Centre for Energy Studies

ESL-730 Direct Energy Conversion

Time : 2 hrs. (A+B) **Major Test (2/5/15)** **M.M. : 15**

Note : Attempt all questions

PART A

1. Concerning the design of a constant Mach Number MHD generator, give the scaling of pressure, density, area and conductivity versus temperature and hence efficiency, η. Also give duct length for the case of constant conductivity. (9)

or

Concerning the design of a constant velocity MHD generator, give variation of parameters such as pressure temperature density, power density and length of duct. (9)

2. Calculate for continuous Faraday and segmented electrode configurations, the current density and power output per unit volume in terms of loading factor. (3+3)

$8V + 2V/\Omega\tau$

MAJOR TEST [ESL 730 DIRECT ENERGY CONVERSION]

TOTAL MARKS: 50

{PART A: 15}+{PART B: 35}

NOTE: Attempt PART A and PART B **separately** in the answer script.

PART B. TIG,TEG,SOLAR CELLS and FUEL CELLS

1. **Fill in the blanks (ANY 6):**

(a) For high Z (having the unit …) value, a TEG should utilize a semiconductor having carrier concentration of … /m^3 and having the constituents like Pb, …, .,. etc.

(b) For a TIG having the emitter with Φ_e = 2.7 eV at T_e = 1627 °C, the optimum temperature T_c for Mo collector should be …. The corresponding values of V_{OC} and J_{SC} will be …. and …. , respectively.

(c) A high efficiency Si solar cell has …-…-… junction structure in the device and the screen printed contact on the top using … paste and that on the bottom using … and … pastes.

(d) The spectral response of an ideal Si solar cell should have a value = .. for the wavelengths above … μm and a value = … for wavelengths below. In an actual solar cell, there is a deviation in the low wavelength range due to ….

(e) The half reactions for (i) Alkaline Fuel cell and (ii) Phosphoric Acid Fuel cell are:

		The Anode	The Cathode
(i)	AFC	…	…
(ii)	PAFC	…	…

(f) The voltage efficiency of a $H_2 - O_2$ Fuel cell for H_2 and Air as reactants and water vapour as the product (all at 1 atm) is …. For H_2 flow rate = 0.20 cm^3/sec with 25% of it unutilized in the Fuel cell, the current efficiency will be … .

(g) The TIG,TEG,SOLAR CELL and FUEL CELL technologies have several common characteristics, some of which can be listed as : (1) … , (2) … , (3) … and (4) …. .

2. **Attempt ANY 3** {12}

(i) Discuss how a TIG –TEG combination can help in making a thermal energy to electrical energy converter with improved efficiency.

(ii) Describe: (a) Surface Texturing , (b) ARC, (c) BSF , (d) PSG removal, (e) Edge removal and (f) Grid line design and explain each's role in Si solar cell .

(iii) Identify the conducting ion and the electrolyte used in: (a) PMFC, (b) MCFC and (c) SOFC.

(iv) Give the corresponding NERNST equations for the three Fuel cells given in (iii) . The equations can be for H_2 or Methane as the Fuel and Air used for the other reactant.

{9}

3. Derive the expression for (a) the temperature dependence of V_{OC} in a solar cell , (b) the temperature drop across the thermo-elements in a TEG for maximum power with the hot and cold heat exchangers matched **OR** (b) the heat energy taken by the emitted electrons and heat energy due to radiation in TIG.

4. (a) Draw the I-V characteristics of a Fuel cell and explain how the different polarizations determine the characteristics. {4}

(b) Under standard conditions, a H_2-O_2 Fuel Cell yields 35A for current efficiency of 90%. Find the reversible and irreversible heat transfers.

5. (a) Draw schematically the I-V characteristics of 4 identical Si solar cells connected in series, with each cell having V_{OC} = 0.6 V and I_{SC} = 5A under STC. Taking FF =0.81 and V_{max} = 0.9 V_{OC} , determine the load resistance required to operate the series combination at the maximum power point. {5}.

(b) If one of the cells gets only 50% of the incident solar radiation, explain the changes that need to be done in the characteristics.

OR

(b) What will be values of V_{OC}, I_{SC} and P_{max} if the intensity falling on all the cells is 800 W/m^2 and the cell temperatures are 50 °C?

{5}