KIBABII UNIVERSITY

2020/2021 ACADEMIC YEAR

THIRD YEAR SECOND SEMESTER

SPECIAL/SUPPLEMENTARY EXAMINATIONS

FOR THE DEGREE OF BACHELOR OF SCIENCE IN RENEWABLE ENERGY AND BIOFUELS TECHNOLOGY

COURSE CODE: REN 321

COURSE TITLE: Solar Energy 2

DATE: 19/1/2022 TIME:8-10AM

INSTRUCTIONS TO CANDIDATES

Answer question ONE and any other two questions

This paper consists of 4 printed pages. Please Turn over

Question One

(a)	On a sketch of an IV and power curve, indicate open circuit voltage, short circuit current and maximum power point for a typical crystalline solar cell including typical magnitudes for open circuit voltage and short circuit current	[6 marks]
(b)	Explain the geometric concept of fill factor with the aid of a diagram and give the equation that relates fill factor to the parameters in part (a)	[6 marks]
(c)	With refence to the underlying physics, explain how a built-in voltage arises at a semiconductor p-n junction	[6 marks]
(d)	Describe how a photocurrent and a photovoltage are generated in an illuminated p-n junction. Your answer should make reference to absorption, charge separation dark current and recombination	[6 marks]
(e)	With aid of a clearly labelled sketch, explain a grid-connected PV system	[6 marks]

Question Two

You have to install a PV system for maximum energy production in Kibabii

(a)	Outline the effects of temperature and irradiance on device efficiency. What is crucial for Kibabii?	[5 marks]
(b)	Given the design constraints of achieving maximum energy production, how would you mount the system? What are the two other design options and explain how each would impact the system design methodology?	[5 marks]
(c)	For 1kW system in Kibabii, what size of inverter would you choose? Explain your choice. Qualitatively, how would you size an inverter differently in high latitude temperate environment compared to a low latitude location with high irradiance such as Kibabii.	[4 marks]
(d)	What factor could be used as an indicator of the quality of the system? Given a definition of this factor, what range of values would a good system show in this factor and what would be an alarming value	[4 marks]

indicating a poor system.

(e) What measurement are required to determine the quality of the system? Outline such a monitoring system [2 marks]

Question Three

The following table shows data for two different PV modules, one of which incorporates monocrystalline cells, while the other uses amorphous silicon cells.

	Module 1	**Module 2**
Power	40 W	43 W
V_{oc}	22V	11.15
I_{sc}	2.35A	3.3
V_{MPP}	18V	8.35
Cells in Series	36	8
Cells in Parallel	1	2

(i) Identify which of the modules uses monocrystalline and amorphous technologies respectively. Describe the factor(s) in volved in your identification. [4 marks]

(ii) The areas of the modules are 0.308 m^2 for the monocrystalline modules and 0.845 $m^2$for the amorphous module. The losses per ^0C are 0.2W/^0C (c-Si) and 0.04W/^0C (a-Si). Calculate the efficiency and performance ratio for each module, given an operating temperature of 60^0C and an irradiation equivalent to STC. [10 marks]

(iii) Which of the modules would you use for a satellite and why? Would you choose the same module for building integrated application? Justify your choice. [6 marks]

Question Four

You have 3 modules and want to mount them in a position where you know that one of them will be shaded.

i) Explain using a sketch (based on a typical shape of an I-V curve) the energy lost when one module is shaded by 50% and the modules are connected in series. **(5 marks)**

ii) Explain using a sketch (based on a typical shape of an I-V curve) the energy lost when one module is shaded by 50% and the modules are connected in parallel **(5 marks)**

iii) How could you minimise the losses for series connection/parallel connection? Explain how the I-V characteristic of the generator would change due to these measures. **(5 marks)**

iv) Which arrangement (series or parallel) would you choose and why, assuming that all other components are indifferent to any changes in the module interconnection? **(5 marks)**

Question Five

i) Why might a building-integrated PV array provide less power than a rooftop rack-mounted array on the same building, using the same modules and the same wiring arrangements?

[6 marks]

ii) Explain briefly, how shading a PV cell can cause it to overheat.

[3 marks]

iii) Using a sketch of power-versus-voltage for two PV modules at different temperatures, illustrate and explain why the maximum power obtainable from the two connected in PARALLEL is less than the sum of their individual maximum powers.

[6 marks]

iv) A 4kW PV array is directly connected to a 120V lead-acid battery bank. Explain how power electronics could be used to improve system performance.

[5 marks]