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PHYSICS

NEET and JEE Main 2020 : 45 Days Crash Course

Problem Solving Class

(Modern Physics)

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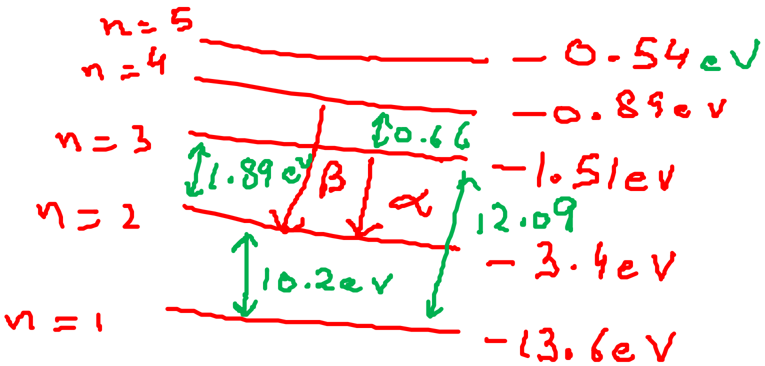
P-Q3001

Calculate the frequency of the H_β of the Balmer series for hydrogen

(A) $6.12 \times 10^{14}\ Hz$ (B) $6.12 \times 10^{13}\ Hz$

(C) $6.12 \times 10^{12}\ Hz$ (D) $6.12 \times 10^{10}\ Hz$



$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{4^2}\right)$

$\nu = Rc\left(\frac{1}{4} - \frac{1}{16}\right)$

$c = \nu\lambda$

$\frac{1}{\lambda} = \frac{\nu}{c}$

$\Delta E = 2.55\ eV$

$h\nu = 2.55 \times 1.6 \times 10^{-19}$

$\nu = \frac{2.55 \times 1.6 \times 10^{-19}}{6.6 \times 10^{-34}}$

$0.6 \ldots \times 10^{34-19}$

$6 \ldots \times 10^{14}$

P-Q3001-Solution

Ans [A]

H_β line of Balmer series corresponds to the transition from $n = 4$ to $n = 2$ level.

$$\frac{1}{\lambda} = (1.097 \times 10^7)\left(\frac{1}{2^2} - \frac{1}{4^2}\right)$$

For balmer series n_i is equal to 2

$$= 0.2056 \times 10^7$$

$$\lambda = 4.9 \times 10^{-7} \text{ m}$$

$$f = \frac{c}{\lambda} = \frac{3.0 \times 10^8}{4.9 \times 10^{-7}}$$

$$= 6.12 \times 10^{14} \text{ Hz}$$

P-Q3003

A small particle of mass m moves in a such way that the potential energy $\boldsymbol{U = ar^2}$ where $\boldsymbol{a}$ is constant and $\boldsymbol{r}$ is the distance of the particle from the origin. Assuming Bohr's model of quantization of angular momentum and circular orbits, Find the radius of $\boldsymbol{n^{th}}$ allowed orbit.

(A) $r = \left(\frac{n^3h^2}{8\,am\,\pi^2}\right)^{\frac{1}{4}}$

(B) $r = \left(\frac{n^2h^2}{8\,am\,\pi^2}\right)^{\frac{1}{4}}$

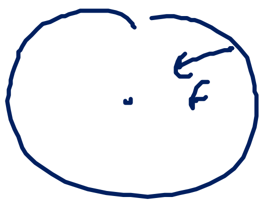
(C) $r = \left(\frac{n^2h^2}{8\,a\,\pi^2}\right)^{\frac{1}{4}}$

(D) $r = \left(\frac{n^2h^2}{4\,am\,\pi^2}\right)^{\frac{1}{4}}$

$F = -\frac{dU}{dr} = -2ar$

$2ar = \frac{mv^2}{r}$ —(1)

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



P-Q3003-Solution

Ans [B]

The force at a distance r is,

$$F = -\frac{dU}{dr} = -2ar$$

Suppose r be the radius of n^{th} orbit. Then the necessary centripetal force is provided by the above force. Thus,

$$\frac{mv^2}{r} = 2ar \longrightarrow (1)$$

Further, the quantization of angular momentum gives,

$$mvr = \frac{nh}{2\pi} \longrightarrow (2)$$

$$r = \left(\frac{n^2h^2}{8am\pi^2}\right)^{1/4} \longleftarrow \text{Solving eqn. 1 and 2}$$

P-Q3006

Find the longest wavelength present in the Balmer series of hydrogen.

