Direct Energy Conversion
ESL-730

Time : 2 hrs. M.M. : 60 (Part A + Part B)

Note : Answer Section A and Section B on separate sheets

Section B

1. a) Describe a thermoelectric generator with diagram and show that the thermal efficiency of the generator can be written as

$$\eta_{th} = \frac{P}{Q_s} = (\frac{T_1 - T_2}{T_1}) G(m)$$

$$G(m) = \frac{m / m+1}{1 + \frac{k_g r_g}{\alpha^2_{s12}} (\frac{m+1}{T_1}) - (\frac{T_1 - T_2}{2T_1})\ 1/1+m}$$

Where m is the ratio of the load to internal resistance of the thermoelectric generator and other symbols have their usual meanings.

(10)

b) A thermoelectric generator that will operate between 30°C and 500°C is to be constructed of n-p semiconductors with the following properties

Seebeck coefficient n type - 170 μV/°K
p type 210 μV/°K

Electrical resistivity n type 14 μ Ω.m
p type 18 μ Ω.m

Thermal conductivity n type 1.5 W/m.K
p type 1.1 W/m.K

Length of n and p leg 1 cm
Cross sectional area of n leg 1 cm^2

Calculate maximum thermal efficiency of the thermoelectric generator and area of p leg.

(4)

2. Explain the principle of MHD power generation. How MHD generators are classified? Drive the expressions for the output voltage and current from axially spaced electrodes Hall generator.

(9)

3. a) Draw potential diagrams for basic thermionic generator (neglecting space charge effects and for fixed ϕ_c and ϕ_a) in the following two cases :

i) $\phi_c > \phi_a + eV_L$
ii) $\phi_c < \phi_a + eV_L$

Where ϕ_c and ϕ_a are work functions of cathode and anode respectively and V_L is the voltage developed across the load. Drive expressions for maximum power for above mentioned eases. Whieh configuration you reeommend for a praetical generator. Justify your answer.

(8)

b) Following data are given for a thermionic generator :

Cathode Work funetion	$\phi_c = 2.7$ eV
Cathode Spaee charge barrier energy	$\phi_{bc} = 0.3$ eV
Cathode temperature	$T_c = 1900^{\circ}K$
Anode Work function	$\phi_a = 1.5$ eV
Anode space eharge barrier energy	$\phi_{ba} = 0.5$ eV
Anode temperature	$T_a = 1056^{\circ}K$
Universal constant for cathode material	$A = 0.04 \times 10^6 A/m^2.k^2$
Universal constant for anode material	$A = 0.001 \times 10^6 A/m^2.k^2$
Boltzman's constant	$= 1.38 \times 10^{-23} J/^{\circ}k$
Electron charge	$= 1.6 \times 10^{-19}$ Coulomb

Find the emitter area needed to produce 100 W_e.

(4)

4. Suggest whether the following statements are true or false :

a) To achieve large power output in MHD generators the applied magnetic flux density must be as large as possible.

b) Thermionic generator is a low current, high voltage device.

c) The best thermoelectrie material has low value of electrical eonductivity

d) Faraday MHD generator output power decreases as β increases.

e) The inter-eleetrode distance in thermionic generator is kept large

f) The best thermoelectric material has high value of thermal conductivity

g) To achieve a large output in MHD generators gas must have low conduetivity.

h) The thermoelectrie power is positive for p type material and negative for n type material.

i) The thermoelectric generators are best suited for low temperature applications and thermionic generators for high temperature application

j) To achieve a large output in MHD generators gas must have a low velocity.

($\frac{1}{2} \times 10 = 5$)