Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. - SEMESTER – III • EXAMINATION – SUMMER • 2014

Subject code: 732102 Date: 05-06-2014

Subject Name: Cryogenic Engineering

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. ***Use of Thermodynamic Diagrams of Cryogenic Fluids is permissible.***

Q.1 **(a)** Define cryogenics. Discuss the importance of cryogenics. **07**

(b) Determine the heat transferred in an Aluminum slab of uniform cross sectional area 100 cm^2 and length of 5 m, when the end faces are maintained at 303 K and 100 K using k_{avg} and kdT method and comment on the result. Assume thermal conductivity of aluminum at 303 K and 100 K as 210 W/mK and 415 W/mK respectively. Use following integral values **07**

$$\theta_2 = \int_0^{303} k(T)dT = 53000 \text{ and } \theta_1 = \int_0^{100} k(T)dT = 18000$$

Q.2 **(a)** State the importance of insulation is for cryogenic vessels. List the different types of insulations used in cryogenics and write a note on Multilayer Insulation. **07**

(b) Discuss the change in any three mechanical properties at cryogenic temperature. **07**

OR

(b) Explain following phenomenon for He II **07**
(1) Roll-in-Film, (2) Fountain effect and (3) Second sound

Q.3 **(a)** Explain the applications of cryogenics in space simulation. Discuss in detail. **07**

(b) Determine the mean thermal conductivity of multilayer insulation for following cases. **07**
(i) between 312 K and 20.5 K, (ii) between 20.5 and 4.2 K and (iii) between 312 K and 4.2 K.
Assume insulation is made up of 50 layers per cm of aluminum foil having emissivity of 0.05 on both the sides. The value of h_C = 85 mW/m^2 K.

OR

Q.3 **(a)** State difference methods of producing low temperature and explain Joule-Thomson effect to produce of low temperature **07**

(b) Determine the time required to boil 1 litre of liquid at its normal boiling point for (i) LH_2 and (ii) LO_2 if heat transfer rate to the flask is 5 watts. Latent heat of vaporization of H_2 and O_2 are 443 kJ/kg and 212.9 kJ/kg. The density of H_2 and O_2 are 70.78 kg/m^3 and 1141 kg/m^3. Consider atmospheric temperature is 27 ^OC. **07**

Q.4 **(a)** With a schematic diagram explain the working of pulse tube refrigerator and its configurations. **07**

(b) A refrigerator working on Gifford-McMahon cycle operates between the pressure limits of 1 atm. and 10 atm. using helium as the working fluid. The maximum temperature of the space to be cooled is 70 K, and the temperature of gas leaving the compressor is 300 K. Assume that the regenerator is 100 percent effective, and compressor overall efficiency is 70 percent. The expansion efficiency is 95 percent. Determine the work required per unit mass of helium compressed, refrigerating effect and COP for the system. Use the following properties values of helium where symbols have usual meaning. **07**

At 1 atm. Pressure and 300 K, h_1 = 1572.7 J/gm and S_1 = 31.41 J/gm-K
At 10 atm. Pressure and 300 K, h_2 = 1575.8 J/gm and S_2 = 26.63 J/gm-K
At 10 atm. Pressure and 70 K, h_3 = 379.2 J/gm and ρ_3 = 6.85 gm/L
At 1 atm. Pressure, h_4 = 158.8 J/gm and S_4 = 19.05 J/gm-K
At 1 atm. Pressure and 70 K, h_5 = 378.2 J/gm
At 1 atm. Pressure and h_4ô = 169.82 J/gm, ρ_4ô = 1.45 gm/L.

OR

Q.4 **(a)** Explain the Magnetic refrigeration cycle with neat sketch. **07**

(b) Reverse Carnot cycle is not considered as the ideal cycle for liquefaction. Justify the statement with sketches. **07**

Q.5 **(a)** Explain Claude system for gas liquefaction system with neat sketch and T ï S diagram. **07**

(b) Determine the refrigerating effect, COP and FOM for a simple Linde-Hampson refrigerator operating from 300 K and 101.3 kPa to 10.13 MPa. The overall efficiency of the compressor is 85 % and the heat exchanger effectiveness is 0.98. The working fluid for the refrigerator is nitrogen. Use the following properties values of nitrogen where symbol haves usual meaning. **07**

At 101.3 kPa Pressure and 300 K, h_1 = 462 J/gm and S_1 = 4.42 J/gm-K
At 10.13 MPa Pressure and 300 K, h_2 = 444 J/gm and S_2 = 3.0 J/gm-K
At 101.3 kPa Pressure, h_g = 229 J/gm and h_f = 29 J/gm.

OR

Q.5 **(a)** With neat sketch and T ï S diagram explain Simple Linde Hampson liquefaction system and derive the equations of yield and FOM. **07**

(b) A Linde dual-pressure system operates with nitrogen as working fluid between 1 atm. and 300 K, and 200 atm. The intermediate pressure is 50 atm., and the intermediate pressure flow rate ratio is 0.85. Determine the liquid yield, work requirement per unit mass compressed in the high-pressure compressor, work requirement per unit mass liquefied and FOM. Use the following properties values of nitrogen where symbols have usual meaning. **07**

At 1 atm. Pressure and 300 K, h_1 = 462 J/gm and S_1 = 4.42 J/gm-K
At 50 atm. Pressure and 300 K, h_2 = 452 J/gm and S_2 = 3.23 J/gm-K
At 200 atm. Pressure and 300 K, h_3 = 432 J/gm and S_3 = 2.74 J/gm-K
At 1 atm. Pressure, h_f = 29 J/gm and S_f = 0.42 J/gm-K