Group - C (Answer any **three**) [8x3=24]

7. A steel plate of size 0.25 m x 0.65 m is maintained at temperature of 80°C is placed in surrounding air at 35°C. Find heat transfer rate when the plate has vertical height as 0.5m. Given the properties of air at 35°C, $\nu = 2 \times 10^{-5}$ m²/s, $k = 30 \times 10^{-3}$ w/mK, $P_r = 0.7$ (8)

8. A 1.5 m high, 1.0 m wide double plane window consists of two 6 mm thick layer of glass (k = 0.78 W / m K) and is separated by a 12 mm wide stagnant air space (k = 0.026 W /m K) .The room is at 24°C and the outside air is at 2°C. The heat transfer coefficients are $h_i = 10$ W/m² K and $h_o = 40$ W/ m² K. Find (a) The rate of heat transfer through the window, (b) Draw the thermal circuit diagram along with the space diagram showing all the resistances. (6+2=8)

9. A room 3 m in length, 2 m in width and 4 m in height is heated from the ceiling by maintaining it at a temperature of 300°C. The side walls and floor are maintained at 200°C. (a) Calculate the rate of heat transfer from the ceiling to floor and side walls when the emissivity of all surfaces is 0.5, (b) Draw the radiation network diagram with the space diagram showing all the resistances. (6+2=8)

10. A heat exchanger cools a liquid flowing at 10 kg/s from 90°C to 60°C . Specific heat of the liquid is 3800J/kg °C. The cooling water has flow rate 20 kg/sec in tube side and entry temperature of 15°C. Overall heat transfer coefficient is 450 W/m² °C. (a) Find the heat transfer area for one shell and two tube pass. Given correction factor is 0.84, (b) Draw the space diagram and corresponding temperature profile diagram. (6+2=8)

11.(a) A plane wall is fitted with an aluminium (k = 200 W / m K) pin fin of 15 mm diameter and 350 mm long. The fin base temperature is 250°C and the pin fin is in contact with air at 25°C. The convection heat transfer co-efficient between fin surface and air is 15 W / m² K. Assume that the fin is infinitely long. Calculate the fin efficiency for the fins. (4+4=8)

(b) Two parallel plates, each has surface area 3 m², are radiating to each other having temperature of 200 °C and 100 °C. Determine the heat transfer rate assuming the plates are gray body having emissivity 0.5. Draw also the radiation network diagram showing all the resistances.

Ex/Prod/PC/B/T/212/2024

JADAVPUR UNIVERSITY

Bachelor in Production Engineering Examination - 2024

2nd Year – 1st Semester

Thermodynamics & Heat Transfer

Time : 3 Hours Full Marks : 100

*Answer **Group – A(Compulsory) and any two** from **Group – B** & **any three from Group – C***

[46+30+24=100]

Group – A (Compulsory) [(10x1)+(8x2)+(5x4)=46]

Note:1. All the notations or symbols used in any formula should be explained clearly.
2. Assume any appropriate missing data if you feel so.

1. Answer the following questions: (10x1=10)

(a) What is fouling factor of a heat exchanger.

(b) Why PMM2 is impossible?

(c) Why does free expansion have zero work transfer?

(d) Draw a plot on P-V coordinate for an isochoric process from state '1' to '2'.

(e) When a heat exchanger is considered as a compact heat exchanger?

(f) State the principle of entropy.

(g) Find the emissivity of the sun when its surface temperature is 5500°C and diameter of about 1.39×10^9 m.

(h) State Clausius theorem.

(i) Why are metals like copper, aluminium etc good thermal conductors, while non-metals like wood, glass are bad conductors of heat.

(j) Define the term 'capacity of a refrigeration plant is 800 Tons'.

2. Answer the following questions: (8x2=16)

(a) Draw line diagram of a 2 – 4 heat exchanger.

(b) Prove that in a boiler, the amount of heat supplied to the water to convert it into steam is equal to the change in enthalpy.

(c) How does a heat pump differ from a refrigerator? Explain with block diagrams.

(d) In a two fluid heat exchanger, the inlet temperatures of the hot fluid and cold fluid are 60°C & 30°C and outlet temperatures of the hot fluid and cold fluid are 60°C & 40°C. What will be the name of that heat exchanger (not flow type)? Draw the temperature profile diagram corresponding to space diagram.

