



Dual Nature of Light and Structure Of Atom

Marks: 50

ANSWER KEY

Physics

Q.1 C	Q.2 B	Q.3 B	Q.4 C	Q.5 C	Q.6 C	Q.7 D	Q.8 A
Q.9 C	Q.10 C	Q.11 D	Q.12 C	Q.13 B	Q.14 C	Q.15 B	Q.16 D
Q.17 C	Q.18 B	Q.19 C	Q.20 C	Q.21 A	Q.22 A	Q.23 A	Q.24 C
Q.25 D	Q.26 C	Q.27 B	Q.28 D	Q.29 D	Q.30 D	Q.31 B	Q.32 A
Q.33 B	Q.34 A	Q.35 A	Q.36 B	Q.37 D	Q.38 D	Q.39 D	Q.40 B
Q.41 D	Q.42 C	Q.43 D	Q.44 B	Q.45 D	Q.46 A	Q.47 D	Q.48 C
Q.49 C	Q.50 B						

## Physics

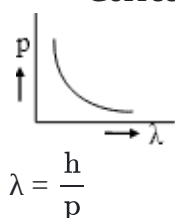
**Q.1 In photoelectric effect,**

**Correct option: (C)**

The photoelectric effect involves the emission of electrons from a material when light shines on it. This process is governed by the interaction of photons with electrons. In this interaction, a photon transfers its energy to an electron, causing it to be ejected from the material. This transfer of energy is not elastic as it results in the absorption of the photon and the emission of the electron. Therefore, the correct option is that the emission of an electron is a result of an inelastic collision between the photon and the electron.

**Q.2 Which of the following figures represent the variation of particle momentum and the associated de-Broglie wavelength?**

**Correct option: (B)**



$$\therefore p \propto \frac{1}{\lambda}$$

This implies, the graph of  $p$  v/s  $\lambda$  will be exponential as shown in option [B].

**Q.3 The idea of matter waves was given by**

**Correct option: (B)**

**de Broglie** proposed the concept of matter waves, suggesting that all matter exhibits wave-like properties. His hypothesis, known as the de Broglie hypothesis, states that the wavelength of a particle is inversely proportional to its momentum. This was later confirmed by the Davisson-Germer experiment, which demonstrated the wave-like nature of electrons.

**Q.4 The first member of the Brackett series in the hydrogen spectrum has a wavelength of 40,500 Å. The short wavelengths limit of Brackett series is**

**Correct option: (C)**

For Brackett series

$$\bar{\nu} = \frac{1}{\lambda} = R \left[ \frac{1}{4^2} - \frac{1}{n^2} \right]; n = 5, 6, \dots$$

For first member of Brackett series  $n = 5$

$$\frac{1}{\lambda_1} = R \left[ \frac{1}{4^2} - \frac{1}{5^2} \right] \Rightarrow \frac{1}{\lambda_1} = \frac{9R}{400}$$

$$\therefore R = \frac{400}{9\lambda_1} = \frac{400}{9 \times 40,500 \times 10^{-10}} = 1.1 \times 10^7$$

For shortest wave length  $n = \infty$

$$\text{So } \frac{1}{\lambda} = R \left[ \frac{1}{4^2} - \frac{1}{\infty^2} \right] = \frac{R}{16}$$

$$\therefore \lambda = \frac{16}{R} = \frac{16}{1.1 \times 10^7} = 1.460 \times 10^{-7} m = 1460 \text{ \AA}$$

**Q.5 Two identical photocathodes receive light of frequencies 'f<sub>1</sub>' and 'f<sub>2</sub>'. The velocity of the photoelectrons of mass 'm' emitted are respectively 'v<sub>1</sub>' and 'v<sub>2</sub>'. Then the correct relation is (h = Planck's constant)**

