

Subject : Solar Energy Thermal Processes (Elective – I)

Paper Code : ME-705/9

Time : 3 hours

Branch : Mech. Engg.

Full Marks : 100

Answer SIX questions, taking THREE from each half

The questions are of equal value

Use separate answer script for each half

### FIRST HALF

1 (a) With the help of a neat labeled diagram, discuss in brief the function of each component of a flat plate collector.

(b) A thermionic power generating system operates at maximum thermal efficiency with its cathode and anode temperatures as  $1560^{\circ}\text{C}$  and  $720^{\circ}\text{C}$  respectively. Estimate (i) power output per unit area, (ii) thermal efficiency and (iii) emitter area in  $\text{cm}^2$  when it produces power of 92 kW. Assume  $e = 1.602 \times 10^{-19}$  Coulomb;  $K = 1.38 \times 10^{-23}$  J/molecules-K; for cathode and anode ( $eV/KT$ ) as 21; emission factor as  $118 \text{ amps/cm}^2 - \text{K}^2$ .

2. (a) Explain Seebeck effect and Peltier effect. What do you mean by maximum figure of merit in relation to thermoelectric power generation and how is it assessed?

(b) A thermo-electric generator operates between the temperatures of 1155K and 580K respectively. For the power production capacity of 95 kW at 110 V and maximum thermal efficiency, compute (i) maximum value of figure of merit, (ii) number of couples in series, (iii) heat addition to and heat rejection from the generator in load and no load conditions in kW and (iii) maximum thermal efficiency. The properties of thermoelements are as, Seebeck coefficient = 0.001 V/K; Thermal conductivity = 0.03 W/cm-K; Electric resistivity = 0.012 ohm-cm. Ratio of cross sectional area and length of both thermoelements is 100.

3. (a) Explain torrid, temperate and frigid zones. Draw the schematic diagram of a solar distillation system and discuss its working. Mention its merits and demerits.

(b) Find the day length for August 28 in Kolkata ( $22.34^{\circ}\text{N}$ ,  $88.24^{\circ}\text{E}$ ). Find also the local sun-rise and sun-set hours on a horizontal surface for that day.

4. (a) Explain the terms (i) latitude, (ii) declination, (iii) hour angle and (iii) altitude angle.

(b) Estimate the average value of solar radiation that will fall on a horizontal surface of unit area on March 12 for a location at  $40^{\circ}\text{N}$  latitude. Average sunshine hours per day is 8.2;  $a$  and  $b$  are as 0.3 and 0.6 respectively.

5 Write short notes on any THREE of the following :

(i) Nature of electron energy and energy level

(ii) Forced circulation closed solar water heating system

(iii) Cylindrical parabolic collector

(iv) Central receiver and distributed collector type solar thermal power plants

**SECOND HALF (ME-705/9)**

6. (a) Discuss the merits and demerits of Molten carbonate fuel cell (MCFC).  
(b) Discuss the importance of fuel processing in Alkaline fuel cell (AFC) and water management in Polymer electrolyte fuel cell (PEFC).  
(c) With the help of a block diagram, show the components of a fuel-cell based power production system.
7. (a) Briefly discuss the merits and demerits of a packed-bed-based energy storage system.  
(b) List the chemical reactions happening on both the electrodes for all five types of fuel cells.  
(c) An MCFC is operating on 450 kg/hr of fuel gas with 80% fuel utilization and 75% oxidant utilization. Fuel is composed of 2% CO, 12% CO<sub>2</sub>, 3% H<sub>2</sub>O and remaining H<sub>2</sub> on molar basis. Oxidant is a mixture of air and CO<sub>2</sub>. Corresponding molar percentages are given as: 25% CO<sub>2</sub>, 55% N<sub>2</sub> and remaining O<sub>2</sub>. Estimate  
(i) mass flow rate of H<sub>2</sub> consumption  
(ii) required mass flow rate of total oxidant consumption  
(iii) mass flow rate of CO<sub>2</sub> transfer from cathode to anode  
and (iv) effluent composition on both the electrodes
8. (a) Derive the mathematical expression for estimation of maximum power available per unit volume from a MHD unit.  
(b) Compare the advantages and disadvantages of MHD-based plants with respect to conventional units.  
(c) List the merits and demerits of water as the working medium of liquid media energy storage.
9. (a) With a neat schematic diagram, explain the working of a closed MHD system running on seeded inert gas, with a Rankine cycle in the bottoming unit.  
(b) What are the limitations of tidal energy production?  
(c) What are the factors that need to be considered while selecting site for a wind turbine?
10. (a) Derive the expression for power production by a wind turbine. Also find the value of maximum possible efficiency from theoretical point of view.  
(b) With a neat schematic diagram, explain the working of a closed-cycle OTEC plant.