ADVANCED CHEMISTRY

QUANTUM MECHANICS H.W.#① WINTER 2008

Chapter 9

③ $\lambda = 200\ nm$

$$h\nu = \frac{hc}{\lambda} = \frac{(6.626\times10^{-34}\ J\,s)(2.99\times10^{8}\ m\,s^{-1})}{200\ nm \times \left(\frac{10^{-9}\ m}{1\ nm}\right)}$$

$$h\nu = 9.9059\times10^{-19}\ J$$

$$\frac{1}{2}mv^2 = \frac{1}{2}(9.109\times10^{-31}\ kg)(7.42\times10^{5}\ m\,s^{-1})^2$$

$$= 2.508\times10^{-19}\ J \qquad (kg\,m^2\,s^{-2} = J)$$

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

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

$$= 9.9059\times10^{-19}\ J - 2.508\times10^{-19}\ J$$

$$= 7.39\times10^{-19}\ J$$

$$\phi = 7.39\times10^{-19}\ J \times \frac{eV}{1.602\times10^{-19}\ J} = \underline{4.62\ eV}$$

④ $\lambda = 0.2\ nm = 0.2\times10^{-9}\ m$

$$h\nu = \frac{hc}{\lambda} = \frac{(6.626\times10^{-34}\ J\,s)(2.99\times10^{8}\ m\,s^{-1})}{(0.2\times10^{-9}\ m)}$$

$$h\nu = 9.906\times10^{-16}\ J = 9.906\times10^{-16}\ J \times \frac{eV}{1.602\times10^{-19}\ J}$$

$$h\nu = 6183.44\ eV$$

If $\phi = 10\ eV$

$$\frac{1}{2}mv^2 = h\nu - \phi = 6183.44\ eV - 10\ eV = 6173.44\ eV$$

$$v^2 = \frac{2\,(6173.44\ eV)}{9.109 \times 10^{-31}\ kg} \cdot \left(\frac{1.602 \times 10^{-19}\ J}{eV}\right)$$

$$= 2.171 \times 10^{15}\ m^2 s^{-2}$$

$$v = \underline{\underline{4.66 \times 10^{7}\ ms^{-1}}}$$

If $\phi = 100\ eV$

$$\frac{1}{2}mv^2 = h\nu - \phi = 6183.44\ eV - 100\ eV = 6083.44\ eV$$

$$v = \sqrt{\frac{2\,(6083.44\ eV)}{9.109 \times 10^{-31}\ kg} \left(\frac{1.602 \times 10^{-19}\ J}{eV}\right)}$$

$$= \underline{\underline{4.63 \times 10^{7}\ ms^{-1}}}$$

If $\phi = 500\ eV$

$$\frac{1}{2}mv^2 = h\nu - \phi = 6183.44\ eV - 500\ eV = 5683.44\ eV$$

$$v = \sqrt{\frac{2\,(5683.44\ eV)}{9.109 \times 10^{-31}\ kg} \cdot \left(\frac{1.602 \times 10^{-19}\ J}{eV}\right)}$$

$$= \underline{\underline{4.47 \times 10^{7}\ ms^{-1}}}$$

⑤ (a) energy = 1000 eV (one $\bar{e}$ w/ 1000 V potential drop)

$$\frac{1}{2}mv^2 = 1000\ eV \times \left(\frac{1.602\times10^{-19}\ J}{1\ eV}\right) = 1.602\times10^{-16}\ J$$

$$v^2 = \frac{2\,(1.602\times10^{-16}\ J)}{(9.109\times10^{-31}\ kg)} = 3.517\times10^{14}\ m^2 s^{-2}$$

$$v = 1.875\times10^{7}\ m s^{-1}$$

$$\lambda = \frac{h}{mv} = \frac{6.626\times10^{-34}\ J s}{(9.109\times10^{-31}\ kg)(1.875\times10^{7}\ m s^{-1})}$$

$$= 3.879\times10^{-11}\left(\frac{J s}{kg\ m s^{-1}}\right) \longrightarrow \frac{(kg\ m^2 s^{-2})(s)}{(kg\ m\ s^{-1})}$$

$$= 3.879\times10^{-11}\ m \times \frac{10^9\ nm}{m}$$

$$\lambda = \underline{\underline{3.88\times10^{-2}\ nm}}$$

(b) energy of the electron that strike the solid $= 1000\ eV = 1.602\times10^{-16}\ J$

without any energy loss, this energy is then transferred to x-ray radiation.

Energy of x-ray radiation $= 1.602\times10^{-16}\ J = \frac{hc}{\lambda}$

$$\lambda = \frac{(6.626\times10^{-34}\ J s)(2.99\times10^{8}\ m s^{-1})}{(1.602\times10^{-16}\ J)}$$

$$\lambda = 1.24 \times 10^{-9}\ m = \underline{1.24\ nm}$$

(9) (a) $\lambda = \dfrac{h}{mv}$

$$\lambda = \frac{(6.626 \times 10^{-34}\ Js)}{(1.0g)\ (300\ ms^{-1})} \left(\frac{10^{+3}\ g}{kg}\right) = \underline{2.209 \times 10^{-33}\ m}$$

(b) $\lambda = \dfrac{(6.626 \times 10^{-34}\ Js)}{(10^{-6}\ g)\ (10^{-6}\ ms^{-1})} \left(\frac{10^{3}\ g}{kg}\right) = \underline{6.626 \times 10^{-19}\ m}$

(c) $\lambda = \dfrac{(6.626 \times 10^{-34}\ Js)}{(10^{-10}\ g)\ (10^{-10}\ ms^{-1})} \left(\frac{10^{3}\ g}{kg}\right)$ $\underline{6.626 \times 10^{-11}\ m}$

(d) mass of H_2 molecule $= 2\left(\frac{1.008\ g}{mol}\right) \times \left(\frac{1\ mol}{6.02 \times 10^{23}\ molecules}\right)$

$$= 3.349 \times 10^{-24}\ g = 3.349 \times 10^{-27}\ kg$$

$$\text{Energy} = \frac{1}{2}mv^2 = \left(\frac{mv^2}{2}\right)\cdot\left(\frac{m}{m}\right) = \frac{m^2v^2}{2m}$$

$\therefore\ m^2v^2 = 2m(\text{energy})$

$$mv = \sqrt{2m(\text{energy})}$$

$$mv = \sqrt{2(3.349 \times 10^{-27}\ kg)\left(\frac{3}{2} \times 1.381 \times 10^{-23}\ J\ K^{-1} \times 20\ K\right)}$$

$= 1.666 \times 10^{-24}\ kg\ ms^{-1}$

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$$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34}\ Js}{1.666 \times 10^{-24}\ kg\ ms^{-1}} = 3.98 \times 10^{-10}\ m$$