PHYSICS

Q.1 Hydrogen atom emits blue light when it changes from n = 4 to n = 2 level. Which colour of light would the atom emit when it changes n = 5 to n = 2

(A) Red (B) Yellow

(C) Green (D) Violet **[D]**

Q.2 The ionisation potential of mercury is 10.39 volt. To gain energy sufficient enough to ionise mercury,an electron must travel in an electric field of 1.5×10^6 V/m, a distance of -

(A) $\frac{10.39}{1.5\times10^6}$ m

(B) $10.39 \times 1.5 \times 10^6$ m

(C) $10.39 \times 1.6 \times 10^{-19}$ m

(D) $\frac{10.39\times1.6\times10^{-19}}{1.5\times10^6}$ m **[A]**

Q.3 A hydrogen atom in its fourth excited state de-excites to ground state. The number of different possible ways of de-excitation are –

(A) 3 (B) 6

(C) 8 (D) 10 **[B]**

Q.4 The energy required to remove the electron from second execited state of Triply ionised Lithium is –

(A) 54.4 eV (B) 51 eV

(C) 40.8 eV (D) 122.4 eV **[C]**

Q.5 A hydrogen atom has electron in the fourth energy level. The number of different possible photons lie in which of following series –

(A) 3 Lyman, 2 Balmer, 1 Paschen

(B) 2 Lyman, 1 Balmer, 1 Paschen

(C) 2 Lyman, 1 Paschen, 1 Brackett

(D) 1 Lyman, 1 Balmer, 1 Paschen **[A]**

Q.6 According to Bohr correspondence principle when quantum number is very large –

(A) frequency of revolution of electron in an orbit is equal to the frequency of photon emitted when electron jumps from that orbit to next lower orbit

(B) classical physics approaches quantum physics

(C) wavelength of electron De Broglie wavelength does not depend on kinetic energy of electron

(D) Energy of electrons are not quantized **[A]**

Sol. Frequency of revolution of electron is $f \propto \frac{1}{n^3}$

frequency of photon emitted

$$\nu \propto \left(\frac{1}{(n-1)^2} - \frac{1}{n^2}\right)$$

$$\nu \propto \left[\frac{n^2-(n-1)^2}{n(n-1)]^2}\right]$$

$$\nu \propto \frac{[(2n-1)]}{n^2(n-1)^2}$$

when n >> 1

$$\nu \propto \frac{2n}{n^4}$$

$$\nu \propto \frac{1}{n^3}$$

Q.7 In a transition to a state of excitation energy 10.19ev, a hydrogen atom emits a 4890Aº photon. The Binding energy of the initial state is -

(A) 1.51 ev (B) 3.4 ev

(C) 0.54 ev (D) 0.87 ev **[D]**

Sol. Energy of emitted photon is

$E = \frac{hc}{\lambda} = 2.54$ ev

The excitation energy is the energy to excite the atom to a level above the ground state.

Therefore the energy level is

E = – 13.6 + 10.19 = – 3.41 eV

Photon arises from transition between energy state such that

$E_i - E_f = h\nu = 2.54$ eV

$E_i = 2.54 + E_f$

$E_i = 2.54 + (E) = 2.54 - 3.41\text{eV} = -0.87\text{eV}$

Q.8 According to Bohr model, magnetic field at centre (at the nucleus) of a hydrogen atom due to motion of electron in the n^{th} orbit is proportional to -

(A) $1/n^3$ (B) $1/n^5$

(C) n^5 (D) n^3 **[B]**

Sol. $B = \frac{\mu_0 i}{2r}$; magnetic field at centre of hydrogen atom i.e. at nucleus.

