximum at the nucleus

(2) The electron can be found at a distance $2a_0$ from the nucleus

(3) The magnitude of the potential energy is double that of its kinetic energy on an average

(4) The total energy of the electron is maximum when it is at a distance a_0 from the nucleus

25. The graph between $|\psi|^2$ and r(radial distance) is shown below. This represents [JEE (Main)-2019]



(1) 1s orbital (2) 2s orbital

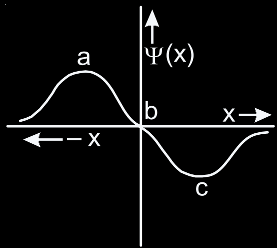
(3) 2p orbital (4) 3s orbital

26. The ratio of the shortest wavelength of two spectral series of hydrogen spectrum is found to be about 9. The spectral series are [JEE (Main)-2019]

(1) Paschen and Pfund (2) Brackett and Pfund

(3) Lyman and Paschen (4) Balmer and Brackett

27. The electrons are more likely to be found **[JEE (Main)-2019]**



(1) In the region a and c (2) Only in the region c

(3) Only in the region a (4) In the region a and b

28. Among the following, the energy of 2s orbital is lowest in **[JEE (Main)-2019]**

(1) Li (2) K

(3) H (4) Na

29. The number of orbitals associated with quantum numbers $n = 5$, $m_s = +\frac{1}{2}$ is **[JEE (Main)-2020]**

(1) 15 (2) 50

(3) 25 (4) 11

30. For the Balmer series in the spectrum of H atom, $\bar{\nu}=R_H\left\{\frac{1}{n_1^2}-\frac{1}{n_2^2}\right\}$, the correct statements among (I) to (VI) are

(I) As wavelength decreases, the lines in the series converge

(II) The integer n_1 is equal to 2

(III) The lines of longest wavelength corresponds to $n_2 = 3$

(IV) The ionization energy of hydrogen can be calculated from wave number of these lines

[JEE (Main)-2020]

(1) (I), (II), (III) (2) (II), (III), (IV)

(3) (I), (III), (IV) (4) (I), (II), (IV)

31. The radius of the second Bohr orbit, in terms of the Bohr radius, a_0, in Li^{2+} is **[JEE (Main)-2020]**

(1) $\frac{4a_0}{3}$ (2) $\frac{4a_0}{9}$

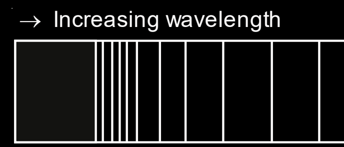
(3) $\frac{2a_0}{3}$ (4) $\frac{2a_0}{9}$

32. The de Broglie wavelength of an electron in the 4th Bohr orbit is **[JEE (Main)-2020]**

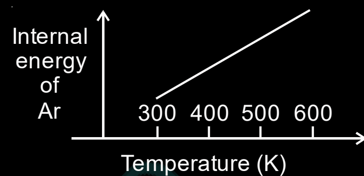
(1) $4\pi a_0$ (2) $6\pi a_0$

(3) $8\pi a_0$ (4) $2\pi a_0$

33. The figure that is not a direct manifestation of the quantum nature of atoms is **[JEE (Main)-2020]**

(1)


Absorption spectrum

(2)


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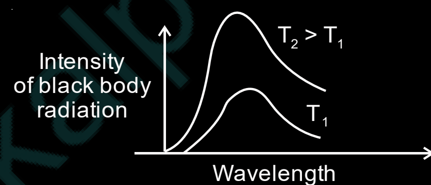

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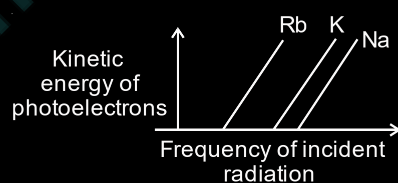


34. The number of subshells associated with $n = 4$ and $m = -2$ quantum numbers is **[JEE (Main)-2020]**

(1) 2 (2) 8

(3) 4 (4) 16

35. The region in the electromagnetic spectrum where the Balmar series lines appear is

[JEE (Main)-2020]

(1) Microwave (2) Ultraviolet

(3) Visible (4) Infrared

36. The shortest wavelength of H atom in the Lyman series is λ_1. The longest wavelength in the Balmar series of He^+ is **[JEE (Main)-2020]**

(1) $\frac{5\lambda_1}{9}$ (2) $\frac{36\lambda_1}{5}$

(3) $\frac{27\lambda_1}{5}$ (4) $\frac{9\lambda_1}{5}$

37. The difference between radii of 3rd and 4th orbits of Li^{2+} is ΔR_1. The difference between the radii of 3rd and 4th orbits of He^+ is ΔR_2. Ratio $\Delta R_1 : \Delta R_2$ is **[JEE (Main)-2020]**

(1) 3 : 2　　(2) 8 : 3

(3) 2 : 3　　(4) 3 : 8

38. The correct statement about probability density (except at infinite distance from nucleus) is

[JEE (Main)-2020]

(1) It can never be zero for 2s orbital

(2) It can be zero for 3p orbital

(3) It can be zero for 1s orbital

(4) It can be negative for 2p orbital

39. The work function of sodium metal is 4.41×10^{-19} J. If photons of wavelength 300 nm are incident on the metal, the kinetic energy of the ejected electrons will be ($h = 6.63 \times 10^{-34}$ J s; $c = 3 \times 10^8$ m/s) ________ $\times 10^{-21}$ J.

[JEE (Main)-2020]

40. A proton and a Li^{3+} nucleus are accelerated by the same potential. If λ_{Li} and λ_p denote the de Broglie wavelengths of Li^{3+} and proton respectively, then the value of $\dfrac{\lambda_{Li}}{\lambda_p}$ is $x \times 10^{-1}$.

The value of x is _____. (Rounded off to the nearest integer)

[Mass of Li^{3+} = 8.3 mass of proton]

[JEE (Main)-2021]

41. According to Bohr's atomic theory:

(A) Kinetic energy of electron is $\propto \dfrac{Z^2}{n^2}$

(B) The product of velocity (v) of electron and principal quantum number (n), 'vn' $\propto Z^2$

(C) Frequency of revolution of electron in an orbit is $\propto \dfrac{Z^3}{n^3}$

(D) Coulombic force of attraction on the electron is $\propto \dfrac{Z^3}{n^4}$

Choose the most appropriate answer from the options given below: **[JEE (Main)-2021]**

