Tutorial problems (23750) for "Solar Energy" lecture (23745), WS 2014/2015

Michael Oldenburg & Bryce Richards

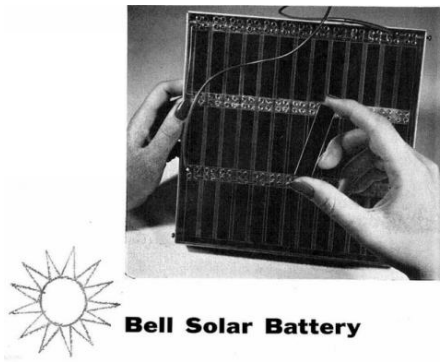
Tutorial Questions #2:

1. **Density and thermodynamics of charge carriers**
   a) Find an expression for the charge carrier density in a semiconductor (similar to photons, here an integral expression is enough).
   b) How is the electronic distribution function $f_e(\epsilon_e)$ connected to the distribution function of holes?
   c) Use the expression found in a) to find an integral for the mean energy of charge carriers. The final solution for this is

$$\langle \epsilon_e \rangle = \epsilon_C + \frac{3}{2} k_B T.$$

   Neglecting the constant energy, how can this result be interpreted?
2. **Illuminated IV characteristic of a solar cell**
   In the lecture the dark IV characteristic was found. How can one find an expression for the illuminated case (think of the generation rate G). The phenomenological equivalent circuit presented in the lecture is justified except to the different resistors. How could one justify those as well?
3. **Solar Cell Design**

The illustrated solar module has 13 solar cells in each row and 3 rows in total. The dimensions of the



solar cells are $6\ cm \times 1.4\ cm$ and the spacing between them $0.33\ cm$. The efficiency is $\eta = 6\%$

   a) What is the maximum amount of power that could be generated from this PV module under STC (standard testing conditions)?
   b) What area would be required to produce 50 W under STC?
   c) Assuming that all cells are connected in series, provide an estimate of the following parameters: $V_{OC}, I_{SC}, V_{mp}, I_{mp}$ and FF?

4. Anti-reflection coating

A thin layer of a transparent material on top of a glass surface should be used to eliminate reflections.

a) Which refractive index is needed that the thin layer can be used as an anti-reflection coating?

b) What is the optical path difference between light which is directly reflected from the anti-reflection coating and light reflected from the glass surface?

c) Calculate the thickness of the layer which suppresses the reflection for light with a wavelength of 600 nm?