## **GUJARAT TECHNOLOGICAL UNIVERSITY** M. E. - SEMESTER – I • EXAMINATION – WINTER 2012

# Subject code: 713904N Subject Name: Advanced Thermal Engineering Time: 02.30 pm – 05.00 pm

**Total Marks: 70** 

Date: 16-01-2013

# **Instructions:**

- 1. Attempt all questions.
- 2. Make suitable assumptions wherever necessary.
- 3. Figures to the right indicate full marks.
- 4. Use of Steam table is permitted.
- (a) Explain meaning of terms available energy and unavailable energy with 07 0.1 suitable examples. 07
  - (b) Differentiate between Nucleate boiling and Film boiling.

#### (a) Derive General heat conduction equation in Cylindrical co-ordinates. Q.2

(b) Two reversible heat engines A and B are arranged in series. Engine A rejects 07 heat directly to engine B. A receives 200 kJ at a temperature of 421°C from hot source while engine B is in communication with a cold sink at a temperature of  $5^{\circ}$ C. If the work output of A is twice that of B, find(a) intermediate temperature between A and B,(b) efficiency of each engine and(c) heat rejected to the sink.

## OR

(b) A square plate heater (15 \* 15) is inserted between two slabs. Slab is 2 cm 07 thick (k = 50 W/m<sup>0</sup>C) and slab B is 1 cm thick(k =  $0.2 \text{ W/m}^{\circ}C$ ). The outside heat transfer coefficients on side A and side B are 200 W/m<sup>2</sup> <sup>0</sup>Cand 50 W/m<sup>2</sup> <sup>0</sup>C respectively. The temperature of surrounding air is 25 <sup>0</sup>C. If rating of heater is 1 kW, find: (a) Maximum temperature in the system (b) Outer surface temperature of two slabs. Draw the equivalent electrical circuit also.

#### Q.3 (a) Using Gibbs relations derive Maxwell relations

(b) The composite wall of an oven consists of three materials, two of which are of 07known thermal conductivity,  $k_A = 20$  W/mK and kc = 50 W/mK and known thickness,  $L_A = 0.3$  m and  $L_c = 0.15$  m. The third material, B, which is sandwiched between materials A and C, is of known thickness,  $L_B = 0.15$  m, but unknown thermal conductivity k<sub>B</sub>. Under steady state conditions, measurements reveal an outer surface temperature of 20°C, an inner surface temperature of 600°C, and oven air temperature of 800°C. The inside convection coefficient h is known to be 25 W/m<sup>2</sup>K. What is the value of  $k_B$ ?

## OR

- (a) Explain thermal insulation and derive the equation for the critical thickness of 07 **Q.3** insulation of pipe.
  - (b) A refrigerant suction line having outer diameter 30 mm is required to be 07 thermally insulated. The outside air film coefficient of heat transfer is 12  $W/m^2 {}^{0}C$ . The thermal conductivity of insulation is 0.3  $W/m^{0}C$ . (a) Determine whether the insulation will be effective or not; (b) Estimate the maximum value of thermal conductivity of insulating material to reduce heat transfer;(c) Determine the thickness of cork insulation to reduce the heat transfer to 22 percent if the thermal conductivity of cork is 0.038 W/m<sup>o</sup>C.

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07 A vertical plate 350mm high and 420mm wide at  $40^{\circ}$ C is exposed to saturated 07 **(b)** steam at 1 atm. Calculate: (1) The film thickness and max. velocity at the bottom of the plate (2) total heat flux to the plate. Assume vapour density is small compared to that of the condensate.

### OR

- **Q.4** Derive the expression for LMTD for the counter flow heat exchangers. (a)
  - Water at atmospheric pressure is to be boiled in polished copper pan. The 07 **(b)** diameter of the pan is 350 mm and is kept at  $115^{\circ}$ C. Calculate (i) power of the burner (ii) Rate of evaporation in Kg/h (iii) Critical heat flux for these conditions. Take:  $C_{pl} = 4220 \text{ J/KgK}, n=1$
- Write a short note on Gas radiation. **Q.5** (a)
  - (b) Determine the heat loss by radiation per meter length of 80mm diameter pipe 07 at  $300^{\circ}$ C when (i) located in a large room with red brick walls at a temp. of 270C and (ii) enclosed in a 160 mm diameter red conduit at a temp. of  $27^{\circ}$ C. Also Calculate % reduction in heat flow. Take  $\varepsilon_1=0.79 \ \varepsilon_2=0.93$

### OR

- Q.5 (a) Derive the expression for the radiant heat exchange between the two non-07 black infinite parallel planes.
  - **(b)** In a certain double pipe heat exchanger, hot water flows at a rate of 5000 kg/h 07 and gets cooled from  $95^{\circ}$ C to  $65^{\circ}$ C. At the same time 50000Kg/h of cooling water at 30<sup>°</sup>C enters the heat exchanger. The overall heat transfer co-efficient remains constant at 2270 W/m<sup>2</sup>K. Determine the heat transfer area required and the effectiveness, assuming parallel flow streams. Assume for both the streams Cp = 4.2 KJ/KgK

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