(1) (A) only

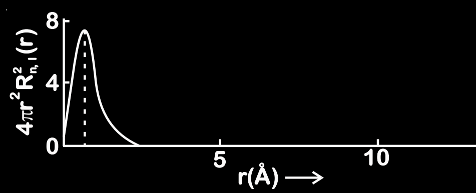
(2) (A) and (D) only

(3) (C) only

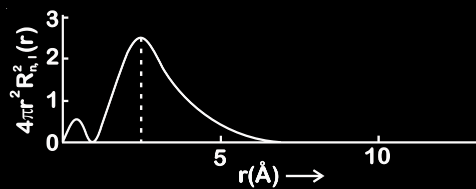
(4) (A), (C) and (D) only

42. The plots of radial distribution functions for various orbitals of hydrogen atom against 'r' are given below

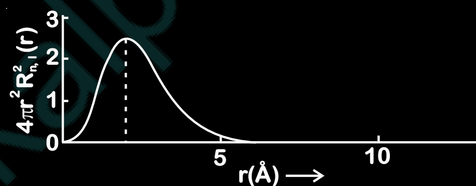
(A)



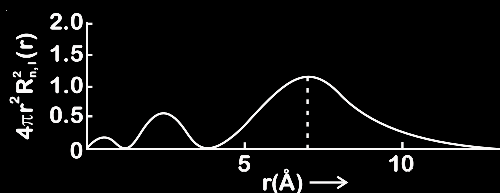
(B)



(C)



(D)



The correct plot for 3s orbital is

(1) (C)　　(2) (D)

(3) (B)　　(4) (A)

[JEE (Main)-2021]

43. Electromagnetic radiation of wavelength 663 nm is just sufficient to ionise the atom of metal A. The ionization energy of metal A in kJ mol^{-1} is _____. (Rounded-off to the nearest integer)

[$h = 6.63 \times 10^{-34}$ Js, $c = 3.00 \times 10^8$ ms^{-1}, $N_A = 6.02 \times 10^{23}$ mol^{-1}] **[JEE (Main)-2021]**

44. The orbital having two radial as well as two angular nodes is : **[JEE (Main)-2021]**

(1) 3p　　(2) 4d

(3) 5d　　(4) 4f

45. A ball weighing 10 g is moving with a velocity of 90 ms^{-1}. If the uncertainty in its velocity is 5%, then the uncertainty in its position is ___________ $\times 10^{-33}$ m. (Rounded off to the nearest integer)

[Given : $h = 6.63 \times 10^{-34}$ Js] **[JEE (Main)-2021]**

46. When light of wavelength 248 nm falls on a metal of threshold energy 3.0 eV, the de-Broglie wavelength of emitted electrons is _____ Å. (Round off to the Nearest Integer).

[Use : $\sqrt{3} = 1.73$, $h = 6.63 \times 10^{-34}$ Js

$m_e = 9.1 \times 10^{-31}$ kg; $c = 3.0 \times 10^8$ ms^{-1} ; 1eV = 1.6×10^{-19}J] **[JEE (Main)-2021]**

47. The number of orbitals with n = 5, $m_\ell = +2$ is ______.

(Round off to the Nearest Integer).

[JEE (Main)-2021]

48. A certain orbital has n = 4 and $m_L = -3$. The number of radial nodes in this orbital is __________.

(Round off to the Nearest Integer).

[JEE (Main)-2021]

49. In the ground state of atomic Fe(Z = 26), the spin-only magnetic moment is ______ $\times 10^{-1}$ BM. (Round off to the Nearest Integer).

[Given: $\sqrt{3} = 1.73, \sqrt{2} = 1.41$]

[JEE (Main)-2021]

50. Given below are two statements :

Statement I : Bohr's theory accounts for the stability and line spectrum of Li^+ ion.

Statement II : Bohr's theory was unable to explain the splitting of spectral lines in the presence of a magnetic field.

In the light of the above statements, choose the **most appropriate** answer from the options given below. **[JEE (Main)-2021]**

(1) Both statement I and statement II are true

(2) Statement I is false but statement II is true

(3) Both statement I and statement II are false

(4) Statement I is true but statement II is false

51. A certain orbital has no angular nodes and two radial nodes. The orbital is **[JEE (Main)-2021]**

(1) 2*p* (2) 3*p*

(3) 3*s* (4) 2*s*

52. The Azimuthal quantum number for the valence electrons of Ga^+ ion is _______.

(Atomic number of Ga = 31) **[JEE (Main)-2021]**

53. The wavelength of electrons accelerated from rest through a potential difference of 40 kV is $x \times 10^{-2}$ m. The value of *x* is _______. (Nearest integer)

Given: Mass of electron = 9.1×10^{-31} kg

Charge on an electron = 1.6×10^{-19} C

Planck's constant = 6.63×10^{-34} Js

[JEE (Main)-2021]

54. Number of electrons that Vanadium (Z = 23) has in p-orbitals is equal to _______. **[JEE (Main)-2021]**

55. A source of monochromatic radiation of wavelength 400 nm provides 1000 J of energy in 10 seconds. When this radiation falls on the surface of sodium, $x \times 10^{20}$ electrons are ejected per second. Assume that wavelength 400 nm is sufficient for ejection of electron from the surface of sodium metal. The value of x is _______. (Nearest integer)

($h = 6.626 \times 10^{-34}$ Js) **[JEE (Main)-2021]**

56. An accelerated electron has a speed of 5×10^6 ms^{-1} with an uncertainty of 0.02%. The uncertainty in finding its location while in motion is $x \times 10^{-9}$ m. The value of *x* is _________. **[JEE (Main)-2021]**

[Use mass of electron = 9.1×10^{-31} kg, h = 6.63×10^{-34} Js, $\pi = 3.14$]

57. Given below are two statements :

Statement I : Rutherford's gold foil experiment cannot explain the line spectrum of hydrogen atom.

Statement II : Bohr's model of hydrogen atom contradicts Heisenberg's uncertainty principle.

In the light of the above statement, choose the **most appropriate** answer from the options given below: **[JEE (Main)-2021]**

(1) Both **statement I** and **statement II** are false.

(2) **Statement I** is true but **statement II** is false.

(3) **Statement I** is false but **statement II** is true.

(4) Both **statement I** and **statement II** are true.

58. If the Thompson model of the atom was correct, then the result of Rutherford's gold foil experiment would have been : **[JEE (Main)-2021]**

(1) All α-particles get bounced back by 180°

(2) α-particles pass through the gold foil deflected by small angles and with reduced speed

(3) α-particles are deflected over a wide range of angles

(4) All of the α-particles pass through the gold foil without decrease in speed

59. Given below are two statements :

Statement I : According to Bohr's model of an atom, qualitatively the magnitude of velocity of electron increases with decrease in positive charges on the nucleus as there is no strong hold on the electron by the nucleus.

Statement II : According to Bohr's model of an atom, qualitatively the magnitude of velocity of electron increases with decrease in principal quantum number.