$i = \frac{e}{T} = ef = \alpha\ z^2/n^3$

$r \propto n^2/Z$

$B \propto i/r \propto Z^3/n^5$

$B \propto 1/n^5$

Q.9 The shortest wavelength of the Braqkett series of a hydrogen like atom (atomic number = Z) is the same as the shortest wavelength of the Balmar series of hydrogen atom. The value of Z is –

(A) 2 (B) 3

(C) 4 (D) 6 **[A]**

Sol. Shortest wavelength of Bracket series corresponds to the transition of electron $n_1 = 4$ and $n_2 = \infty$ and the shortest wavelength of Balmer series corresponds to the transition of electron between $n_1 = 2$ and $n_2 = \infty$. So

$$(Z^2)\left(\frac{13.6}{16}\right) = \left(\frac{13.6}{4}\right)$$

$\therefore\quad Z^2 = 4$ or $Z = 2$

Q. 10 Assume an imaginary world, where angular momentum is quantized to even multiple $\hbar$. Find the longest possible wavelength emitted by Hydrogen in the visible spectrum.

(A) 700nm (B) 484 nm

(C) 600nm (D) 584 nm **[B]**

Sol. $Mvr = 2n\hbar$

or $mv = \frac{2n\hbar}{r}$

$mv^2 = \frac{m^2v^2}{n} = \frac{(2n\hbar)^2}{mr^2}$

$\frac{Ze^2}{4\pi\varepsilon_0 r^2} = \frac{mv^2}{r}$

or $\frac{Ze^2}{4\pi\varepsilon_0 r^2} = \frac{(2n\hbar)}{mr^2(r)}$

or $r = \frac{(2n\hbar)24\pi\varepsilon_0}{mZe^2}$

$be = k + e = \frac{-Ze^2}{8\pi\varepsilon_0 r} = \frac{-Z^2e^4m}{8\pi\varepsilon_0(2n\hbar)^2 4\pi\varepsilon_0}$

$= \frac{-Z^2e^4m}{32\varepsilon_0 n^2h^2}$

$BE = \frac{-3.4}{n^2}$ eV for Hydrogen. To find longest wavelength $h\nu = 3.4\left[1-\frac{1}{4}\right]$

$= 3.4 \times \frac{3}{4} = 2.55$

$\lambda\ (nm) = \frac{1250}{2.55} = 484$ nm

Q.11 The ground state and first excited state energies of hydrogen atom are – 13.6 eV and –3.4 eV respectively. If potential energy in ground state is taken to be zero, then :

(A) Potential energy in the first excited state would be 20.4eV

(B) total energy in the first excited state would be 23.8 eV

(C) kinetic energy in the first excited state would 3.4 eV

(D) all of the above **[D]**

Q.12 When hydrogen like atom in excited state make a transition from excited state to ground state. Most energetic photons have energy E_{max} = 52.224 eV and least energetic photon have energy E_{min} = 1.224 eV. Find the atomic number -

(A) 4 (B) 6

(C) 2 (D) 8 **[C]**

Sol. Max energy is liberated for transition $E_n \rightarrow 1$ minimum energy for $E_n \rightarrow E_{n-1}$

Hence $\frac{E_1}{n^2} - E_1 = 52.224$ eV …..(i)

$\frac{E_1}{n^2} - \frac{E_1}{(n-1)^2} = 1.224$ eV…..(ii)

Solving (i) and (ii)

$E_1 = -54.4$eV

$E_1 = \frac{-13.6Z^2}{1^2}$

$Z = 2$

Q.13 Find the quantum number 'n' corresponding to the exciting state of He^+ ion. If on transition to the ground state that ion emits two photons in succession with wavelength 1026.7Å and 304 Å. (assume $R = 1.096 \times 10^7$/m).

(A) 4 (B) 6

(C) 2 (D) 1 **[B]**

Sol. $\frac{nc}{\lambda_1} + \frac{nc}{\lambda_2} = RchZ^2\left(\frac{1}{1^2} - \frac{1}{n^2}\right)$

put λ_1 = 1026.7 Å & λ_1 = 304 Å

Z = 2

Calculate n, n = 6

Q.14 α-particles are projected towards the nuclei of the following metals, with the same kinetic energy. Towards, which metal, the distance of closest approach is minimum ?

