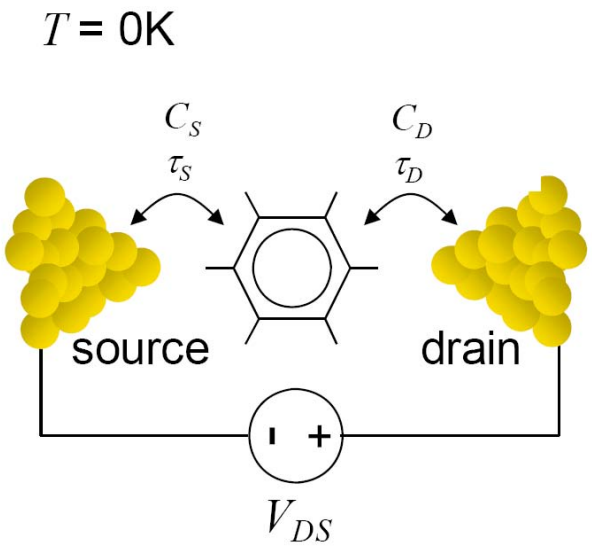
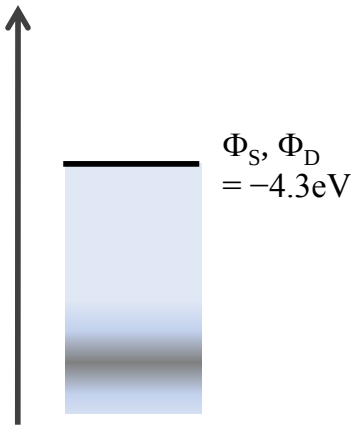
6.701/6.719 Midterm April 2nd 2010

Name: _____

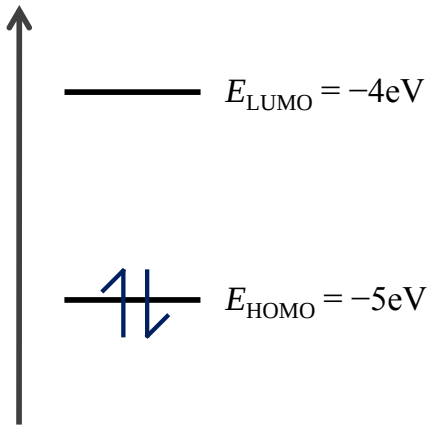
All questions relate to the two terminal molecular device shown below.



Source and Drain Contacts



Molecule (Isolated) Density of States



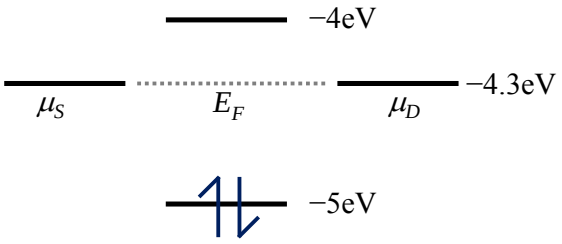
Question 1.

When $\tau_S = \tau_D \rightarrow 0$, calculate the I_{DS}–V_{DS} characteristics and sketch it.

Question 2.

When $\tau_S = \tau_D = 1\mu s$, calculate the I_{DS}–V_{DS} characteristics for positive V_{DS} and sketch it. Assume that the charging energy equals zero and C_S and C_D are identical.

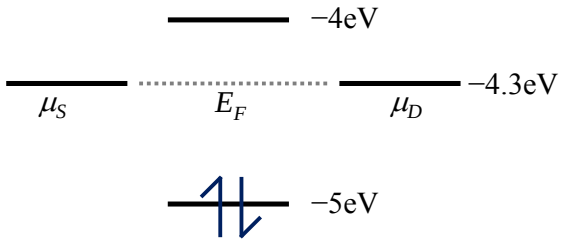
Assume that at equilibrium,



Question 3. (6.719 only)

When $\tau_S = \tau_D = 1\mu s$, calculate the I_{DS}–V_{DS} characteristics for positive V_{DS} and sketch it. Assume that the charging energy per an electron is 1eV and C_S and C_D are identical.

Assume that at equilibrium the device can be described by,



Question 4.

In Questions 1-3, we have assumed that the HOMO of LUMO of the molecule are discrete energy levels. When $\tau_S = 10$ fs, $\tau_D = 5$ fs, calculate the actual molecular density of states versus energy. Determine the full width half maximum of HOMO and LUMO.

Question 5.

Based on the actual density of states calculated in Question 4, find the number of electrons and the charging energy when the molecule is brought into contact with the metal electrode and reached equilibrium (applied voltage = 0). Also sketch the energy diagram at equilibrium. Assume that the charging energy per electron is 1eV and $\tau_S = 10$ fs, $\tau_D = 5$ fs.

Hint: You will need your calculator to solve this. You might use $\int \frac{1}{1+x^2} dx = \tan^{-1}(x)$.

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Spring 2010