Assignment

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Question 4 Solution

Part a

For an electron with rest energy of 1 ev:

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2km}}$$

$$\lambda = \frac{6.26 \times 10^{-34} Js}{\sqrt{2 \times 1ev \times 511Kev/c^2}}$$

$$\lambda = 1.23nm$$

Part b

We need to first find the momentum of the benzene molecule:

$$p = mv = 78g/mol \times 1m/s = 1.295 \times 10^{-25} kgm/s$$

The de Broglie wave length is given by:

$$\lambda = \frac{h}{p} = \frac{6.26 \times 10^{-34} Js}{1.295 \times 10^{-25} kgm/s}$$

$$\lambda = 0.512nm$$

Question 5 Solution

We know that uncertainty principle is given by:

$$\Delta x \times \Delta p = \frac{h}{4\pi}$$

But, we also know, from de Broglie's law, that:

$$\lambda = \frac{h}{p} \implies \frac{\Delta p}{p} = \frac{\Delta \lambda}{\lambda}$$

$$\Delta p = p\frac{\Delta \lambda}{\lambda} = \frac{h}{\lambda}\frac{\Delta \lambda}{\lambda} = \frac{h\Delta \lambda}{\lambda^2}$$

$$\Delta p = \frac{\Delta \lambda h}{\lambda^2} = \frac{10^{-6} \times 6.626 \times 10^{-34} Js}{(10^{-10} m)^2} = 6.626 \times 10^{-20} kgm/s$$

Which means,

$$\Delta x = \frac{h}{\Delta p \times 4\pi} = \frac{6.62 \times 10^{-34} Js}{6.62 \times 10^{-20} kgm/s \times 4\pi}$$

$$\Delta x = \frac{10^{-14}}{4\pi} m$$

Question 10 Solution

Part a

The zero point energy is:

$$E = h\omega(0 + \frac{1}{2}) = \frac{h\omega}{2}$$

ω is given as follows:

$$\omega = \sqrt{\frac{K}{\mu}}$$

$$\omega = \sqrt{\frac{480.6 Nm^{-1}}{6.053 \times 10^{-25} kg}} = \sqrt{7.94 \times 10^{24}/s^2}$$

$$\omega = 2.82 \times 10^{12}/s$$

We can now calculate the energy since we have ω

$$E = \frac{h\omega}{2}$$

$$E = \frac{6.626 \times 10^{-34} Js \times 2.82 \times 10^{12}/s}{2}$$

$$E = 9.34 \times 10^{-22} J$$

Part b

The zero point energy is:

$$E = h\omega(0 + \frac{1}{2}) = \frac{h\omega}{2}$$

ω is given as follows:

$$\omega = \sqrt{\frac{K}{\mu}}$$

$$\omega = \sqrt{\frac{480.6 Nm^{-1}}{0.036458 kg}} = \sqrt{13182.2/s^2} = 114.8/s$$

We can now calculate the energy since we have ω

$$E = \frac{h\omega}{2}$$

$$E = \frac{6.626 \times 10^{-34} Js \times 114.8/s}{2}$$

$$E = \frac{7.61 \times 10^{-32} J}{2}$$

$$E = 3.80 \times 10^{-32} J$$

Question 11 Solution

The transmission coefficient is given as follows:

$$T \approxeq e^{-2bL} \text{ such that } b = \sqrt{\frac{8\pi^2 m(U_b - E)}{h^2}}$$

We first need to calculate b:

$$b = \sqrt{\frac{8\pi^2 m(U_b - E)}{h^2}} = \sqrt{\frac{8\pi^2 \times 9.11 \times 10^{-31} kg(5ev - 1ev)}{(6.626 \times 10^{-34} Js)^2}}$$

$$b = \sqrt{\frac{8\pi^2 \times 9.11 \times 10^{-31} kg(4ev)}{(6.626 \times 10^{-34} Js)^2}}$$

$$b = \sqrt{1.05 \times 10^{20}/m^2} = 1.025 \times 10^{10}/m$$

We can now find the transmission coefficient:

$$T \approxeq e^{-2bL}$$

$$T \approxeq e^{-2 \times 1.025 \times 10^{10}/m \times 2 \times 10^{-9} m}$$

$$T \approxeq e^{-40.99}$$

$$T \approxeq 1.59 \times 10^{-18}$$

Question 10 Solution