**Correct option: (C)**

Using Einstein photoelectric equation,

$$E = \phi_0 + K.E_{\max}$$

$$hf_1 = \phi_0 + \frac{1}{2}mv_1^2 \quad \dots(i)$$

$$hf_2 = \phi_0 + \frac{1}{2}mv_2^2 \quad \dots(ii)$$

$$hf_3 = \phi_0 + \frac{1}{2}mv_3^2 \quad \dots(iii)$$

Subtracting equation (ii) from equation (i) we get,

$$h(f_1 - f_2) = \frac{1}{2}m(v_1^2 - v_2^2)$$

$$\therefore (v_1^2 - v_2^2) = \frac{2h}{m} (f_1 - f_2)$$

**Q.6 The magnitude of stopping potential for the photoelectric effect is**

**Correct option: (C)**

The stopping potential is the minimum negative potential that needs to be applied to stop the most

energetic electrons from reaching the other side of the circuit. The stopping potential is directly proportional to the kinetic energy of the electrons, and the kinetic energy of the electrons is directly proportional to the frequency of the incident light.

This can be represented by the following equation:  $KE = h\nu - \Phi$  Where: KE is the kinetic energy of

the emitted electron, h is Planck's constant,  $\nu$  is the frequency of the incident light, and  $\Phi$  is the work function of the metal. Therefore, the stopping potential is directly proportional to the frequency of incident light.

**Q.7 Assuming photoemission to take place, the factor by which the maximum velocity of the emitted photoelectrons changes when the wavelength of the incident radiation is increased four times, is**

**Correct option: (D)**

$$\frac{hc}{\lambda} = \phi_0 + \frac{1}{2}mv_{\max}^2$$

Assuming  $\phi_0$  to be negligible in comparison to  $\frac{hc}{\lambda}$ ,

$$v_{\max}^2 \propto \frac{1}{\lambda} \Rightarrow v_{\max} \propto \frac{1}{\sqrt{\lambda}}$$

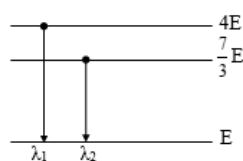
$\therefore$  On increasing wavelength from  $\lambda$  to  $4\lambda$ ,  $v_{\max}$  becomes half.

**Q.8 The following diagram indicates the energy levels of certain atom. When an electron moves from '4E' level to 'E' level, a photon of wavelength ' $\lambda_1$ ', is emitted.**

**The wavelength of photon produced during transition of electron from  $\frac{7}{3}E$**

**level to 'E' level is ' $\lambda_2$ '. Then the ratio  $\frac{\lambda_1}{\lambda_2}$**

**is**



**Correct option: (A)**

Energy of electron (E) =  $h\nu$  ... (i)

When an electron moves from '4E' level to 'E' level,

$$h\nu = 4E - E$$

$$\therefore \frac{hc}{\lambda_1} = 3E$$

$$\therefore \lambda_1 = \frac{hc}{3E} \quad \dots (ii)$$

When an electron moves from  $\frac{7}{3}E$  level to 'E'

level,

$$h\nu = \frac{7}{3}E - E$$

$$\therefore \frac{hc}{\lambda_2} = \frac{4E}{3} \Rightarrow \lambda_2 = \frac{3hc}{4E} \quad \dots (iii)$$

$$\therefore \frac{\lambda_1}{\lambda_2} = \frac{\frac{hc}{3E}}{\frac{3hc}{4E}} = \frac{4}{9}$$

**Q.9 The orbital velocity of the electron in the ground state of hydrogen atom is v. What will be its orbital velocity when excited to the energy state - 0.544 eV?**

**Correct option: (C)  $\frac{v}{5}$**

Energy of electron,  $E_n = \frac{-13.6}{n^2}$  eV

$$\therefore -0.544 \text{ eV} = \frac{-13.6}{n^2} \text{ eV}$$

$$\therefore n^2 = 25 \Rightarrow n = 5$$

Orbital velocity of electron in orbit  $n = 5$ ,

$$v_n = \frac{e^2}{2\epsilon_0 h n} = \frac{e^2}{2\epsilon_0 h (5)} = \frac{v}{5}$$

**Q.10 If the electron in hydrogen atom jumps from second Bohr orbit to ground state and difference between energies of the two states is radiated in the form of photons. If the work function of the material is 4.2 eV then stopping potential is**

$$[\text{Energy of electron in } n^{\text{th}} \text{ orbit} = -\frac{13.6}{n^2}$$