In the light of the above statements, choose the **most appropriate** answer from the options given below : **[JEE (Main)-2021]**

(1) Both **Statement I** and **Statement II** are false

(2) **Statement I** is false but **Statement II** is true

(3) Both **Statement I** and **Statement II** are true

(4) **Statement I** is true but **Statement II** is false

60. A metal surface is exposed to 500 nm radiation. The threshold frequency of the metal for photoelectric current is 4.3×10^{14} Hz. The velocity of ejected electron is _____ $\times 10^5$ ms^{-1}. (Nearest integer)

[Use : $h = 6.63 \times 10^{-34}$ Js, $m_e = 9.0 \times 10^{-31}$ kg]

[JEE (Main)-2021]

61. The kinetic energy of an electron in the second Bohr orbit of a hydrogen atom is equal to $\dfrac{h^2}{xma_0^2}$. The value of 10x is _______. (a_0 is radius of Bohr's orbit) (Nearest integer)

[Given : $\pi = 3.14$] **[JEE (Main)-2021]**

62. The number of photons emitted by a monochromatic (single frequency) infrared range finder of power 1 mW and wavelength of 1000 nm, in 0.1 second is $x \times 10^{13}$. The value of x is _____. (Nearest integer)

($h = 6.63 \times 10^{-34}$ Js, $c = 3.00 \times 10^8$ ms^{-1})

[JEE (Main)-2021]

63. Ge (Z = 32) in its ground state electronic configuration has x completely filled orbitals with $m_l = 0$. The value of x is _____.

[JEE (Main)-2021]

64. A 50 watt bulb emits monochromatic red light of wavelength of 795 nm. The number of photons emitted per second by the bulb is $x \times 10^{20}$. The value of x is ______. (Nearest integer)

[Given : $h = 6.63 \times 10^{-34}$ Js and $c = 3.0 \times 10^8$ ms^{-1}]

[JEE (Main)-2021]

65. Consider the following pairs of electrons

[JEE (Main)-2022]

A (a) $n = 3, l = 1, m_\ell = 1, m_s = +\frac{1}{2}$

(b) $n = 3, l = 2, m_\ell = 1, m_s = +\frac{1}{2}$

B (a) $n = 3, l = 2, m_\ell = -2, m_s = -\frac{1}{2}$

(b) $n = 3, l = 2, m_\ell = -1, m_s = -\frac{1}{2}$

C (a) $n = 4, l = 2, m_\ell = 2, m_s = +\frac{1}{2}$

(b) $n = 3, l = 2, m_\ell = 2, m_s = +\frac{1}{2}$

The pairs of electrons present in degenerate orbitals is /are:

(1) Only (A) (2) Only (B)

(3) Only (C) (4) (B) and (C)

66. The energy of one mole of photons of radiation of wavelength 300 nm is (Given $h = 6.63 \times 10^{-34}$ Js, $N_A = 6.02 \times 10^{23}$ mol^{-1}, $c = 3 \times 10^8$ ms^{-1})

[JEE (Main)-2022]

(1) 235 kJ mol^{-1} (2) 325 kJ mol^{-1}

(3) 399 kJ mol^{-1} (4) 435 kJ mol^{-1}

67. The pair, in which ions are isoelectronic with Al^{3+} is:

[JEE (Main)-2022]

(1) Br^- and Be^{2+} (2) Cl^- and Li^+

(3) S^{2-} and K^+ (4) O^{2-} and Mg^{2+}

68. The longest wavelength of light that can be used for the ionisation of lithium atom (Li) in its ground state is $x \times 10^{-8}$ m. The value of x is ______. (Nearest Integer)

(Given : Energy of the electron in the first shell of the hydrogen atom is -2.2×10^{-18} J; $h = 6.63 \times 10^{-34}$ Js and $c = 3 \times 10^{8}\ ms^{-1}$)

[JEE (Main)-2022]

69. The minimum energy that must be possessed by photons in order to produce the photoelectric effect with platinum metal is

[Given The threshold frequency of platinum is $1.3 \times 10^{15}\ s^{-1}$ and $h = 6.6 \times 10^{-34}$ Js.]

[JEE (Main)-2022]

(1) 3.21×10^{-14} J (2) 6.24×10^{-16} J

(3) 8.58×10^{-19} J (4) 8.58×10^{-19} J

70. If the radius of the 3^{rd} Bohr's orbit of hydrogen atom is r_3 and the radius of 4^{th} Bohr's orbit is r_4. Then :

[JEE (Main)-2022]

(1) $r_4 = \frac{9}{16} r_3$ (2) $r_4 = \frac{16}{9} r_3$

(3) $r_4 = \frac{3}{4} r_3$ (4) $r_4 = \frac{4}{3} r_3$

71. The number of radial and angular nodes in 4d orbital are, respectively

[JEE (Main)-2022]

(1) 1 and 2 (2) 3 and 2

(3) 1 and 0 (4) 2 and 1

72. If the uncertainty in velocity and position of a minute particle in space are, 2.4×10^{-26} ($m\ s^{-1}$) and 10^{-7} (m) respectively. The mass of the particle in g is ______. (Nearest integer)

(Given : $h = 6.626 \times 10^{-34}$ Js)

[JEE (Main)-2022]

73. Consider the following set of quantum numbers.

	n	l	m_l
A.	3	3	–3
B.	3	2	–2
C.	2	1	+1
D.	2	2	+2

The number of correct sets of quantum numbers is ______.

[JEE (Main)-2022]

74. Consider the following statements :

[JEE (Main)-2022]

(A) The principal quantum number 'n' is a positive integer with values of 'n' = 1, 2, 3, ...

(B) The azimuthal quantum number 'l' for a given 'n' (principal quantum number) can have values as 'l' = 0, 1, 2, …n

(C) Magnetic orbital quantum number 'm_l' for a particular 'l' (azimuthal quantum number) has (2l + 1) values.

(D) ±1/2 are the two possible orientations of electron spin.

(E) For l = 5, there will be a total of 9 orbital

Which of the above statements are correct?

(1) (A), (B) and (C)

(2) (A), (C), (D) and (E)

(3) (A), (C) and (D)

(4) (A), (B), (C) and (D)

75. Which of the following statements are **correct**?

[JEE (Main)-2022]

(A) The electronic configuration of Cr is [Ar] $3d^5 4s^1$.

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

(C) In the ground state of an atom, the orbitals are filled in order of their increasing energies.

(D) The total number of nodes are given by n – 2.

Choose the **most appropriate** answer from the options given below :

(1) (A), (C) and (D) only

(2) (A) and (B) only

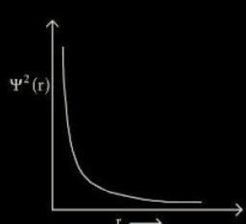
(3) (A) and (C) only

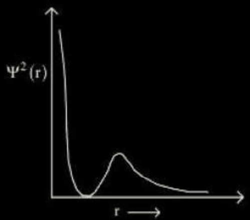
(4) (A), (B) and (C) only

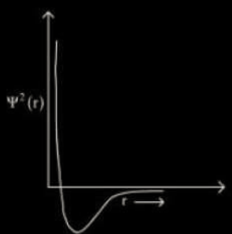
76. Which of the following is the correct plot for the probability density $\psi^2(r)$ as a function of distance 'r' of the electron from the nucleus for 2s orbital?