(e) Draw velocity profile diagram for forced convection heat transfer when a fluid flows over a flat plate.

(f) Convert 1 m of H_2O gauge pressure to absolute pressure in KPa.

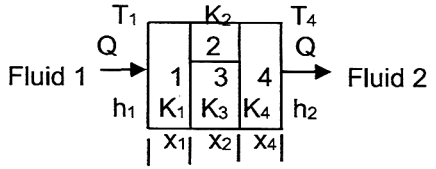
(g) A mixture of ideal gases consists of 2kg of gas 'A' and 5 kg of gas "B' at a pressure of 200 kPa and a temperature of 50°C. Mole fraction of gas 'A' is 0.41. Calculate the mole fraction of gas 'B'.

(h) An electric wire of 10 m length and 1 mm diameter dissipates 200 W in air at 25°C. The convection heat transfer co-efficient between the wire surface and air is 15 W / m^2 K. The wire is insulated with mica of thermal conductivity 0.5815 W / m K. Calculate critical radius of insulation.

3. Answer the following questions: (5x4=20)

(a) Draw the Flow Diagram and corresponding P-H Diagram of an actual Vapour Compression refrigeration plant using superheating and subcooling systems. Show the heat rejection, heat absorption and work-done on the diagrams.

(b) Cross section of a composite wall is shown in Fig. Draw thermal circuit diagram showing all the resistances and find the total thermal resistance.



(c) An air-water vapour mixture enters an adiabatic saturator at 35°C and leaves at 18°C, which is the adiabatic saturation temperature. The pressure remains constant at 1.01325 bar. Determine the relative humidity(Φ) and the humidity ratio(w) of the inlet mixture and outlet mixture from the ***Psychrometric Chart***. Locate the inlet and outlet of the saturator by points '1' & '2' respectively on the chart. Write the corresponding data on the chart as well on the answer sheet. Also find the amount of moisture removed from the system.

(d) Draw a plot on P-V coordinate when 1 kg of ice at –20°C is heated at 1 atmospheric pressure to steam at 200°C. Show different lines and regions like solid, solid+liquid, solid+vapour, liquid+vapour and vapour.

(e) Steam at 0.5 MPa pressure passes through a pipe and expands to 0.02 MPa in a throttling device. The temperature of steam after expansion is 100°C. Find specific enthalpy, specific entropy and dryness fraction of steam before expansion from the ***Mollier Diagram***. Mark the different states by '1' & '2' on the diagram and also the corresponding data as h_1, s_1 and x_1. Write the corresponding data on the chart as well on the answer sheet.

Group - B (Answer any **Two**) [15x2=30]

4.(a) Water at 45°C is continuously spayed into a pipeline carrying 6 tonnes of steam at 0.55 MPa, 252°C per hour. At a section downstream where pressure is 3.5 bar, the quality is to be 90%. Find the rate of water spray in kg/h. (8+7=15)

(b) A lump of steel of mass 25 kg at 520°C is dropped in 110 kg of oil at 35°C. The specific heats of steel and oil are 0.52 kJ/kg.K and 3.7 kJ/kg.K respectively. Calculate the entropy change of the steel, oil and the universe.

5.(a) A house is to be maintained at a temperature of 25°C by means of a heat pump pumping heat from the atmosphere. Heat losses through the walls of the house are estimated at 0,5 kW per unit of temperature difference between the inside of the house and the atmosphere. The atmospheric temperature is 0°C. Find the minimum power required to drive the pump? Also draw the block diagram. (6+2=8)

(b) A gaseous system undergoes three quasi-static processes in sequence. The gas initially at 6 bar & 0.02 m^3 is expanded at constant pressure. It is then further expanded according to the relation PV^3 = Constant to 2 bar & 0.035 m^3. The gas is then returned to its initial state during which process PV = Constant. (i) Sketch the cycle in the P-V plane, (ii) Calculate the net work done for the system. (4+3=7)

