

GUJARAT TECHNOLOGICAL UNIVERSITYM. E. Sem. – IInd - Examination – June/July- 2011

Subject code: 1721001

Subject Name: Cryogenic Systems

Date: 22/06/2011

Time: 10:30 am – 01:00 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 scientific calculators and gas properties charts/tables permitted.

- Q.1** (a) Explain with necessary figures working of Linde-Hampson refrigerator operating on $J-T$ effect. Also derive expression for its COP with usual notations. **07**
- (b) Define Joule-Thomson coefficient. Also derive the following expression for it with usual notations. **07**

$$\mu_{JT} = -\frac{1}{C_p} \left\{ \left(\frac{\partial u}{\partial P} \right)_T + \left[\frac{\partial(pv)}{\partial p} \right]_T \right\}$$

- Q.2** (a) Determine the work requirement for an ideal isobaric source refrigerator which uses gaseous helium as the working medium and which removes 2 kW of energy from the low temperature source. The source temperature varies from 5 K to 20 K. The sink temperature is 300 K. **07**
- (b) Derive following expression for thermodynamically ideal isobaric source refrigeration system. **07**

$$COP_i = \frac{(T_2/T_1) - 1}{(T_0/T_1) \ln(T_2/T_1) - (T_2/T_1) + 1}$$

OR

- (b) An ideal gas refrigerator operates between 72 K and 88 K while rejecting heat at 300 K. Assuming that the working fluid is a perfect gas, determine the COP of the refrigerator and compare the value with the COP of Carnot refrigerator operating between (i) 72 K and 300 K and (ii) 88 K and 300 K. **07**
- Q.3** (a) State the desirable features of a regenerator of Philips refrigerator. Discuss how ineffectiveness of a regenerator affects the refrigerating effect. **07**
- (b) Describe briefly the working of Double volume G-M refrigerator. Write its merits and demerits with reference to single volume G-M refrigerator. **07**

OR

- Q.3** (a) Enlist different types of Pulse Tube refrigerators. Explain any one with figure. **07**
- (b) Write brief short note on followings. **07**
- (i) Magnetic cooling (ii) Thermal Valves

- Q.4** (a) Determine liquid yield, work per unit mass liquefied and F.O.M. for simple Linde-Hampson system operating between the pressure limits of 1 bar and 200 bar. Air enters the compressor at 300 K. Take heat exchanger effectiveness 95 % and compressor isothermal efficiency of 80 %. **07**

- (b) Describe helium gas refrigerated hydrogen liquefaction system with neat schematic diagram. 07

OR

- Q.4** (a) Determine the liquid yield, the total work per unit mass of gas compressed and the work to liquefy the unit mass of gas in a Claude system using Nitrogen as working gas. The system operates between 101.3 kPa, 300 K and 5.066 MPa. The expander flow rate ratio is 0.60 and the expander work is utilized to aid in compression of the gas. The condition of the gas at the inlet of the expander is 270 K and 5.066 MPa. 07
- (b) In an ideal Kapitza system N_2 gas enters the compressor at 1.013 bar and 300 K and is compressed to 50.66 bar. The gas enters the reversible adiabatic expander at condition of 50.66 bar and 260 K. The expander flow rate ratio is 0.50. Determine the liquid yield, the work per unit mass compressed and work per unit liquefied, assuming that the expander work utilized in the compression process. Represent the cycle on T-s diagram with different states. 07
- Q.5** (a) What modification in Claude system was carried out by Heylandt? Explain the the modified system with neat schematic diagram. 07
- (b) Describe pressure swing adsorption system for separation of nitrogen from air with neat schematic diagram. 07

OR

- Q.5** (a) Explain briefly Langmuir Monolayer Theory of adsorption process. 07
- (b) Determine the mass of silica gel required to adsorb 15 m^3 of carbon monoxide at 75 kPa and 90 K. The saturation pressure for CO at 90 K is 242 kPa. Take $V_m = 133 \text{ dm}^3/\text{kg}$ and $\theta_a = 491 \text{ K}$ in BET equation. 07
