Solution to Exercise 8.1-6

Constructing Quantitative Logarithmic *IV* Characteristics

Illustration

- First we get a few important relations and numbers.
  - If $1/kT = 40\ eV^{-1}$ at **300 K**, we have $1/kT = 40 \cdot 300/400 = 30\ eV^{-1}$ at **400 K**
  - The current densities j_1 and j_2 can always be written as

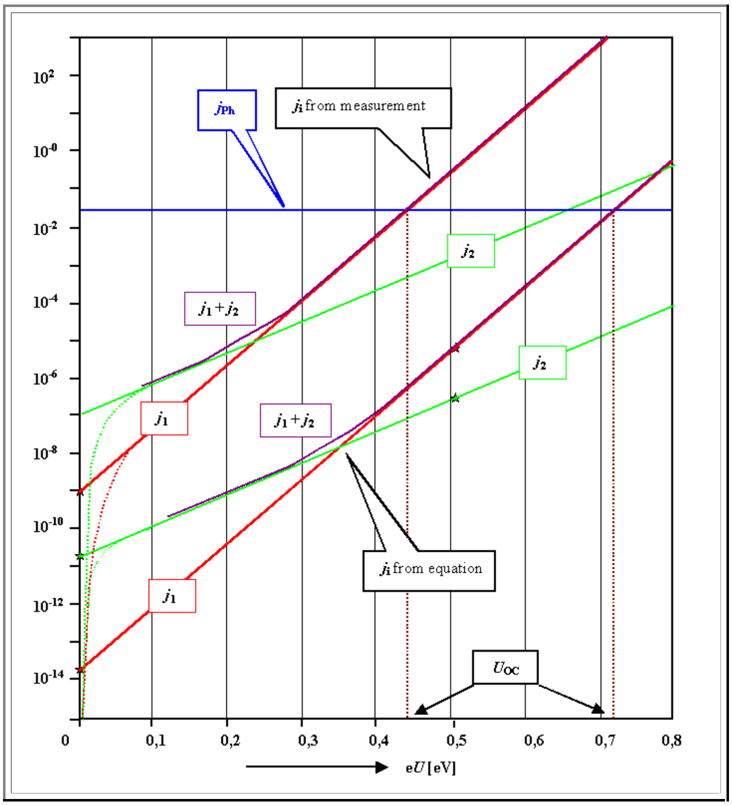
$j_1 = c_1 \cdot n_i^{\ 2} = j_1' \cdot \exp-(E_g/kT)$	$j_1' = j_1 \cdot \exp(E_g/kT)$
$j_2 = c_2 \cdot n_i = j_2' \cdot \exp-(E_g/2kT)$	$j_2' = j_2 \cdot \exp(E_g/2kT)$

- This gives us the following numbers:

	Theory		Measured	
	j_1	j_2	j_1	j_2
Calculated j_i'	$2.06 \cdot 10^{5}$ A/cm^2	$5.74 \cdot 10^{-1}$ A/cm^2	$1.29 \cdot 10^{10}$ A/cm^2	$3.58 \cdot 10^{2}$ A/cm^2
	***T* = 300 K**			
Starting values j_i U = 0 V	$1.6 \cdot 10^{-14}$ A/cm^2	$1.6 \cdot 10^{-10}$ A/cm^2	10^{-9} A/cm^2	10^{-7} A/cm^2
Calculated j_i U = 0.5	$7.76 \cdot 10^{-6}$ A/cm^2	$3.52 \cdot 10^{-7}$ A/cm^2	0.46 A/cm^2	$2.2 \cdot 10^{-3}$ A/cm^2
	***T* = 400 K**			
Starting values j_i U = 0 V	$9.60 \cdot 10^{-10}$ A/cm^2	$3.92 \cdot 10^{-8}$ A/cm^2	$6.01 \cdot 10^{-5}$ A/cm^2	$2{,}44 \cdot 10^{-5}$ A/cm^2
Calculated j_i U = 0,5 V	$9.67 \cdot 10^{-3}$ A/cm^2	$1{,}5 \cdot 10^{-4}$ A/cm^2		

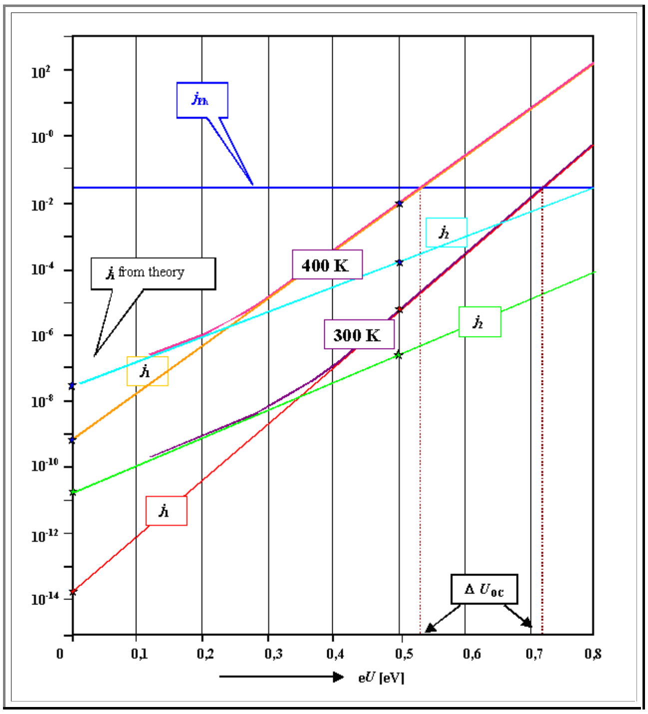
- Now to the questions:
  Question 1. Construct rather quantitatively the logarithmic ***IV*** characteristics (= **log *j* - e*U*** plot) of two solar cells with the j_2 and j_2 values as given in the table.
  Question 2: Determine the open circuit voltage U_{OC} for room temperature and for **400 K** and discuss your finding.

- Constructing the graph is easy now; here is the result:



- We note that the **"-1"** term can be neglected as soon as we have current density values about **10** times larger then the starting values, i.e. below ***U*** ≈ **0.1 V**. At lower values this term dominates the characteristics by forcing the currents to zero, i.e. to **–∞** in a **log** plot, but that is of no interest here.
- The addition of both curves only introduces a slight "rounding" at the intersection point.
- The open circuit voltage follows from the intersection of the ***j*(U)** curves with a straight line at $j = -j_{Ph}$. It is immediately clear that only the j_1 part is of interest here.

The effect of temperature is shown in a separate graph and only for the "theoretical" set of the j_{Ph}:



- While the decreasing slope of the curves would increase U_{OC}, the large increase in the starting value of j_1 has a much stronger effect and causes a substantial decrease of U_{OC} with temperature.