Remember to give feedback in the Kaiku-system to get the final grade.
You can answer to the questions either in English or in Finnish.

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53117 Solar Power Systems

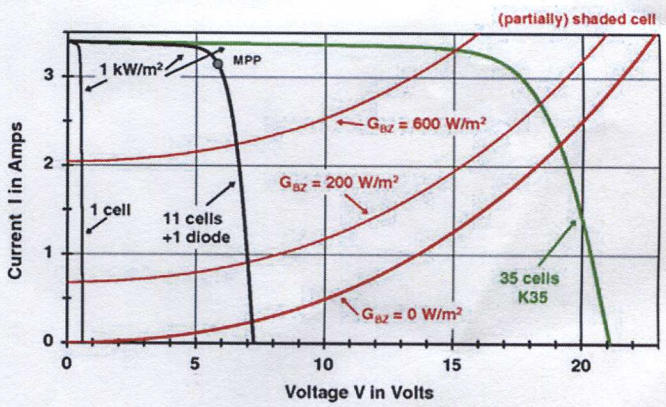
Examination, 4.5.2016

Answer to each question 1, 2, 3 and 4 should fit into one page of a common writing paper.

1. a) Tell one concrete measured effect caused by the climatic change during the last 50 to 100 years.
   b) When took place the first discoveries of the present photovoltaic (PV) cell?
   c) What is the share of Solar PV power of the total installed electricity production capacity worldwide?
   d) What has been the average price reduction of PV modules as a function of their installed cumulative power production capacity?
   e) What has been the price development of PV power plant installations during the past 5 to 10 years?
   f) What has been the market share of solar PV power plants of the total installed global power production capacity during the past few years?

2. a) How does series resistance of PV modules and generator affect to the currents, voltages and powers of the PV generator?
   b) Define the quantity relative air mass number for a PV system location at a mountain top, when a 10 meter high object causes a 5 meter long shadow on a horizontal surface.
   c) What are the light absorption processes in direct and indirect band gap PV semiconductors? How do they effect on needed PV cell thickness?

3. PV system includes 36 series connected identical PV cells. 35 of the cells are under full irradiance of 1 kW/m^2 having the green I-V curve shown in the figure. One of the PV cells is partially shaded obtaining three different irradiances of 0, 200 and 600 W/m^2. The corresponding I-V curves are shown in the figure in the reversed voltage and current directions with red lines.



   a) Draw the characteristic I-V curves of the 36 series connected PV cells, when one cell operates under those three partial shading conditions and bypass diodes have not been used.
   b) Draw the characteristic I-V curves of the 36 series connected PV cells, when one cell operates under those three partial shading conditions and three bypass diodes are connected in parallel with 12 PV cells each.

4. Imagine that you are selling a PV power system to your customer to be installed on a sloped rooftop of an existing building. Your customer asks you about the average annual power production of the system after five years of operation. How do you estimate that (what issues you need to take into account), when the electrical characteristics of the PV modules are known in standard test conditions?