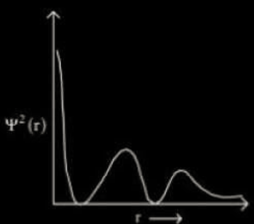
[JEE (Main)-2022]

(1)



(2) 

(3) 

(4) 

77. Which of the following sets of quantum numbers is not allowed?

[JEE (Main)-2022]

(1) $n = 3, l = 2, m_l = 0, s = +\frac{1}{2}$

(2) $n = 3, l = 2, m_l = -2, s = +\frac{1}{2}$

(3) $n = 3, l = 3, m_l = -3, s = -\frac{1}{2}$

(4) $n = 3, l = 0, m_l = 0, s = -\frac{1}{2}$

78. When the excited electron of a H atom from n = 5 drops to the ground state, the maximum number of emission lines observed are ____.

[JEE (Main)-2022]

79. The wavelength of an electron and a neutron will become equal when the velocity of the electron is x times the velocity of neutron. The value of x is ______. (Nearest integer)

(Mass of electron is 9.1×10^{-31} kg and mass of neutron is 1.6×10^{-27} kg) **[JEE (Main)-2022]**

80. Consider an imaginary ion $^{48}_{22}X^{3-}$. The nucleus contains 'a'% more neutrons than the number of electrons in the ion. The value of 'a' is ________. [nearest integer] **[JEE (Main)-2022]**

81. Given below are two statements. One is labelled as **Assertion A** and the other is labelled as **Reason R.**

Assertion A: Energy of 2s orbital of hydrogen atom is greater than that of 2s orbital of lithium.

Reason R : Energies of the orbitals in the same subshell decrease with increase in the atomic number.

In the light of the above statements, choose the ***correct*** answer from the options given below.

[JEE (Main)-2022]

(1) Both **A** and **R** are true and **R** is the correct explanation of **A**.

(2) Both **A** and **R** are true but **R** is NOT the correct explanation of **A**.

(3) **A** is true but **R** is false.

(4) **A** is false but **R** is true.

82. The correct decreasing order of energy for the orbitals having, following set of quantum numbers:

(A) n = 3, l = 0, m = 0 (B) n = 4, l = 0, m = 0

(C) n = 3, l = 1, m = 0 (D) n = 3, l = 2, m = 1

[JEE (Main)-2022]

(1) (D) > (B) > (C) > (A) (2) (B) > (D) > (C) > (A)

(3) (C) > (B) > (D) > (A) (4) (B) > (C) > (D) > (A)

83. Identify the incorrect statement from the following.

[JEE (Main)-2022]

(1) A circular path around the nucleus in which an electron moves is proposed as Bohr's orbit.

(2) An orbital is the one electron wave function (Ψ) in an atom.

(3) The existence of Bohr's orbits is supported by hydrogen spectrum.

(4) Atomic orbital is characterised by the quantum numbers n and l only.

84. If the wavelength for an electron emitted from H-atom is 3.3×10^{-10} m, then energy absorbed by the electron in its ground state compared to minimum energy required for its escape from the atom, is _______ times. (Nearest integer)

[Given : h = 6.626×10^{-34} J s]

[Mass of electron = 9.1×10^{-31} kg]

[JEE (Main)-2022]

85. The minimum uncertainty in the speed of an electron in one dimensional region of length $2a_0$ (Where a_0 = Bohr radius 52.9 pm) is ____ km s^{-1}.

(Given : Mass of electron = 9.1×10^{-31} kg, Planck's constant h = 6.63×10^{-34} Js) **[JEE (Main)-2022]**

86. Given below are the quantum numbers for 4 electrons.

A. $n = 3, l = 2, m_l = 1, m_s = +1/2$

B. $n = 4, l = 1, m_l = 0, m_s = +1/2$

C. $n = 4, l = 2, m_l = -2, m_s = -1/2$

D. $n = 3, l = 1, m_l = -1, m_s- = +1/2$

The correct order of increasing energy is

[JEE (Main)-2022]

(1) D < B < A < C (2) D < A < B < C

(3) B < D < A < C (4) B < D < C < A

87. If the work function of a metal is 6.63×10^{-19} J, the maximum wavelength of the photon required to remove a photoelectron from the metal is _______ nm. (Nearest integer)

[Given : h = 6.63×10^{-34} J s, and c = 3×10^{8} m s^{-1}]

[JEE (Main)-2022]

❑ ❑ ❑

Chapter 2

Structure of Atom

1. Answer (1)

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

or $\lambda = \dfrac{6.63 \times 10^{-34}}{1.67 \times 10^{-27} \times 10^{3}}$ = 0.4 nm

2. Answer (2)

$$\Delta p \cdot \Delta x \geq \frac{h}{4\pi}$$

$$\Delta x = \frac{h}{4\pi \cdot m\Delta V}$$

$$= \frac{6.6 \times 10^{-34} \times 100}{4 \times 3.14 \times 9.1 \times 10^{-31} \times 600 \times 0.005}$$

$= 1.92 \times 10^{-3}$ m

3. Answer (1)

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

$$E = \frac{242 \times 10^3}{6.023 \times 10^{23}} \text{ J/atom}$$

$$\therefore \frac{242 \times 10^3}{6.023 \times 10^{23}} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{\lambda}$$

$$\lambda = \frac{19.8 \times 10^{-26} \times 6.023 \times 10^{23}}{242 \times 10^3} = 0.494 \times 10^{-6}$$

= 494 nm

4. Answer (3)

$$\frac{E_{He^+}}{E_{Li^{+2}}} = \frac{Z^2_{He^+}}{Z^2_{Li^{+2}}}$$

$$\frac{19.6 \times 10^{-18}}{E_{Li^{+2}}} = \frac{4}{9}$$

$$E_{Li^{+2}} = \frac{9}{4} \times 19.6 \times 10^{-18}$$

$= 4.41 \times 10^{-17}$ J/atom

$\therefore$ Energy of orbit of Li^{+2} is -4.41×10^{-17} J/atom

5. Answer (3)

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

$$\therefore (1)^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] = (2)^2 \left[\frac{1}{(2)^2} - \frac{1}{(4)^2}\right]$$

$$\frac{1}{n_1^2} - \frac{1}{n_2^2} = \frac{3}{4}$$

$\Rightarrow n_1 = 1, n_2 = 2$

6. Answer (1)

7. Answer (1)

$$E_1 = -2.178 \times 10^{-18} \text{ J}$$

$$E_2 = -2.178 \times 10^{-18} \left(\frac{1}{4}\right) \text{ J}$$

$$\frac{hc}{\lambda} = E_2 - E_1 = 2.178 \times \frac{3}{4} \times 10^{-18}$$

$$\lambda = \frac{6.62 \times 10^{-34} \times 3 \times 10^8 \times 4}{2.178 \times 3 \times 10^{-18}} = 1.214 \times 10^{-7} \text{ m}$$