(A) 615nm

(B) 651nm ✓

(C) 620nm

(D) 685nm

$$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$$

$$= R\left(\frac{1}{4} - \frac{1}{9}\right)$$

$$= R \frac{5}{36}$$

$$\lambda = \frac{36}{5} \cdot \frac{1}{R} = \frac{36}{5} \times (910\ \text{Å})$$

$$= 6552\ \text{Å}$$

$$\simeq 655\ \text{nm}$$

182 × 36 = 1152 + 546 = 6552

P-Q3006-Solution

Ans [B]

Longest wavelength, means minimum energy.

$$(\Delta E)_{min} = E_3 - E_2$$

$$= -\frac{13.6}{9} + \frac{13.6}{4} = 1.9 \text{ eV}$$

Minimum energy calculated between 2nd and 3rd orbital

$$\lambda \text{ (in Å)} = \frac{12375}{1.9} = 6513 \quad \text{or} \quad \lambda \approx 651 \text{ nm}$$

P-Q3010

When a metal is illuminated with light of frequency f the maximum kinetic energy of the photoelectrons is $\mathbf{1.2eV}$. When the frequency is increased by $\mathbf{50\%}$ the maximum kinetic energy increases to $\mathbf{4.2eV}$. What is the threshold frequency for this metal.

(A) $2.16 \times 10^{15}\ Hz$

(B) $1.16 \times 10^{17}\ Hz$

(C) $1.16 \times 10^{15}\ Hz$ ✓

(D) $11.6 \times 10^{15}\ Hz$

x, $x\%$ increase: $x' = x\left(1 + \frac{x}{100}\right)$

1.5ν

$\nu' = \nu\left(1 + \frac{50}{100}\right) = 1.5\nu$

$K_{max} = h\nu - \phi$

$1.2 = h\nu - \phi$

$4.2 = \frac{3}{2}h\nu - \phi$

$4.2 = \frac{3}{2}(1.2 + \phi) - \phi$

$8.4 = 3.6 + 3\phi - 2\phi$

$4.8 = \phi$

$\phi = 4.8\ eV$

$h\nu_{th} \Rightarrow \nu_{th} = \frac{4.8 \times 1.6 \times 10^{-19}}{6.6 \times 10^{-34}} = 1.2 \times 10^{15}$

P-Q3010-Solution

Ans [C]

$$K_{max} = E - W$$

$$1.2 = E - W$$

$$4.2 = 1.5\,E - W$$

Max kinetic energy is calculated here

Solving this equation, we get

$$W = 4.8 \text{ eV} = hf_0$$

$$\therefore \quad f_0 = \frac{4.8 \times 1.6 \times 10^{-19}}{6.63 \times 10^{-34}}$$

$$= 1.16 \times 10^{15} \text{ Hz}$$

P-Q3020

An electron, in a hydrogen-like atom is in excited state. It has a total energy of $-\mathbf{3.4}\boldsymbol{eV}$, find the de-Broglie wavelength of the electron.

(A) 3.660Å

(B) 5.661Å

(C) 66.52Å

(D) 6.663Å ✓

$T.E. = -3.4eV$

$K.E. = -T.E = 3.4eV$

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}} = \frac{6.6\times10^{-34}}{\sqrt{2\times9.1\times10^{-31}\times3.4\times1.6\times10^{-19}}}$$

$$= \frac{6.6\times10^{-34+25}}{\sqrt{3.2\times3.4\times9.1}}$$

$$= \frac{2.2\times10^{-9}}{3.2}$$

$$= \frac{220}{32}\ \text{Å} = \frac{110}{16}$$

$= 6$

P-Q3020-Solution

Ans [D]

For hydrogen like atom

$$E = -K \text{ Here } E = -3.4 \text{ eV}$$

$$\Rightarrow \quad K = 3.4 \text{ eV} = 3.4 \times 1.6 \times 10^{-19} \text{ J}$$

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2m_e K}}$$

Calculating the wavelength by this relation

$$= \frac{6.6 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 3.4 \times 1.6 \times 10^{-19}}}$$

$$\Rightarrow \lambda = 6.663 \text{ Å}$$

P-Q3024

What are the respective number of $\alpha - particle\ and\ \beta - particles$ emitted in the following radioactive decay?

$$_{90}X^{200} \longrightarrow {}_{80}Y^{168}$$

(A) 6 and 8

(B) 6 and 6

(C) 8 and 8

✓(D) 8 and 6

$$_{90}X^{200} \longrightarrow {}_{80}Y^{168} + n\,{}_{2}\alpha^{4} + m\,{}_{-1}\beta^{0}$$

$$90 = 80 + 2n - m \Rightarrow 2n - m = 10 \quad -(1)$$

$$200 = 168 + 4n + 0 \Rightarrow 4n = 32 \Rightarrow \boxed{n = 8} \quad -(2)$$

$$2 \times 8 - m = 10 \Rightarrow \boxed{m = 6}$$

P-Q3024-Solution

Ans [D]

Given reaction is ${}_{90}X^{200} \longrightarrow {}_{80}Y^{168}$

Difference in mass number $= 200 - 168 = 32$

Hence Number of α-particles $= \frac{32}{4} = 8$

One α-particle has a mass of 4 amu

Difference in atomic number $= 10$

hence number of β -particles $= 6$

One β-particle has a mass of 2 amu

P-Q3025

$\frac{7}{8}^{th}$ of the active nuclei present in a radioactive sample has decayed in 8s. The half life of the sample is

