A photon of 300 nm is absorbed by a gas and then emits two photons. One photon has a wavelength of 496 nm then the wavelength of second photon in nm is :

(a) 759 (b) 859 (c) 959 (d) 659

a

$$\frac{hc}{300} = \frac{hc}{496} + \frac{hc}{\lambda}$$

$$\lambda = 759 \text{ nm}$$

Photon having wavelength 310 nm is used to break the bond of $A_2$ molecule having bond energy 288 kJ mol$^{-1}$ then % of energy of photon converted to the *KE* is:

[$hc = 12400$ eV $\overset{o}{A}$, 1 eV = 96 kJ/mol]

(a) 25 (b) 50 (c) 75 (d) 80

a

$$\underset{A}{\overset{A}{|}} \xrightarrow{h\nu} 2A^* \quad KE$$

$$\frac{\cancel{12400}^{\,4}}{\cancel{3100}} \times 96 = 288 + KE$$

$$KE = 96 \text{ kJ/mol}$$

$$\% \text{ Converted} = \frac{96}{4 \times 96} \times 100 = 25\%$$

A bulb of 40 W is producing a light of wavelength 620 nm with 80% of efficiency, then the number of photons emitted by the bulb in 20 seconds are:

(1 eV = 1.6 x $10^{-19}$ *J, hc* = 12400 eV)

(a) 2 x $10^{18}$ (b) $10^{18}$ (c) $10^{21}$ (d) 2 x $10^{21}$

d

$$40 \times 20 \times 0.8 \text{ J} = N \times \left(\frac{12400}{6200}\right) \times 1.6 \times 10^{-19} \text{ J}$$

$$\underline{N = 2 \times 10^{21}}$$

A photosensitive metallic surface has work function $h\nu_o$. If photons of $2h\nu_0$ fall on the surface, the electrons come out with a maximum velocity of 4 x $10^6$ m/s. If energy of photon is increased to $5h\nu_o$, the maximum velocity of photoelectrons will be:

(a) 2 x $10^7$ m/s (b) 8 x $10^6$ m/s (c) 2 x $10^6$ m/s (d) 8 x $10^5$ m/s

b

$$(KE)_{max} = h\nu - \phi$$

$$\frac{1}{2} m v_1^2 = 2h\nu_0 - h\nu_0 = h\nu_0$$

$$\frac{1}{2} m v_2^2 = 5h\nu_0 - h\nu_0 = 4h\nu_0$$

$$\frac{v_1}{v_2} = \frac{1}{2} \Rightarrow v_2 = 8 \times 10^6 \text{ m/s}$$

A 124 W bulb converts only 15% of the energy supplied to it into visible light of wavelength 640 nm. How many photons are emitted by the light bulb in one second?

(a) $4 \times 10^{19}$ (b) $6 \times 10^{19}$ (c) $8 \times 10^{18}$ (d) $3 \times 10^{19}$

: [redacted]

The radii of two Bohr's orbits of hydrogen atom are in the ratio of 4 : 9. Which of the following value of energy difference is not possible between the two orbits? [*I.E.* = 13.6 eV]

(a) 1.9 eV (b) 0.472 eV ✓(c) 0.66 eV (d) 0.21 eV

c

$$r = r_0 \times \frac{n^2}{1} \Rightarrow \frac{r_1}{r_2} = \left(\frac{n_1}{n_2}\right)^2 = \frac{4}{9} \Rightarrow \frac{n_1}{n_2} = \frac{2n}{3n}$$

$$\Delta E = 13.6\left[\frac{1}{4n^2} - \frac{1}{9n^2}\right] = \frac{13.6}{n^2} \times \left(\frac{5}{36}\right)$$

The time period of revolution in the 3rd orbit of $Li^{2+}$ ion is $x$ sec. The time period of revolution in the 2nd orbit of He ion, should be :

