PRACTICE PROBLEMS FOR EXAM 1 (CHM 3411)

ANSWERS WILL BE POSTED ON FRIDAY, FEB. 16

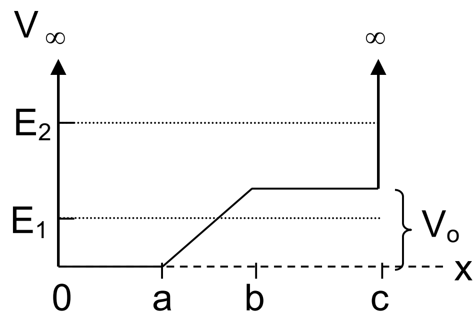
1. A photon of wavelength 465 nm encountering the surface of an unknown metal ejects an electron with a kinetic energy of 3.252×10^{-19} J.

(a) What is the minimum frequency of radiation required to eject an electron from the metal surface?

(b) What about this is contradictory to classical expectation?

2. For a particular diatomic molecule, absorption of light of wavelength 4292 nm causes a transition from the ground vibrational state (v=0) to the first excited vibrational state (v=1). Compute the zero-point energy for vibration of the molecule.

3. Consider the potential energy function sketched below. Two particular energy levels for consideration are labeled E_1 and E_2. The potential energy is infinite for $x < 0$ and $x > L$.



(a) On the figure above, sketch the wave functions [just the real parts, i.e. Re(ψ)] for particles with energies E_1 and E_2. No calculations are needed, but the wave functions should qualitatively show the important features. [The finely dashed lines at E_1 and E_2 are drawn for your convenience; offset the wave functions so that each is zero along the corresponding finely dashed line.]

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(b) Define three regions (ranges of x), and give the Schrödinger equation for each region.

(c) What boundary conditions are needed to obtain specific solutions to the Schrödinger equation for a particle confined to this "box" (i.e., the potential energy function sketched)?

(d) Discuss the concept of tunneling and how it relates to the wave functions you drew in part (a). Be sure to identify any tunneling regions for a particle with energy E_1 or energy E_2.

4. Consider a particle of mass m in a box of length L = 1 (neglecting units) which is in a state that is a superposition of sine functions:

$$\psi(x) = \left(\frac{1}{3}\right)^{1/2} \phi_1 + \left(\frac{2}{3}\right)^{1/2} \phi_1$$

$\phi_1(x)$ and $\phi_2(x)$ are orthonormal functions (over the interval $0 < x < 1$) defined by:

$$\phi_1(x) = \sqrt{2}\sin(\pi x)$$
$$\phi_2(x) = \sqrt{2}\sin(2\pi x)$$

(a) Show that $\phi_1(x)$ and $\phi_2(x)$ are eigenfunctions of the kinetic energy operater, $\hat{E}_K$, but $\psi(x)$ is not.

(b) What is the expectation value of E_K (in terms of m)?

(c) Suppose a single measurement of the kinetic energy, E_K, is made. What possible values might be obtained (your answer should be in terms of m)?