The initial state of a 1D PIB is

$$\Psi(x,0) = \frac{1}{\sqrt{2}}\left[\psi_1(x) + \psi_2(x)\right]$$

where $\psi_1(x)$ and $\psi_2(x)$ are the ground and first-excited PIB energy eigenstates. You measure the energy of the particle at time $t = 0$ and obtain E_1. Then immediately following the energy measurement at time $t = \delta t$, you measure the position of the particle.

What is the probability that you find the particle in the region between x_0 and $x_0 + dx$?

(a) $|\Psi(x_0, \delta t)|^2 dx$

(b) $x|\Psi(x_0, \delta t)|^2 dx$

(c) $|\psi_1(x_0)|^2 dx$

(d) $x|\psi_1(x_0)|^2 dx$

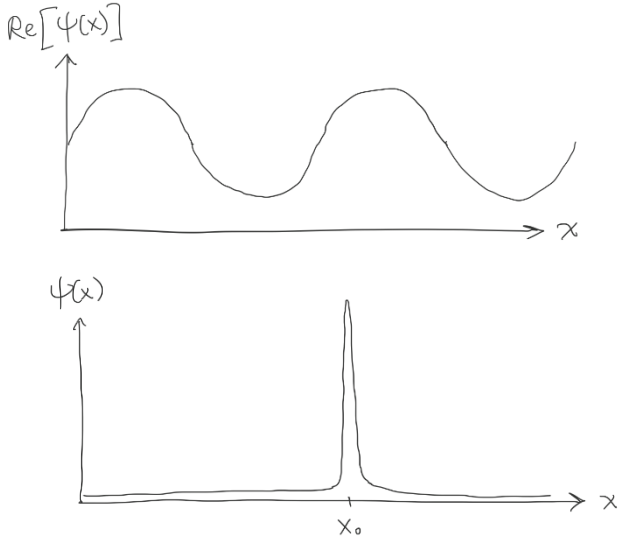
(e) None of the above

CHM 305 The Quantum World

Lecture 9: Quantum Tunneling

Last time we discussed the uncertainty principle

- The rules for quantum measurements and about “wavefunction collapse”
- Trade-offs in uncertainty between knowing a free particle’s momentum and position
- The variance and standard deviation as metrics for the uncertainty of a measurement
- Heisenberg’s uncertainty principle
- Consequences for operators that do and do not commute

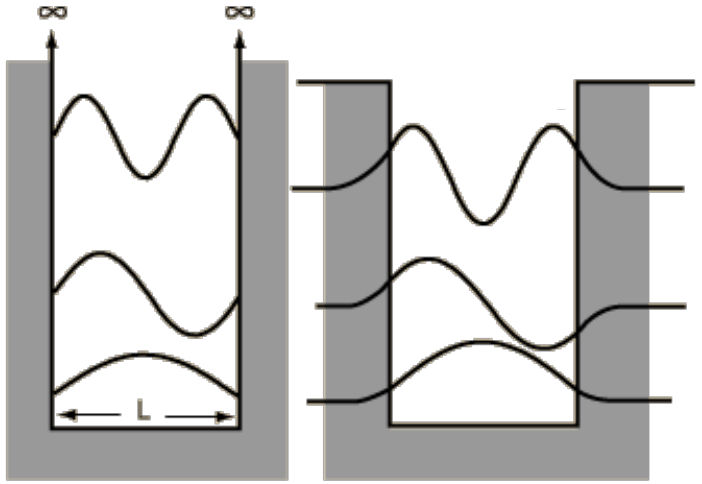


$$\sigma_A^2 = \langle A^2 \rangle - \langle A \rangle^2$$

$$\sigma_A^2 \sigma_B^2 \geq -\frac{1}{4}\left(\int \psi^* \left[\hat{A}, \hat{B} \right] \psi \, dx \right)^2$$

