JEE Mains 2019 Chapter wise Question Bank

Atomic Structure - Questions

Q1

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 uint)

(1) Linear with intercept $-R_H$
(2) Non linear
(3) Linear with slope R_H
(4) Linear with slope $-R_H$

9 Jan Morning

Q2

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 azimuthal quantum numbers, shows peak shifting towards higher r value.

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

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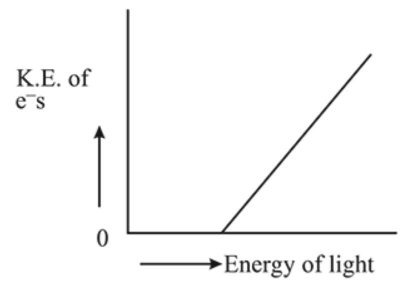
Q3

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

(1)


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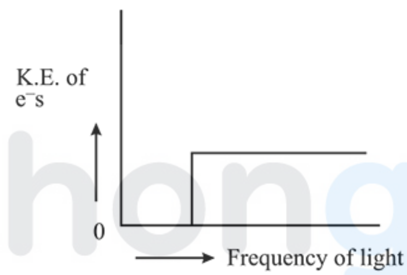

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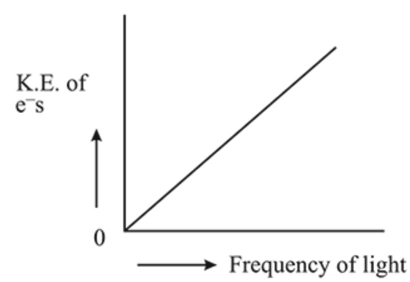

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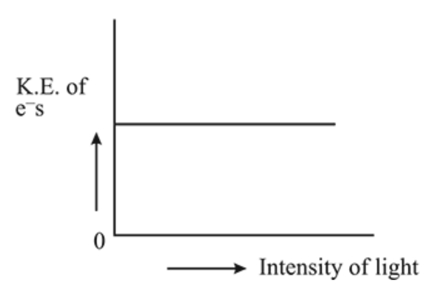

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Q4

The ground state energy of hydrogen atom is –13.6 eV. The energy of second excited state of He^{+} ion in eV is:

(1) – 54.4 (2) – 3.4
(3) – 6.04 (4) – 27.2

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Q5

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

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

(1) Paschen, $\infty \to 3$ (2) Paschen, $5 \to 3$
(3) Balmer, $\infty \to 2$ (4) Lyman, $\infty \to 1$

11 Jan Morning

Q6

The de Broglie wavelength (λ) associated with a photo-electron varies with the frequency (v) of the incident radiation as, [v_0 is threshold frequency]:

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

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

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Q7

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

(Mass of electron $= 9 \times 10^{-31}$ kg

Velocity of light $= 3 \times 10^8$ ms^{-1}

Planck's constant $= 6.626 \times 10^{-34}$ Js

Charge of electron $= 1.6 \times 10^{-19}$ JeV^{-1})

(1) 0.9 eV (2) 3.1 eV
(3) 2.1 eV (4) 4.0 eV

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Q8

If the de Broglie wavelength of the electron in n^{th} 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 :

(1) 0.40 (2) 1.50
(3) 1.0 (4) 0.75

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Q9

The quantum number of four electrons are given below :

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

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

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

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

The correct order of their increasing energies will be :

(1) IV < III < II < I (2) I < II < III < IV
(3) IV < II < III < I (4) I < III < II < IV

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Q10

If p is the momentum of the fastest electron ejected from a metal surface after the irradiation of light having wavelength λ, then for 1.5p 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):

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

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Q11

For any given series of spectral lines of atomic hydrogen, let $\Delta\bar{v} = \bar{v}_{max}$ fl $\bar{v}_{min}$ be the difference in maximum and minimum frequencies in cm^{-1}. The ratio $\Delta\bar{v}_{Lyman} / \Delta\bar{v}_{Balmer}$ is :

(1) 4 : 1 (2) 9 : 4 (3) 5 : 4 (4) 27 : 5

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Q12

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).

(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.

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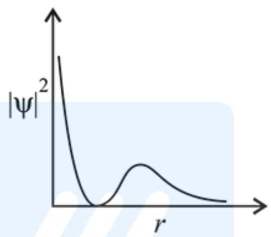
Q13

The graph between $|\psi|^2$ and r (radial distance) is shown below. This represents :



(1) 3s orbital (2) 2s orbital

(3) 1s orbital (4) 2p orbital

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Q14

The isoelectronic set of ions is :

(1) N^{3-}, O^{2-}, F^- and Na^+ (2) N^{3-}, Li^+, Mg^{2+} and O^{2-}

(3) F^-, Li^+, Na^+ and Mg^{2+} (4) Li^+, Na^+, O^{2-} and F^-

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Q15

The ratio of the shortest wavelength of two spectral series of hydrogen spectrum is found to be about 9. The spectral series are :

(1) Lyman and Paschen (2) Balmer and Brackett

(3) Brackett and Pfund (4) Paschen and Pfund

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Q16

The group number, number of valence electrons, and valency of an element with atomic number 15, respectively, are :

(1) 16, 5 and 2 (2) 15, 5 and 3

(3) 16, 6 and 3 (4) 15, 6 and 2

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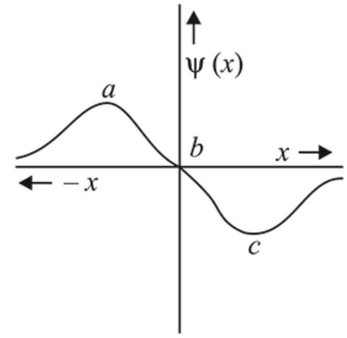
Q17

