Problem Set 2
CHM102A

1. Considering nonrelativistic conditions (which is what this course is confined to), if a free electron has wave function $\psi(x,t) = sin(kx - \omega t)$, determine its de Broglie wavelength, momentum, kinetic energy and speed when k = 50 nm^{-1}.

2. A particle is in the nth Energy state $\psi_n(x)$ of an infinite square well potential with width L. Determine the probability $P_n\left(\frac{1}{a}\right)$ that the particle is confined to the first $\left(\frac{1}{a}\right)$ of the width of the well. Comment on the n-dependence of $P_n\left(\frac{1}{a}\right)$.

3. A particle is in a state described by a wavefunction:

$$\psi(x) = \cos\theta\, e^{ikx} + \sin\theta\, e^{-ikx}$$

with θ being a constant. What is the probability that the particle will be found with linear momentum $+k\hbar$? If it is only 25 percent certain that the particle has linear momentum $+k\hbar$, then what is the value of θ?

4. An electron in a one-dimensional box undergoes a transition from the n=3 level to the n=6 level by absorbing a photon of wavelength 500 nm. What is the width (L) of the box? Will the solution to the problem change if the electron is confined between $-\frac{L}{2}$ and $\frac{L}{2}$ instead of it being confined between 0 and L?

5. Simplify the operator: $\hat{O} = \left(\frac{d}{dx} - x\right)\left(\frac{d}{dx} + x\right) - \left(\frac{d}{dx} + x\right)\left(\frac{d}{dx} - x\right)$.