**eV]**

**Correct option: (C)**

$$\Delta E = E_1 - E_2$$

$$\therefore \Delta E = \frac{13.6}{1} - \frac{13.6}{2^2}$$

$$\Delta E = 13.6 \times \frac{3}{4} = 10.2 \text{ eV}$$

This is the energy associated with emitted photon

i.e.,  $h\nu = 10.2 \text{ eV}$

but according to photoelectric equations,

$$h\nu = \phi_0 + eV_0$$

$$\therefore 10.2 \text{ eV} = 4.2 \text{ eV} + eV_0$$

$$\therefore eV_0 = 6 \text{ eV}$$

**Q.11** The wavelength ' $\lambda$ ' of a photon and de Broglie wavelength of an electron have same value. The ratio of energy of a photon to kinetic energy of electron is ( $m$  = mass of electron,  $c$  = velocity of light,  $h$  = Planck's constant)

**Correct option: (D)**

$$\lambda_e = \lambda_p$$

$\therefore$

$$\frac{\text{K.E. of photon}}{\text{K.E. of electron}} = \frac{hc/\lambda}{\frac{1}{2} \frac{p^2}{m}} = \frac{2mhc}{\lambda p^2} = \frac{2mhc\lambda}{\lambda^2 p^2}$$

$$= \frac{2mc\lambda}{h^2} \times h = \frac{2mc\lambda}{h}$$

**Q.12** The shortest wavelength for Lyman series is  $912 \text{ \AA}$ . What will be the longest wavelength in Paschen series?

**Correct option: (C)**

For Lyman series,

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

$$\therefore \frac{1}{\lambda_{\min}} = RZ^2 \left[ 1 - \frac{1}{\infty} \right] = RZ^2 \dots (i)$$

For Paschen series,

$$\frac{1}{\lambda_{\max}} = RZ^2 \left[ \frac{1}{3^2} - \frac{1}{4^2} \right] = \frac{7RZ^2}{144} \dots (ii)$$

$\therefore$  By dividing equation (i) by equation (ii),

$$\frac{\lambda_{\max}}{\lambda_{\min}} = RZ^2 \times \frac{144}{7RZ^2} = \frac{144}{7}$$

$$\therefore \lambda_{\max} = \frac{144}{7} \times 912 \approx 18761 \text{ \AA}$$

**Q.13** A point source of light is used in photoelectric effect. If the source is moved away from the photo-sensitive cathode, the stopping potential will

**Correct option: (B)**

The stopping potential depends on the frequency of the light source. So moving the light source further

away will not change the stopping potential.

**Q.14** The kinetic energies of photoelectrons emitted from a photosensitive surface are ' $k_1$ ' and ' $k_2$ ' when it is irradiated with lights of wavelength ' $\lambda_1$ ' and ' $\lambda_2$ ' respectively. The work function of the photosensitive surface is

**Correct option: (C)**

From Einstein's photoelectric equation,

$$k_1 = \frac{hc}{\lambda_1} - W_0$$

$$\therefore k_1 \lambda_1 = hc - W_0 \lambda_1$$

$$k_2 = \frac{hc}{\lambda_2} - W_0$$

$$\therefore hc = k_1 \lambda_1 + W_0 \lambda_1 \dots (i)$$

$$\therefore k_2 \lambda_2 = hc - W_0 \lambda_2$$

$$\Rightarrow hc = k_2 \lambda_2 + W_0 \lambda_2 \dots (ii)$$

From equations (i) and (ii),

$$k_1 \lambda_1 + W_0 \lambda_1 = k_2 \lambda_2 + W_0 \lambda_2$$

$$\therefore k_1 \lambda_1 - k_2 \lambda_2 = W_0 (\lambda_2 - \lambda_1)$$

$$\therefore W_0 = \frac{\lambda_1 k_1 - \lambda_2 k_2}{\lambda_2 - \lambda_1}$$

**Q.15** If  $M_0$  is the mass of an oxygen isotope  ${}^8\text{O}^{17}$ ,  $M_p$  and  $M_n$  are the masses of a proton and a neutron, respectively, the nuclear binding energy of the isotope is