6.(a) A vapour compression cycle works on R-134a refrigerant with evaporation pressure of 0.12 MPa and condensation pressure of 0.7 MPa. The mass flow rate of the working fluid is 0.05 kg/sec. (a) Find the rate of heat removal from the refrigerated space, (b) The power input to the compressor, (c) Draw the flow diagram along with T-S and P-H coordinates showing heat rejection, heat absorption and work-done on the diagrams. (4+3+3=10)

(b) A mixture of ideal gases consists of 2.7 kg of O_2 and 4.7 kg of N_2 at a pressure of 0.25 MPa and a temperature of 25°C. Find partial pressures of the mixture. (5)

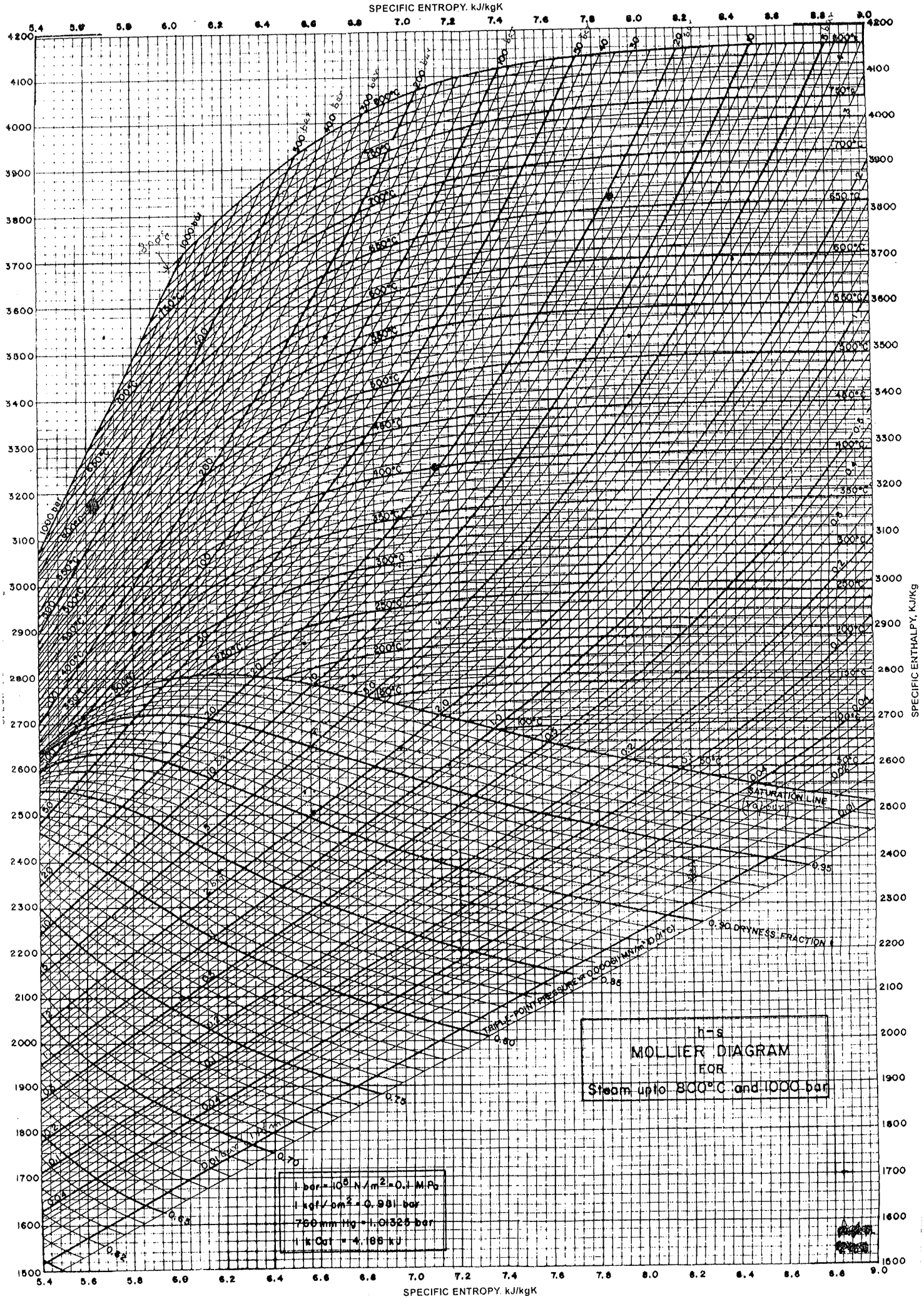
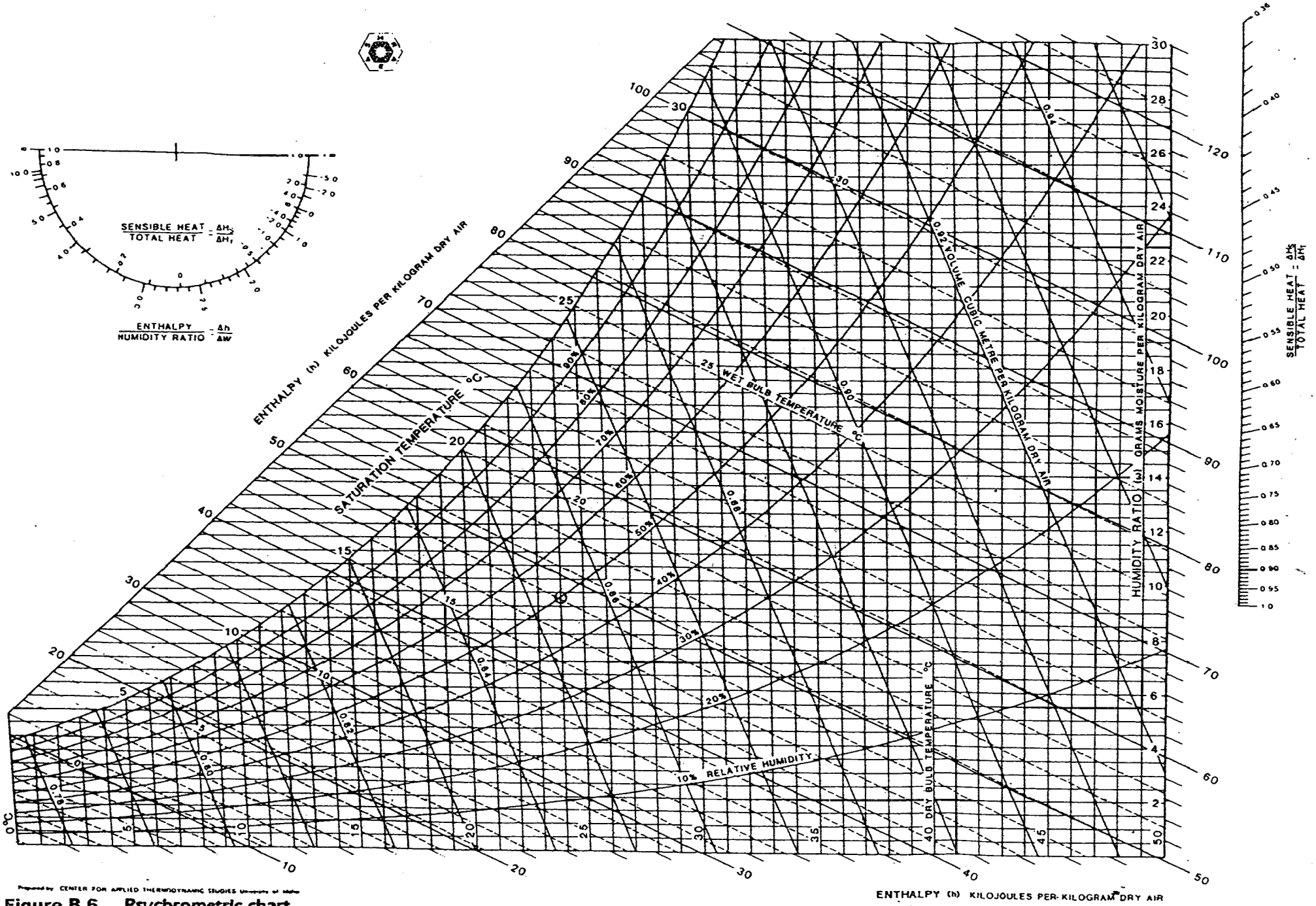


Figure B.1: *Mollier Chart*



Prepared by CENTER FOR APPLIED THERMODYNAMIC STUDIES University of Idaho

Figure B.6 Psychrometric chart.