(A) 2s

(B) 7s

(C) 1s

(D) $\frac{8}{3}s$

Initial = N_0

At 8 s $N = N_0 - \frac{7N_0}{8} = \frac{N_0}{8} = \frac{N_0}{2^3}$

After n half lives, $N = \frac{N_0}{2^n}$

3 half lives = 8 s

1 half life = $\frac{8}{3}$ s

P-Q3025-Solution

Ans [D]

The fraction of nuclei left after 8 sec will be this

$$N = N_0 - \frac{7}{8}N_0 = \frac{1}{8}N_0$$

$$\frac{1}{8} = \left(\frac{1}{2}\right)^3$$

$$\text{But } N = N_0\left(\frac{1}{2}\right)^n \Rightarrow \frac{1}{8}N_0 = N_0\left(\frac{1}{2}\right)^n$$

$$\Rightarrow \quad n = 3$$

$$\Rightarrow \quad 3 \times T_{1/2} = 8 \text{ s}$$

$$\Rightarrow \quad T_{1/2} = \frac{8}{3}\text{s}$$

P-Q3026

A radioactive element disintegrates for a time interval equal to its mean life. The fraction that has disintegrated is

(A) $\frac{1}{e}$

(B) $\frac{0.693}{e}$

(C) $1-\frac{1}{e}$

(D) $0.693\left(1-\frac{1}{e}\right)$

$N = N_0 e^{-\lambda t}$

$t = \tau = \frac{1}{\lambda}$

$N = N_0 e^{-\lambda \frac{1}{\lambda}} = \frac{N_0}{e}$

$\frac{\text{Nuclei decayed}}{\text{Original nuclei}} = \frac{N_0 - N}{N_0} = \frac{N_0 - N_0/e}{N_0}$

$= 1 - \frac{1}{e}$

P-Q3026-Solution

Ans [C]

$$N = N_0\, e^{-\lambda t} \text{ for mean life } t = \frac{1}{\lambda}$$

$$\Rightarrow \; N = N_0\, e^{-\lambda \times \frac{1}{\lambda}} = \frac{N_0}{e}$$

$$= \frac{N_0 - N}{N_0} = \left(1 - \frac{1}{e}\right)$$

This is the fraction of nuclei disintegrated

P-Q3028

A radioactive element is disintegrating having half-life $6.93s$. The fractional change in number nuclei of the radioactive element during $10s$ is

(A) 0.37 (B) 0.50

(C) 0.25 (D) 0.63

$$\frac{N_0 - N}{N_0} = \left(1 - \frac{1}{e}\right)$$

$$\frac{N}{N_0} = \frac{N_0 e^{-\lambda t}}{N_0}$$

$$= e^{-\frac{1}{10} \times 10}$$

$$= \frac{1}{e} = 0.37$$

$$e \approx 2.7$$

$$\left(1 - \frac{1}{e}\right) = 0.63$$

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

$$\lambda = \frac{0.693}{6.93} = \frac{1}{10}$$

P-Q3028-Solution

Ans [D]

$$N = N_0 e^{-\lambda t} \Rightarrow \frac{N}{N_0} = e^{-\lambda t}$$

$$\Rightarrow \quad \frac{N}{N_0} = e^{-\frac{0.693}{6.93}\times 10} = e^{-1} = \frac{1}{e}$$

This is the fraction left after 10 second

Fractional change

$$= \frac{N_0 - N}{N_0} = \left(1 - \frac{1}{e}\right) \simeq 0.63$$

Subtracting the above fraction from 1

P-Q3030

The count rate observed for a radioactive source at t second was N_0 and at $4t$ second it was $\frac{N_0}{16}$. The count rate observed, at $\left(\frac{11}{2}\right)t$ second will be

(A) $\frac{N_0}{128}$

(B) $\frac{N_0}{64}$

(C) $\frac{N_0}{32}$

(D) none of these

A

$t \rightarrow N_0$

$4t \rightarrow \frac{N_0}{16} = \frac{N_0}{2^4}$

$\frac{11}{2}t \rightarrow \ ?$ $\quad \frac{N_0}{2^6} = \frac{N_0}{64}$

$4T_{1/2} = 3t$

$t = \frac{4}{3}T_{1/2}$

P-Q3030-Solution

Ans [B]

Let initially substance have N_i nuclei then

$$N = N_i e^{-\lambda t}$$

$$\frac{dN}{dt} = -\lambda N_i e^{-\lambda t}$$

At $t = t$

we get

$$\left(\frac{dN}{dt}\right)_{t=t} = -\lambda N_i e^{-\lambda t} = N_0 \longrightarrow (1)$$

At $t = 4t$

$$\left(\frac{dN}{dt}\right)_{t=4t} = -\lambda N_i e^{-4\lambda t} = \frac{N_0}{16} \longrightarrow (2)$$

Dividing 1 & 2 we get

$$e^{3\lambda t} = 16 \longrightarrow (3)$$

Now at $t = \left(\frac{11}{2}\right)t$

$$\left(\frac{dN}{dt}\right)_{t=\frac{11t}{2}} = -\lambda N_i e^{\frac{-11\lambda}{2}t}$$

$$= -\lambda N_i e^{\frac{-8\lambda t}{2}} \times e^{\frac{-3\lambda t}{2}}$$

$$= \frac{-\lambda N_i e^{-4\lambda t}}{\sqrt{e^{3\lambda t}}} = \frac{N_0}{16 \times \sqrt{16}}$$

