JEE Mains 2019 Chapter wise Question Bank

Atomic Physics - Questions

Q1

A hydrogen atom, initially in the ground state is excited by absorbing a photon of wavelength 980Å. The radius of the atom in the excited state, in terms of Bohr radius a_0, will be: (hc = 12500 eV–Å)

(1) $25a_0$ (2) $9a_0$
(3) $16a_0$ (4) $4a_0$

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Q2

In a hydrogen like atom, when an electron jumps from the M-shell to the L-shell, the wavelength of emitted radiation is λ. If an electron jumps from N-shell to the L-shell, the wavelength of emitted radiation will be:

(1) $\frac{27}{20}\lambda$ (2) $\frac{16}{25}\lambda$

(3) $\frac{25}{16}\lambda$ (4) $\frac{20}{27}\lambda$

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Q3

A particle of mass m moves in a circular orbit in a central potential field $U(r)=\frac{1}{2}kr^2$. If Bohr's quantization conditions are applied, radii of possible orbitls and energy levels vary with quantum number n as:

(1) $r_n \propto \sqrt{n}, E_n \propto n$ (2) $r_n \propto \sqrt{n}, E_n \propto \frac{1}{n}$

(3) $r_n \propto n, E_n \propto n$ (4) $r_n \propto n^2, E_n \propto \frac{1}{n^2}$

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Q4

Radiation coming from transitions $n = 2$ to $n = 1$ of hydrogen atoms fall on He^+ ions in $n = 1$ and $n = 2$ states. The possible transition of helium ions as they absorb energy from the radiation is :

(1) $n = 2 \rightarrow n = 3$ (2) $n = 1 \rightarrow n = 4$
(3) $n = 2 \rightarrow n = 5$ (4) $n = 2 \rightarrow n = 4$

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Q5

Taking the wavelength of first Balmer line in hydrogen spectrum (n = 3 to n = 2) as 660 nm, the wavelength of the 2nd Balmer line (n = 4 to n = 2) will be;

(1) 889.2 nm (2) 488.9 nm
(3) 642.7 nm (4) 388.9 nm

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Q6

A He^+ ion is in its first excited state. Its ionization energy is:
(1) 48.36 eV (2) 54.40 eV
(3) 13.60 eV (4) 6.04 eV

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Q7

In Li^{++}, electron in first Bohr orbit is excited to a level by a radiation of wavelength λ. When the ion gets deexcited to the ground state in all possible ways (including intermediate emissions), a total of six spectral lines are observed. What is the value of λ ?
(Given : $h = 6.63 \times 10^{-34}$ Js; $c = 3 \times 10^8$ ms^{-1})
(1) 11.4 nm (2) 9.4 nm (3) 12.3 nm (4) 10.8 nm

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Q8

An excited He^+ ion emits two photons in succession, with wavelengths 108.5 nm and 30.4 nm, in making a transition to ground state. The quantum number n, corresponding to its initial excited state is (for photon of wavelength λ, energy $E = \dfrac{1240eV}{\lambda(innm)}$

(1) $n = 4$ (2) $n = 5$ (3) $n = 7$ (4) $n = 6$

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Q9

The electron in a hydrogen atom first jumps from the third excited state to the second excited state and subsequently to the first excited state. The ratio of the respective wavelengths, λ_1 / λ_2, of the photons emitted in this process is :

(1) 20/7 (2) 27/5 (3) 7/5 (4) 9/7

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Q10

Consider an electron in a hydrogen atom, revolving in its second excited state (having radius 4.65 Å). The de-Broglie wavelength of this electron is :

(1) 3.5 Å (2) 6.6 Å (3) 12.9 Å (4) 9.7 Å

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Atomic Physics - Answers

Q1

(3) Energy of photon $= \dfrac{hc}{\lambda} = \dfrac{12500}{980} = 12.75\text{eV}$

Energy of electron in n^{th} orbit is given by

$$En = \frac{-13.6}{n^2} \Rightarrow E_n - E_1 = -13.6\left[\frac{1}{n^2} \frac{-1}{1^2}\right]$$

$$\Rightarrow 12.75 = 13.6\left[\frac{1}{1^2} \frac{-1}{n^2}\right] \Rightarrow n = 4$$

$\therefore$ Electron will excite to $n = 4$

We know that 'R' $\propto n^2$

$\therefore$ Radius of atom will be $16a_0$

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Q2

(4) When electron jumps from $M \to L$ shell

$$\frac{1}{\lambda} = K\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{K \times 5}{36} \qquad \text{..... (i)}$$

