PHY3101
3-24-99

Name:______________________
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Midterm 2

Closed book exam. One 8.5x11" study sheet is allowed. A calculator is allowed also.
Exam is worth 30 points, 15% of your total grade.

Forms of the Schrodinger equation:

$$-\frac{\hbar^2}{2m}\frac{\partial^2\psi}{\partial x^2}+V(x,t)\psi = i\hbar\frac{\partial\psi}{\partial t} \qquad -\frac{\hbar^2}{2m}\frac{d^2\psi}{dx^2}+V(x)\psi = E\psi$$

Constants and equations:

$h = 6.6261\cdot 10^{-34}$ J-s	$c = 3.0\cdot 10^{8}$ m/s	$e = 1.6022\cdot 10^{-19}$ C
$h = 4.1357\cdot 10^{-15}$ eV-s	$\lambda\nu = c$	1 eV $= 1.6022\cdot 10^{-19}$ J
$hc = 1240$ eV-nm	$E_\gamma = h\nu$	1 MeV $= 10^6$ eV
$\hbar = h/2\pi = 1.0546\cdot 10^{-34}$ J-s	$\lambda = h/p$	1 nm $= 10^{-9}$ m
$\hbar = 6.5821\cdot 10^{-16}$ eV-s	1 Watt = 1 J/s	1 MHz $= 10^6$ s^{-1}
$m_e = 9.11\cdot 10^{-31}$ kg	$m_p = 1.673\cdot 10^{-27}$ kg	$m_\alpha = 1.881\cdot 10^{-28}$ kg
$m_e = 0.511$ MeV$/c^2$	$m_p = 938.3$ MeV$/c^2$	$m_\alpha = 105.7$ MeV$/c^2$
$\frac{e^2}{4\pi\varepsilon_0} = 1.44\cdot 10^{-9}$ eV-m	$\mathbf{F} = q(\mathbf{E}+\mathbf{v}\cdot\mathbf{B})$	$W = qV$

$$R_\infty = \frac{E_0}{hc} = 1.09737\cdot 10^7\ \text{m}^{-1} \qquad R_H = \frac{E_0}{hc} = 1.09678\cdot 10^7\ \text{m}^{-1}$$

$$\frac{1}{\lambda} = R\left(\frac{1}{n_l^2}-\frac{1}{n_u^2}\right) \qquad a_0 = \frac{4\pi\varepsilon_0\hbar^2}{me^2} = 0.53\cdot 10^{-10}\ \text{m}$$

$$E_n = \frac{-Z^2e^4m_e}{2\hbar^2(4\pi\varepsilon_0)^2n^2} = (-13.6\ \text{eV})\ \frac{Z^2}{n^2} \qquad \propto_B = \frac{e\hbar}{2m_e} = 5.7884\cdot 10^{-5}\ \text{eV/T}$$

$$\Delta x\,\Delta p \ge \hbar/2 \qquad \Delta E\,\Delta t \ge \hbar/2$$

$$\langle f(x)\rangle = \int \psi^*(x)f(x)\psi(x)dx$$

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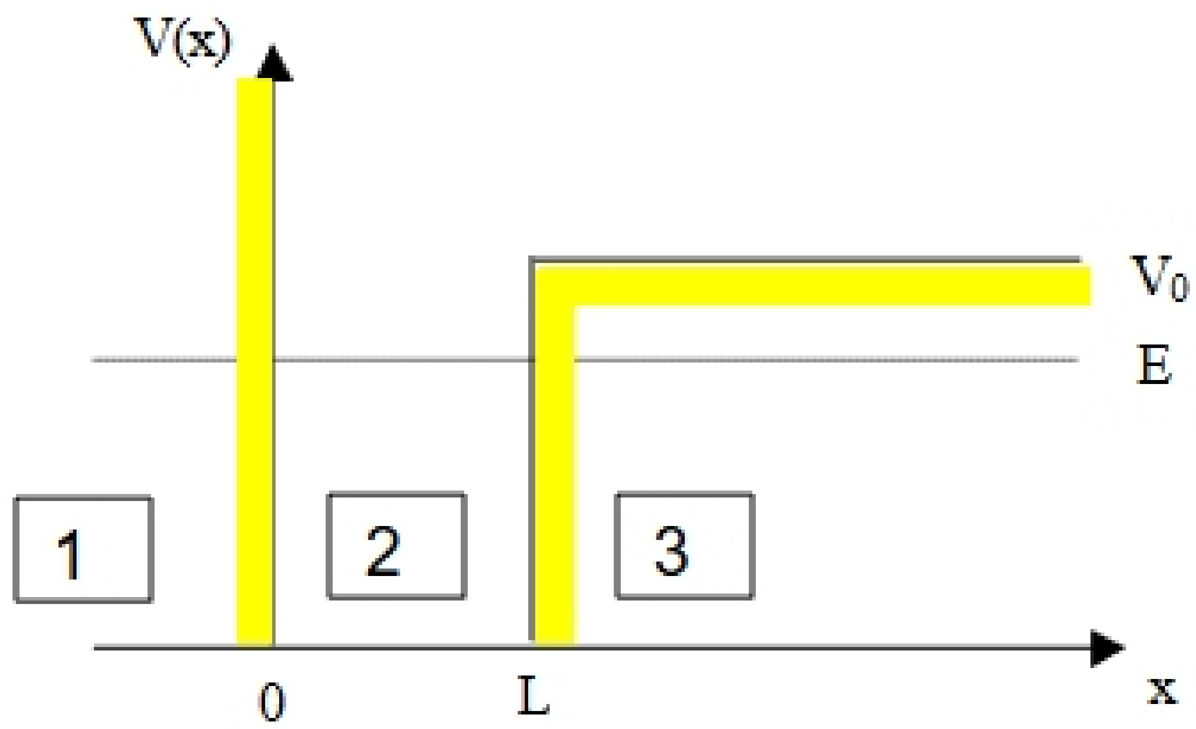
1. Consider the semi-infinite potential well shown below. The kinetic energy E of a particle of mass m is smaller than the barrier height V_0, so it is trapped in the well.



$$V(x) = \begin{cases} \infty & x < 0 \\ 0 & 0 \le x < L \\ V_0 & x \ge L \end{cases}$$

(a) [2 points] What is the wavefunction solution to the time-independent Schrodinger Equation for region 1 ($x < 0$)?

(b) [4 points] What is the general form of the wavefunction solution for region 2 ($0 \le x < L$) taking into account the boundary condition at $x = 0$? Express your answer as a function of (kx), and determine the constant k.

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(c) [4 points] What is the general form of the wavefunction solution for region 3 ($x \geq L$) taking into account the boundary condition at $x = \infty$? Express your answer as a function of $(\alpha\, x)$, and determine the constant α .

(d) [4 points] Determine two relations between the solution of region 2 and the solution of region 3 by applying boundary conditions at $x = L$.