(A) Cu (Z = 29) (B) Ag (Z = 47)

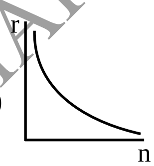
(C) Au (Z = 79) (D) Pd (Z = 46) **[A]**

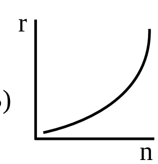
Q.15 The distance of closest approach of an α-particle fired towards a nucleus with momentum p, is r. What will be the distance of closest approach when the momentum of α-particle is 2p ?

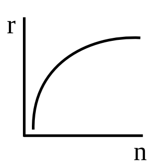
(A) 2r (B) 4r

(C) r/2 (D) r/4 **[D]**

Q.16 Which of the following curves may represent radius of orbit in H-atom as a function of principal quantum number ?

(A) 

(B) 

(C) 

(D) None **[B]**

Q.17 How many times larger is the spacing between the energy levels with n = 3 and n = 4 than the spacing between the energy levels with n = 8 and n = 9 for a hydrogen like atom or ion ?

(A) 0.71 (B) 0.41

(C) 2.43 (D) 14.82 **[D]**

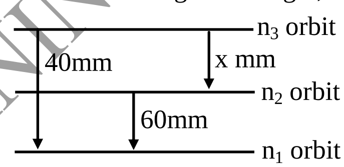
Q.18 Balmer gives an equation for wavelength of visible radiation of H-spectrum as $\lambda = \frac{kn^2}{n^2 - 4}$.

The value of k in terms of Rydberg's constant R, is -

(A) R (B) 4R

(C) R/4 (D) 4/R **[D]**

Q.19 For an atom of ion having single electron, the following wavelengths are observed. What is the value of missing wavelength, x ?



(A) 20 (B) 40

(C) 60 (D) 120 **[D]**

Q.20 If an electron drops from 4th orbit to 2nd orbit in an H-atom, then -

(A) it gains 2.55 eV of potential energy

(B) it gains 2.55 eV of total energy

(C) it emits a 2.55 eV electron

(D) it emits a 2.55 eV photon **[D]**

Q.21 A H-atom moving with speed v makes a head on collision with a H-atom in rest. Both atoms are in ground state. The minimum value of velocity v for which one of atom may excite is -

(A) 6.25×10^4 m/s (B) 8×10^4 m/s

(C) 7.25×10^4 m/s (D) 13.6×10^4 m/s **[A]**

Q.22 Which of the following is wrong about spin of electron according to quantum mechanics ?

(A) It is related to intrinsic angular momentum

(B) Spin is rotation of electron about its own axis

(C) Value of spin quantum number must not be 1

(D) + $\frac{1}{2}$ value of spin quantum number represents up spin **[B]**

Q.23 What would happen, if the electrons in an atom were stationary ?

(A) The electrons will be pulled into the nucleus due to coulomb's attractive force.
(B) The structure of the atom would be more stable.
(C) The atom would be negatively charged.
(D) The rest portion of the atom would have been circulating around the electrons. **[A]**

Q.24 An α-particle of energy 5 MeV is scattered through 180° by a stationary uranium nucleus. The distance of closest approach is of the order of -

(A) 1Å (B) 10^{-10} cm
(C) 10^{-12} cm (D) 10^{-14} cm **[C]**

Q.25 In a head-on collision between an alpha particle and a gold nucleus, the distance of closest approach is 4×10^{-14} m. Calculate the energy of the α-particle in MeV –

(A) 5.2 (B) 5.0 (C) 5.69 (D) 5.86 **[C]**

Q.26 A proton moves with a speed of 7.45×10^5 m/s directly towards a free proton originally at rest. Find the distance of closest approach for the two protons. Take mass of a proton = 1.67×10^{-27} kg –

(A) 10^{-11} m (B) 10^{-12} m **[B]**
(C) 10^{-10} m (D) 10^{-9} m

Q.27 Consider a gold atom (Z = 79) model of radius 7×10^{-15} m according to Thomson. Find the strength of the electric field at the middle point of a radius, consider only positive charge –