8. Answer (2)

$$Na(g) \longrightarrow Na^+(g) + e, \ \Delta H_{IE} = +5.1 \text{ eV}$$

$$Na^+(g) + e \longrightarrow Na(g), \ \Delta H_{eg} = -5.1 \text{ eV}$$

9. Answer (1)

$37 \rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 5s^1$

So last electron enters 5*s* orbital

Hence n = 5, l = 0, $m_l = 0$, $m_s = \pm\frac{1}{2}$

10. Answer (3)

Energy of excited state is negative and correspond to n > 1.

$$n = \sqrt{\frac{-13.6}{E_{\text{excited state}}}} = \sqrt{\frac{-13.6}{-3.4}} = \sqrt{4} = 2$$

11. Answer (3)

Kinetic energy of electron is = e × V

As per de-Broglie's equation

$$\lambda = \frac{h}{\sqrt{2mE_k}} = \frac{h}{\sqrt{2meV}}$$

$$\therefore \quad \frac{h}{\lambda} = \sqrt{2meV}$$

12. Answer (2)

$$r = a_0 \frac{n^2}{Z} = 0.529 \times 4 = 2.12 \text{ Å}$$

13. Answer (4)

$$\bar{\nu} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)Z^2 \ \ (Z = 1)$$

$$\bar{\nu} = R_H\left(\frac{-1}{n^2} + \frac{1}{8^2}\right)$$

$$\bar{\nu} = \frac{-R_H}{n^2} + \frac{R_H}{64}$$

y = mx + c

$x = \frac{1}{n^2}$, m = $-R_H$ (slope)

14. Answer (1)

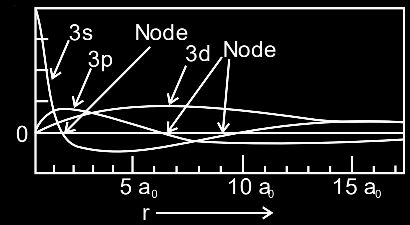
(a) Angular momentum (L) = $\frac{nh}{2\pi}$

So, as n increases, L increases.

(b) $r \propto \frac{n^2}{Z}$

(c) For n = 1, L = $\frac{h}{2\pi}$

(d) As l increases, the peak of ψ vs r shifts towards higher 'r' value.



15. Answer (4)

$$h\nu_{\text{incident}} = h\nu_{th} + KE$$

KE is independent of intensity and number of photoelectrons does not depend on frequency of light.

$$\Rightarrow KE = h\nu_{\text{incident}} - h\nu_{th}$$

16. Answer (2)

Energy in n^{th} state as per Bohr's model

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

$\therefore$ 2^{nd} excited state

$\Rightarrow$ $n = 3$

$$\therefore \quad E_{3,He^+} = -13.6 \times \frac{2^2}{3^2} \text{ eV}$$

$$= -6.04 \text{ eV}$$

17. Answer (4)

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

$n_1 = 3, n_2 = \infty$

$$\frac{1}{\lambda} = R\left(\frac{1}{9}\right) \Rightarrow \lambda = \frac{9}{R} = \frac{9}{10^5} = 9 \times 10^{-5} \text{ cm}$$

= 900 nm

18. Answer (3)

According to de-Broglie wavelength equation

$$\lambda = \frac{h}{mv} \quad \Rightarrow \quad \lambda \propto \frac{1}{v}$$

From photoelectric effect.

$$h\nu - h\nu_0 = \frac{1}{2}mv^2$$

$$v \propto (\nu - \nu_0)^{1/2}$$

$$\therefore \quad \lambda \propto \frac{1}{(\nu - \nu_0)^{1/2}}$$

19. Answer (2)

$$E_{photon} = \frac{12400}{4000} = 3.1\,eV$$

$$KE_{e^-} = \frac{1}{2}mv^2 = \frac{1}{2} \times 9 \times 10^{-31} \times 36 \times 10^{10}\,J$$

$$= 1.62 \times 10^{-19}\,J \simeq 1\,eV$$

$\therefore$ Work function = 3.1 – 1 = 2.1 eV

20. Answer (3)

$n\lambda = 2\pi r$

$$r = a_0 \frac{n^2}{z}$$

$$n\lambda = \frac{2\pi a_0 n^2}{z}$$

$$\lambda = \frac{2\pi a_0 n^2}{z}$$

$$1.5\pi a^0 = 2\pi a_0 \frac{n}{2}$$

$$\frac{n}{z} = \frac{3}{4} = 0.75$$

21. Answer (1)

				n + l
(I)	n = 4	l = 2	4d	6
(II)	n = 3	l = 2	3d	5
(III)	n = 4	l = 1	4p	5
(IV)	n = 3	l = 1	3p	4

more is n + l value, more is energy

3p < 3d < 4p < 4d

22. Answer (2)

In photoelectric effect,

$$\frac{hc}{\lambda} = w + \text{KE of electron}$$

It is given that KE of ejected electron is very high in comparison to w.

$$\frac{hc}{\lambda} = KE \Rightarrow \frac{hc}{\lambda} = \frac{P^2}{2m}$$

New wavelength

$$\frac{hc}{\lambda_1} = \frac{(1.5P)^2}{2m} \Rightarrow \lambda' = \frac{4}{9}\lambda$$

23. Answer (1)

$\bar{\nu} \propto \Delta E$

For H-atom,

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

For Lyman series,

$$\bar{\nu}(\text{max}) \propto 13.6\left(1 - \frac{1}{\infty}\right)$$

$$\bar{\nu}(\text{min}) \propto 13.6\left(1 - \frac{1}{4}\right)$$

$$\therefore \quad \bar{\nu}_{max} - \bar{\nu}_{min} \propto 13.6\left(\frac{1}{4}\right)$$

For Balmer series,

$$\bar{\nu}(\text{max}) \propto 13.6\left(\frac{1}{4} - \frac{1}{\infty}\right)$$

$$\bar{\nu}(\text{min}) \propto 13.6\left(\frac{1}{4} - \frac{1}{9}\right)$$

$$\therefore \quad \bar{\nu}_{min} - \bar{\nu}_{min} \propto 13.6\left(\frac{1}{9}\right)$$

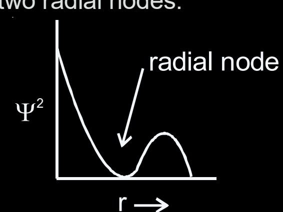
$$\frac{\nu_{Lyman}}{\nu_{Balmer}} = \frac{9}{4}$$

24. Answer (4)

The total energy of the electron is minimum when it is at a distance a_0 from the nucleus for 1s orbital.

25. Answer (2)

The given probability density curve is for 2s orbital because it has only one radial node. Among other given orbitals, 1s and 2p do not have any radial node and 3s has two radial nodes.



