Reg.No.										

MANIPAL INSTITUTE OF TECHNOLOGY
A Constituent Institute of Manipal University, Manipal

II SEMESTER M.Tech (TSES) END SEMESTER EXAMINATIONS, APRIL/MAY 2017

SUBJECT: REFRIGERATION AND CRYOGENIC SYSTEMS [MME-5273]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL the** questions.
- Missing data may be suitable assumed.
- Use of Thermodynamic Data Handbook is permitted

1A. With schematic and T-S diagram, obtain an expression for the mass flow of air passing through the cabin and COP of a regenerative aircraft cooling system. What are its advantages over other cooling systems used in aircraft **05**

1B. A refrigerant R22 vapor compression system includes a liquid-to-suction heat exchanger in the system. The heat exchanger warms saturated vapor coming from the evaporator from -10 to 5^0 C with liquid which comes from the condenser at 30^0 C. The compressions are isentropic

(a) Calculate the coefficient of performance of the system without the heat exchanger but with the condensing temperature at 30 C and an evaporating temperature of -10 C. **05**

(b) Calculate the coefficient of performance of the system with the heat exchanger

(c) If the compressor is capable of pumping 12.0 L/s measured at the compressor suction, what is the refrigeration capacity of the system witht the heat exchanger?

2A. Briefly explain the factors to be considered in the thermal design of evaporators. Explain how the boiling heat transfer coefficient is estimated in evaporators. **05**

2B. In a 25 TR NH3 plant, compression is carried out in 2 stages with water and flash intercooling and water sub-cooling. The vapour is dry at the entry to both HPC and LPC. Condenser pressure is 14 bar and evaporator pressure is 2 bar. Flash intercooler pressure is 6 bar. Limiting temperature for intercooling and sub-cooling is 22^0C. Estimate; **05**

i) COP
ii) Power required for each compressor
iii) Swept volume for each compressor if the volumetric efficiency of the compressors are 80% each

3A. Explain the working of automatic expansion valve used in refrigeration system. What is the effect of load variation on the performance of this valve **05**

3B. The following data refer to a Lithium Bromide water absorption system Capacity 2 TR, Concentration of Lithium Bromide and enthalpy values for weak solution leaving the generator 0.68 and 21 kJ/kg, These values for the strong solution leaving the absorber are 0.58 and – 55 kJ/kg. Temperature of water leaving the condenser is 40^0 C. Enthalpy of steam leaving the evaporator is 2508 kJ/kg. Determine the mass flow rates of strong and weak solutions in kg/min and the heat transfer rates in the generator and absorber in kJ/min. **05**

4A. Explain the working of Gifford-McMahon cryo-cooler with schematic and T-S diagram. Obtain an expression for COP and FOM of this cryo-cooler **05**

4B. A single cylinder reciprocating compressor is to be designed for a domestic refrigerator of 150 W cooling capacity. The refrigerator operates at an evaporator temperature of –25^{o}C and a condensing temperature of 45^0 C. The refrigeration effect at these conditions is 90 kJ/kg. At the suction flange the temperature of the refrigerant is 32^0 C and specific volume is 0.15 m^3/kg. Due to heat transfer within the compressor the temperature of the refrigerant increases by 15^{o}C. The indicated volumetric efficiency of the compressor is 0.85 and the leakage loss factor is 0.04. The rotational speed of the compressor is 2400 RPM. Find **05**

i) The diameter and stroke of the compressor

ii) COP of the system if the actual mean effective pressure of the compressor is 5.2 bar.

5A. Obtain expressions for fraction liquefaction and work of liquefaction for Pre- **05**

cooled Linde-Hampson process. Explain the effect of pressure and coolant flow rate on fraction liquefaction

5B. In an Clude liquefaction system, Nitrogen gas enters the compressor at 1 atm and 300 K and is compressed to 60 atm. The gas enters the reversible adiabatic expander at a condition of 60 atm and 268 K. The expander flow rate ratio is 0.5. Determine the liquid yield, the work per unit mass compressed and the work per unit mass liquefied assuming that the expander work is utilized in the compression process. Assume that the exit temperature of recycled gas from the first heat exchanger is 5K less than the entrance temperature of compressed gas. The following data for Nitrogen may be assumed. **05**

At 1 atm and 300 K, enthalpy is 462 kJ/kg and entropy is 4.42 kJ/kg K

At the exit temp of recycled gas from first H.E, enthalpy is 452 kJ/kg

At 60 atm and 300 K, enthalpy is 426 kJ/kg and entropy is 2.706 kJ/kg K, Enthalpy and entropy at the exit of regenerator 392 kJ/kg and 2.65 kJ/kg K, Enthalpy of liquid Nitrogen is 32 kJ/kg and its entropy is 0.47 kJ/kg K, enthalpy at the exit of expander is 220 kJ/kg