Name: **Enrolment No:**	UPES UNIVERSITY OF TOMORROW

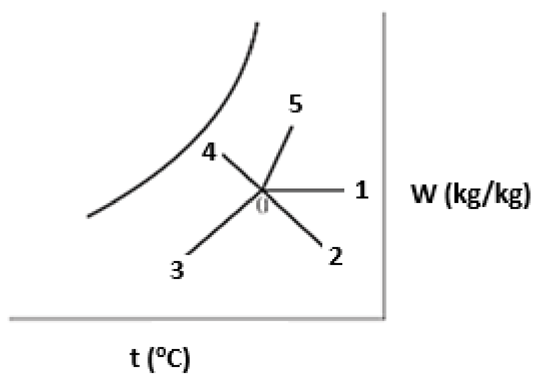
UPES
End Semester Examination, May 2025

Course: Refrigeration and Air Conditioning **Semester: VI**
Program: B. Tech Mechanical **Time : 03 hrs.**
Course Code: MECH3010 **Max. Marks: 100**

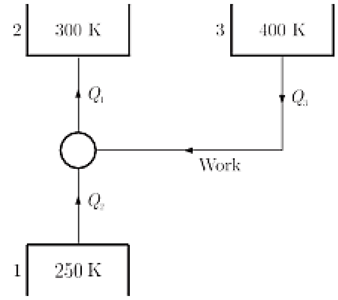
Instructions: Attempt all questions.

Note: Students are permitted to use their own Refrigeration Tables, Steam Tables, and Psychrometric Charts, provided they contain no additional markings or annotations.

SECTION A
(5Qx4M=20Marks)

S. No.		Marks	CO
Q 1	Discuss the Ozone Depletion Potential (ODP) of R114 and R132?	**4**	**CO1**
Q 2	In an ideal vapour compression refrigeration cycle, the specific enthalpy of refrigerant (in kJ / kg) at the following states is given as: Inlet of condenser :283 Exit of condenser :116 Exit of evaporator :232 Determine the COP of this cycle.	**4**	**CO1**
Q 3	Discuss the various psychometric processes shown in the figure below. 	**4**	**CO1**
Q 4	For a typical sample of ambient air (at 35 ^{0}C, 75% relative humidity and standard atmosphere pressure), determine the amount of moisture in kg per kg of dry air?	**4**	**CO2**
Q 5	A vapour absorption refrigeration system is a heat pump with three thermal reservoirs as shown in the figure. A refrigeration effect of 100 W is required at 250 K when the heat source available is at 400 K. Heat	**4**	**CO2**

rejection occurs at 300 K. Determine the minimum value of heat required (in W).



SECTION B

(4Qx10M= 40 Marks)

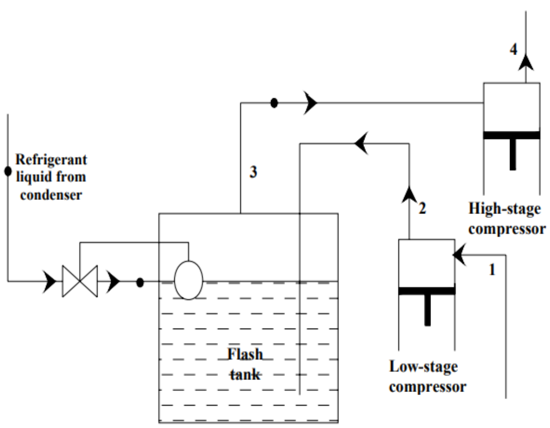
Q 6 | Discuss the importance of multi-evaporator refrigeration system for industrial applications. | **10** | **CO1**

Q 7 | A refrigerator operates between 120 kPa and 800 kPa in an ideal vapour compression cycle with R-134a as the refrigerant. The refrigerant enters the compressor as saturated vapour and leaves the condenser as saturated liquid. The mass flow rate of the refrigerant is 0.2 kg/ s. Properties for R134a are as follows: | **10** | **CO2**

