PHY3101
3-29-00

Name:______________________

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	$\lambda f = c$	1 eV $= 1.6022 \cdot 10^{-19}$ J
$hc = 1240$ eV-nm	$f = E/h$	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	$m_\propto = 1.881 \cdot 10^{-28}$ kg
$m_e = 0.511$ MeV / c^2	$m_p = 938.3$ MeV / c^2	$m_\propto = 105.7$ MeV / c^2
$\frac{e^2}{4\pi\varepsilon_0} = 1.44 \cdot 10^{-9}$ eV-m	$\mathbf{F} = q(\mathbf{E} + \mathbf{v} \cdot \mathbf{B})$	$W = qV$

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

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

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

$$\Delta x\, \Delta p \approx \hbar \qquad \Delta E\, \Delta t \approx \hbar$$

$$\langle \hat{f} \rangle = \int \psi^*(x)\, \hat{f}\, \psi(x) dx \qquad \int_0^\infty x^n e^{-x/\alpha} dx = n!\,\alpha^{n+1} \qquad n! = n\cdot(n-1)\cdot(n-2)\cdots 2\cdot 1$$

$$\int dx \sin^2 x = \frac{x}{2} - \frac{1}{4}\sin 2x \qquad \int dx\, x^2 \sin^2 x = \frac{x^3}{6} - \left(\frac{x^2}{4} - \frac{1}{8}\right)\sin 2x - \frac{x\cos 2x}{4}$$

$$I_n = \int_0^\infty x^n \exp(-\alpha x^2)\, dx \qquad I_0 = \frac{1}{2}\sqrt{\frac{\pi}{\alpha}} \qquad I_1 = \frac{1}{2\alpha} \qquad I_2 = \frac{1}{4\alpha}\sqrt{\frac{\pi}{\alpha}}$$

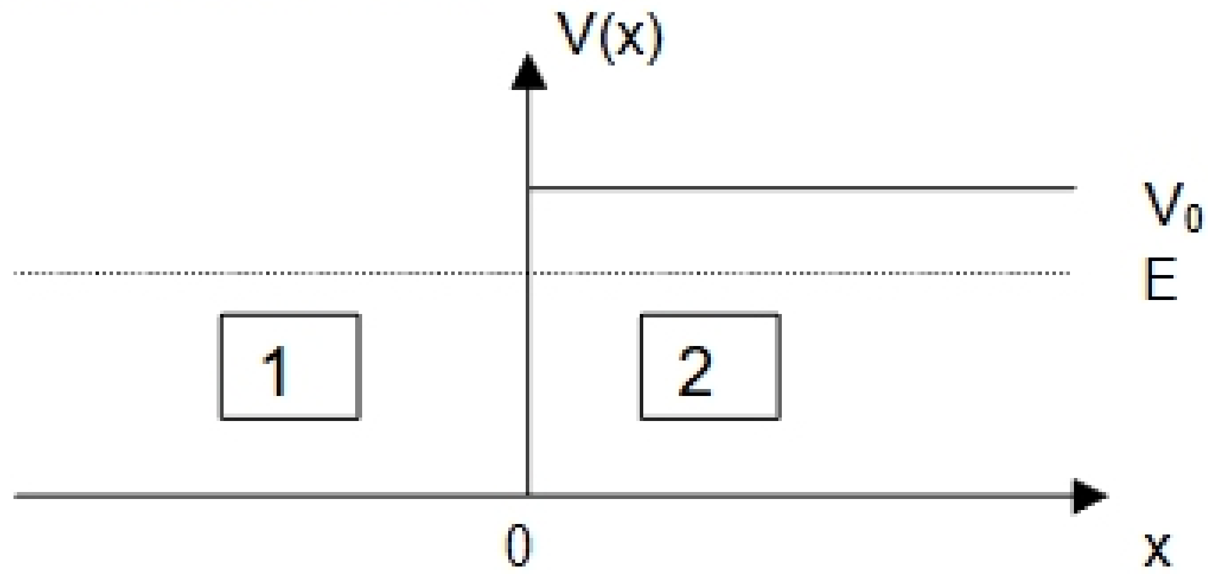
Name:______________________

1. [3 points] If the wavelength of an electron is known to be 1 nm, what is its kinetic energy?

2. [3 points] If the lifetime of an atom in an excited state is 1 ns (10^{-9} s), what is the intrinsic uncertainty in the energy of the photon emitted in the transition to the ground state?

Name:______________________

3. Consider the step potential shown below. The energy E of a particle of mass m is less than the barrier height V_0.



$$V(x) = \begin{Bmatrix} V_0 & x > 0 \\ 0 & x \le 0 \end{Bmatrix}$$

(a) [3 points] The solution to the time-independent Schrodinger Equation for region 1 ($x<0$) can be written $\psi_1(x) = e^{ikx} + R e^{-ikx}$. What is the constant k?

(b) [4 points] Solve the time-independent Schrodinger Equation to obtain the *general* solution for region 2 ($x > 0$). You should have at least one constant analogous to k in region 1 which depends on the barrier height, the particle energy, the particle mass, and $\hbar$.

(c) [3 points] Apply the boundary conditions at $x = \infty$ and $x = 0$ to eliminate any constants and to solve the remaining constants in terms of R.