When eletron jumps from $N \to L$ shell

$$\frac{1}{\lambda'} = K\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = \frac{K \times 3}{16} \qquad \text{....(ii)}$$

solving equation (i) and (ii) we get

$$\lambda' = \frac{20}{27}\lambda$$

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Q3

(1) Let force of attraction towards the centre is F, then

$$F = \frac{dU}{dr} = kr = \frac{mv^2}{r} = \text{ centripetal force}$$

$$mvr = \frac{nh}{2\pi} \qquad \text{[Bohr's Quantization rule]}$$

so, $\dfrac{m^2v^2}{m} = kr^2 \Rightarrow \left(\dfrac{nh}{2\pi r}\right)^2 \dfrac{1}{m} = kr^2$

$\Rightarrow \quad r^2 \propto n$

$\Rightarrow \quad r \propto \sqrt{n}$

Also E = K.E + P.E.

$$E = \frac{1}{2}kr^2 + \frac{1}{2}mv^2 = \frac{1}{2}kr^2 + \frac{1}{2} \times (kr^2)$$

$= kr^2 \propto n$ [as k is constant and $r^2 \propto n$]

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Q4

(4) Energy released by hydrogen atom for transition $n = 2$ to $n = 1$

$$\therefore \Delta E_1 = 13.6 \times \left(\frac{1}{1^2} - \frac{1}{2^2}\right) = \frac{3}{4} \times 13.6 \text{ eV} = 10.2 \text{ eV}$$

This energy is absorbed by He^+ ion in transition from $n = 2$ to $n = n_1$ (say)

$$\therefore \Delta E_2 = 13.6 \times 4 \times \left(\frac{1}{4} - \frac{1}{n_1^2}\right) = 10.2 \text{ eV}$$

$\Rightarrow \quad n_1 = 4$

So, possible transition is $n = 2 \to n = 4$

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Q5

(2) $\dfrac{1}{\lambda_1} = R\left(\dfrac{1}{2^2} - \dfrac{1}{3^2}\right) = \dfrac{5R}{36}$

$$\frac{1}{\lambda_2} = R\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = \frac{3R}{16}$$

$$\therefore \frac{\lambda_2}{\lambda_1} = \frac{80}{108}$$

$$\lambda_2 = \frac{80}{108}\lambda_1 = \frac{80}{108} \times 660 = 488.9\text{nm}.$$

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Q6

(3) $E_n = -13.6\dfrac{Z^2}{n^2}$

For $He^+, E_2 = \dfrac{-13.6(2)^2}{2^2} = -13.60\,eV$

Ionization energy $= 0 - E_2 = 13.60$ eV

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Q7

(4) Spectral lines obtained on account of transition from n^{th} orbit to various lower orbits is $\dfrac{n(n-1)}{2}$

$\Rightarrow 6 = \dfrac{n(n-1)}{2}$

$\Rightarrow n = 4$

$\Delta E = \dfrac{hc}{\lambda} = \dfrac{-Z^2}{n^2}(13.6eV)$

$\Rightarrow \quad \dfrac{1}{\lambda} = Z^2\left(\dfrac{13.6eV}{hc}\right)\left(\dfrac{1}{n_2^2}-\dfrac{1}{n_1^2}\right)$

$= (13.4)(3)^2\left[1-\dfrac{1}{16}\right]eV$

$\Rightarrow \lambda = \dfrac{1242\times16}{(13.4)\times(9)(15)}\text{nm} \simeq 10.8\text{nm}$

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Q8

(2) $E = E_1 + E_2$

$13.6\dfrac{z^2}{n^2} = \dfrac{1240}{\lambda_1} + \dfrac{1240}{\lambda_2}$

or $\quad \dfrac{13.6(2)^2}{n^2} = 1240\left(\dfrac{1}{108.5}+\dfrac{1}{30.4}\right)\times\dfrac{1}{10^{-9}}$

On solving, $n = 5$

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Q9

(1) $\dfrac{1}{\;} = \left(\dfrac{1}{3^2}-\dfrac{1}{4^2}\right)$

$= \dfrac{7R}{16\times9}$

And $\dfrac{1}{\lambda_2} = R\left(\dfrac{1}{2^2}-\dfrac{1}{3^2}\right)$

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

Now $\dfrac{\lambda_1}{\lambda_2} = \dfrac{(5R/36)}{7R/(16\times9)} = \dfrac{20}{7}$

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Q10

(4) $v = \dfrac{c}{137n} = \dfrac{c}{137\times3}$

$\lambda = \dfrac{h}{p} = \dfrac{h}{mv} = \dfrac{h}{\left(\dfrac{m\times c}{3\times137}\right)} = \dfrac{h}{mc}\times(3\times137) = 9.7\,\text{Å}$

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