From equation 2 & 3 we get

$$= \frac{N_0}{64}$$

P-Q3031

The half lives of a radioactive sample are $30\ years\ and\ 60\ years$ for two decay processes. If the sample decays by both the processes simultaneously. The time after which, only one-fourth of the sample will remain is

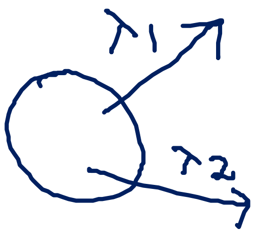
(A) 10 years

(B) 20 years

(C) 40 years

(D) 60 years

→ 2 half lives.



$\lambda_{eff.} = \lambda_1 + \lambda_2$

$\frac{\ln 2}{t_{eff}} = \frac{\ln 2}{t_1} + \frac{\ln 2}{t_2} \Rightarrow \frac{1}{t_{eff}} = \frac{1}{t_1} + \frac{1}{t_2}$

half life → t_{eff}

$\frac{1}{t_{eff}} = \frac{1}{30} + \frac{1}{60} = \frac{2+1}{60} = \frac{1}{20}$

$t_{eff} = 20$ years

P-Q3031-Solution

Ans [C]

We have $\lambda = \lambda_1 + \lambda_2 = \dfrac{\log 2}{30} + \dfrac{\log 2}{60}$

Since both the processes are occurring so the mean life of the sample will be the addition of both

$$\Rightarrow \qquad \lambda = \frac{\log 2}{20}$$

Now $\qquad N = N_0\, e^{-\lambda t}$

$$\Rightarrow \qquad \frac{N_0}{4} = N_0\, e^{\frac{-t \log 2}{20}}$$

Here N_0 is the initial number of nuclei

$$\Rightarrow \qquad \log 4 = \frac{t}{20} \log 2$$

$$\Rightarrow \qquad 2\log 2 = \frac{t}{20} \log 2$$

$$\Rightarrow \qquad t = 40\,\text{yr}$$

P-Q3032

Two identical samples (same materials and same amount) $P\ and\ Q$ of a radioactive substance having mean life T are observed to have activities A_P and A_Q respectively at the time of observation. If P is older than Q, then the difference in their age is

$t + t_0$ t t_0

(A) $T\ ln\left(\frac{A_P}{A_Q}\right)$

(B) $T\ ln\left(\frac{A_Q}{A_P}\right)$ ✓

(C) $T\ ln\left(\frac{1}{A_Q}\right)$

(D) $T\ ln\left(\frac{2A_Q}{A_P}\right)$

$$A_P = A_0 e^{-\lambda(t+t_0)} = A_0 e^{-\lambda t} \cdot e^{-\lambda t_0} \quad -(1)$$

$$A_Q = A_0 e^{-\lambda t} \quad -(2)$$

$(1) \div (2)$

$$\frac{A_P}{A_Q} = e^{-\lambda t_0} \Rightarrow e^{\lambda t_0} = \frac{A_Q}{A_P}$$

$$\Rightarrow \lambda t_0 = ln \frac{A_Q}{A_P}$$

P-Q3032-Solution

Ans [B]

Note :We are assuming here that the difference in their age is t_1

$$N_P = N_0\, e^{-\lambda(t_1 + t)}$$

and $\quad N_Q = N_0\, e^{-\lambda t}$

Now $\quad A_P = \lambda N_P$ and $A_Q = \lambda N_Q$

$$\Rightarrow \quad \frac{A_P}{A_Q} = \frac{N_P}{N_Q} = e^{-\lambda t_1}$$

$$\Rightarrow \quad \lambda t_1 = \log\left(\frac{A_Q}{A_P}\right)$$

$$\Rightarrow \quad t_1 = \frac{1}{\lambda}\log\left(\frac{A_Q}{A_P}\right) = T\log\left(\frac{A_Q}{A_P}\right)$$

P-Q3053

The energy required to knock out the electron in the third orbit of a hydrogen atom is equal to

(A) $13.6\,eV$

(B) $+\frac{13.6}{9}eV$

(C) $-\frac{13.6}{3}eV$

(D) $-\frac{3}{13.6}eV$

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

$$\text{Ans} = \frac{13.6\,eV}{3^2} = \frac{13.6}{9}\,eV$$

P-Q3053-Solution

Ans [B]

Energy required to knock out the electron in the n^{th} orbit $= +\frac{13.6}{n^2} eV \Rightarrow E_3 = +\frac{13.6}{9} eV$.

To knock out electron from 3rd orbit

P-Q3054

In a beryllium atom, if a_0 be the radius of the first orbit, then the radius of the n^{th} orbit will be in general

(A) na_0

(B) a_0

(C) $n^2 a_0$

(D) $\frac{a_0}{n^2}$

P-Q3054-Solution

Ans [C]

If the smallest radius correspond to $n = 1$ is a_0.

