PROBLEM-SOLVING TACTICS

(a) This section of Physics is more fact-based. The key to answering questions of these sections is establish a lonk between the known and asked quantities

(b) One has to be very conversant with the formulae and standard scientific constants.

(c) In this section, graphical questions seeking relationship between various fundamental quantities are usually asked. Assign the dependent variable as y and the independent variable as x and then look for a relation between them.

(d) One must not get confused about approaching the questions from a wave nature or particle nature or try to combine both. Just solve questions on the basis of the known and asked quantities and the relationship between the two.

(e) It is important to learn the scientific constants in various units to avoid unnecessary unit conversion. (e.g., if energy of a photon is in eV units and wavelength asked in angstrom, one can directly use the relation = 12400/E, here 12400 is the product of Planck's constant and speed of light.)

(f) Analytical questions pertaining to H-atom can be solved easily if one knows proportionality relation between quantities. They need not be learnt by heart. They can be derived without bothering about constants appearing in these relations. (e.g., radius of nth shell is directly proportional to n^2, keeping Z constant.)

FORMULAE SHEET

Speed of E.M.W. in vacuum c = $3\times10^8\ m/s = \nu\lambda$

Each photon having a frequency ν and energy $E = h\nu = \frac{hc}{\lambda}$ where h = 6.63×10^{-34} Js is Planck's Constant

Einstein's Photo Electric Equation:

Photon energy = K.E. of electron + work function.

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

ϕ = Work function = energy needed by the electron in freeing itself from the atoms of the metal.

$$\phi = hv_0$$

The minimum value of the retarding potential to prevent electron emission is:

$$eV_{cut\ off} = (KE)_{max}$$

De Broglie wave length given by $\lambda = \frac{h}{p}$ (wave length of a particle)

The electron in a stable orbit does not radiate energy i.e. $\frac{mv^2}{r} = \frac{kZe^2}{r^2}$

A stable orbit is that in which the angular momentum of the electron about nucleus is an integral (n) multiple of $\frac{h}{2\pi}$ i.e. mvr = $n\frac{h}{2\pi}$; n = 1, 2, 3, ... $(n \neq 0)$.

For Hydrogen atom : (Z = atomic number = 1)

(i) L_n = angular momentum in the nth orbit = $n\frac{h}{2\pi}$

(ii) r_n = radius of nth circular orbit = $r_n = \frac{n^2h^2\varepsilon_0}{\pi me^2}$ (0.529 Å) n^2 ; (1 Å = 10^{-10} m) ; $r_n \propto n^2$

(iii) E_n energy of the electron in the nth orbit = $\frac{-13.6\text{eV}}{n^2}$ i.e. $E_n \propto \frac{1}{n^2}$

(iv) n^{th} orbital speed $v_n = \frac{e^2}{2\varepsilon_0 nh}$

Note: Total energy of the electron in an atom is negative, indicating that it is bound.

Binding Energy $(BE)_n = -E_n = \frac{13.6\text{eV}}{n^2}$

(iv) $E_{n_2} - E_{n_1}$ = Energy emitted when an electron jumps from n_2 orbit to n_1 orbit $(n_2 > n_1)$.

$$\Delta E = (13.6\text{ eV})\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

$\Delta E = h\nu$; ν= frequency of spectral line emitted.

Wave number= $\bar{\nu} = \frac{1}{\lambda}$ = [no. of waves in unit length (1m)] = $R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

Where R = Rydberg's constant for hydrogen = $1.097 \times 10^7 m^{-1}$

(v) For hydrogen like atoms of atomic number Z:

$$r_{nz} = \frac{\text{Bohr radius}}{Z} \times n^2 = (0.529\text{Å})\frac{n^2}{Z} \;;$$

$$E_{nZ} = (-13.6)\frac{Z^2}{n^2}\text{ev}$$

Note: If motion of the nucleus is also considered, then m is replaced by μ.

Where μ = reduced mass of electron – nucleus system = $\frac{mM}{m+M}$

In this case, $E_n = (-13.6\,\text{eV})\ \frac{Z^2}{n^2} \cdot \frac{\mu}{m_e}$

Excitation potential for quantum jump from $n_1 \rightarrow n_2$ = $\frac{E_{n_2} - E_{n_1}}{\text{electron charge}}$

From Mosley's Law $\sqrt{\nu} = a(z-b)$ where b (shielding factor) is different for different series.

For x-rays $\frac{1}{\lambda} = R \times (Z-b)^2 \times \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

$R = R_0 A^{1/3}$. Where R_0 = empirical constant = 1.1×10^{-15}m ; A = Mass number of the atom.