MID TERM #3

THIS EXAM CONSISTS OF 15 MULTIPLE-CHOICE PROBLEMS (2 POINTS EACH) PLUS TWO ESSAY QUESTIONS (20 POINTS) FOR A SCORE OF 50 POINTS..

IMPORTANT INFORMATION that you may need:

Speed of light in empty space (c)	3.0×10^8 m/s
Planck's constant (h)	6.626×10^{-34} J-sec
$\hbar = h/2\pi$	
Coulomb's constant (k)	8.99×10^9 N-m^2/C^2
Charge of an electron (e)	$1.6\text{x}10^{-19}$ C
Ground state energy of electron in Hydrogen	-13.6eV
Mass of electron (kg)	9.11×10^{-31} kg
Mass of proton or Mass of neutron (kg)	1.67×10^{-27} kg

hc = 1240 eV-nm
ke^2 = 1.440 eV-nm
1 electron – Volt = 1.602×10^{-19} Joules
1 nm = $1\text{x}10^{-9}$ m

Work functions of common metals: Sodium=2.28eV; Cadmium=4.07eV; Aluminum=4.08eV; Copper=4.7eV; Lead= 4.14eV; Silver= 4.73eV; Carbon= 4.81eV; Nickel= 5.01eV;

Atomic configurations: neutral Hydrogen (H): 1 proton, 1 electron;
neutral Helium (He): 2 protons, 2 neutrons, 2 electrons

Some Useful Equations:

$$-\frac{\hbar^2 \partial^2 \Psi(x,t)}{2m\partial x^2} + V(x,t)\Psi(x,t) = i\hbar \frac{\partial \Psi(x,t)}{\partial t}$$

$$-\frac{\hbar^2}{2m}\left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}\right)\psi(x,y,z) + V(x,y,z)\psi(x,y,z) = E\psi(x,y,z)$$

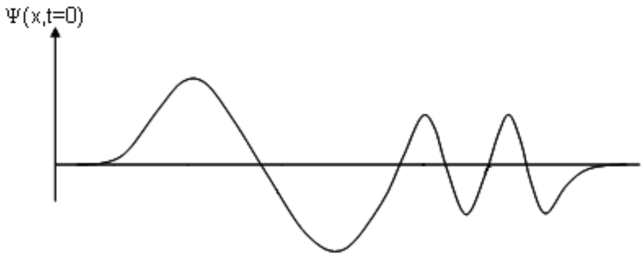
PRACTICE

<u>Honor Code Pledge</u>

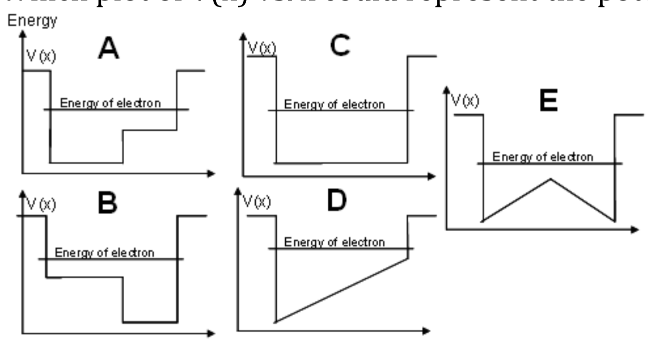
"On my honor as a University of Colorado at Boulder student I have neither given nor received unauthorized assistance on this work."

Signature: ______________________

1. An electron is bound in a potential well. The wave function of the electron is: $\Psi(x,t)=\psi(x)e^{-i\omega t}$ where $\psi(x)$ is shown below and ω is a real number.



Which plot of V(x) vs. x could represent the potential well in which this electron is bound?