Then n^{th} orbital radius $r_n = n^2 a_0$.

Remember to usful this relation.

P-Q3055

The ionization potential for second He electron is

(A) 13.6 eV

(B) 27.2 eV

(C) 54.4 eV

(D) 100 eV

P-Q3055-Solution

Ans [C]

For the ionization of second He electron. He^+ will act as hydrogen like atom.

Hence ionization potential

$$= Z^2 \times 13.6\, volt = (2)^2 \times 13.6 = 54.4\ V$$

P-Q3057

The kinetic energy of the electron in an orbit of radius r in hydrogen atom is (e = electronic charge) **(In CGS units)**

(A) $\frac{e^2}{r^2}$

(B) $\frac{e^2}{2r}$

(C) $\frac{e^2}{r}$

(D) $\frac{e^2}{2r^2}$

P-Q3057-Solution

Ans [B]

$$U = -\frac{e^2}{r} \text{ (in CGS)}$$

Potential energy of electron in n^{th} orbit of radius r in H-atom

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

P-Q3058

Hydrogen atoms in the ground state are excited by monochromatic radiation of photon energy 12.1 eV. The spectral lines emitted by hydrogen atoms according to Bohr's theory will be

(A) One

(B) Two

(C) Three

(D) Four

P-Q3058-Solution

Ans [C]

Final energy of electron $= -13.6 + 12.1 = -1.51\ eV$. which is corresponds to third level *i.e.* $n = 3$. Hence number of spectral lines emitted $= \frac{n(n-1)}{2} = \frac{3(3-1)}{2} = 3$

Maximum no. of spectral lines emitted will be $\frac{n(n-1)}{2}$

P-Q3059

The ratio of the energies of the hydrogen atom in its first to second excited state is

(A) 1/ 4 (B) 4/9

(C) 9/ 4 (D) 4

P-Q3059-Solution

Ans [C]

First excited state i.e. second orbit (n = 2)

Second excited state i.e. third orbit (n = 3)

$$\because E = -\frac{13.6}{n^2} \Rightarrow \frac{E_2}{E_3} = \left(\frac{3}{2}\right)^2 = \frac{9}{4}$$

P-Q3060

An electron jumps from the 4^{th} orbit to the 2^{nd} orbit of hydrogen atom. Given the Rydberg's constant $R = 10^5 \, cm^{-1}$. The frequency in Hz of the emitted radiation will be

(A) $\frac{3}{16} \times 10^5$

(B) $\frac{3}{16} \times 10^{15}$

(C) $\frac{9}{16} \times 10^{15}$

(D) $\frac{3}{4} \times 10^{15}$

P-Q3060-Solution

Ans [C]

First we will calculate wavelength from Rydberg's eq. and then frequency by it

Rydberg's Equation

$$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = \frac{3R}{16} \Rightarrow \lambda = \frac{16}{3R} = \frac{16}{3} \times 10^{-5}\ cm$$

$$\text{Frequency } n = \frac{c}{\lambda} = \frac{3 \times 10^{10}}{\frac{16}{3} \times 10^{-5}} = \frac{9}{16} \times 10^{15}\ Hz$$

P-Q3061

According to Bohr's theory the radius of electron in an orbit described by principal quantum number n and atomic number Z is proportional to

(A) $Z^2 n^2$

(B) $\frac{Z^2}{n^2}$

(C) $\frac{Z^2}{n}$

(D) $\frac{n^2}{Z}$

P-Q3061-Solution

Ans [D]

$$r = \frac{\varepsilon_0 n^2 h^2}{\pi Z m e^2};$$

$$\therefore r \propto \frac{n^2}{Z}$$

If all the other terms are constant

P-Q3062

The radius of electron's second stationary orbit in Bohr's atom is R. The radius of the third orbit will be

(A) $3R$

(B) $2.25R$

(C) $9R$

(D) $\frac{R}{3}$

P-Q3062-Solution

Ans [B]

$$r = \frac{\varepsilon_0 n^2 h^2}{\pi Z m e^2};$$

$$r \propto n^2$$

$$\Rightarrow \frac{r_{(n=2)}}{r_{(n=3)}} = \frac{4}{9}$$

Ratio of different radius

$$\Rightarrow r_{(n=3)} = \frac{9}{4} R = 2.25\ R$$

P-Q3063

Consider an electron in the n^{th} orbit of a hydrogen atom in the Bohr model. The circumference of the orbit can be expressed in terms of the de Broglie wavelength λ of that electron as

(A) $(0.259)\, n\lambda$

(B) $\sqrt{n}\lambda$

(C) $(13.6)\, \lambda$

(D) $n\lambda$

P-Q3063-Solution

Ans [D]

According to Bohr's theory $mvr = n\frac{h}{2\pi}$

$$\Rightarrow \text{Circumference } 2\pi r = n\left(\frac{h}{mv}\right) = n\lambda$$

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

P-Q3064

In any Bohr orbit of the hydrogen atom, the ratio of kinetic energy to potential energy of the electron is