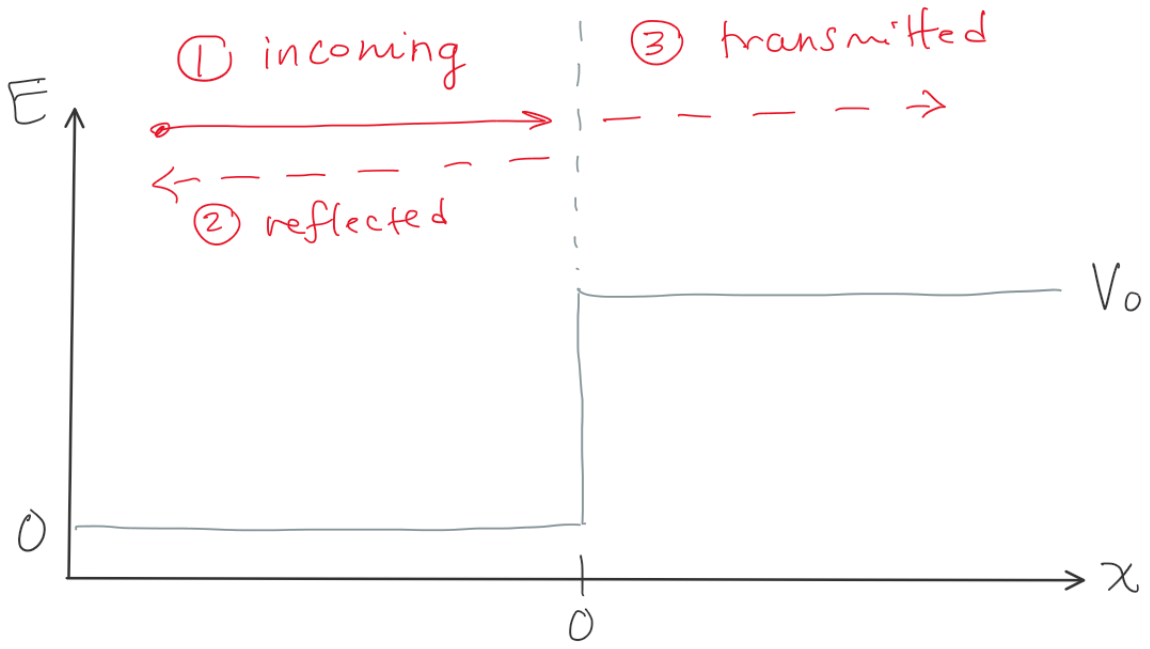
Road map for today's lecture

We will find wavefunction solutions for several problems involving potentials with *finite* walls



- Particle in a finite box
- Particle hitting a finite step
- Particle tunneling through a finite barrier
- How quantum tunneling can be important to chemical reactions

Practice Problem #1: Finite step potential



Qualitatively, what do you expect to happen for an incoming particle with $\mathbf{E < V_0}$?

Use what we learned about the particle in a finite box to write down general expressions for the three pieces of the total wavefunction:

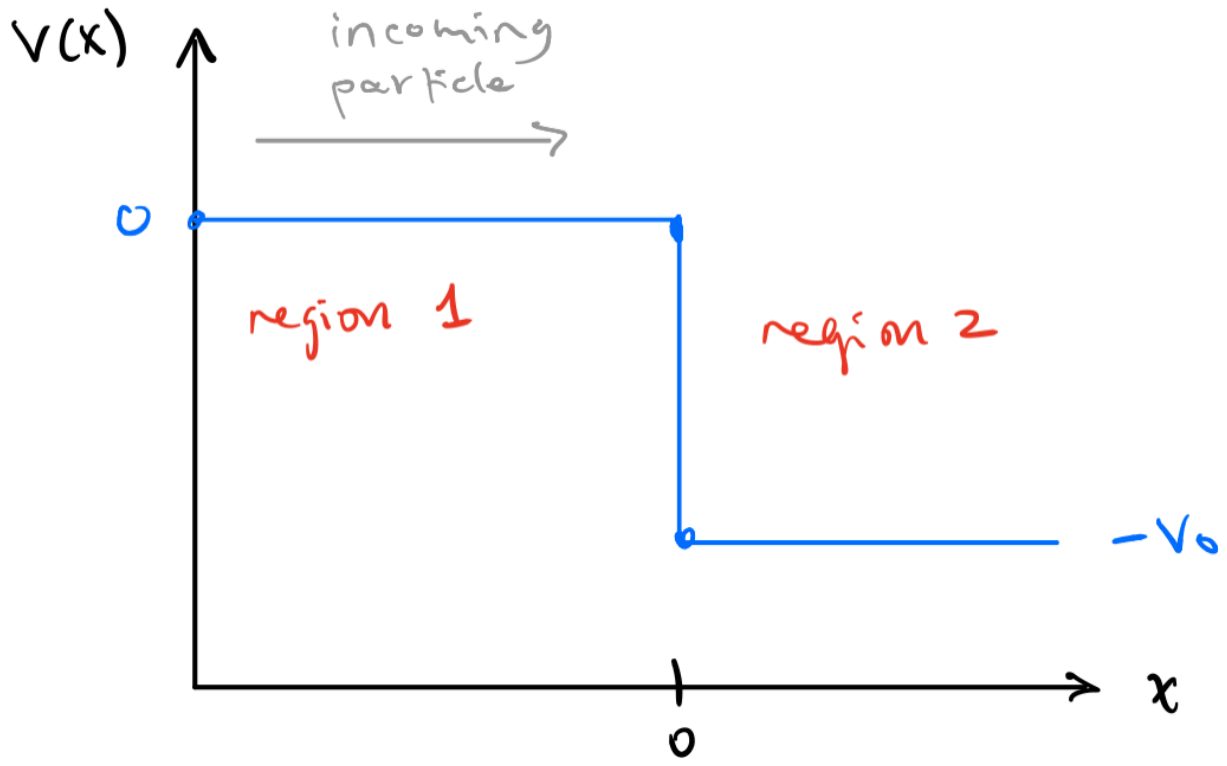
1. Incoming wave
2. Reflected wave
3. Transmitted wave

What are the relevant boundary conditions you would use to constrain these general expressions?

Wrapping up

- **Next time:** the quantum harmonic oscillator
- **Problem sets:** PS3 due Monday
- **Before you go:** muddiest point?

Practice Problem #2: A particle and a cliff



- Qualitatively, what do you expect to happen for a particle incoming from the left that hits a cliff where V(x) drops from 0 to $-V_0$?
- What would the wavefunctions look like in regions 1 and 2?
- What are the relevant boundary conditions?