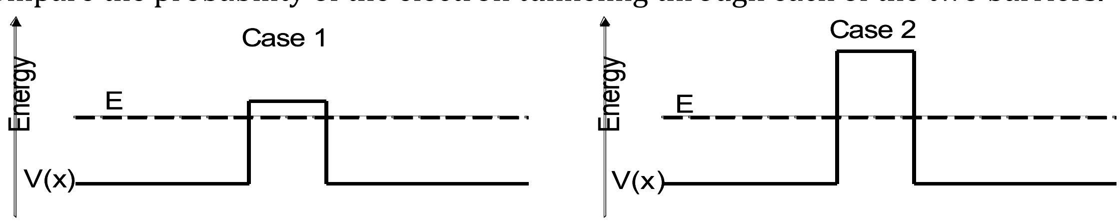


2. The f-orbitals in atoms include all the orbitals with ℓ quantum number of 3. What is the total number of wave functions/states with n=4, l=3?

a. 5 b. 7 c. 10 d. 12 e. 14

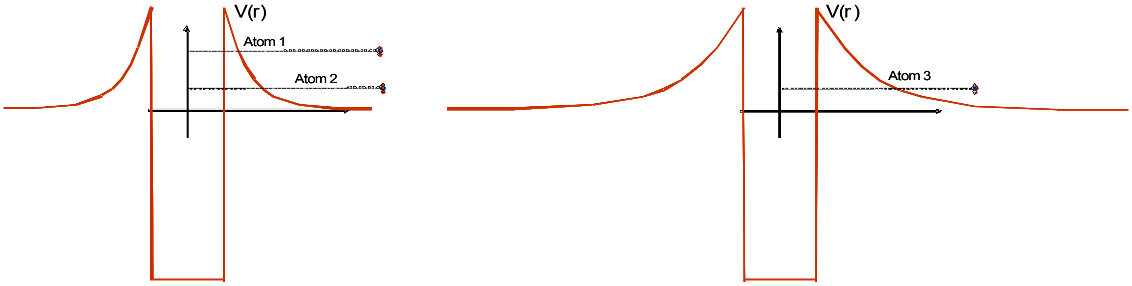
3. You have two wire-gap-wire situations as shown below. In each case, the gap between the wires forms a potential energy barrier that severely limits the current flow. An electron, with total energy shown as the dashed line, is traveling through the wire from left to right.

Compare the probability of the electron tunneling through each of the two barriers.



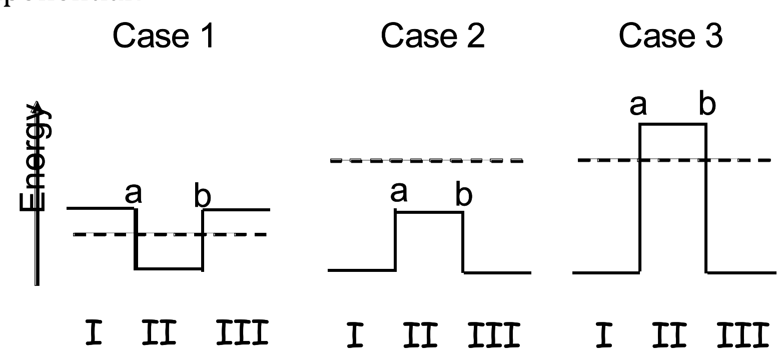
a. The tunneling probabilities for case 2 and case 1 will be the same.
b. The probability in case 2 will be greater than in case 1.
c. The probability in case 2 will be less than in case 1.
d. There is not enough information to compare the probabilities.

4. Atoms 1, 2, and 3 undergo alpha-decay. Atoms 1 and 2 are isotopes of each other. Their potential energy curve is shown along with the energies of the respective alpha-particles that are emitted (dashed lines labeled with atom #) when the atoms decay. Atom 3 has a different potential energy curve and the energy of its emitted alpha particle is also shown. Predict the how the decay lifetimes of these atoms compare by ranking them **from longest lifetime to shortest lifetime.**



