

(3 Hours)

[ Total Marks : 100

- N.B. (1) Question No. 1 is compulsory and attempt any four questions from remaining six questions.  
(2) Assume suitable data is missing.  
(3) Use of T-S charts, h-c charts are permitted.

1. (a) Explain how a cascade system can be used to produce liquid Nitrogen. 5  
(b) Explain what is meant by inversion temperature and maximum inversion temperature. 5  
(c) Describe Walker's chart for classification of cryo-coolers. 5  
(d) Describe construction of rectification column used in separation of gas mixtures such as air. Explain the principle involved. 5
2. (a) Derive an expression for yield and figure of Merit of a simple Linde Hampson system, with heat exchanger effectiveness not ideal. 10  
(b) A liquefaction system for air operates on simple Linde Hampson Cycle. High and low pressure are 200 atm and 1 atm respectively. 10  
Temperature of isothermal compression is 300 K.  
The heat in leak into storage vessel is 3.5 kJ/kg of air. The heat exchanger effectiveness is 0.97 and isothermal efficiency of the compressor is 75%. Find the power required to produce 20 kg/h of liquid air. Derive all formula used and show schematic of system together with T-S diagram.
3. (a) Compare various insulations used in cryogenic systems. 10  
(b) With the help of neat sketch explain the construction of a Dewar vessel for storing cryogens. 10
4. (a) Air enter a Claude System at 1 atm and 20 °C and is compressed to 100 atm. At 100 atm and 250 K, 40% of main flow is diverted to the expander. The remainder flows through the heat exchanger and expand, through the expansion valve to 1 atm. 10  
Adiabatic efficiency of expander = 80%  
Mechanical efficiency of expander = 90%  
Compressor efficiency of expander = 75%  
Effectiveness of Heat Exchangers = 100%.

Determine :-

- (i) Liquid yield  
(ii) Expander work output per unit mass compressed  
(iii) Figure of Merit.
- (b) Explain Claude cycle used in liquification with a neat sketch and T-S diagram. 10
5. (a) Derive an expression for COP of a V-M refrigerator. Compare it with COP of Philips refrigerator. 10  
(b) Determine the fraction of the ideal refrigeration effect  $\Delta\phi/\phi_a$  that is lost in Philips refrigerator 10  
having a regenerator that is 98% effective. The refrigerator uses Hydrogen as the working fluid ( $C_p/C_v = 1.4$ ) and the volumetric ratio  $V_4/V_3$  is 1.85.  
The refrigerator operates between the temperature limits of 300 K and 80 K.
6. (a) Explain the working of :- 10  
(i) Diffusion pump (ii) Cryo pump  
Make a neat sketch in each of them.
- (b) Explain two methods for measuring flow rate of cryogenic liquids with neat sketch. 10
7. Write notes on : 20  
(a) Ortho-para conversion at Hydrogen  
(b) Mechanical properties of materials of cryogenic temperatures  
(c) Food preservation using cryogen  
(d) Magnetic refrigeration.