UNIVERSITY EXAMINATIONS
2022/2023 ACADEMIC YEAR

THIRD YEAR SECOND SEMESTER
SPEC IAL EXAMINATIONS

FOR THE DEGREE OF BACHELOR OF SCIENCE IN RENEWABLE ENERGY AND BIO FUELS TECHNOLOGY

COURSE CODE: REN 321

COURSE TITLE: Solar Energy II

DURATION: **2 HOURS**

DATE: 10/8/2023 **2:00-4:00PM**

INSTRUCTIONS TO CANDIDATES

- Answer **QUESTION ONE** (Compulsory) and any other **TWO** (2) Question.
- Indicate **answered questions** on the front cover.
- Start every question on a new page and make sure question's number is written on each page.
- Where sketches are used, they MUST be neat and CLEAR to get full marks

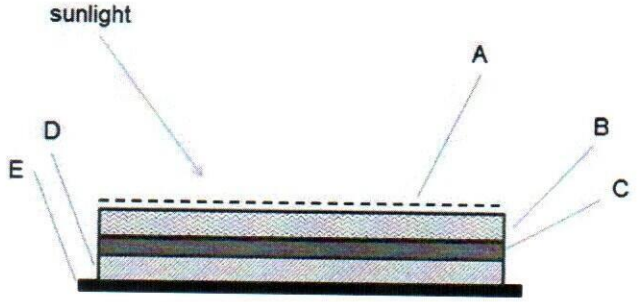
Question One

a) State the effect of temporarily shorting the output terminals of a PV module **[1 mark]**

b) A PV system needs to supply 5834 Wh per day. The daily average insolation is 4.8 peak sun hours. The battery system charging efficiency is 0.9. The nominal voltage is 48V. What is the required array current, not including any additional deration factors? **[2 marks]**

c) State any THREE reasons why lithium chemistry batteries are preferred in PV systems compared to Lead-Acid chemistry batteries. **[3 marks]**

d) **[2.5 marks]**

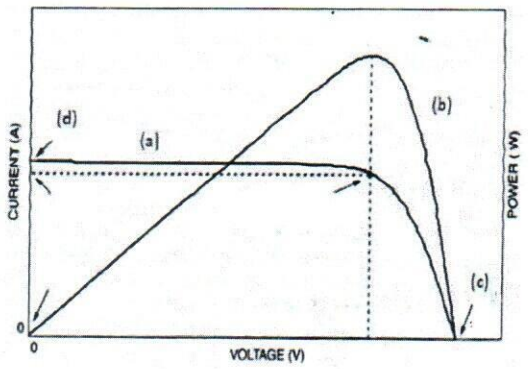


The diagram above is of a PV cell. Identify all the feathers represented by the letters A-E

(i) Compare the thickness of layer B and D and explain the difference **[2.5 marks]**

(ii) Explain in detail what happens in PV cell when illuminated as shown **[3 marks]**

e) The figure below shows characteristics of a PV module. Study it and answer questions that follow



(i) What is the name of the characteristics shown? **[1 mark]**

(ii) Explain how graph (b) is obtained **[3 marks]**

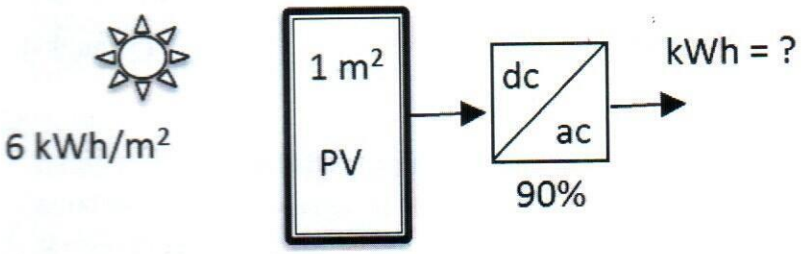
(iii) Name the points labelled (d) and (c) and explain their significance **[3 marks]**

(f) Explain the "voltage window/voltage range in MPPT charge controllers and inverters **[4.5 marks]**

(g) Clearly outline the key features of grid-tie inverters and off-grid inverters **[4.5 marks]**