(a) $x$ sec (b) $\frac{3}{2}x$ sec ✓(c) $\frac{2}{3}x$ sec (d) $\frac{8}{27}x$ sec

c

$$T = \frac{2\pi r}{v} = \frac{2\pi r_0 \times n^2/Z}{v_0 \times Z/n} \Rightarrow T \propto \frac{n^3}{Z^2}$$

$$\frac{T_1}{T_2} = \left(\frac{n_1}{n_2}\right)^3 \times \left(\frac{Z_2}{Z_1}\right)^2$$

$$\frac{x}{T} = \frac{\cancel{27}^{3}}{\cancel{8}_{2}} \times \frac{\cancel{4}}{\cancel{9}}$$

$$T = \frac{2}{3}x$$

In a certain electronic transition in the hydrogen atoms from an initial state (a) to a final state (b), the difference in the orbit radius ($r_1 - r_2$) is 24 times the first Bohr radius. Identify the transition:

✓(a) 5 → 1 (b) 25 → 1 (c) 8 → 3 (d) 6 → 5

a

$$r_1 - r_2 = 24 r_0 = r_0 \times n_1^2 - r_0 \times n_2^2$$

$$n_1^2 - n_2^2 = 24$$

A collection of H–atoms in $9^{th}$ excited state returns to ground state. Calculate ratio of total number of spectral lines emitted without emitting any line in Brackett series to number of Brackett series lines.

(a) 39/6 (b) 45/6 (c) 45/39 (d) 6

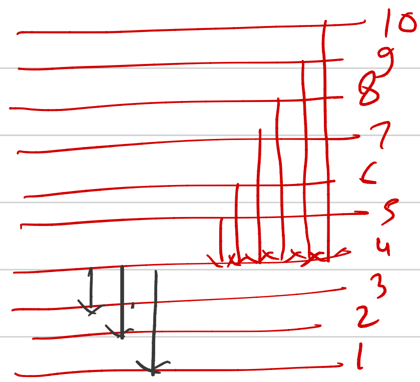
a

$n = 10$ $(n-4) = 6$

$\frac{n(n-1)}{2} = \frac{10 \times 9}{2} = 45$

$45 - 6 - 3 = 36$

$\frac{36}{6} = 6$



The number of possible lines of Paschen series when electron jumps from $7^{th}$ excited state to ground state (in hydrogen like atom) is:

(a) 2 (b) 5 (c) 4 (d) 3

b

$n = 8$ $n - 3 = 8 - 3 = 5$

The longest wavelength of the Lyman series for Hydrogen atom is the same as the wavelength of a certain line in the spectrum of $He^{+}$ when the electron makes a transition from $n \rightarrow 2$. The value of $n$ is:

(a) 3 (b) 4 (c) 5 (d) 6

The difference between the wave number of 1st line of Balmer series and last line of Paschen series for $Li^{2+}$ ion is:

(a) $\frac{R}{36}$ (b) $\frac{5R}{36}$ (c) $4R$ (d) $\frac{R}{4}$

Change in angular momentum when an electron makes a transition corresponding to the 3rd line of the Balmer series in $Li^{2+}$ ion is:

(a) $\frac{h}{2\pi}$ (b) $\frac{2h}{2\pi}$ (c) $\frac{3h}{2\pi}$ (d) $\frac{4h}{2\pi}$

What possibly can be the ratio of the de–Broglie wavelengths for two electrons each having zero initial energy and accelerated through 50 volts and 200 volts?