**Correct option: (B)**

Binding energy,

$$\text{BE} = (M_{\text{nucleus}} - M_{\text{nucleons}})c^2$$

$$= (M_0 - 8 M_p - 9 M_n)c^2$$

**Q.16** A radioactive element  ${}_{90}\text{X}^{238}$  decays into  ${}_{83}\text{Y}^{222}$ . The number of  $\beta$  - particles emitted are

**Correct option: (D) 1**

Refer **Shortcut 4**: Number of  $\alpha$  and  $\beta$  particles emitted in a decay process is given as,

$$n_\alpha = \frac{A-A'}{4} \text{ and } n_\beta = (2n_\alpha - Z + Z')$$

$$\text{Number of } \alpha\text{-particles emitted} = \frac{238-222}{4} = 4$$

This decreases atomic number to  $90 - 4 \times 2 = 82$

Since atomic number of  ${}_{83}\text{Y}^{222}$  is 83, this is possible if one  $\beta$  particle is emitted.

**Q.17** The magnitude of the P.E. of the electron in the first orbit of the Bohr's atom is E.

Its K.E is

Correct option: (C)

$$\frac{1}{2} (\text{P.E.}) = - (\text{K.E.})$$

∴ In magnitude,

$$\text{K.E.} = \frac{E}{2}$$

**Q.18** If the binding energy per nucleon of deuteron is 2.115 MeV. Its mass defect in atomic mass unit is

Correct option: (B)

Binding energy per nucleon,

$$E_{\text{bn}} = \frac{E_b}{A}$$

For deuteron,  $A = 2$

$$\therefore 2.115 \text{ MeV} = \frac{E_b}{A} \Rightarrow E_b = 2 \times 2.115 \text{ MeV}$$

$$\text{Now, } E_b = \Delta mc^2$$

Mass defect,

$$\Delta m = \frac{2 \times 2.115}{931.5} \text{ u} \dots [\because 1 \text{ u} = 931.5 \text{ MeV}/c^2]$$

$$= 0.0045 \text{ u}$$

**Q.19** The decay constant of a radio isotope is  $\lambda$ . If  $A_1$  and  $A_2$  are its activities at times  $t_1$  and  $t_2$  respectively, the number of nuclei which have decayed during the time  $(t_1 - t_2)$  [CBSE PMT (Mains) 2010]

Correct option: (C)

$$A_1 = \lambda N_1 \text{ and } A_2 = \lambda N_2$$

$$\therefore N_1 - N_2 = \left[ \frac{A_1 - A_2}{\lambda} \right]$$

**Q.20** If the frequency of incident light in a photoelectric experiment is doubled, then stopping potential will

Correct option: (C)

By photoelectric effect,

$$eV_0 = h\nu - \phi$$

$$\therefore V_0 = \frac{h\nu - \phi}{e} \dots (V_0 = \text{initial stopping potential})$$

Initial frequency ( $\nu$ ) is doubled.

$$\therefore V'_0 = \frac{h(2\nu) - \phi_0}{e} \dots (V'_0 = \text{New stopping potential})$$

$$V'_0 = \frac{2h\nu - \phi_0}{e}$$

$$V'_0 = 2 \cdot \frac{h\nu - \phi}{e} + \frac{\phi}{e} = 2V_0 + \frac{\phi}{e}$$

$$\therefore V'_0 > 2V_0$$

∴ Stopping potential becomes more than double.

**Q.21** The ratio of longest to shortest wavelength emitted in Paschen series of hydrogen atom is

Correct option: (A)

For Paschen series,

Longest wavelength corresponds to

$$n_1 = 3, n_2 = n_1 + 1 = 4$$

$$\lambda_{\text{max}} = \frac{144}{7R}$$

Shortest wavelength corresponds to  $n_1 = 3, n_2 =$

$\infty$

$$\lambda_{\text{min}} = \frac{9}{R}$$

$$\therefore \frac{\lambda_{\text{max}}}{\lambda_{\text{min}}} = \frac{\left(\frac{144}{7R}\right)}{\left(\frac{9}{R}\right)} = \frac{144}{63}$$