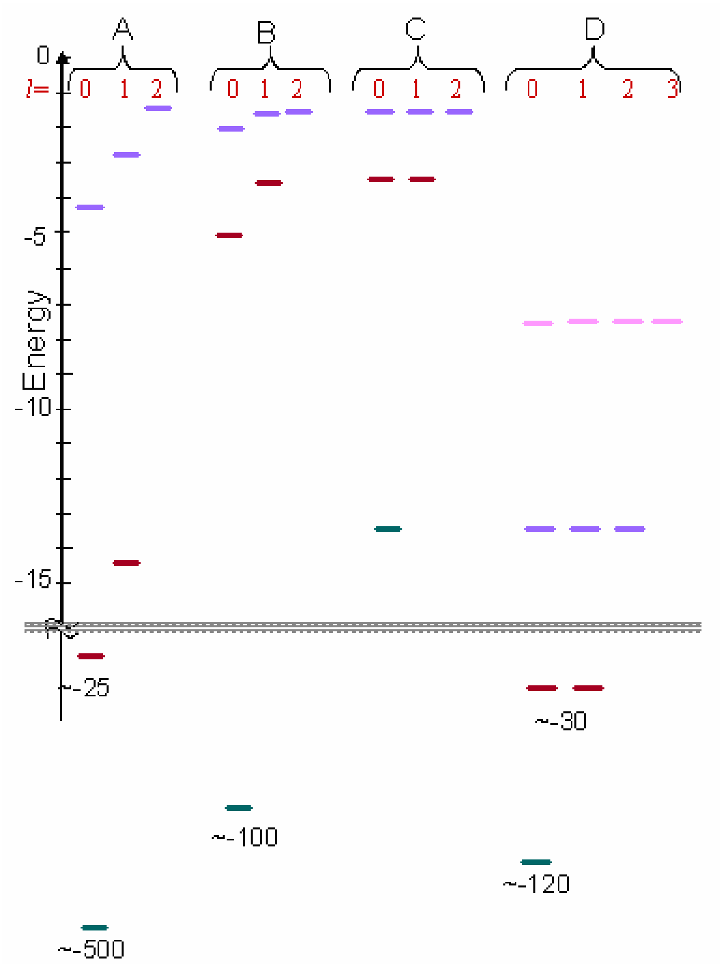
a. Atom 1, then Atom 2, then Atom 3
b. Atom 1, then Atom 2=Atom 3
c. Atom3, then Atom 2, then Atom 1
d. Atom 1=Atom2, then Atom 3
e. Atom 2, then Atom 3, then Atom 1

7. For the following potential energies, the electron's energy is indicated by a dashed line. For each, consider region II (that is the space between a and b). For each case, will the time-independent part of the wave function in region II be a complex exponential or a real exponential?



a. 1, 2, and 3 complex exponential.
b. 1 complex exponential, 2 and 3 real exponential
c. 1 and 3 real exponential, 2 complex exponential
d. 1 real exponential, 2 and 3 complex exponential
e. 1 and 2 complex exponential, 3 real exponential.

8. You can use the spectra observed from various atoms for identifying the composition of distant stars. To the right are 4 electronic energy level diagrams (showing the first 3 or four shells). Note that we have only shown energy levels up through n=3 (n=4 in one case), but there are an infinite number of levels. Also, the diagram couldn't fit on scale so there is a **break in the scale**. These represent the electronic energy level diagrams for Hydrogen (H), neutral Lithium (Li), doubly-ionized Lithium (Li++), and Nitrogen (N).



Which electronic energy level diagram (A-D) best represents Hydrogen?

Long Answer style questions: target 10 points..

A. Compare the Bohr Model of the Hydrogen Atom with the Schrodinger Model of the Hydrogen atom. Make some sketches about energy levels, radii for electrons etc...

B. Consider $\Psi(x,t) = \sqrt{1/2}\Psi_1(x,t) + \sqrt{1/2}\Psi_2(x,t)$ for an electron in of an infinite square well of width 5 nm, is this in an energy eignstate? Position eigenstate?

Will the probability of measuring energy change in time?
Position?
Why?

C. what are the steps for building a fusion bomb? Explain the physics of each step.