(A) $1/2$

(B) 2

(C) $-1/2$

(D) -2

P-Q3064-Solution

Ans [C]

$$K.E = \frac{kZe^2}{2r}$$

and $P.E. = -\frac{kZe^2}{r}$;

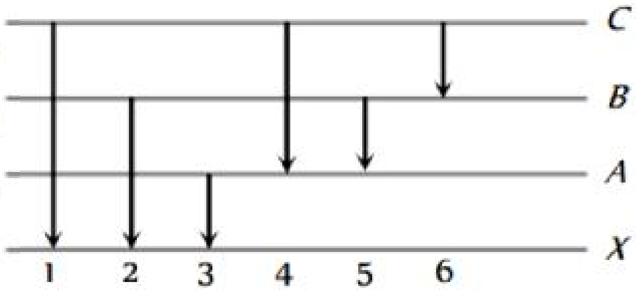
$$\therefore \frac{K.E.}{P.E.} = -\frac{1}{2}.$$

Taking a ratio of both energies

Remember in any orbit of Bohr's Hydrogen atom $P.E. = -2 \times K.E.$

P-Q3065

The figure indicates the energy level diagram of an atom and the origin of six spectral lines in emission (*e.g.* line no. 5 arises from the transition from level *B* to *A*). The following spectral lines will also occur in the absorption spectrum



(A) 1, 4, 6

(B) 4, 5, 6

(C) 1, 2, 3

(D) 1, 2, 3, 4, 5, 6

P-Q3065-Solution

Ans [C]

only 1, 2 and 3 lines will be obtained

The absorption lines are obtained when the electron jumps from ground state ($n = 1$) to the higher energy states.

P-Q3066

When a hydrogen atom is raised from the ground state to an excited state

(A) P.E. increases and K.E. decreases

(B) P.E. decreases and K.E. increases

(C) Both kinetic energy and potential energy increase

(D) Both K.E. and P.E. decrease

P-Q3066-Solution

Ans [A]

$$\text{P.E.} \propto -\frac{1}{r} \text{ and K.E.} \propto \frac{1}{r}$$

As r increases so K.E. decreases but P.E. increases.

P-Q3067

In terms of Rydberg's constant R, the wave number of the first Balmer line is

(A) R

(B) $3R$

(C) $\frac{5R}{36}$

(D) $\frac{8R}{9}$

P-Q3067-Solution

Ans [C]

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

For first Balmer line $n_1=2$, $n_2=3$

$$\therefore \text{Wave number } = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = R\left(\frac{9-4}{9 \times 4}\right) = \frac{5R}{36}$$

P-Q3068

The minimum energy required to excite a hydrogen atom from its ground state is

(A) $13.6\ eV$

(B) $-13.6\ eV$

(C) $3.4\ eV$

(D) $10.2\ eV$

P-Q3068-Solution

Ans [D]

Minimum energy required to excite from ground state

$$E = 13.6\left(\frac{1}{{n_1}^2} - \frac{1}{{n_2}^2}\right)$$

$$= 13.6\left[\frac{1}{1^2} - \frac{1}{2^2}\right] = 10.2\,eV$$

Electron is going to $n = 2$ from $n = 1$ (minimum energy)

P-Q3069

Ratio of the wavelengths of first line of Lyman series and first line of Balmer series is

(A) 1: 3

(B) 27 : 5

(C) 5 : 27

(D) 4 : 9

P-Q3069-Solution

Ans [C]

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

Rydberg's Equation

For first Balmer series $n_1 = 2$ and $n_2 = 3$

For first Lymen series $n_1 = 1$ and $n_2 = 2$

So, $\frac{\lambda_{\text{Lymen}}}{\lambda_{\text{Balmer}}} = \frac{5}{27}$

P-Q3074

When hydrogen atom is in its first excited level, its radius is .... as Its ground state radius

(A) **Half**

(B) **Same**

(C) **Twice**

(D) **Four times**

P-Q3074-Solution

Ans [D]

$$r = \frac{\varepsilon_0 n^2 h^2}{\pi Z m e^2};$$

$$r \propto n^2$$

For ground state n=1 and for first excited state n=2.

$$\frac{r_2}{r_1} = \frac{4}{1} \Rightarrow r_2 = 4r_1$$

P-Q3075

Minimum excitation potential of Bohr's first orbit in hydrogen atom is

(A) $13.6\ V$ (B) $3.4\ V$

(C) $10.2\ V$ (D) $3.6\ V$

P-Q3075-Solution

Ans [C]

$$\text{Excitation potential} = \frac{\text{Excitation energy}}{e}$$

$\therefore$ Minimum excitation energy in hydrogen atom $= E_2 - E_1$

$$= -3.4 - (-13.6) = +10.2\, eV$$

Hence minimum excitation potential = 10.2 V

Minimum excitation energy corresponds to excitation from $n = 1$ to $n = 2$

P-Q3077

In Bohr's model, if the atomic radius of the first orbit is r_0, then the radius of the fourth orbit is