**Q.22** Photoelectrons are emitted from two similar metal plates when wavelengths ' $\lambda_1$ ' and ' $\lambda_2$ ' are incident on them. ( $\lambda_1 = 1.5\lambda_2$ ) if maximum kinetic energy of emitted photoelectrons is ' $E_1$ ' and ' $E_2$ ' respectively then

Correct option: (A)

$$\lambda_1 = 1.5\lambda_2 = \frac{3\lambda_2}{2}$$

Using,  $K = \frac{1}{2}mv^2 = h\nu - h\nu_0$  for same metal,

$$E_1 = \frac{hc}{\lambda_1} - h\nu_0,$$

$$E_2 = \frac{3hc}{2\lambda_1} - h\nu_0$$

$$\therefore E_1 < \frac{2E_2}{3}$$

**Q.23** When the energy of the incident radiation is increased by 40%, the kinetic energy of the photoelectrons emitted from a metal surface increased from 0.54 eV to 0.8 eV. The work function of the metal is

Correct option: (A)

Using,  $E = h\nu - W_0$  for the two cases we get,

$$0.54 = h\nu - W_0 \quad \dots(i) \quad \text{and}$$

$$0.8 = 1.4 hv - W_0 \quad \dots(ii)$$

Multiplying equation (i) by 1.4 and subtracting it from equation (ii) we get,

$$0.4 W_0 = 0.044 \text{ or } W_0 = 0.11 \text{ eV}$$

**Q.24** If the frequency of incident light in photoelectric experiment is made five times then stopping potential will

**Correct option: (C)**

$$hv_1 - W_0 = eV_1$$

$$hv_1 = eV_1 + W_0 \quad \dots(i)$$

$$hv_2 - W_0 = eV_2$$

$$5hv_1 - W_0 = eV_2 \quad \dots(ii)$$

Substituting equation (i) in equation (ii),

$$5(eV_1 + W_0) - W_0 = eV_2$$

$$5eV_1 + 4W_0 = eV_2$$

$$V_2 = 5V_1 + 4 \frac{W_0}{e}$$

Based on the options provided, option (C) which stopping potential will become more than four times is the most appropriate answer.

**Q.25** If an electron has energy such that its de Broglie wavelength is  $5500 \text{ \AA}$ , then the energy value of that electron is ( $h = 6.6 \times 10^{-34} \text{ Js}$ ,  $m_e = 9.1 \times 10^{-31} \text{ kg}$ )

**Correct option: (D)**

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

$$\text{K.E.} = \frac{P^2}{2m} = \frac{h^2}{2m\lambda^2} =$$

$$\frac{(6.6 \times 10^{-34})^2}{2 \times 9.1 \times 10^{-31} \times (5.5 \times 10^{-7})^2} \approx 7.91 \times 10^{-25} \approx 8 \times 10^{-25} \text{ J}$$

**Q.26** The series limit for the frequency of Balmer series is ' $\nu_B$ ', then the series limit frequency of Paschen series ' $\nu_P$ ' is

**Correct option: (C)**

The series limit frequency of Balmer series is observed when  $n = 2$  and  $n = \infty$

$$\therefore h\nu_B = E_0 \left[ \frac{1}{2^2} - \frac{1}{\infty^2} \right] = \frac{E_0}{4} \quad \dots(i)$$

For Paschen series,  $n = 3$  and  $n = \infty$

$$h\nu_P = E_0 \left[ \frac{1}{9} \right] \quad \dots(ii)$$

Dividing (i) by (ii)

$$9\nu_P = 4\nu_B$$

$$\nu_P = \frac{4}{9} \nu_B$$

**Q.27** When the energy of the incident radiation is increased by 20%, the kinetic energy of the photoelectrons emitted from a metal surface increased from 0.5 eV to 0.8 eV. The work function of the metal is