(A) 2.1×10^{21} N/C (B) 3.2×10^{21} N/C
(C) 1.16×10^{21} N/C (D) 4.12×10^{21} N/C **[C]**

Q.28 The Bohr radius of an atom of nuclear charge Z is of order –

(A) $\frac{\hbar}{Z\alpha mc}$ (B) $\frac{Z\alpha\hbar}{mc}$

(C) $\frac{mc}{Z\alpha\hbar}$ (D) $\frac{m\alpha}{Zc\hbar}$ **[A]**

Note : α is the fine structure constant $e^2/\hbar c$.

Sol. The Bohr radius for a hydrogen-like atom of nuclear charge Z and one electron outside complete shells is $\frac{\hbar}{me^2Z} = \frac{\hbar}{Z\alpha mc}$. Thus the correct answer is (A)

Q.29 The energy of an excited hydrogen atom is –3.4 eV. The angular momentum of the electron in that orbit according to Bohr's model will be :

(A) 2.11×10^{-36} J-s (B) 2.11×10^{34} J-s
(C) 2.11×10^{-34} J-s (D) none of these **[C]**

Q.30 A hydrogen atom rises from its n = 1 state to the n = 4 state by absorbing energy. The energy absorbed by the atom in this transition is :

(A) 12.75 eV (B) 12.01 eV
(C) 1.89 eV (D) –3.4 eV **[A]**

Q.31 What is the wavelength of the radiation emitted when the electron in a H-atom jumps from n = ∞ to n = 2 ?

(A) 400 nm (B) 420 nm
(C) 350 nm (D) 365 nm **[D]**

Q.32 Find the binding energy of a H-atom in the state n = 2 –

(A) 2.1 eV (B) 3.4 eV
(C) 4.2 eV (D) 2.8 eV **[B]**

Q.33 Calculate the value of the first excitation potential of He^+ ion –

(A) 40.8 V (B) 20.4 V
(C) 10.2 V (D) 81.6 V **[A]**

Q.34 The angular momentum of an electron in an orbit is quantized because it is a necessary condition for the compatibility with:

(A) the wave nature of electron
(B) particle nature of electron
(C) Paulli's exclusion behaviour
(D) none of the above **[A]**

Sol. $mvr = \frac{nh}{2\pi}$

$\therefore \frac{h}{mv} = \frac{(2\pi r)}{n}$

$\frac{h}{mv}$ = de-Broglie wavelength

Q.34 If n >> 1, then the dependence of frequency of a photon, emitted as a result of transition of electron from n^{th} orbit to (n–1)th orbit, on n will be-

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

(C) $\upsilon \propto \frac{1}{n^3}$ (D) $\upsilon \propto \frac{1}{v^3}$ **[C]**

Q.36 In which of the following systems will the radius of the first orbit be minimum ?

(A) hydrogen atom

(B) deuterium atom

(C) singly ionized helium

(D) doubly ionized lithium **[D]**

Q.37 In which of the following systems will the wavelength corresponding to n = 2 to n = 1 be minimum ?

(A) H atom (B) D atom

(C) He^+ (D) Li^{+2} **[D]**

Q.38 As one consider orbits with higher values of n in a hydrogen atom, the electric potential energy of the atom.

(A) decreases (B) increases

(C) remains the same (D) does not increase

[B]

Q.39 The energy of an atom (ion) in its ground state is –54.4 eV. It may be –

(A) H (B) D

(C) He^+ (D) Li^{+2} **[C]**

Q.40 The radius of the shortest orbit in a one electron system is 18 pm. It may be–

(A) H (B) D

(C) He^+ (D) Li^{+2} **[D]**

Q.41-A A hydrogen atom in ground state absorbs 10.2 eV of energy. The orbital angular momentum of the electron is increased by -

