# Homework 7.2 – Quantum Models of Motion

Name: _____

**Excercise 7D.1(b)** (5 points)

Evaluate the linear momentum and kinetic energy of a free proton described by the wavefunction $e^{-ikx}$ with $k = 5\,nm^{-1}$

**Exercise 7D.8(a)** (5 points)

An electron is confined to a square well of length $L$. What would be the length of the box such that the zero-point energy of the electron is equal to its rest mass energy, $m_e c^2$? Express your answer in terms of the parameter $\lambda_C = {}^{h}/_{m_e c}$, the "Compton wavelength" of the electron.

**Exercise 7D.9(a)** (5 points)

For a particle in a box of length $L$ and in the state with $n = 3$, at what positions is the probability density at a maximum? At what positions is the probability density zero?

**Exercise 7D.15(b)** (5 points)

Suppose that a proton of an acidic hydrogen atom is confined to an acid that can be represented by a barrier of height $2.0\,eV$ and length $100\,pm$. Calculate the probability that a proton with energy $1.4\,eV$ can escape from the acid.

**Exercise 7E.2(a)** (5 points)

For a certain harmonic oscillator of effective mass $1.33 \times 10^{-25}\,kg$, the difference in adjacent energy levels is $4.82\,zJ$. Calculate the force constant of the oscillator

**Exercise 7E.5(a)** (5 points)

Assuming the vibrations of a $^{35}Cl_2$ molecule are equivalent to those of a harmonic oscillator with a force constant $k_f = 329\,Nm^{-1}$, what is the zero-point energy of vibration of this molecule? Use $m(^{35}\text{Cl}) = 34.9688\,m_u$.

**Exercise 7E.7(a)** (5 points)

How many nodes are there in the wavefunction of a harmonic oscillator with (i) $v = 3$; (ii) $v = 4$?

**Exercise 7F.1(b)** (5 points)

The rotation of a molecule an be represented by the motion of a particle moving over the surface of a sphere with angular momentum quantum number $l = 2$. Calculate the magnitude of its angular momentum and the possible components of the angular momentum along the z-axis. Express your results as multiples of $\hbar$.

**Exercise 7F.10(a)** (5 points)

How many angular nodes are there for the spherical harmonic $Y_{3,0}$ and at which values of $\theta$ do they occur?

**Exercise 7F.12(a)** (5 points)

What is the degeneracy of a molecule rotating with $J = 3$?