**Correct option: (B)**

Using,  $E = hv - \phi$  for the two cases we get,

$$0.5 = hv - \phi \quad \dots(i) \text{ and}$$

$$0.8 = 1.2 hv - \phi \quad \dots(ii)$$

Multiplying equation (i) by 1.2 and subtracting equation (ii) from it we get,

$$0.2 \phi = 0.2 \Rightarrow \phi = 1 \text{ eV}$$

**Q.28** Radius of  $n$ th Bohr's orbit is directly proportional to

**Correct option: (D)**

**Q.29** In an X-ray tube, electrons bombarding the anode produce X-rays of wavelength  $0.5 \text{ \AA}$ . The energy of an electron, when it hits the anode, is

**Correct option: (D)**

$$E = hv$$

$$= \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{0.5 \times 10^{-10}} \approx 39.8 \times 10^{-16} \text{ J}$$

**Q.30** An electron moving with initial velocity  $\vec{v} = v_0 \hat{i}$  is moving in a magnetic field  $\vec{B} =$

$B_0 \hat{j}$  then its de-Broglie wavelength

**Correct option: (D)**

$$\vec{v} = v_0 \hat{i}, \vec{B} = B_0 \hat{j}$$

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

$$F = q(\vec{v} \times \vec{B}) = q v B \hat{k}$$

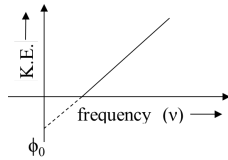
This force is perpendicular to  $\vec{v}$  and  $\vec{B}$ . Also the magnitude of  $\vec{v}$  does not change, therefore the momentum will not change. Hence,  $\lambda$  will not change.

**Q.31** The de Broglie wavelength of a particle with mass ' $m$ ' and kinetic energy ' $K$ ' is

( $h$  = Planck's constant)

Correct option: (B)

Q.32 The graph of kinetic energy against the frequency ( $\nu$ ) of incident light is as shown in the figure. The slope of the graph and intercept on X axis respectively are



Correct option: (A)

The slope of the graph between kinetic energy and frequency gives the Planck's constant ( $h$ ) and its X intercept gives the value of threshold frequency.

**Alternate Method:**

According to Einstein's equation,

$$h\nu = h\nu_0 + K.E_{\max}$$

$\therefore K.E_{\max} = h\nu - h\nu_0$ . Comparing it with

$y = mx + c$ , we can say that,

this is the equation of straight line having positive slope ( $h$ ) and negative intercept ( $h\nu_0$ ) on K.E. axis.

Q.33 If the binding energy of the electron in a hydrogen atom is 13.6 eV, the energy required to remove the electron from the first excited state of  $Li^{++}$  is

Correct option: (B)

$$E_n = \frac{13.6}{n^2} \times Z^2. \text{ For first excited state, } n = 2 \text{ and}$$

for  $Li^{++}$ ,  $Z = 3$

$$\therefore E = \frac{13.6}{4} \times 9 = 30.6 \text{ eV}$$

Q.34 Detector used in Marsden experiment is

Correct option: (A)

In the Rutherford (or Geiger-Marsden) experiment, alpha particles were directed at a thin gold foil. To detect the scattered alpha particles, a circular screen coated with *zinc sulphide* ( $ZnS$ ) was used. When an alpha particle struck the  $ZnS$  screen, it produced a tiny flash of light, known as a scintillation. These scintillations were observed and counted by a scientist using a *microscope*. Therefore, the detector used consisted of a **zinc sulphide screen** and a **microscope**.

Q.35 When a photosensitive surface is irradiated by light of wavelengths ' $\lambda_1$ ' and ' $\lambda_2$ ', kinetic energies of emitted photoelectrons are ' $E_1$ ' and ' $E_2$ ' respectively. The work function of photosensitive surface is

Correct option: (A)

From Einstein's photoelectric equation,

$$E_1 = \frac{hc}{\lambda_1} - W_0$$

$$\therefore E_1\lambda_1 = hc - W_0\lambda_1$$

$$E_2 = \frac{hc}{\lambda_2} - W_0$$

$$\therefore hc = E_1\lambda_1 + W_0\lambda_1 \dots(i)$$

$$\therefore E_2\lambda_2 = hc - W_0\lambda_2$$

$$\Rightarrow hc = E_2\lambda_2 + W_0\lambda_2 \dots(ii)$$

From Eq. (i) and (ii),

$$E_1\lambda_1 + W\lambda_1 = E_2\lambda_2 + W\lambda_2$$

$$\therefore E_1\lambda_1 - E_2\lambda_2 = W(\lambda_2 - \lambda_1)$$

$$\therefore W = \frac{E_1\lambda_1 - E_2\lambda_2}{\lambda_2 - \lambda_1}$$

Q.36 The hydrogen atom gives spectral lines in the Lyman, Balmer and Paschen series. Out of the following statements, the 'CORRECT' one is