(A) 1.05×10^{-34} Js (B) 2.11×10^{-34} Js

(C) 3.16×10^{-34} Js (D) 4.22×10^{-34} Js

Sol. **[A]**

$\Delta E = E_2 - E_1 = 10.2eV = -3.4eV + 13.6eV$

so, $n_2 = 2$ & $n_1 = 1$

$$\Delta L = \frac{2h}{2\pi} - \frac{h}{2\pi} = \frac{h}{2\pi} = \frac{6.63 \times 10^{-34}}{2 \times 3.14} \text{ J.s}$$

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

Q.41-B A particle moving with a velocity 1/10th of that of light will cross a nucleus in about-

(A) 10^{-47} s (B) 10^{-21} s

(C) 10^{-12} s (D) 10^{-8} s

Sol.. **[B]**

$$t = \frac{2r}{v} = \frac{210^{-15}\text{m}}{3 \times 10^7 \text{m/s}} = \frac{2}{3} \times 10^{-22}\text{s}$$

Q.42 The shortest wavelength of the Brackett series of a hydrogen like atom (atomic number = Z) is the same as the shortest wavelength of the Balmar series of hydrogen atom. The value of Z is:

(A) 2 (B) 3

(C) 4 (D) 6 **[A]**

Sol. Shortest wavelength of Brackett series corresponds to the transition of electron between $n_1 = 4$ and $n_2 = \infty$ and the shortest wavelength of Balmer series corresponds to the transition of electron between $n_1 = 2$ and $n_2 = \infty$, So,

$$(Z^2)\left(\frac{13.6}{16}\right) = \left(\frac{13.6}{4}\right)$$

$\therefore Z^2 = 4$ or $Z = 2$

Q.43 The binding energy of the deuteron is of order –

(A) 10^6 eV (B) 10^8 eV

(C) 10^{10} eV (D) None of these

[A]

Sol. The uncertainty principle gives $2pr \sim \hbar$, where p is the momentum of each nucleon and r is their separation, or

$$p \sim \frac{\hbar}{2r}.$$

The binding energy is then

$$\frac{p^2}{2m} \sim \frac{\hbar^2 c^2}{8r^2 mc^2} = \frac{(6.6 \times 10^{-16} \times 3 \times 10^{10})^2}{8 \times (1.4 \times 10^{-13})^2 \times 940 \times 10^6}$$

$= 2.7 \times 10^6$ eV.

Q.44 The binding energy of the ground state of positronium is a factor **f** times that of a hydrogen atom. **f** =

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

(C) 2 (D) $\frac{1}{4}$ **[B]**

Sol. An electron moving in the field of a proton or positron has potential energy $-\frac{e^2}{\tau}$, for which the radial Schrodinger equation gives eigenvalue

$E_n = -\frac{\mu e^2}{2\hbar^2 n^2}$,   n = 1, 2, 3, …..,

where μ is the reduced mass of the orbiting electron. For the positronium $\mu = \frac{1}{2} m_e$, for hydron atom $\mu \approx m_e$. Hence

$$f = \frac{E_p}{E_h} = \frac{\frac{1}{2} m_e}{m_e} = \frac{1}{2}.$$

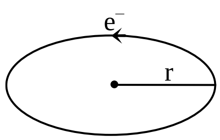
Q.45 When an electron revolves around the nucleus, then ratio of magnetic moment to angular momentum is –

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

(C) e/m   (D) $(e/m)^2$ **[A]**

Sol. Angular momentum : $L = n\frac{h}{2\pi} = mvr$

Magnetic moment : $\mu = iA = \frac{e}{2\pi r} v \times \pi r^2$



$\mu = \frac{e(vr)}{2}$

$\mu = \frac{e}{2}\left(\frac{L}{m}\right)$

$$\boxed{\frac{\mu}{L} = \frac{e}{2m}}$$

Q.46 When an electron makes transition from one energy level to the other in an atom then which of the following quantities is conserved ?

