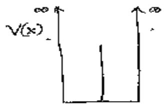
Applied Quantum Mechanics

Applied Quantum Mech. Exam 1.



1. $V(x) = \alpha\,\delta(x) \quad |x| < \frac{a}{2}$

$= \infty \quad |x| > \frac{a}{2}$

$-\frac{\hbar^2}{2m}\frac{d^2\psi}{dx^2} + V\psi = E\psi$ with $E > 0$.

where $V = 0$. $\frac{d^2\psi}{dx^2} = -\frac{2mE}{\hbar^2}\psi = -k^2\psi \qquad \psi \sim e^{\pm ikx}$

$k^2 = \frac{2mE}{\hbar^2}$.

a) $x<0 \qquad \psi_I(x) = A e^{ikx} + B e^{-ikx}$

$x>0 \qquad \psi_{II}(x) = C e^{ikx} + D e^{-ikx}$.

b) b.c. at $x = -\frac{a}{2}$, $\psi_I = 0$. $\quad A e^{-ika/2} + B e^{ika/2} = 0 \Rightarrow B = -A e^{-ika}$

at $x = +\frac{a}{2}$, $\psi_{II} = 0 \quad C e^{ika/2} + D e^{-ika/2} = 0 \Rightarrow D = -C e^{ika}$

c) $\psi_I(0) = \psi_{II}(0) \Rightarrow \quad A + B = C + D$

Condition on derivative, at $x=0$.

$-\frac{\hbar^2}{2m}\Delta\left(\frac{d\psi}{dx}\right) + \alpha\psi(0) = 0 \quad$ or $\quad \Delta\left(\frac{d\psi}{dx}\right) = \frac{2m\alpha}{\hbar^2}\psi(0)$

This becomes $\left.\frac{d\psi_{II}}{dx}\right|_0 - \left.\frac{d\psi_I}{dx}\right|_0 = \frac{2m\alpha}{\hbar^2}\psi_I(0)$

$ik\left(Ce^{ikx} - De^{-ikx}\right)_0 - ik\left(Ae^{ikx} - Be^{-ikx}\right)_0 = \frac{2m\alpha}{\hbar^2}(A+B)$

or $\quad ik\left[C - D - A + B\right] = \frac{2m\alpha}{\hbar^2}(A+B)$

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