ATOMIC STRUCTURE

1. What is the work function of the metal if the light of wavelength 4000 Å generates photoelectrons of velocity 6×10^5 ms^{-1} form it ?
(Mass of electron = 9×10^{-31} kg
Velocity of light = 3×10^8 ms^{-1}
Planck's constant = 6.626×10^{-34} Js
Charge of electron = 1.6×10^{-19} JeV^{-1})
(1) 0.9 eV (2) 4.0 eV
(3) 2.1 eV (4) 3.1 eV

2. If the de Broglie wavelength of the electron in n^{th} Bohr orbit in a hydrogenic atom is equal to $1.5\ \pi a_0$(a_0 is Bohr radius), then the value of n/z is :
(1) 1.0 (2) 0.75
(3) 0.40 (4) 1.50

3. The upper stratosphere consisting of the ozone layer protects us from the sun's radiation that falls in the wavelength region of :
(1) 600-750 nm (2) 0.8-1.5 nm
(3) 400-550 nm (4) 200-315 nm

4. Heat treatment of muscular pain involves radiation of wavelength of about 900 nm. Which spectral line of H-atom is suitable for this purpose ?
[$R_H = 1 \times 10^5$ cm^{-1}, $h = 6.6 \times 10^{-34}$ Js, $c = 3 \times 10^8$ ms^{-1}]
(1) Paschen, $5 \rightarrow 3$
(2) Paschen, $\infty \rightarrow 3$
(3) Lyman, $\infty \rightarrow 1$
(4) Balmer, $\infty \rightarrow 2$

5. The de Broglie wavelength (λ) associated with a photoelectron varies with the frequency (v) of the incident radiation as, [v_0 is thershold frequency] :

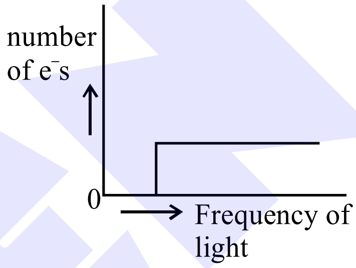
(1) $\lambda \propto \dfrac{1}{(v-v_0)^{\frac{3}{2}}}$ (2) $\lambda \propto \dfrac{1}{(v-v_0)^{\frac{1}{2}}}$

(3) $\lambda \propto \dfrac{1}{(v-v_0)^{\frac{1}{4}}}$ (4) $\lambda \propto \dfrac{1}{(v-v_0)}$

6. The ground state energy of hydrogen atom is –13.6 eV. The energy of second excited state He^+ ion in eV is :
(1) –6.04 (2) –27.2
(3) –54.4 (4) –3.4

7. Among the following, the energy of 2s orbital is lowest in :
(1) K (2) Na (3) Li (4) H

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

(1)


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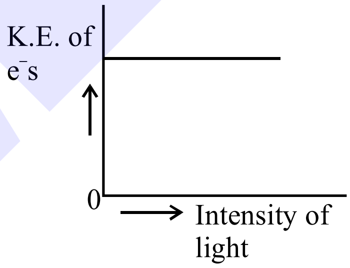

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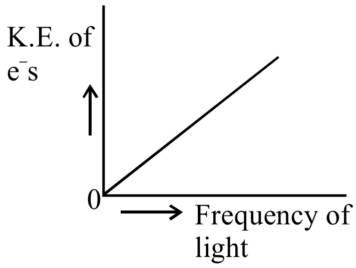

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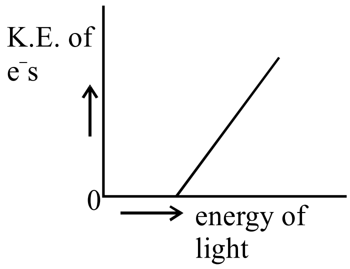

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9. Which of the following combination of statements is true regarding the interpretation of the atomic orbitals ?

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

10. For emission line of atomic hydrogen from $n_i = 8$ to $n_f = n$ the plot of wave number $(\bar{v})$ against $\left(\frac{1}{n^2}\right)$ will be (The Rydberg constant, R_H is in wave number unit).