26. Answer (3)

Shortest wavelength means $n_2 = \infty$

Lyman series $\bar{\nu}_L = \frac{1}{\lambda_L} = -1312 \times \frac{1}{1^2} \times 1^2$

Paschen series $\bar{\nu}_P = \frac{1}{\lambda_P} = -1312 \times \frac{1}{3^2} \times 1^2$

$$\frac{\bar{\nu}_L}{\bar{\nu}_P} = \frac{\lambda_P}{\lambda_L} = 9$$

27. Answer (1)

Probability of finding an electron is given by $4\pi r^2 dr \, \Psi^2$ and it will have maximum value at both 'a' and 'c'.

28. Answer (2)

As the value of Z (atomic number) increases, energy of orbitals decreases (becomes more –ve value)

$\therefore$ order of energy of 2s orbital is

H > Li > Na > K

29. Answer (3)

The number of orbitals possible in a shell with principal quantum number 'n' is 'n^2'.

30. Answer (1)

In Balmer series of H-atom, the electronic transitions take place from higher orbits to 2nd orbit and the longest wavelength will correspond to transition from 3rd orbit to 2nd orbit.

$\therefore$ $n_1 = 2$ and $n_2 = 3$ for longest wavelength.

As wavelength decreases the lines in the Balmer series converge. The correct statements are (I), (II) and (III).

31. Answer (1)

$$r = 0.529 \frac{n^2}{Z} \text{Å}$$

Bohr's radius for hydrogen atom (a_0) = 0.529 Å

Bohr's radius of Li^{+2} ion for n = 2

$$= a_0 \frac{n^2}{Z}$$

$$= \frac{4a_0}{3}$$

32. Answer (3)

According to Bohr's model

$$r_n = \frac{n^2}{Z} \times a_0 \quad (a_0 = 1^{st} \text{ Bohr radius})$$

$$\because \quad 2\pi r = n\lambda \quad \text{(using de-Broglie relation)}$$

$$\Rightarrow \quad 2\pi \times \frac{4^2}{1} \times a_0 = 4\lambda$$

$$\Rightarrow \quad \boxed{\lambda = 8\pi a_0}$$

33. Answer (2)

Explanation of variation of internal energy of Ar with temperature (Straight line and $U \propto T$) is not a direct manifestation of the quantum nature of atoms.

While explanation of absorption spectrum, nature of emission of radiation from hot bodies (black body radiation) and photoelectric effect are direct manifestation of the quantum nature of atoms.

34. Answer (1)

2 subshells are associated with n = 4 and m = –2.

35. Answer (3)

In the hydrogen spectrum,

Balmer series lies in visible region.

36. Answer (4)

Shortest wavelength $\rightarrow$ Max energy ($\infty \rightarrow 1$) (Lyman series)

$$\frac{1}{\lambda_1} = R_H(1)^2\left[\frac{1}{1} - 0\right]$$

$$\frac{1}{\lambda_1} = R_H \Rightarrow R_H = \frac{1}{\lambda_1}$$

For Balmer series,

$$\frac{1}{\lambda} = R_H(2)^2\left[\frac{1}{2^2} - \frac{1}{3^2}\right] \Rightarrow \frac{1}{\lambda} = R_H(4)\left(\frac{9-4}{36}\right)$$

$$\frac{1}{\lambda} = \frac{5R_H}{9} \Rightarrow \lambda = \frac{9}{5R_H} = \frac{9\lambda_1}{5}$$

37. Answer (3)

$$r_n = a_0 \frac{n^2}{Z}$$

$$r_n \propto \frac{n^2}{Z}$$

$$\therefore \quad \frac{\Delta R_1}{\Delta R_2} = \frac{Z_{He^+}}{Z_{Li^{2+}}} = \frac{2}{3}$$

38. Answer (2)

$(\psi)^2$ (probability density) can be zero for 3p orbital other than infinite distance. It has one radial node.

39. Answer (222)

w, work function of sodium metal

= 4.41 × 10^{-19} J

λ, wavelength of incident light = 300 nm

= 3 × 10^{-7} m

According to photoelectric effect

$$\frac{hc}{\lambda} = w + KE$$

$$\frac{6.63\times10^{-34}\times3\times10^{8}}{3\times10^{-7}} = 4.41\times10^{-19} + KE$$

6.63 × 10^{-19} = 4.41 × 10^{-19} + KE

KE = 2.22 × 10^{-19} J = 222 × 10^{-21} J

40. Answer (2)

de-Broglie wavelength (λ) = $\frac{h}{mV} = \frac{h}{\sqrt{2m(K.E.)}}$

When a charge particle is accelerated by potential difference (V) then increase in K.E. = q.V

$$\lambda_{Li} = \frac{h}{\sqrt{2\times m_p\times8.3\times3\times V}}$$

$$\lambda_p = \frac{h}{\sqrt{2\times m_p\times1\times V}}$$

$$\therefore \frac{\lambda_{Li}}{\lambda_p} = \frac{h}{\sqrt{2\times24.9\times m_p\times V}}\times\frac{\sqrt{2\times m_p\times V}}{h} \simeq \frac{1}{5}$$

= 2 × 10^{-1}

41. Answer (2)

In Bohr's atomic theory:

$$K.E. \propto \frac{Z^2}{n^2}$$

Velocity (v) $\propto \frac{Z}{n}$

$\therefore$ V.n $\propto$ Z

Frequency of revolution $= \frac{V}{2\pi r}$

Frequency of revolution $\propto \frac{V}{r}$

$$\propto \frac{Z\times Z}{n\times n^2}$$

$$\propto \frac{Z^2}{n^3}$$

Force of attraction $= \frac{mV^2}{r}$

Force of attraction $\propto \frac{V^2}{r}$

$$\propto \frac{Z^2\times z}{n^2\times n^2}$$

$$\propto \frac{Z^3}{n^4}$$

Correct statements : (A) and (D).

42. Answer (2)

3s orbital has 2 radial nodes

Number of radial nodes = n – (l + 1)

$\therefore$ Graph (A) can be for 1s

Graph (B) can be for 2s

Graph (C) can be for 2p

Graph (D) can be for 3s

43. Answer (181)

Ionisation energy of an atom of metal A = Quantum energy of radiation of wavelength 663 nm

$$= \frac{6.63\times10^{-34}\times3\times10^{8}}{663\times10^{-9}} J = 3\times10^{-19} J$$

Ionisation energy per mol

= 3 × 10^{-19} × 10^{-3} × 6.02 × 10^{23}

= 180.6 kJ mol^{-1} ≃ 181

44. Answer (3)

Number of radial nodes = (n – l – 1)

Number of angular nodes = l

for 5d; n = 5, l = 2

5d orbital has two radial nodes and two angular nodes

So, the correct option should be (3)

45. Answer (1)

According to Heisenberg uncertainty principle

$$\Delta x \Delta p \geq \frac{h}{4\pi}$$

$$\Delta x = \frac{h}{4\pi m \Delta V} \; (\Delta P = m\Delta V)$$

$$= \frac{6.63 \times 10^{-34}\,\text{Js}}{4 \times 3.14 \times 10 \times 10^{-3}\,\text{kg} \times 90\,\text{ms}^{-1} \times 0.05}$$