The electrons are more likely to be found :



(1) in the region a and c (2) in the region a and b

(3) only in the region a (4) only in the region c

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JEE Mains 2019 Chapter wise Question Bank

Atomic Structure - Answers

Q1

(4) As we know,

$$\bar{v} = -R_H\left(\frac{1}{n_2^2} - \frac{1}{n_1^2}\right)Z^2 \text{ (where, } Z = 1)$$

After putting the values, we get

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

$$\Rightarrow \bar{v} = \frac{R_H}{64} - \frac{R_H}{n^2}$$

Comparing to $y = mx + c$, we get

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

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Q2

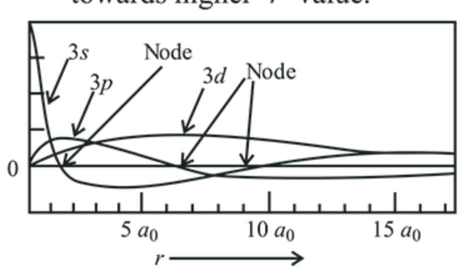
(1) (a) Angular momentum $(L) = \frac{nh}{2\pi}$

Therefore, as n increases, L also 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.



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Q3

(3) K.E. = $h\nu - h\nu_0$

where, ν = Frequency of incident radiation

ν_0 = Threshold frequency

KE is independent of intensity, it depends on frequency of light. Intensity is directly proportional to the no. of electrons emitted.

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Q4

(3) According to Bohr's model energy in n^{th} state

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

For second excited state, of He^+, $n = 3$

$$\therefore E_3(He^+) = -13.6 \times \frac{2^2}{3^2} \text{ eV} = -6.04 \text{ eV}$$

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Q5

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

$n_1 = 3$, $n_2 = \infty$

$$\frac{1}{\lambda} = R\left(\frac{1}{9}\right) \Rightarrow \lambda = \frac{9}{R} = \frac{9}{10^5} = 9 \times 10^{-5}\text{cm} = 900 \text{ nm}$$

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Q6

(4) According to de-Broglie wavelength equation,

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

According to photoelectric effect,

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

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

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

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Q7

(3) $E = h\nu = \frac{hc}{\lambda}$

$$E = \frac{6.626\times10^{-34}\times3\times10^{8}}{4000\times10^{-10}\times1.6\times10^{-19}} = 3.1 \text{ eV}$$

$$\text{KE} = \frac{1}{2}mv^2 = \frac{1}{2}\times9\times10^{-31}\times36\times10^{10} \text{ J}$$

$= 1.62 \times 10^{-19}$ J

= 1 eV

According to photoelectric effect,

$\text{K.E.} = h\nu - h\nu_0$

$h\nu_0 = h\nu - \text{K.E.}$

Work function $(W_0) = E - \text{K.E.}$

$= 3.1 - 1 = 2.1$ eV

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Q8

(4) Given $\lambda = 1.5\pi a_0$

$n\lambda = 2\pi r$ ...(i)

Radii of stationary states (r) is expressed as:

$$r = a_0\frac{n^2}{z} \quad ...(ii)$$

From eqn (i) and (ii)

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

$$1.5\pi a_0 = 2\pi a_0\frac{n}{z}$$

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

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Q9

(3)

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

The energy of an atomic orbital increases with increasing $n+\ell$. For identical values of $n+\ell$, energy increases with increasing n. Therefore the correct order of energy is:

$3p < 3d < 4p < 4d$

IV II III I

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Q10

(4) In photoelectric effect,

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

Given that KE of ejected photoelectron is very high in comparison to work function w.

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

New wavelength

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

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Q11

(2) $\bar{\nu} \propto \Delta E$

For H-atom

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

For Lyman series,

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

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

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

For Balmer series,

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

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

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

$$\frac{\Delta\bar{\nu}_{\text{Lyman}}}{\Delta\bar{\nu}_{\text{Balmer}}} = \frac{9}{4}$$

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Q12

(4) The total energy of the electron is minimum at a distance of a_0 from the nucleus for 1 s orbital.

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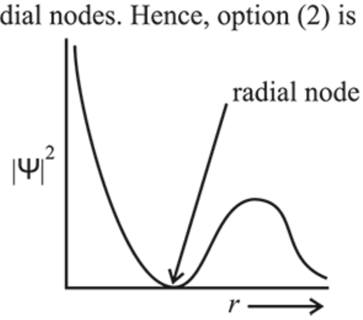
Q13

(2) The given probability density curve is for 2s orbital due to the presence of only one radial node. 1s and 2p orbital do not have any radial node and 3s orbital has two radial nodes. Hence, option (2) is correct.



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Q14

(1) Atomic numbers of N, O, F and Na are 7, 8, 9 and 11 respectively. Therefore, total number of electrons in each of N^{3-}, O^{2-}, F^-, and Na^+ are 10 and hence they are isoelectronic.

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Q15

(1) For determined shortest wavelength, $n_2 = \infty$

$$\text{Lyman series } \bar{\nu}_L = \frac{1}{\lambda_L} = R\left[\frac{1}{(1)^2} - \frac{1}{\infty^2}\right]$$

$$\text{Paschen series } \bar{\nu}_P = \frac{1}{\lambda_P} = R\left[\frac{1}{(3)^2} - \frac{1}{\infty^2}\right]$$

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

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Q16

(2) Phosphorus has atomic number 15. Its group number is 15, number of valence electrons is 5 and valency is 3.

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Q17

(1) Probability of finding an electron will have maximum value at both 'a' and 'c'. There is zero probability of finding an electron at 'b'.

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