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

11. If p is the momentum of the fastest electron ejected from a metal surface after the irradiation of light having wavelength λ, then for 1.5 p 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) $\frac{1}{2}\lambda$ (2) $\frac{3}{4}\lambda$
(3) $\frac{2}{3}\lambda$ (4) $\frac{4}{9}\lambda$

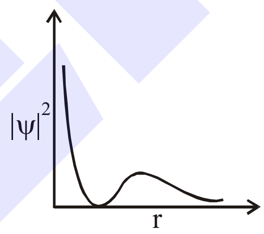
12. For any given series of spectral lines of atomic hydrogen, let $\Delta\bar{v} = \bar{v}_{max} - \bar{v}_{min}$ be the difference in maximum and minimum frequencies in cm^{-1}. The ratio $\Delta\bar{v}_{Lyman}/\Delta\bar{v}_{Balmer}$ is :

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

13. 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 electron can be found at a distance $2a_0$ from the nucleus
(2) The probability density of finding the electron is maximum at the nucleus.
(3) The magnitude of 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.

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

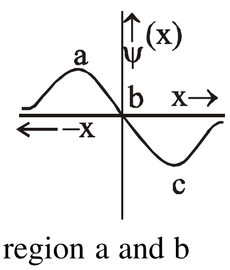


(1) 3s orbital (2) 1s orbital
(3) 2p orbital (4) 2s orbital

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

(1) Paschen and P fund
(2) Lyman and Paschen
(3) Brackett and Piund
(4) Balmer and Brackett

16. The electrons are more likely to be found



(1) in the region a and b
(2) in the region a and c
(3) only in the region c
(4) only in the region a

SOLUTION

1. Ans.(3)

$h\nu = \phi + h\nu^{\circ}$

$$\frac{1}{2}mv^2 = hc\left(\frac{1}{\lambda}-\frac{1}{\lambda_0}\right)$$

$$h\nu=\phi+\frac{1}{2}mv^2$$

$$\phi=\frac{6.626\times10^{-34}\times3\times10^{8}}{4000\times10^{-10}}-\frac{1}{2}\times9\times10^{-31}\times(6\times10^{5})^2$$

$\phi = 3.35 \times 10^{-19}$ J $\Rightarrow$ $\phi \simeq 2.1$ eV

2. Ans. (2)

According to de-broglie's hypothesis

$$2\pi r_n = n\lambda \Rightarrow 2\pi \, . \, a_0\frac{n^2}{z} = n\times1.5\pi a_0$$

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

3. Ans.(4)

Ozone protects most of the medium freequnecies ultravoilet light from 200 - 315 nm wave length.

4. Ans. (2)

5. Ans. (2)

For electron

$$\lambda_{DB} = \frac{\lambda}{\sqrt{2mK.E.}}$$ (de broglie wavelength)

By photoelectric effect

$h\nu = h\nu_0 + KE$

$KE = h\nu - h\nu_0$

$$\lambda_{DB}=\frac{h}{\sqrt{2m\times(h\nu-h\nu_0)}}$$

$$\lambda_{DB}\propto\frac{1}{(\nu-\nu_0)^{1/2}}$$

6. Ans. (1)

$$(E)_{n^{th}} = (E_1)_H\cdot\frac{Z^2}{n^2}$$

Second excited state, n = 3

$$E_{3^{rd}}(He^+)=(-13.6eV)\cdot\frac{2^2}{3^2}=-6.04 \text{ eV}$$

7. Ans.(1)

Sol. In 'K', 2s orbital feel maximum attraction from nucleus (So having less energy) due to more Z_{eff}.

8. Ans. (3)

Number of ejected electrons are independent of frequency of light , & kinetic energy of electrons is independent of intensity of light.