Question Two

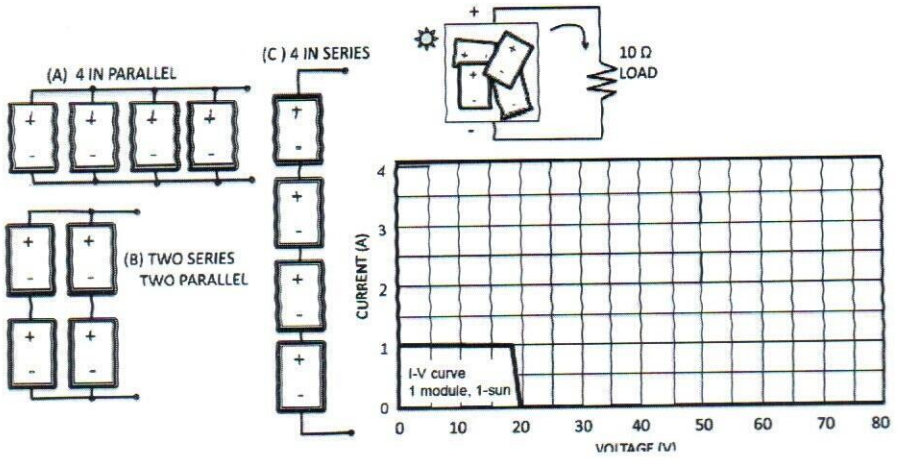
a) A clean, 1 m^2, 15% efficient module (STC), has its own 90% efficient inverter. Its NOCT is 45^{0}C and its rated power degrades by 0.5% above the 25^{0}C STC.



(i) What is the standard test condition (STC) rated power of the module? **[3 marks]**

(ii) For a day with 6kWh/m^2 insolation, find the kWh that it would deliver if it operates at its NOTC temperature. Assume the only deratings are due to temperature and inverter efficiency. **[4 marks]**

b) You have four PV modules with identical *I-V* curves (I_{SC} = 1A, V_{OC} = 20V) as shown. There are three ways you could wire them up to deliver power to a dc-motor (which acts like a 10-Ω load): **[13 marks]**



Draw the I-V curves for all three combinations on the same graph. Which wiring system would be best?

Briefly explain your answer.

Question Three

a) Explain what is meant by "commissioning a PV system" **[2 marks]**

b) Why is commissioning of equipment always necessary after installation? **[1 mark]**

c) Give a detailed description of commissioning of a PV system **[17 marks]**

Question Four

a) Explain the operational principal of

(i) **Pulse-Width-Modulation** charge controller **[5 marks]**

(ii) **Maximum Power Point Tracking** charge controller **[8 marks]**

(iii) What are the advantages of MPPT charge controllers and inverters? **[3 marks]**

b) In reference to PV system yield and performance, explain the following terms

(i) Yearly energy yield **[1 mark]**

(ii) Monthly energy yield **[1 mark]**

(iii) System yield **[1 mark]**

(iv) Performance ratio **[1 mark]**

Question Five

a) (i) A customer has a 6000W grid-tied PV system. Every day around noon during the summer, the 25A solar breaker trips. The inverter is on the south side of the house. The conduit run from the inverter to the transition box is 200 ft. The array is facing true south at latitude. What should be done to prevent the breaker from tripping? **[4 marks]**

(ii) Why does the breaker trip at noon and not any other time? **[2 marks]**

b) When troubleshooting modules, what do you do and why? **[5 marks]**

c) A grid-connected PV array consisting of sixteen 150-W modules can be arranged in a number of series and parallel combinations: (16S, 1P), (8S, 2P), (4S, 4P), (2S, 4P), (1S, 16P). The array delivers power to a 2500-W inverter. The key parameters of modules and inverter are given below. **[9 marks]**

Inverter		**Module**	
Max AC power	2500W	Rated power (STC)	150
Input voltage range for MPP	250-550V	Voltage at MPP	34V
Max input voltage	600V	V_{OC}	43.4V
Max input current	11A	Current at MPP	4.40A
Short circuit current		I_{SC}	4.8A

Using the voltage input range of the inverter MPP tracker and the maximum input voltage of the inverter constraints, what series/parallel combinations of the modules best match the PV modules to the inverter? Check the results to see whether the inverter maximum input current is satisfied. Ignore temp effects for this simple check.