(A) r_0

(B) $4r_0$

(C) $r_0/16$

(D) $16r_0$

P-Q3077-Solution

Ans [D]

$$r_n \propto n^2$$

$r = \dfrac{\epsilon_0 n^2 h^2}{\pi m e^2}$

$$\Rightarrow \frac{r_4}{r_1} = \left(\frac{4}{1}\right)^2 = \frac{16}{1}$$

Taking ratio of different radius

$$\Rightarrow r_4 = 16\, r_1$$

$$\Rightarrow r_4 = 16\, r_0$$

P-Q3078

The ratio of the largest to shortest wavelengths in Lyman series of hydrogen spectra is

(A) $\frac{25}{9}$

(B) $\frac{17}{6}$

(C) $\frac{9}{5}$

(D) $\frac{4}{3}$

P-Q3078-Solution

Ans [D]

Using Rydberg's eq. for different series

For Lyman series $\frac{1}{\lambda_{max}} = R\left[\frac{1}{1^2} - \frac{1}{2^2}\right] = \frac{3}{4}R$ and

$$\frac{1}{\lambda_{min}} = R\left[\frac{1}{1^2} - \frac{1}{\infty^2}\right] = \frac{R}{1} \Rightarrow \frac{\lambda_{max}}{\lambda_{min}} = \frac{4}{3}$$

Here λ will be minimum corresponding to maximum energy and vice versa.

P-Q3082

An electron jumps from 5^{th} orbit to 4^{th} orbit of hydrogen atom. Taking the Rydberg constant as 10^{7} *per metre*. What will be the frequency of radiation emitted

(A) $6.75 \times 10^{12}\ Hz$

(B) $6.75 \times 10^{14}\ Hz$

(C) $6.75 \times 10^{13}\ Hz$

(D) None of these

P-Q3082-Solution

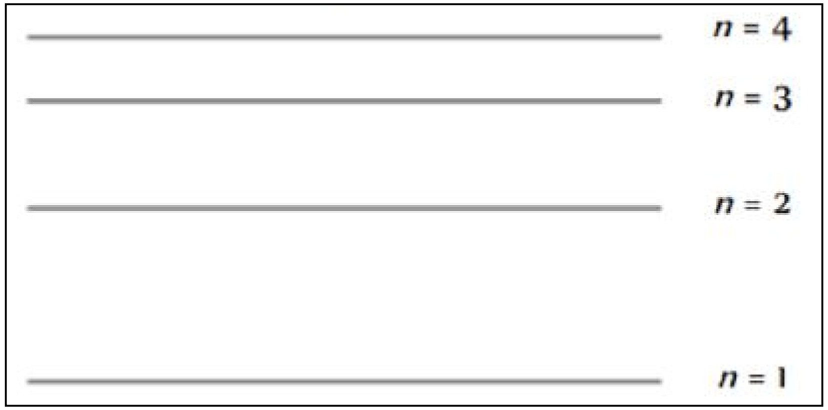
Ans [C]

By using $\nu = RC\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$ ← Using Rydberg's eq. $\left(\frac{1}{\lambda} = \frac{v}{c}\right)$

$$\Rightarrow \nu = 10^7 \times (3 \times 10^8)\left[\frac{1}{4^2} - \frac{1}{5^2}\right] = 6.75 \times 10^{13} \text{Hz}$$

P-Q3084

Four lowest energy levels of H-atom are shown in the figure. The number of possible emission lines would be



(A) 3

(B) 4

(C) 5

(D) 6

P-Q3084-Solution

Ans [D]

$$\text{Number of possible emission lines} = \frac{n(n-1)}{2}$$

$$\text{Where } n = 4; \text{ Number} = \frac{4(4-1)}{2} = 6.$$

This is the maximum no of lines possible in emission

P-Q3085

The wavelength of light emitted from second orbit to first orbits in a hydrogen atom is

(A) $1.215 \times 10^{-7}\,m$

(B) $1.215 \times 10^{-5}\,m$

(C) $1.215 \times 10^{-4}\,m$

(D) $1.215 \times 10^{-3}\,m$

P-Q3085-Solution

Ans [A]

Energy radiated $E = 10.2\,eV = 10.2 \times 1.6 \times 10^{-19}\,J$

$$\Rightarrow E = \frac{hc}{\lambda} \Rightarrow \lambda = 1.215 \times 10^{-7}\,m$$

We can calculate the wavelength from Energy of transition.

P-Q3086

Energy of the electron in n^{th} orbit of hydrogen atom is given by $E_n = -\frac{13.6}{n^2} eV$. The amount of energy needed to transfer electron from first orbit to third orbit is

(A) 13.6 eV

(B) 3.4 eV

(C) 12.09 eV

(D) 1.51 eV

P-Q3086-Solution

Ans [C]

For $n = 1$, $E_1 = -\frac{13.6}{(1)^2} = -13.6\ eV$

and for $n = 3$, $E_3 = -\frac{13.6}{(3)^2} = -1.51\ eV$

So required energy

$= E_3 - E_1 = -1.51 - (-13.6) = 12.09\ eV$

For transition from 1st orbit to 3rd orbit

P-Q3087

The de-Broglie wavelength of an electron in the first Bohr orbit is

(A) Equal to one fourth the circumference of the first orbit

(B) Equal to half the circumference of the first orbit

(C) Equal to twice the circumference of the first orbit

(D) Equal to the circumference of the first orbit

P-Q3087-Solution

Ans [D]