(a) 3 : 10 (b) 10 :3 (c) 1 :2 (d) 2 : 1

If uncertainties in position and momentum are equal, the uncertainty of velocity is given by:

(a) $\sqrt{\frac{h}{\pi}}$ (b) $\sqrt{\frac{h}{2\pi}}$ ✓(c) $\frac{1}{2m}\sqrt{\frac{h}{\pi}}$ (d) zero

:: c

$\Delta x \times \Delta P \geq \frac{h}{4\pi}$

$\Delta P = \sqrt{\frac{h}{4\pi}} \Rightarrow \Delta v = \frac{1}{m}\sqrt{\frac{h}{4\pi}}$

The de Broglie wavelength of an electron moving in a circular orbit is $\lambda$. The minimum radius of orbit is:

(a) $\frac{\lambda}{4}$ ✓(b) $\frac{\lambda}{2\pi}$ (c) $\frac{\lambda}{4\pi}$ (d) $\frac{\lambda}{3\pi}$

b

$2\pi r = n\lambda \Rightarrow r = \left(\frac{n\lambda}{2\pi}\right)$ $n=1$

Uncertainty in position of a hypothetical subatomic particle is 1 Å and uncertainty in velocity is $\frac{3.3}{4\pi}\times 10^5$ m/s then the mass of the particle is approximately ($h$ = 6.6 x $10^{-34}$ Js):

(a) 2 x $10^{-28}$ kg (b) 2 x $10^{-27}$ kg (c) 2 x $10^{-29}$ kg (d) 4 x $10^{-29}$ kg

c

$\Delta x \times \Delta P = \frac{h}{4\pi} \Rightarrow 10^{-10} \times m \times \frac{3.3}{4\pi} \times 10^5 = \frac{6.6\times 10^{-34}}{4\pi}$

$m = 2\times 10^{-29}$ kg

The Schrodinger wave equation for hydrogen atom of 4s–orbital is given by:

$$\psi(r) = \frac{1}{16\sqrt{4}}\left(\frac{1}{a_0}\right)^{3/2}\left[(\sigma-1)(\sigma^2-8\sigma+12)\right]e^{-\sigma/2}$$

where $a_o$ = 1st Bohr radius and $\sigma = \frac{2r}{a_0}$. The distance from the nucleus where there will be no radial node will be:

(a) $r = \frac{a_0}{2}$ (b) $r = 3a_0$ (c) $r = a_o$ (d) $r = 2a_0$

The Schrodinger wave equation for hydrogen atom is

$\psi_{2s} = \frac{1}{4\sqrt{2\pi}}\left(\frac{1}{a_0}\right)^{3/2}\left(2-\frac{r}{a_0}\right)e^{-r/a_0}$, where $a_o$ is Bohr's radius. If the radial node in 2s be at $r_o$, then $r_0$ would be equal to:

(a) $\frac{a_0}{2}$ (b) $2a_0$ (c) $\sqrt{2}a_0$ (d) $\frac{a_0}{\sqrt{2}}$

For an orbital, having no planar angular nodes following the equation:

$$\psi_{(r)} = Ke^{-r/K'}.r^2\left(K''-r\right)$$

Identify the orbital:

(a) $4d_{z^2}$ (b) 2s (c) $3d_{z^2}$ (d) $4d_{xy}$

$\Psi_{(r)} = ke^{-r/k_1}.r^2\left(r^2-k_2r+k_3\right)$. If the orbital has no nodal plane, then, orbital can be:

(a) $5d_{xy}$ (b) $5d_{z^2}$ (c) $4d_{z^2}$ (d) $4p_x$

For the wave function

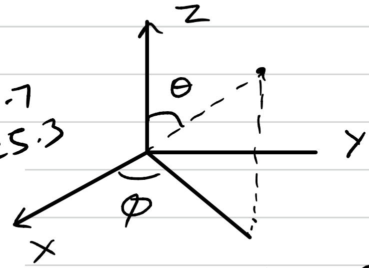
$$\Psi = \frac{\sqrt{2}}{81\sqrt{\pi}a_0^{3/2}}\left[6-\frac{r}{a_0}\right]\frac{r}{a_0}\times e^{-r/3a_0}\sin\theta.\cos\phi$$

Identify the orbital.

