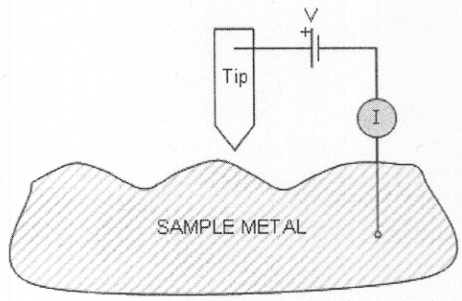
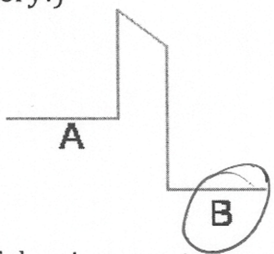
PHYS 225 – Spring 2011 **Marie Lopez del Puerto**

HW #15

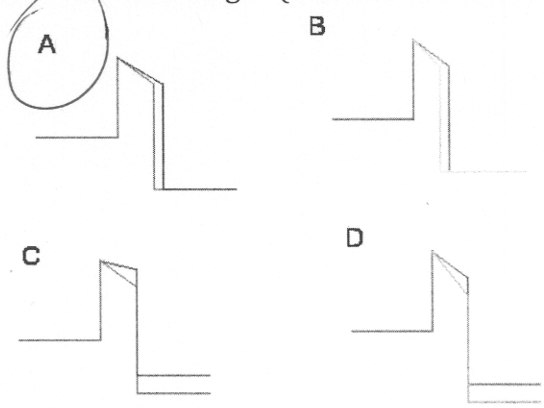
1. In a scanning tunneling microscope, when a metal probe tip is positioned a small distance from the surface of a metal (~1 nm) a current flows through the circuit formed by the tip, the sample, and the voltage supply. The position of the tip is precisely controlled.



a. The potential energy curve for an electron moving between the two metals is shown below. For this diagram, which potential well (A or B) is the tip of the probe? (Note the orientation of the battery!)



b. In this example, if the tip were to move to the right, how would potential energy surface for this situation change? (The red curve shows the original surface.)



c. In this example, if the tip were to move to the right, how would the measured current change?

- o Increase
- o Decrease
- o Stay the same

d. What would have to change to return the current to its original value?

- o The tip would have to move closer to the surface.
- o The tip would have to move further from the surface.
- o It would not be possible to return the current to its original value in the new position.

2. For each statement below, circle whether it is true or false for an electron in a hydrogen atom within the context of the Bohr model, the deBroglie model, and the Schrödinger model.

i. The electron is a particle that obeys all the laws of classical physics.

Bohr: True/**False**
deBroglie: True/**False**
Schrodinger: True/**False**

ii. The electron is a particle that moves in a circle around the atom.

Bohr: **True**/False
deBroglie: True/**False**
Schrodinger: True/**False**

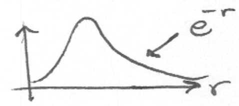
iii. The electron can only have certain discrete energies.

Bohr: **True**/False
deBroglie: **True**/False
Schrodinger: **True**/False

iv. The electron can only be found at certain distances from the nucleus.

Bohr: **True**/False
deBroglie: **True**/False
Schrodinger: True/**False**

it is more probable to find the e^- at certain distances, but all distances are possible, for the ground state



v. The electron behaves as a wave.

Bohr: True/**False**
deBroglie: **True**/False
Schrodinger: **True**/False

vi. The potential energy of the electron is $-ke^2/r$.

Bohr: **True**/False
deBroglie: **True**/False
Schrodinger: **True**/False

vii. The total energy of the electron is $\frac{n^2\pi^2\hbar^2}{2mL^2}$.