$= 1.173 \times 10^{-33}$ m

$= 1 \times 10^{-33}$ m

46. Answer (9)

$$\underset{\text{photon}}{\text{Incident energy of}} = \underset{\text{metal}}{\text{Work function of}} + \underset{\text{photoelectron}}{\text{K.E. of}}$$

$h\nu = h\nu_0 + KE$

$$\frac{6.63 \times 10^{-34}\,\text{Js} \times 3 \times 10^{8}\,\text{ms}^{-1}}{248 \times 10^{-9}\,\text{m} \times 1.6 \times 10^{-19}\,\text{J eV}^{-1}} = 3.0 + \text{K. E.}$$

K. E. = 2.0 eV

$$\lambda = \frac{h}{\sqrt{2m\,\text{K. E.}}} = \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 2 \times 10^{-19} \times 1.6}}$$

$= 8.68 \times 10^{-10}$ m $\approx$ 9 Å

47. Answer (03)

n = 5

Possible values of ℓ = 4, 3, 2, 1, 0

m_ℓ = 2 is possible for ℓ = 4, 3 & 2

as m_ℓ takes values from ($-\ell$ to ℓ)

$\therefore$ Possible orbitals (n, ℓ, m_ℓ) : (5, 4, 2) (5, 3, 2) (5, 2, 2)

48. Answer (0)

The orbital having n = 4 and $m_L = -3$ is 4*f*.

The number of radial nodes is an orbital is given by

Number of radial nodes $= n - m_L - 1$

$= 4 - 3 - 1$

$= 0$

49. Answer (49)

Fe(Z = 26)

Electronic configuration : $4s^2 3d^6$

⇅	↑	↑	↑	↑

n = 4

$\therefore \mu = \sqrt{4(4+2)} = \sqrt{24}$ BM

= 4.89

$\approx 49 \times 10^{-1}$ BM

50. Answer (2)

Bohr's theory is applicable for unielectronic species only

Li^+ has two electrons

Bohr's theory could not explain the splitting of spectral lines in the presence of external magnetic field (Zeeman effect)

Statement I – false

Statement II – true

51. Answer (3)

3*s* has no angular node two radial nodes.

52. Answer (0)

Ga – $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,4s^2\,3d^{10}\,4p^1$

Ga^+ – $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,4s^2\,3d^{10}$

$4s^2$ are the valence electrons, so l = 0.

53. Answer (6)

Wavelength of electron is given by

$$\lambda = \frac{h}{\sqrt{2mqV}}$$

Here q = charge on electron, V = potential difference

$$\lambda = \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 1.6 \times 10^{-19} \times 40 \times 10^{3}}}$$

$$= \frac{6.63 \times 10^{-34}}{\sqrt{1164.8 \times 10^{-47}}} = 6.144 \times 10^{-12} \approx 6 \times 10^{-12}$$

x = 6

54. Answer (12)

Vanadium (Z = 23)

V = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3\ 4s^2$

Number of electrons in p-orbital are 12

55. Answer (2)

E = nhν

$$1000 = \frac{n \times 6.626 \times 10^{-34} \times 3 \times 10^8}{400 \times 10^{-9}}$$

n = 20.122 × 10^{20} photons incidented on metal surface in 10 seconds

n = 2.0122 × 10^{20} photon incidented on metal surface in 1 second

Number of electrons ejected equal to number of photon incidented.

56. Answer (58)

Uncertainty in speed of electron = $\frac{0.02}{100} \times 5 \times 10^6$

$= 10^3\ ms^{-1}$

$$m\Delta v \times \Delta x = \frac{h}{4\pi}$$

$$\Delta x = \frac{6.63 \times 10^{-34}}{4 \times 3.14 \times 9.1 \times 10^{-31} \times 10^3}$$

$= 5.80 \times 10^{-8}m = 58.00 \times 10^{-9}\ m$

57. Answer (4)

One of the drawback of Rutherford model is that, it says nothing about the electronic structure of atom. It cannot explain the line spectra of hydrogen atom.

Since uncertainty principle rules out existence of definite paths or trajectories of electrons and other similar particles. So Bohr's model contradicts H.U.P.

58. Answer (2)

According to thompson model of atom, the mass of each gold atom is uniformly distributed. And as the α-particles had enough energy to pass directly through such mass, it slowed down with small changes in its directions.

59. Answer (2)

$$v_n = 2.18 \times 10^6 \times \frac{Z}{n}\ m/s$$

Qualitatively the magnitude of velocity of electron increases with increase of positive charge on the nucleus and decreases with increase of principal quantum number.

60. Answer (5)

$$h\nu = h\nu_0 + \frac{1}{2}m_e v^2$$

$$\frac{6.63 \times 10^{-34} \times 3 \times 10^8}{500 \times 10^{-9}}$$

$$= 6.63 \times 10^{-34} \times 4.3 \times 10^{14} + \frac{1}{2} \times 9 \times 10^{-31} \times v^2$$

$v \approx 5 \times 10^5\ ms^{-1}$

61. Answer (3155)

Kinetic energy of an electron in n^{th} orbit of Bohr atom $= \frac{1}{2}mv^2 = \frac{(mv)^2}{2m} = \frac{n^2h^2}{2(4\pi^2 mr^2)}$

For 2nd orbit of H-atom

n = 2 and r = $4a_0$

$$\therefore\ KE = \frac{h^2}{8\pi^2 m \times 4a_0^2} = \frac{h^2}{315.5\ ma_0^2}$$

∴ x = 315.5; 10x = 3155

62. Answer (50)

Power = 1 mW

= 10^{-3} J in 1 sec.

= 10^{-4} J in 0.1 sec.

$$\therefore\ \text{Energy} = \frac{nhc}{\lambda}$$

$$10^{-4} = \frac{n \times 6.63 \times 10^{-34} \times 3 \times 10^8}{1000 \times 10^{-9}}$$

n = 50.2 × 10^{13}

∴ $x \approx 50$

63. Answer (7)

Ge (32) = $1s^2 \quad 2s^2 \quad 2p^6 \quad 3s^2 \quad 3p^6$

$4s^2 \quad 3d^{10} \quad 4p^2$

$m_l = 0 \quad 1s, 2s, 2p_z, 3s, 3p_z, 4s, 3d_{z^2}$

64. Answer (2)

E = nhν

50 watt bulb emits 50 J energy per second.

$$50 = \frac{n \times 6.63 \times 10^{-34} \times 3 \times 10^8}{795 \times 10^{-9}}$$

$$n = \frac{50 \times 795 \times 10^{-9}}{6.63 \times 10^{-34} \times 3 \times 10^8}$$

$$n \approx 2 \times 10^{20}$$

65. Answer (2)

For degenerate orbitals, only the value of m must be different. The value of 'n' and 'l' must be the same.

Hence, the pair of electrons with quantum numbers given in (B) are degenerate.