(a) $3p_x$ (b) $3p_y$ (c) $3p_z$ (d) $6p_x$ or $6p_y$ or $^6P_z$

## ③ d orbital:- No of angular node = $l$ = 2

$\theta = 54.7$
$\theta = 125.3$




$d_{z^2}$ -orbital : $\ell = 2,\ m = 0$ $\qquad \Theta(\theta)\ .\ \Phi(\phi) = \sqrt{\frac{5}{16\pi}}(3\cos^2\theta - 1)$

$d_{x^2-y^2}$ -orbital : $\ell = 2,\ m = -2$ $\qquad \Theta(\theta)\ .\ \Phi(\phi) = \sqrt{\frac{15}{4\pi}}\cdot\sin^2\theta\cos 2\phi$ $\Rightarrow (\theta = 0, \phi = \frac{\pi}{4})\ (\theta = 0, \phi = \frac{3\pi}{4})$

$d_{xy}$ -orbital : $\ell = 2,\ m = +2$ $\qquad \Theta(\theta)\ .\ \Phi(\phi) = \sqrt{\frac{15}{4\pi}}\cdot\sin^2\theta\sin 2\phi$ $\Rightarrow (\theta = 0, \phi = 0),\ (\theta = 0, \phi = \frac{\pi}{2})$