Correct option: (B)

Lyman series: Ultraviolet region

Balmer series: Visible region

Paschen series: Infrared region

Q.37 Assertion: Lyman series lies in the visible region of electromagnetic spectrum.

Reason: This is because Balmer series also lies in visible region.

Correct option: (D)

Lyman series belongs to the ultraviolet region.

Q.38 According to Bohr's theory of hydrogen atom, the total energy of the electron in the  $n^{\text{th}}$  stationary orbit is

Correct option: (D)

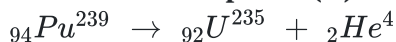
According to Bohr's theory of hydrogen atom, the equation for total energy of the electron in the  $n^{\text{th}}$  stationary orbit is,

$$E_n = \frac{-mZ^2e^4}{8\epsilon_0^2h^2n^2}$$

$$\therefore E_n \propto \frac{1}{n^2}$$

**Q.39** Which of the following is emitted when  ${}_{94}\text{Pu}^{239}$  decays into  ${}_{92}\text{U}^{235}$ ?

**Correct option: (D)**



Hence, the particle emitted when Pu decays into U is,  $\alpha$ -particle.

**Q.40** Which one of the following is a pair of isotones?

**Correct option: (B)**

In isotones the number of neutrons is same.

$$\text{Also, } N = A - Z$$

For Hg,  $N = 198 - 90 = 108$  and for Au,  $N = 197 - 79 = 118$ .

**Q.41** Which of the following expression is the formula for the total energy of electron in hydrogen atom?

**Correct option: (D)**

The total energy of an electron in a hydrogen atom is quantized and is given by the **Rydberg formula**.

This formula expresses the energy as inversely proportional to the square of the *principal quantum number*,  $n$ . The formula is:  $E_n = -\frac{R_{ch}}{n^2}$  Here,

$E_n$  represents the total energy for the  $n$ -th energy level, and  $R_{ch}$  is the Rydberg constant in energy units. This is a standard and compact representation of the energy levels in a hydrogen atom. Options A, B, and C are either incorrect forms of the formula or represent different physical quantities.

**Q.42** If  $R_1$  and  $R_2$  are the radii of the atomic nuclei of mass numbers 27 and 125 respectively, then the ratio  $R_2 : R_1$  is

**Correct option: (C)**

Radius is related to atomic mass with relation,

$$R \propto A^{1/3}$$

$$\therefore \frac{R_1}{R_2} = \left(\frac{A_1}{A_2}\right)^{1/3} \Rightarrow \frac{R_2}{R_1} = \left(\frac{125}{27}\right)^{1/3}$$

$$\therefore R_2 : R_1 = \frac{5}{3}$$

**Q.43** The half-life of tritium is 12.5 years. What mass of tritium of initial mass 64 mg will remain undecayed after 100 years?

**Correct option: (D)**

$$\frac{m}{m_0} = \left(\frac{1}{2}\right)^{t/T_{1/2}}$$

Given:  $T_{1/2} = 12.5$  years,  $t = 100$  years

$$\begin{aligned} \therefore \frac{m}{m_0} &= \left(\frac{1}{2}\right)^{100/12.5} \\ &= \left(\frac{1}{2}\right)^8 = \frac{1}{256} \end{aligned}$$

$$\therefore m = \frac{64}{256} = 0.25 \text{ mg}$$

**Q.44** Energy of photon whose frequency is  $10^{12}$  MHz, is [Planck's constant,  $h = 6.63 \times 10^{-34}$  Js,  $e = 1.6 \times 10^{-19}$  C]

**Correct option: (B)**

$$\begin{aligned} E &= h\nu = 6.63 \times 10^{-34} \times 10^{12} \times 10^6 \\ &= 6.63 \times 10^{-16} \text{ J} = \frac{6.63 \times 10^{-16}}{1.6 \times 10^{-19}} = 4.14 \times 10^3 \text{ eV} \end{aligned}$$

**Q.45** Hydrogen atom emits blue light when it changes from  $n = 4$  energy level to the  $n = 2$  level. Which colour of light would the atom emit when it changes from  $n = 5$  level to the  $n = 2$  level?