(A) Angular momentum

(B) Linear momentum

(C) Mechanical energy

(D) None of the above   **[D]**

Sol. Change in angular momentum

$\Delta L = (n_f - n_i)h/2\pi$

Since velocity of electron is

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

Hence linear momentum changes

Difference in energy between energy levels is released as electromagnetic energy.

Q.47 An α - particle after passing through a potential difference of V-volts collides with a nucleus. If the atomic number of the nucleus is Z then the distance of closest approach of α-particle to the nucleus will be -

(A) $14.4\frac{Z}{V}$ Å   (B) $14.4\frac{Z}{V}$ m

(C) $14.4\frac{Z}{V}$ cm   (D) all of these   **[A]**

Sol. K.E. = P.E. = qV

$2eV = \frac{K(Ze)(2e)}{d} = qV$

$\therefore d = \frac{9\times10^9 \times Z \times e \times 2e}{2eV}$

$\therefore d = \frac{9\times10^9 \times 1.6\times10^{-19} \times Z}{V}$

$d = 14.4 \times 10^{-10}\left(\frac{Z}{V}\right)$ m

Q.48 The wavelength of first line of Balmer series is 6563 Å. The wavelength of first line of Lyman series will be –

(A) 1215.4 Å   (B) 2500 Å

(C) 7500 Å   (D) 600 Å   **[A]**

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

$\frac{1}{\lambda_1} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right] = R\left(\frac{1}{4} - \frac{1}{9}\right) = \frac{5R}{36}$

$\frac{1}{\lambda_2} = R\left[\frac{1}{1} - \frac{1}{4}\right] = R\left(\frac{3}{4}\right) = \frac{3}{4}R$

$\therefore \frac{\lambda_2}{\lambda_1} = \frac{5/36}{3/4} = \frac{5}{36} \times \frac{4}{3} = \frac{5}{27}$

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

$$\lambda_2 = \frac{5}{27} \times 6563Å = 1215.4Å$$

Q.49 The order of energies of energy levels A, B and C is $E_A < E_B < E_C$. If the wavelength corresponding to transition $C \rightarrow B$, $B \rightarrow A$ and $C \rightarrow A$ are λ_1, λ_2 and λ_3 respectively, then which of the following relation is correct ?

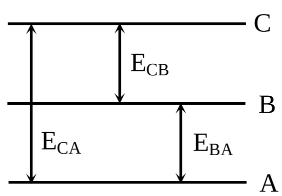
(A) $\lambda_1 + \lambda_2 + \lambda_3 = 0$

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

(C) $\lambda_3 = \lambda_1 + \lambda_2$

(D) $\lambda_3 = \dfrac{\lambda_1\lambda_2}{\lambda_1 + \lambda_2}$ **[D]**

Sol. $E_{CA} = E_{CB} + E_{BA}$



$$\frac{1}{\lambda_3} = \frac{\lambda_1 + \lambda_2}{\lambda_1\lambda_2}$$

$$\therefore \quad \lambda_3 = \frac{\lambda_1\lambda_2}{\lambda_1 + \lambda_2}$$

Q.50 Which the following series fall in the visible range of electromagnetic spectrum ?

(A) Brackett series (B) Lyman series

(C) Balmer series (D) Paschan series **[C]**

Sol. $\dfrac{1}{\lambda} = R\left[\dfrac{1}{n_f^2} - \dfrac{1}{n_i^2}\right]$

Balmer Series; $n_f = 2$; $n_i = 3, 4, 5.....$

$$\frac{1}{\lambda} = 1.097 \times 10^7 \left[\frac{1}{4} - \frac{1}{9}\right]$$

$$\frac{1}{\lambda} = 1.097 \times 10^7 \left[\frac{5}{36}\right]$$

$$\lambda = \frac{36}{5} \times \frac{10^{-7}}{1.097}\ \text{m}$$

$$\lambda = 6.56 \times 10^{-7}\ \text{m}$$

$$\boxed{\lambda = 656 \times 10^{-9}\ \text{m}}$$

This wavelength falls in visible range