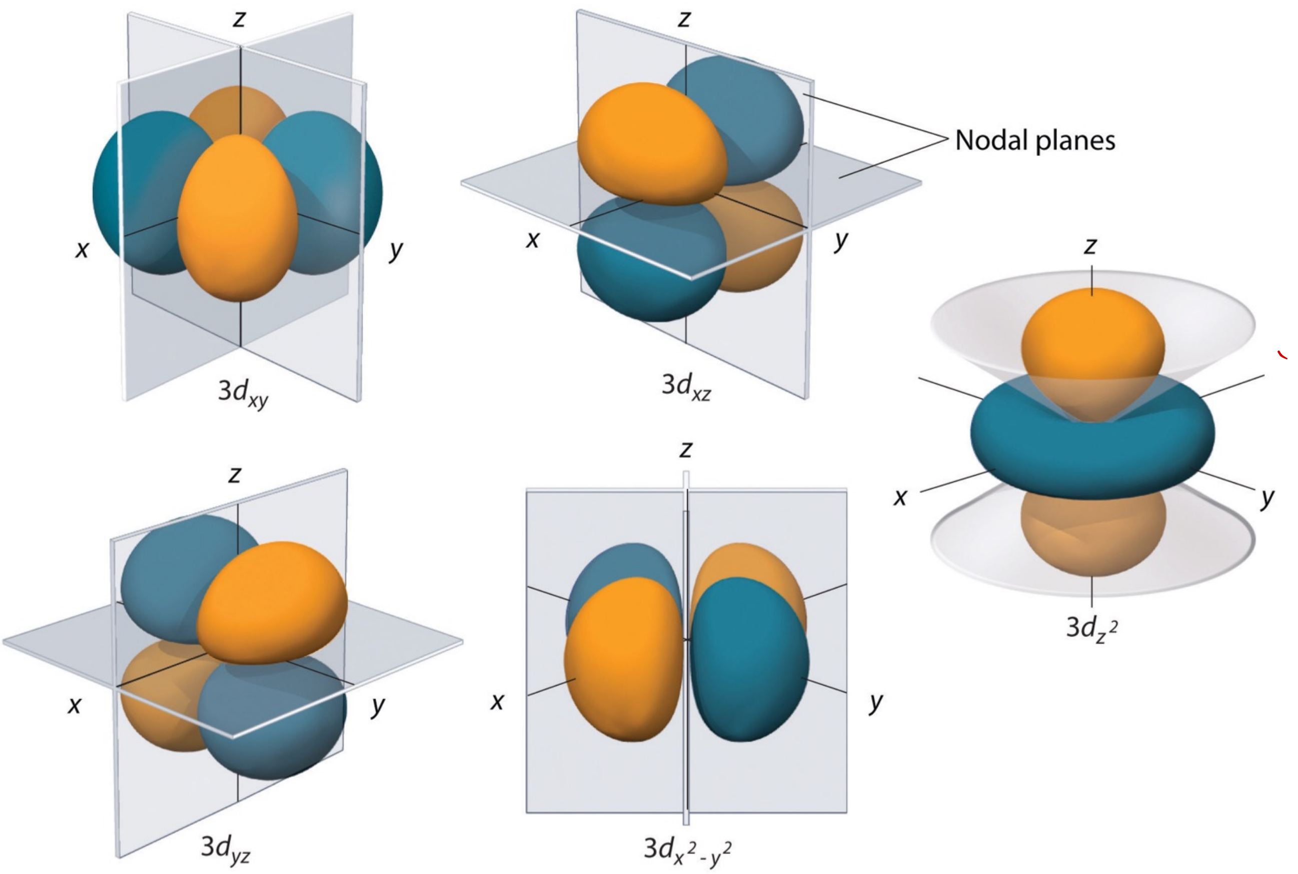
XZ YZ

$d_{xz}$ -orbital : $\ell = 2,\ m = +1$ $\qquad \Theta(\theta)\ .\ \Phi(\phi) = \sqrt{\frac{15}{4\pi}}\cdot\sin\theta\cos\theta\sin 2\phi$

$d_{yz}$ -orbital : $\ell = 2,\ m = +1$ $\qquad \Theta(\theta)\ .\ \Phi(\phi) = \sqrt{\frac{15}{4\pi}}\cdot\sin\theta\cos\theta\cdot\sin\phi$

$(\theta = 0, \phi = 0)\ (\frac{\pi}{2}, 0)$

XZ XY



## Note:

① Angular momentum $= m(r \times v) = mvr$

② Orbital Angular momentum $= \sqrt{l(l+1)}\left(\frac{h}{2\pi}\right)$ $\qquad \frac{h}{2\pi} = \hbar$

where $l$ = Azimuthal quantum No

③ Spin angular momentum $= \sqrt{s(s+1)}\,(h/2\pi)$

$\Rightarrow s = \frac{1}{2}$

$\alpha^1 = \alpha^1 \Rightarrow l = 1$

$n - l - 1 = 1 \Rightarrow n = 3$

3P

Prob:

**For the wave function**

$$\psi = \frac{\sqrt{2}}{81\sqrt{\pi}a_0^{3/2}}\left[6 - \frac{r}{a_0}\right]\frac{r}{a_0} \times e^{-r/3a_0}\ \sin\theta \cdot \cos\phi$$

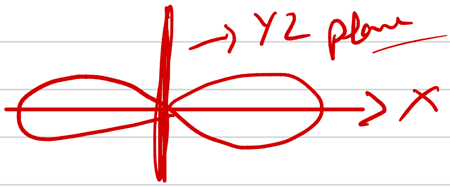
**Identify the orbital.**

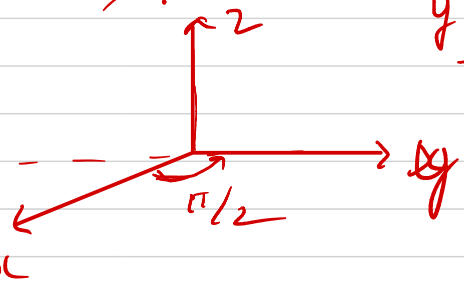
(a) $3p_x$ (b) $3p_y$

(c) $3p_z$ (d) $6p_x$ or $6p_y$ or $6p_z$

$\theta = 0,\ \phi = \pi/2$

y Z plane




$\alpha^l = \alpha^1 \Rightarrow l = 1$

$n - l - 1 = 3$

$n = 5$ 5P

**The wave function for an atomic orbital of single electron atom or ion is**

$$\psi(r, \theta, \phi) = \frac{2}{3}\left(\frac{Z}{3a_o}\right)^{3/2}(1-\sigma)(12 - 8\sigma + \sigma^2)\cdot\sigma\cdot e^{-\sigma/2}\cdot\cos\theta$$

