Homework Questions for Unit 3

1. An organic field-effect transistor (OFET) device has the following transfer curve. The width of the channel is 0.1 mm and the length of the channel is 0.05 mm. The capacitance of the dielectric material is approximately 15 nF cm\(^{-2}\). The bias between the source and drain electrodes (\(V_D\)) was –60 V. Assume that the threshold voltage is 0 V. Note that 1 F = 1 A·s V\(^{-1}\). Calculate the mobility of the OFET. — Answer \(3.7 \times 10^{-4} \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}\) (error +/- 20%)

2. In polymer semiconductor materials, charge transport is a difficult parameter to predict beforehand for a material. However, the following questions probe the current understanding of the field

a) For a semicrystalline material, the degree of crystallinity needs to be in tune with which of the following statements for relatively high charge transport to occur?

   a. The film needs to be completely crystalline for the semiconducting polymer to reach its maximum charge transport ability.
   b. There exists a trade-off between crystallinity and mobility in semiconducting polymer thin films such that an optimal crystallinity exists prior to complete crystallinity.
   c. There exists a given level of crystallinity in which a percolating network forms across the thin film, which allows the material to reach an asymptotic charge transport ability.
   d. The degree of crystallinity only matters if the appropriate crystalline alignment is structured into the material.

b) Electronically-active polymers can have charge mobility values greater to or equal to 0.1 cm\(^2\) V\(^{-1}\) s\(^{-1}\) if:

   a. They are single crystals
   b. They are semicrystalline
   c. They are poorly ordered
   d. (a) and (b) only
   e. All of the above
   f. None of the above
3. Name the 5 steps of free charge conversion in the photoconversion process of an organic photovoltaic (OPV) device.

1) Light Absorption 
2) Exciton Diffusion 
3) Exciton Separation 
4) Charge Separation 
5) Charge Collection

4. In Lecture 3.4, the following set of curves was shown. Answer the following questions regarding this set of curves

![Graph with blue and red curves]

a) What is the difference between the blue curve and the red curve?
   a. The blue curve is for an OPV device that has an electrical short in it while the red curve is for a functioning device.
   b. The red curve is for a device with 10-fold the surface area as the blue curve.
   c. The blue curve is for a device that is in the dark while the red curve is for the same device in the light.
   d. The blue curve is for a field-effect transistor while the red curve is for a solar cell.
   e. The two curves have just been offset for clarity.

b) In the plot, the point where the red curve strikes the horizontal axis is known as what?
   a. Open-circuit voltage
   b. Short-circuit current
   c. Fill factor
   d. Power conversion efficiency
   e. Rectification ratio
c) In the plot, the point where the red curve strikes the vertical axis is known as what?

   a. Open-circuit voltage
   b. Short-circuit current
   c. Fill factor
   d. Power conversion efficiency
   e. Rectification ratio

d) In the plot, the area of the shaded box divided by the area of the box that is made by finding the maximum power point is known as what?

   a. Open-circuit voltage
   b. Short-circuit current
   c. Fill factor
   d. Power conversion efficiency
   e. Rectification ratio

5. In the United States, 94.6 Quads of energy are used each year, based on a 2009 survey conducted by Lawrence Livermore National Laboratory. Of those 94.6 Quads, what percentage is sent as rejected energy?

   a. 20%
   b. 33%
   c. 42%
   d. 58%
   e. 67%

6. Calculate the figure of merit (to 2 significant figures) for materials with the following properties at an absolute temperature of 400 K: \( \sigma = 10^4 \text{ S cm}^{-1} \), \( S = 200 \mu \text{V K}^{-1} \); \( \kappa = 1 \text{ W m}^{-1} \text{ K}^{-1} \). – Answer: 0.16 (+/- 10% error)