1. Describe Young's Double Slit experiment, how it works for both light and small particles. Explain how it tells us about wave-particle duality and the need for a wave function.

2. The potential $V(x) = A(e^{-bx} + dx^3)$ is shown in the figure below.
   a) Write the time-independent Schrodinger Equation for this potential. (You need not solve for $\psi(x)$, but extra credit will be awarded for doing so.)
   b) Write down all boundary conditions on $\psi(x)$ for this potential. (Note: In mathematical terms, infinity is a boundary.)
   c) If the energy is as shown, sketch $\psi(x)$. Explain.
   d) For the energy shown, are there bound states? Is energy quantized? Explain.

3. The wave function for a particular potential in polar coordinates is given as:
   $\Psi(r, t) = A \left( r^{1/2} e^{(-\alpha r^2 + iEt/\hbar)} \right)$, where $r$ is the radial coordinate (distance from the origin).
   a) Write the time-independent wave function, $\psi(r)$.
   b) Normalize $\Psi(r, t)$; that is, find $A$.
   c) Write an expression for the expectation value of kinetic energy ($p^2/2m$). You need not calculate the value (although you may if you wish, for extra credit).
4. When a particle in a particular potential is excited out of the ground (lowest energy) state, it quickly makes transitions back to the ground state by emitting photons. When a particular particle is excited, it is found to emit the following photons:

<table>
<thead>
<tr>
<th>Transition</th>
<th>Frequency (ν, in Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>From first excited state to ground</td>
<td>7.86 x 10^{16}</td>
</tr>
<tr>
<td>From second excited state to ground</td>
<td>2.10 x 10^{17}</td>
</tr>
<tr>
<td>From third excited state to ground</td>
<td>3.93 x 10^{17}</td>
</tr>
</tbody>
</table>

a) Based on this information, would you expect that the particle is in a square well (box) potential, or a simple harmonic oscillator potential? Explain.
b) What is the ground state energy of the particle, given that it is in that sort of potential?
c) If the particle had been in the other sort of potential, with the same ground state energy, what would be the frequency of the photons emitted in the transitions?

5. An electron whose kinetic energy is 1.0 eV is trapped in a cubic box of 1.0 m$^3$ with perfectly reflecting walls. What is the probability that the electron can be found in a volume element of 1.0 cm$^3$ in one of the corners of the wall? (Hint: Do not calculate (much). Think!) Explain your answer.