$\theta = \pi/2 \Rightarrow xy$ plane

**where** $\sigma = \frac{2Zr}{na_o}$ **and** $a_o = 0.529$ **Å. All other parameters have their usual meaning.**

**43.** The number of radial and angular nodes for the orbital is, respectively,

(a) 3, 1 (b) 2, 1

(c) 3, 2 (d) 2, 2

**44.** The atomic orbital should be

(a) $4p$ (b) $5p$

(c) $5d$ (d) $5f$

**45.** If $\theta$ is the angle measured from $Z$-axis, then the orbital should be

(a) $p_x$ (b) $p_y$

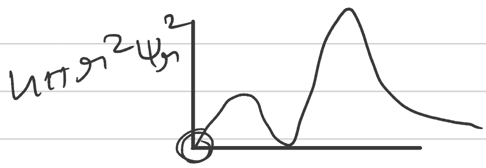
(c) $p_z$ (d) $d_{z^2}$

**46.** The maximum distance of radial node from the nucleus is

(a) $\frac{a_o}{Z}$ (b) $\frac{3a_o}{Z}$

(c) $\frac{6a_o}{Z}$ (d) $\frac{15a_o}{Z}$

$\sigma = 1, 2, 6 = \frac{2Zr}{na_0} \Rightarrow r = \frac{6 \times 5\, a_0}{2Z} = \frac{15a_0}{Z}$




Prob:

**Which statement is not true, regarding 2s orbital?**

(a) Number of radial nodes is greater than zero.

(b) Angular nodes is equal to zero.

(c) $\psi(\theta, \phi) =$ constant.

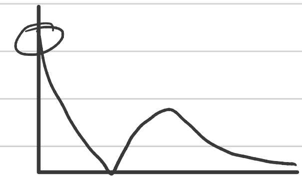
(d) Probability density is zero at nucleus.

+ve

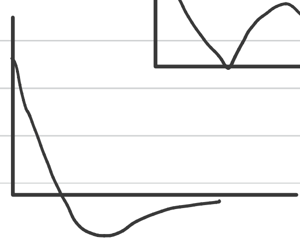
d

$n - l - 1 = 1$

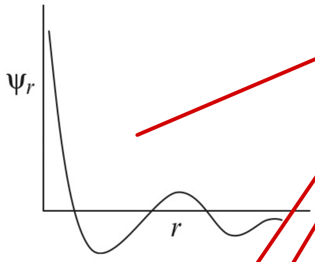
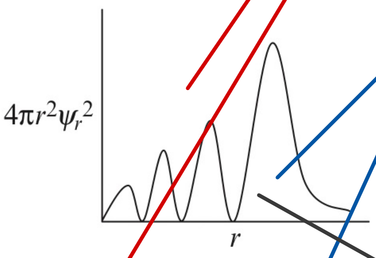
$l = 0$



$\psi^2 =$ Probability density



Match the columns.

| Column I | Column II |
|---|---|
| (A)   | (P) 4$s$ |
| (B)   | (Q) Any of the 5$p$ orbital. $n-l-1=3$ |
| (C) Angular wave function independent from θ and ϕ. | (R) 3$s$ $n-l-1=3$ |
| (D) At least one angular node. | (S) any of the 6$d$ orbital. |

**For an orbital,**

$$\psi_{300} = \frac{1}{81\sqrt{3}\pi}\left(\frac{z}{a_0}\right)^{3/2}[27 - 18u + 2u^2]\exp\left(\frac{-u}{3}\right)$$

**where,** $u = \dfrac{zr}{a_0}$

**What is the maximum radial distance of node from nucleus of He$^+$ ion?**

(a) $(3+\sqrt{3})\dfrac{3a_0}{2}$ (b) $(3+\sqrt{3})\dfrac{3a_0}{4}$

(c) $a_0$ (d) $\dfrac{a_0}{2}$