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

$y = mx + C$

9. Ans. (4)

Refer Theory

10. Ans.(4)

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

$$\bar{v}=R_H\times\left(\frac{1}{n_1^2}-\frac{1}{8^2}\right)$$

$$\bar{v}=R_H\times\frac{1}{n^2}-\frac{R_H}{8^2}$$

$$\bar{v}=R_H\times\frac{1}{n^2}-\frac{R_H}{64}$$

$m = R_H$

Linear with slope R_H

11. Ans.(4)

Sol. $h\nu-\phi=KE$

$$\Rightarrow\left(\frac{hc}{\lambda}\right)_{incident} = KE+\phi$$

$$\left(\frac{hc}{\lambda}\right)_{incident} \simeq KE$$

$$KE = \frac{p^2}{2m}=\frac{hc}{\lambda_{incident}}=\frac{hc}{\lambda} \quad ...(1)$$

$$\Rightarrow \frac{p^2\times(1.5)^2}{2m}=\frac{hc}{\lambda'} \quad ...(2)$$

divide (1) and (2)

$$(1.5)^2 = \frac{\lambda}{\lambda'}$$

$$\Rightarrow\lambda'=\frac{4\lambda}{9}$$

12. Ans.(4)

Sol. For Lyman

$$\bar{\nu}_{max} = R_H\left(\frac{1}{1^2}-\frac{1}{\infty^2}\right) = R_H$$

$$\bar{\nu}_{min} = R_H\left(\frac{1}{1^2}-\frac{1}{2^2}\right) = \frac{3}{4}R_H$$

$$\Delta\bar{\nu}_{Lyman} = \frac{R_H}{4}$$

For Balmer

$$\bar{\nu}_{max} = R_H\left(\frac{1}{2^2}-\frac{1}{\infty^2}\right) = \frac{R_H}{4}$$

$$\bar{\nu}_{min} = R_H\left(\frac{1}{2^2}-\frac{1}{3^2}\right) = \frac{5}{36}R_H$$

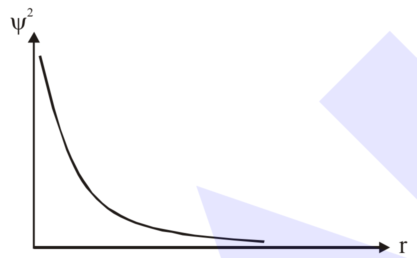
$$\Delta\bar{\nu}_{Balmer} = \frac{R_H}{4}-\frac{5R_H}{36} = \frac{4R_H}{36} = \frac{R_H}{9}$$

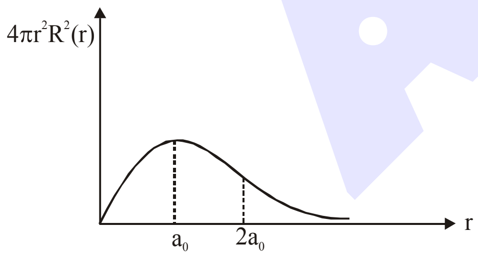
$$\frac{\Delta\bar{\nu}_{Lyman}}{\Delta\bar{\nu}_{Balmer}} = \frac{R_H/4}{R_H/9} = \frac{9}{4}$$

$\therefore$ Ans. is (4)

13. Ans.(4)

Sol.





14. Ans.(4)

Sol. Graph of $|\psi^2|$ v/s r, touches r axis at 1 point so it has one radial node and since at r = 0, it has some value so it should be for 's' orbital.

$\therefore$ $n - \ell - 1 = 1$ where $\ell = 0 \Rightarrow n - 1 = 1$

$\therefore$ $n = 2 \Rightarrow$ '2s' orbital

15. Ans. (2)

Sol.
$$\frac{\dfrac{1}{\lambda_2} = R_H\left(\dfrac{1}{n_1^2}-\dfrac{1}{n_2^2}\right)Z^2}{\dfrac{1}{\lambda_1} = R_H\left(\dfrac{1}{m_1^2}-\dfrac{1}{m_2^2}\right)Z^2}$$

as for shortest wavelengths both n_2 and m_2 are ∞

$$\therefore \quad \frac{\lambda_1}{\lambda_2} = \frac{9}{1} = \frac{m_1^2}{n_1^2}$$

Now if $m_1 = 3$ & $n_1 = 1$ it will justify the statement hence Lyman and Paschen (2) is correct.

16. Ans.(2)

Sol. $P(x) = 4\pi x^2 \times [\Psi(x)]^2$

Probability will be maximum at a and c

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