Numerical solution Key for tutorial 1

Q1. a. $\lambda = h/mv = 4.8 \times 10^{-34}$ m

b. $\lambda = 0.729$ Å

Q2. $\lambda = h/p = h/\sqrt{2mE_K}$

$= 0.02866$ Å

$E_K = \frac{1}{2}mv^2$

(Kinetic energy)

Q3. H_2 molecule $=$ 2 protons + 2 electrons

$m_{H_2} = 2\, m_{Proton} + 2\, m_{electron}$

$\lambda = h/m_{H_2}v = 1.085$ Å

Q4. For electron

$E_e = p^2/2m$

$\Rightarrow p = \sqrt{2mE_e}$

$\Rightarrow \lambda_e = h/\sqrt{2mE_e}$

For Photon

$E_p = hc/\lambda$

$\lambda = hc/E_p$

given $E_e = E_p$

$\frac{\lambda_e}{\lambda_p} = ?$

Q5. a. $E = eV = p^2/2m \Rightarrow p = \sqrt{2meV}$

$\lambda = h/p = \frac{1.228}{\sqrt{V}}$ nm $= 0.01228$ nm

b. $\lambda = h/mv = 0.2429$ nm

Q6. $\Delta E \cdot \Delta t = \hbar/2$

$\Delta t \rightarrow$ life time

$\Delta E = 56$ MeV

$1 \text{ MeV} = 10^6 \text{ eV}$

distance travelled $= \Delta t \cdot v$

$= 5.86$ km

Q7. (i) $p = \sqrt{2meV} = 3.77 \times 10^{-23}$ kg m/s

(ii) $\lambda = 1.228/\sqrt{V}$ nm $= 0.0175$ nm

(iii) $|\vec{k}| = 2\pi/\lambda = 359 \text{ nm}^{-1}$

Q8. $\Delta E \cdot \Delta t = \hbar/2$

$\Delta E = \hbar/2\Delta t = 0.5275$ J

show it in eV

Q9. $\Delta P_{max} = P = mv$

$\Delta P_{max} \cdot \Delta x_{min} = \hbar/2$

$\Rightarrow \Delta x_{min} = \hbar/2\Delta P_{max} = 0.0193$ nm

Q10. $\Delta x = 0.02$ nm

$\Delta P_x = \hbar/2\Delta x = 2.638 \times 10^{-24}$ kgm/s

Numerical solution key for tutorial 2

Q1. a., d. & e. are well behaved.

Q2. $$\nabla^2 \psi = \underbrace{-(k_1^2 + k_2^2 + k_3^2)}_{\text{eigen value}} \psi$$

Q3. (i) $\int_{-\infty}^{\infty} \psi^* \psi \, dx = 1$ $\qquad a = \sqrt{3}$

(ii) $\int_{-0.45}^{0.55} \psi^* \psi \, dx$

(iii) $\langle x \rangle = \int_{-\infty}^{\infty} \psi^* x \psi \, dx$

$= 3/4$

Q4. (i) yes if $\hat{p}_x \psi = p \psi$ otherwise no.

(ii) $\langle \hat{p}_x \rangle = \int_{-\infty}^{\infty} \psi^* \hat{p}_x \psi \, dx$

$= -3i\hbar$

Q5. If $\int_{-\infty}^{\infty} \psi^* \psi \, dx$ if finite, it is normalizable otherwise no.

Q6. $\int_{-\infty}^{\infty} \psi^* \psi \, dx = 1$ $A = (2a/\pi)^{1/4}$

Q7. use $\hat{H}\psi = E\psi$

or $\left[-\frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2} + V(x)\right]\psi = E\psi$ to find E

$E = a\hbar/\sqrt{2m}$

Q8. use Schrodinger eq^n to find $V(x)$

Q9. consult ppt.

Numerical Solution Key for tutorial 3

Q1. $\psi = \sqrt{\frac{2}{L}} \sin\left(\frac{n\pi x}{L}\right)$

(i) find $\int_{-0.45}^{0.55} \psi^* \psi \, dx = 0.64\%$

$(n=2)$

(ii) $\langle x \rangle = \int_{-\infty}^{\infty} \psi^* x \psi \, dx = \int_{0}^{L} \psi^* x \psi \, dx = L/2$

Q2. $E = \frac{1}{2} m v^2 = \frac{\hbar^2 \pi^2}{2mL^2} n^2$ $\quad n = ?$

Q3. (i) $E_2 - E_1 = 113.27 \text{ eV}$

(ii) $\nu = (E_2 - E_1)/h = 0.11 \text{ nm}$

(iii) UV region

Q4. $E_4 - E_2 = h\nu \Rightarrow L = \sqrt{\frac{6\hbar^2\pi^2}{mL\nu}} = 1.784 \text{ nm}$

Q5. $T = e^{-2K_2 L}$ $\quad K_2 = \sqrt{2m(V-E)}/\hbar$

a. $\frac{T_1}{T_2} = ?$

Q6. $T = e^{-2k_2 L}$ $k_2 = \frac{\sqrt{2m(V-E)}}{\hbar}$

$E = ?$

Q7. $T = 2.83\%$

Q8. $T = 3.1\%$

Q9. $|F| = \frac{dE}{dx}$ $E = \frac{\hbar^2 \pi^2}{2mL^2} n^2$

$= \left.\frac{\hbar^2 \pi^2}{mL^3}\right|_{L=0.1\,nm}$

$= 1.21 \times 10^{-7} n^2$ N

$= 1.21 \times 10^{-7}$ N