66. Answer (3)

Wavelength of radiation = 300 nm

Photon energy = $\frac{hc}{\lambda}$

$$= \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{300 \times 10^{-9}}$$

$= 6.63 \times 10^{-19}$ J

Energy of 1 mole of photons

$= 6.63 \times 10^{-19} \times 6.02 \times 10^{23} \times 10^{-3}$

= 399 kJ

67. Answer (4)

O^{2-}, Mg^{2+} and Al^{3+} are isoelectronic. All have 10 electrons.

68. Answer (4)

Energy required for ionisation of Li atom

$= 2.2 \times 10^{-18} \times \frac{9}{4}$ J [Assume this formule is True for Li atom]

$$\because \quad E = \frac{hc}{\lambda}$$

$$2.2 \times 10^{-18} \times \frac{9}{4} = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{\lambda}$$

$$\lambda = 4 \times 10^{-8} \text{m}$$

69. Answer (3)

The minimum energy possessed by photons will be equal to the work function of the metal.

Hence,

$w_0 = h\nu_0$

$= 6.6 \times 10^{-34} \times 1.3 \times 10^{15}$

$= 8.58 \times 10^{-19}$ J

70. Answer (2)

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

$$r_4 = r_0 \times \frac{4^2}{1}$$

and $r_3 = r_0 \times \frac{3^2}{1}$

Therefore $\frac{r_4}{r_3} = \frac{4^2}{3^2} \Rightarrow r_4 = \frac{16}{9} r_3$

71. Answer (1)

n 4d $\quad$ n = 4 $\quad$ l = 2

Radial nodes = n – l – 1

= 4 – 2 – 1

= 1

Angular nodes = l

= 2

72. Answer (22)

$$\Delta v = 2.4 \times 10^{-26} \text{m s}^{-1}$$

$$\Delta x = 10^{-7} \text{m}$$

$$\therefore \quad m \ge \frac{h}{4\pi(\Delta x)(\Delta v)}$$

$$\ge \frac{6.626 \times 10^{-34}}{4 \times 3.14 \times (10^{-7})(2.4) \times 10^{-26}}$$

$$\geq \frac{6.626\times10^{-1}}{4\times2.4\times3.14}$$

$\geq$ 0.02198 kg

$\therefore$ Mass of the particle $\simeq$ 22 g

73. Answer (2)

The correct sets of Quantum numbers are, (02)

n = 3 l = 2 m_l = –2

and n = 2 l = 1 m_l = +1

I can have values from 0 to (n – 1) and m can have values from –l..... 0 ......+l (2l + 1)

74. Answer (3)

Possible values of l for a given 'n' = 0,1,2 …(n – 1)

For l = 5, total orbitals = 2l + 1

= 2(5) + 1 = 11 orbital

Hence A, C and D are correct statements

75. Answer (4)

Cr = (Ar)$3d^5 4s^1$

M = +l to –l

As per Aufbau principle, orbitals are filled in increasing order of energy.

Total number of nodes = (n – 1)

76. Answer (2)

2s

radial node = n – l – 1

= 2 – 0 – 1

= 1

It will have one radial node

77. Answer (3)

If n = 3, then possible values of l = 0, 1, 2

But in option (3), the value of l is given '3', this is not possible.

78. Answer (4)

Since there is a single hydrogen atom, so only $5\rightarrow4$, $4\rightarrow3$, $3\rightarrow2$, $2\rightarrow1$ lines are obtained.

79. Answer (1758)

$$\lambda_e = \frac{h}{m_e\times V_e},\quad \lambda_N = \frac{h}{m_N\times V_N}$$

$\lambda_e = \lambda_N$ When $V_e = xV_N$

$$\frac{1}{m_eV_e} = \frac{1}{m_N\times V_N}$$

$$\frac{m_N}{m_e} = \frac{V_e}{V_N} = x$$

$$x = \frac{1.6\times10^{-27}}{9.1\times10^{-31}} = 0.17582\times10^4$$

$\simeq$ 1758

80. Answer (4)

Number of electrons in ${}^{48}_{22}X^{3-}$ is 25.

Number of neutrons = 48 – 22 = 26.

% increase in the number of neutrons over electrons

$$= \left(\frac{26-25}{25}\right)100 = 4\%$$

$\therefore$ a = 4

81. Answer (1)

As the atomic number increases then the potential energy of electrons present in same shell becomes more and more negative. And therefore total energy also becomes more negative.

$$E_{total} = -13.6\frac{Z^2}{n^2}\text{ eV}$$

$\therefore$ Energies of the orbitals in the same subshell decreases with increase in atomic number.

82. Answer (1)

Energy of an orbital is directly proportional to the (n + l) value

			(n + l)
(A)	n = 3,	l = 0	3
(B)	n = 4,	l = 0	4
(C)	n = 3,	l = 1	4
(D)	n = 3,	l = 2	5

If n + l value is same then the orbital with lower value of 'n' will have lower energy.

$\therefore$ correct order of energy

D > B > C > A

83. Answer (4)

Atomic orbital is characterised by the quantum numbers n, l and m.

Hence option D is incorrect.

84. Answer (2)

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

$$\Rightarrow mv = \frac{h}{\lambda} = \frac{6.626 \times 10^{-34}\ kg\frac{m^2}{sec^2} \times sec}{3.3 \times 10^{-10} m}$$

$$mv = \frac{6.626 \times 10^{-24}}{3.3} = 2 \times 10^{-24}\ kg\ m\ sec^{-1}$$

$$\text{Kinetic energy} = \frac{1}{2}mv^2$$

$$= \frac{(mv)^2}{2m}$$

$$= \frac{\left(2 \times 10^{-24}\right)^2}{2 \times 9.1 \times 10^{-31}\ kg}$$

$= 2.18 \times 10^{-18}$ J

$= 21.8 \times 10^{-19}$ J

Total energy absorbed = Ionization energy + Kinetic energy

$= (21.76 + 21.8) \times 10^{-19}$

$= 43.56 \times 10^{-19}$ J

$\approx$ 2 times of 21.76×10^{-19} J

85. Answer (548)

$$\Delta x.\Delta v \geq \frac{h}{4\pi m}$$

$\Delta x = 2 \times 52.9 \times 10^{-12}$ m

$$\Delta v \geq \frac{6.63 \times 10^{-34}}{4 \times 3.14 \times 9.1 \times 10^{-31} \times 2 \times 52.9 \times 10^{-12}}$$

$$\Delta v \geq 5.48 \times 10^{-4} \times 10^{9}\ m/s$$

$\Delta v \geq 548$ km/s (Rounded off to the nearest integer)

86. Answer (2)

Energy of the sub-shell is given by, (n + l) rule.

	(n + l)
For, A	5
B	5
C	6
D	4

Hence, the correct order of increasing energy is D < A < B < C

87. Answer (300)

$$\because\ E = \frac{hc}{\lambda}$$

$$6.63 \times 10^{-19} = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{\lambda}$$

$\lambda = 3 \times 10^{-7} m$

$= 300 \times 10^{-9}$ m

= 300 nm

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