**Correct option: (D) Violet**

As difference between the levels increases, energy emitted increases and hence wavelength decreases. It means colour must change to violet.

**Q.46** What is the additional energy that should be supplied to a moving electron to reduce its de-Broglie wavelength from 1 nm to 0.5 nm?

**Correct option: (A)**

De Broglie wavelength,

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

$$\text{But } p = \sqrt{2mE}$$

$$\therefore \lambda \propto \frac{1}{\sqrt{E}} \text{ i.e., } E \propto \frac{1}{\lambda^2}$$

$$\therefore \left(\frac{E_2}{E_1}\right) = \left(\frac{\lambda_1}{\lambda_2}\right)^2 = \left(\frac{1}{0.5}\right)^2 = 4$$

$$\text{As, } E_2 = 4E_1$$

$$\Delta E = E_2 - E_1$$

$$= 4E_1 - E_1 = 3E_1$$

**Q.47 Photoelectric cell is NOT used in**

**Correct option: (D)**

A *photoelectric cell* is a device that converts light energy into electrical energy. This process relies on the photoelectric effect, where light strikes a material and releases electrons. This principle is not directly used in the measurement of temperature.

Therefore, the *correct option* is measurement of temperature.

**Q.48 In photoelectric experiment the stopping potential was measured to be 'V<sub>1</sub>' and 'V<sub>2</sub>' volt with incident light of wavelength 'λ' and λ/2 respectively. the value of V<sub>2</sub> is (ϕ<sub>0</sub> = work function, e = electronic charge)**

**Correct option: (C)**

From Einstein's photoelectric equation, we can write

$$eV_1 = \frac{hc}{\lambda} - \phi_0$$

$$eV_2 = \frac{2hc}{\lambda} - \phi_0$$

$$\Rightarrow eV_2 - eV_1 = \frac{2hc}{\lambda} - \frac{hc}{\lambda} - \phi_0 + \phi_0$$

$$\therefore V_2 = V_1 + \frac{1}{e}[eV_1 - \phi_0] = V_1 + V_1 - \frac{\phi_0}{e}$$

$$V_2 = 2V_1 - \frac{\phi_0}{e}$$

**Q.49 If the half-life of a radioactive element is 10 hr, its average life = \_\_\_\_\_**

**Correct option: (C)**

$$T_{1/2} = \frac{0.693}{\lambda}$$

$$\text{Average life } \tau = \frac{1}{\lambda}$$

$$\therefore T_{1/2} = 0.693 \tau$$

$$\therefore \tau = \frac{10}{0.693} = 14.43 \text{ hours}$$



**Thinking Hat**

Average life of any radioactive element is always greater than (1.44 times) its half-life. Hence, the only correct option possible here is (C).

**Q.50 For a surface illuminated with a frequency 'ν' the stopping potential required for emitted photon is 'V<sub>0</sub>'. If the incident frequency is 'ν/2'. Then**

**stopping potential required became 'V<sub>0</sub>/4**

**'V<sub>0</sub>'. Then the threshold frequency for the surface is**

**Correct option: (B)**

Threshold frequency is given by,

$$eV_0 = h\nu - h\nu_0 \quad \dots(i)$$

When frequency is  $\frac{\nu}{2}$ ,

$$\frac{eV_0}{4} = h\left(\frac{\nu}{2}\right) - h\nu_0 \quad \dots(ii)$$

$$\therefore \frac{h\nu}{4} - \frac{h\nu_0}{4} = \frac{h\nu}{2} - h\nu_0$$

$$\frac{3\nu_0}{4} = \frac{\nu}{4}$$

$$\nu_0 = \frac{\nu}{3}$$