Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. - SEMESTER – I • EXAMINATION – WINTER 2012

Subject code: 711006N Date: 16-01-2013

Subject Name: Cryogenic Heat Exchangers(Elective)

Time: 02.30 pm – 05.00 pm Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Student are allowed to use their own Properties tables**

Q.1 **(a)** Classify the heat exchangers in detail and draw neat sketches of (i) Collin's coiled tubular heat exchanger (ii) cross flow plate fin heat exchangers (iii) Giauque Hampson coiled tubular heat exchanger. **07**

(b) Explain the different boiling phenomena regimes with neat sketch. **07**

Q.2 **(a)** Derive the 2-dimensional conduction equation in Cartesian co-ordinates for a homogeneous material with heat generation in steady state conditions. **07**

(b) A pipe of 100 mm OD passes through the centre of a concrete slab of cross section 60x60 cm. the outer surface of the pipe is maintained at 130^{o}C while the outer surface of the concrete slab is at 30^{o}C. Using the Graphical method of flux plot, estimate the heat loss per metre length of the pipe. Assume conductivity of concrete 1.37 W/m.K. **07**

OR

(b) Discuss the conduction in fins considering the one dimensional case and derive the equation for the fin effectiveness. **07**

Q.3 **(a)** State and explain Lockhart – Martinelli correlations of two phase flow pressure drop for cryogenic fluids. **07**

(b) In what important aspects, the cryogenic heat exchangers differ from those used in general services? **07**

OR

Q.3 **(a)** An aluminum fin (k_t = 200 W/m-K) has a length of 100 mm, a thickness of 4.8 mm and a width of 1.50 m. The convective heat transfer co-efficient over the fin 20 W/m^2-K, and there is no frost on the fin. The base of the fin is maintained at 80 K, and the gas flowing over the fin is at 300K. Determine the heat transfer rate at the base of the fin, if the fin is not insulated. **07**

(b) Discuss freezing at cryogenic temperature outside and inside of the tube. **07**

Q.4 **(a)** Determine the heat transfer coefficient for nitrogen gas flowing inside a straight circular tube having an inside diameter of 20 mm. The nitrogen gas is at a bulk temperature of 95 K, and the tube wall has a temperature of 105 K. the mass flow rate of the nitrogen is 40 g/s, and the gas pressure is 140 kPa. Also determine the pressure drop per unit length of tube for the conditions given. **07**

Take properties as: μ= 6.98 μPa-s, c_p = 1.067 kJ/kg-K, k_t = 9.33 mW/m-K & Pr No. = 0.797. & Use the correlation = $j_H = 0.023\ Re^{-0.20}$, $f = 0.184\ Re^{-0.20}$

(b) Explain NTU-effectiveness method for design of parallel flow type heat exchangers. **07**

OR

Q.4 **(a)** A heat exchanger in counter flow Linde - Hampson system operates with the following parameters. **07**

- Warm fluid: air at 20.265 MPa, Mass flow rate = 1.25 kg/s.
- T_{h1} = 300 K; $c_{p,hot}$ = 1.588 kJ/kg-K;
- Cold fluid: air at 101.3 kPa; mass flow rate = 1.149 kg/s.
- T_{c1} = 81 K $c_{p,cold}$ = 1.017 kJ/kg-K;
- U = 120 W/m^2 – K; A = 70 m^2

Determine the heat transfer rate for this exchanger and the exit temperature of the two fluids.

Q.4 **(b)** Describe design procedure of cryogenic plate fin heat exchanger. **07**

Q.5 **(a)** Explain step by step design methodology for matrix type regenerator. **07**

(b) In plate-fin heat exchanger, the frontal area is 5.00 m^2 and the ratio of free flow area to frontal area is 0.40. The equivalent diameter of the flow passages is 3.60 mm. the gas flowing through the heat exchanger is methane (μ = 0.015mPa-s), which flows through the heat exchanger at a mass flow rate of 25.0 kg/s. The density of the methane at the heat exchanger inlet is 2.00 kg/m^3, the density at the outlet is 1.00kg/m^3, and the density at the bulk condition is 1.333kg/m^3. The length of the core in the direction of the flow is 238.8 mm. The contraction co-efficient is K_c= 0.50 and the expansion co-efficient K_e=0.30. The core friction factor correlation is given by f =1.115$Re^{-0.25}$. Determine the total pressure drop through the heat exchanger for the methane stream. **07**

OR

Q.5 **(a)** A regenerator is constructed of 1.882 kg of metal spheres (C_s = 0.84 kJ/kg-K, ks = 155 W/m-K) the total cycle period is 4 seconds) the fluid flowing through the regenerator is helium gas (c_p = 5.2 kJ/kg-K) for both streams. The mass flow rate of hot stream and cold stream is 40g/s and 36 g/s respectively. The convective heat transfer co-efficients are h_c = h_h = 8320W /m^2K, and the heat transfer area Ah=Ac = 0.950 m^2. Determine the regenerator effectiveness. **09**

(b) Write a note on regenerators. Also state its advantages and disadvantages as compared to recuperators. **05**

****