Angular momentum conservation

$$mvr_n = \frac{nh}{2\pi} \Rightarrow pr_n = \frac{nh}{2\pi} \Rightarrow \frac{h}{\lambda} \times r_n = \frac{nh}{2\pi}$$

$\Rightarrow \lambda = \frac{2\pi r_n}{n}$, for first orbit $n = 1$ so $\lambda = 2\pi r_1$

= circumference of first orbit

P-Q3088

Taking Rydberg's constant $R_H = 1.097 \times 10^7 m$ first and second wavelength of Balmer series in hydrogen spectrum is

(A) 2000 Å, 3000 Å

(B) 1575 Å, 2960 Å

(C) 6529 Å, 4280 Å

(D) 6552 Å, 4863 Å

P-Q3088-Solution

Ans [D]

We can calculate the wavelengths using Rydberg's eq.

$\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$. For first wavelength, $n_1 = 2$, $n_2 = 3$

$\Rightarrow \lambda_1 = 6563\ \mathring{A}$. For second wavelength, $n_1 = 2$, $n_2 = 4$

$\Rightarrow \lambda_2 = 4861\ \mathring{A}$

P-Q3089

The energy of the highest energy photon of Balmer series of hydrogen spectrum is close to

(A) 13.6 eV

(B) 3.4 eV

(C) 1.5 eV

(D) 0.85 eV

P-Q3089-Solution

Ans [B]

$E = 13.6\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$. For highest energy in Balmer series

$n_1 = 2$ and $n_2 = \infty \Rightarrow E = 13.6\left[\frac{1}{(2)^2} - \frac{1}{(\infty)^2}\right] = 3.4\,eV$

For highest energy the transition should be from lowest level to infinity.

P-Q3090

An electron changes its position from orbit $n = 4$ to the orbit $n = 2$ of an atom. The wavelength of the emitted radiation's is (R = Rydberg's constant)

(A) $\frac{16}{R}$ (B) $\frac{16}{3R}$

(C) $\frac{16}{5R}$ (D) $\frac{16}{7R}$

P-Q3090-Solution

Ans [B]

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

Using Rydberg's eq.

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

$$\Rightarrow \lambda = \frac{16}{3R}$$

P-Q3076

If λ_{max} is 6563 Å, then wave length of second line for Balmer series will be

(A) $\lambda = \frac{16}{3R}$

(B) $\lambda = \frac{36}{5R}$

(C) $\lambda = \frac{4}{3R}$

(D) None of the above

P-Q3076-Solution

Ans [A]

For Balmer series $\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n^2}\right)$ where $n = 3, 4, 5$

For second line $n = 4$

So $\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = \frac{3}{16}R \Rightarrow \lambda = \frac{16}{3R}$

Here in Balmer series first line will be n=3 , second line will be n=4 and so on

P-Q3004

Use Moseley's law with $\boldsymbol{B} = \mathbf{1}$ find the frequency of the $\boldsymbol{K_\alpha}\ \boldsymbol{X - rays}\ of\ \boldsymbol{La}\ (\boldsymbol{Z} = \mathbf{57})$ if the frequency of the $K_\alpha\ X - rays$ of $\boldsymbol{Cu}(\boldsymbol{Z} = \mathbf{29})$ is known to be $\mathbf{1.88} \times \mathbf{10^{18}}\ Hz$.

(A) $7.52 \times 10^{14}\ Hz$

(B) $7.52 \times 10^{10}\ Hz$

(C) $8.52 \times 10^{18}\ Hz$

(D) $7.52 \times 10^{18}\ Hz$

P-Q3004-Solution

Ans [D]

Using the equation, $\sqrt{f} = a(Z - b)$ $\quad (b = 1)$

Using moseley's equation for $b = 1$ and comparing

$$\frac{f_{La}}{f_{Cu}} = \left(\frac{Z_{La} - 1}{Z_{Cu} - 1}\right)^2 \quad \text{or} \quad f_{La} = f_{Cu}\left(\frac{Z_{La} - 1}{Z_{Cu} - 1}\right)^2$$

$$= 1.88 \times 10^{18}\left(\frac{57 - 1}{29 - 1}\right)^2 = 7.52 \times 10^{18} \text{ Hz}$$

P-Q3081

Radius of the first orbit of the electron in a hydrogen atom is 0.53 Å. So, the radius of the third orbit will be

(A) 2.12 Å
(B) 4.77 Å
(C) 1.06 Å
(D) 1.59 Å

P-Q3081-Solution

Ans [B]

$$r_n \propto n^2$$

$r = \dfrac{\epsilon_0 n^2 h^2}{\pi m e^2}$

$$\Rightarrow \frac{r_3}{r_1} = \frac{3^2}{1}$$

Taking ratio of different radius

$$\Rightarrow r_3 = 9r_1 = 9 \times 0.53 = 4.77\ \mathring{A}$$