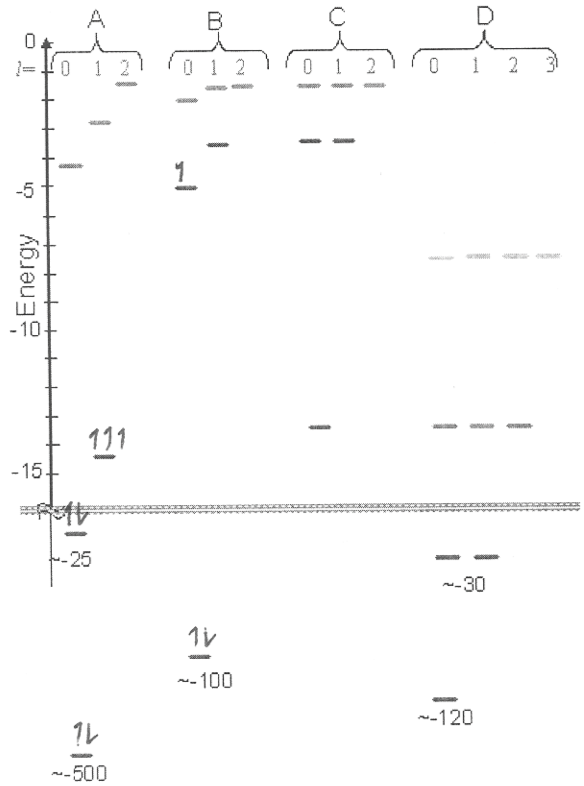
this is for the infinite potential well

Bohr: True/**False**
deBroglie: True/**False**
Schrodinger: True/**False**

viii. The total energy of the electron is $-\frac{mk^2e^4}{2\hbar^2n^2}$.

Bohr: **True**/False
deBroglie: **True**/False
Schrodinger: **True**/False

3. You can use the spectra observed from various atoms for identifying the composition of distant stars. Below are 4 electronic energy level diagrams (showing the n quantum number of the energy level in colors and the l quantum number in columns). 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 below which the levels are not to scale). These represent (qualitatively) the electronic energy level diagrams for Hydrogen (H), neutral Lithium (Li), doubly-ionized Lithium (Li^{++}), and Nitrogen (N).



a. Which electronic energy level diagram (A-D) best represents each atom?

Hydrogen: C

Neutral Lithium: B

Doubly-ionized Lithium: D since $E_0 = -Z^2(13.6\text{ eV}) \sim 120\text{ eV}$

Nitrogen: A since ionization energy increases as Z increases

b. Rank order Li^{++}, Li, N in terms of the size of the atom: (smallest to largest)

N < Li^{++} < Li

c. In looking at the emission spectra from a star, would the number of spectral lines observed for neutral Li be (less than, equal to, or more than) that of hydrogen. (Is your answer consistent with the energy level diagrams above?)

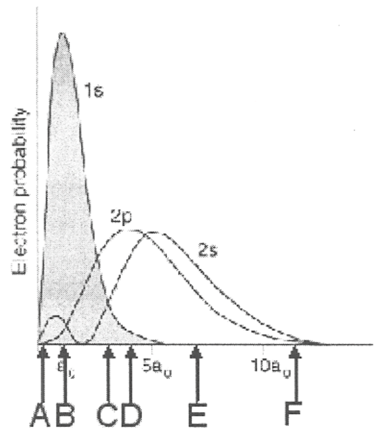
since for Li there is splitting of energy levels

more distinct energy levels → more spectral lines

d. For neutral lithium, the effective attractive charge that the electron in the 2s state feels is:

- greater than the attraction of 3 protons
- equal to the attraction of 3 protons
- less than the attraction of 3 protons, but more than 1 proton — since screening is not perfect.
- exactly equal to the attraction of 1 proton,
- less than the attraction of 1 proton.

e. Below we show the radial distribution of the spherically-symmetric 1s and 2s wave functions for Lithium. Rank which part of the 2s wave function is shielded most by the electrons in the 1s state? (The least shielded part of the electron cloud in the 2s state is the part that would feel something closer to the full attraction from the nucleus that it would feel *at that same distance*).



Rank order region of 2s state from *most* shielded to *least* shielded:

i. A>B>C>D>E>F
ii. B>A>C>D>E=F
iii. B>C>D>A>E=F
iv. F>E>D>C>B>A
v. F=E>D>C>B>A
vi. F=E>D>C>A>B

f. Explain in a few sentences what it means to say that the electrons in the lower energy levels shield the electrons in the highest energy levels from the nucleus, and why this idea is important to consider when thinking about an atom's chemical behavior.