ME4252 Nanomaterials for Energy Engineering

Assignment – 1 (Marks 35; **Grade 10%**)

Submission date: **28 Oct 2022**

Question 1

(a) Consider two physically separated semiconductors as shown below in the Figure 1.

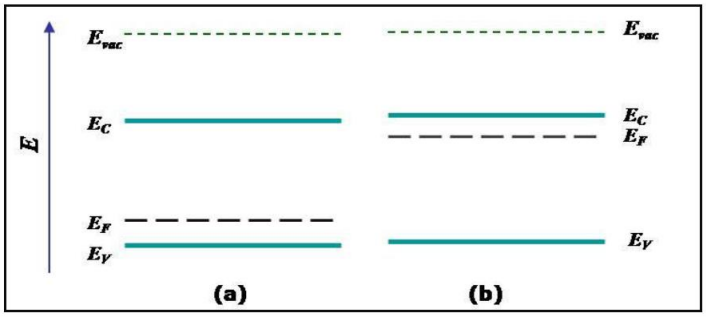


Figure 1

(i) Draw the band diagram if these two semiconductors are placed in direct contact in dark condition. Label the Fermi level, the conduction band, the valance band and the vacuum level. Show the built-in potential.

(ii) Assume that these two semiconductors which are in contact are illuminated by light. Draw the band diagram highlighting the changes in the energy levels. Show the open circuit voltage.

[5 *marks*]

Question 2

Figure 2 below shows I-V curves of a solar panel at 25ºC under various irradiance levels.

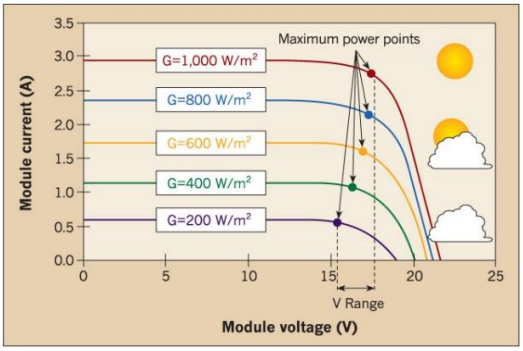


Figure 2

(i) Why the short circuit current increases largely with increase in solar irradiance?

(ii) Why the open circuit voltage increases only slightly with increase in light intensity?

[*4 marks*]

Question 3

Identify three recombination processes in a dye-sensitized solar cell (use a schematic energy level diagram)

[*5 marks*]

Question 4

Calculate the density of the donor atoms which we wish to add to change the intrinsic germanium to *n – type* material with resistivity $0.19\times10^{-2}\ \Omega m$. The mobility of electrons in the *n – type* semiconductor is 0.325 $m^2V^{-1}s^{-1}$.

[*5 marks*]

Question 5

A 5 cm^2 Ge solar cell with a dark saturation current of 2 *nA* has AM1.5 radiation incident upon it producing $4x10^{17}$ EHP *per* cm^3 *per second*. The electron and hole diffusion lengths may be assumed to be 5 μm. Neglecting the photo generated currents within the junction, calculate the I_{SC} and V_{OC} of the cell at room temperature (300K).

[*5 marks*]

Question 6

Provide three ways of increasing conductivity of an ionic solid.

[*3 marks*]

Question 7

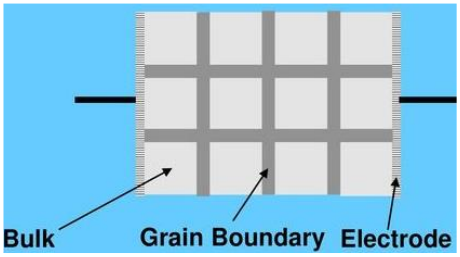
(a) Provide possible defects in KCl upon doping by $CdCl_2$ and write down the equilibrium defect equation.

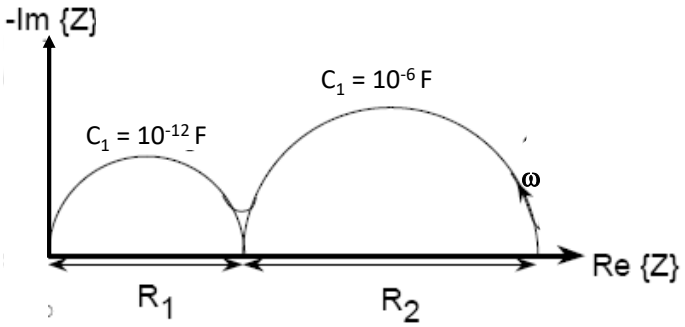
(b) Provide two possible defect reactions in TiO_2.

[*5 marks*]

Question 8

Figure below shows a model of a polycrystalline AgI sample of 5mm thick kept between two Ag electrodes, along with its impedance spectrum recorded at 1Hz – 10 MHz. The capacitance of these two semicircles derived from the equivalent circuit diagram are also shown.





Identify the semicircle that belongs to the bulk and the grain boundaries of the polycrystalline AgI sample. Justify your answer.

[*3 marks*]