Saturated R-134a					
p(kPa)	T (cC)	h_f (kJ /kg)	h_g (kJ /kg)	s_f (kJ /kgK)	s_g (kJ /kgK)
120	−22.32	22.5	237	0.093	0.95
800	31.31	95.5	267.3	0.354	0.918
Superheated R-134a					
p(kPa)		T (cC)	h (kJ /kg)		s(kJ/ kgK)
800		40	276.45		0.95

Determine: (a) The rate at which heat is extracted, in kJ /s from the refrigerated space. (b) The power required for the compressor in kW

Q 8 | Analyze the T-S diagram of the multi-stage VCRS with a Flash tank and discuss the importance of using a Flash tank in the industrial refrigeration system. | **10** | **CO3**



<table>
<tr><td>Q 9</td><td>A 1.8-meter-tall human with a body mass of 60 kg performs light work (activity = 1.2 met) indoors. The indoor conditions are: DBT of 30 ^oC, mean radiant temperature of 32 ^oC, air velocity of 0.2 m/s. Assuming an average surface temperature of 34 ^oC for the surface of the human being and light clothing. Analyze the condition of thermal neutral equilibrium and calculate the amount of evaporative heat transfer required to maintain a human being in a state of thermal comfort.

[Du Bois equation to estimate surface area of human being is: $A_{Du} = 0.202\ m^{0.425}h^{0.725}$, where m = mass and h = activity]

OR

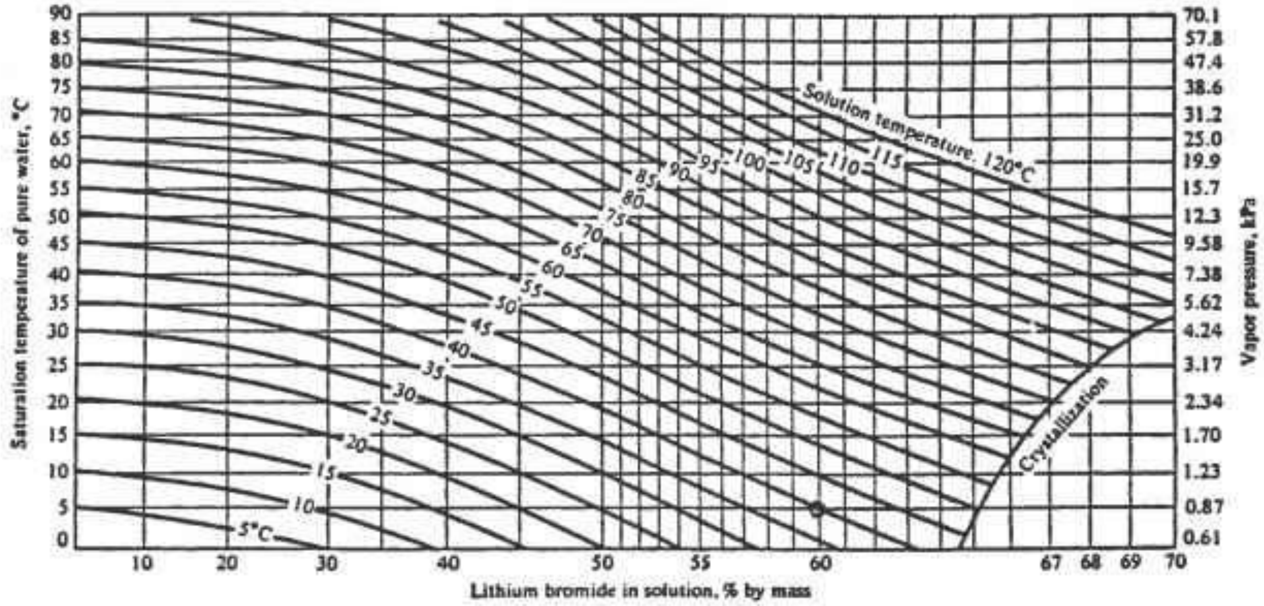
An office room with an area of 25 m² is occupied by 10 sedentary individuals. The room contains 10 personal computers, is equipped with lighting at 15 W/m², and requires a fresh air supply of 10 L/s per person. The outdoor conditions are 35°C and 60% relative humidity, while the indoor design conditions are 24°C and 55% RH.

Assuming standard heat gain values:

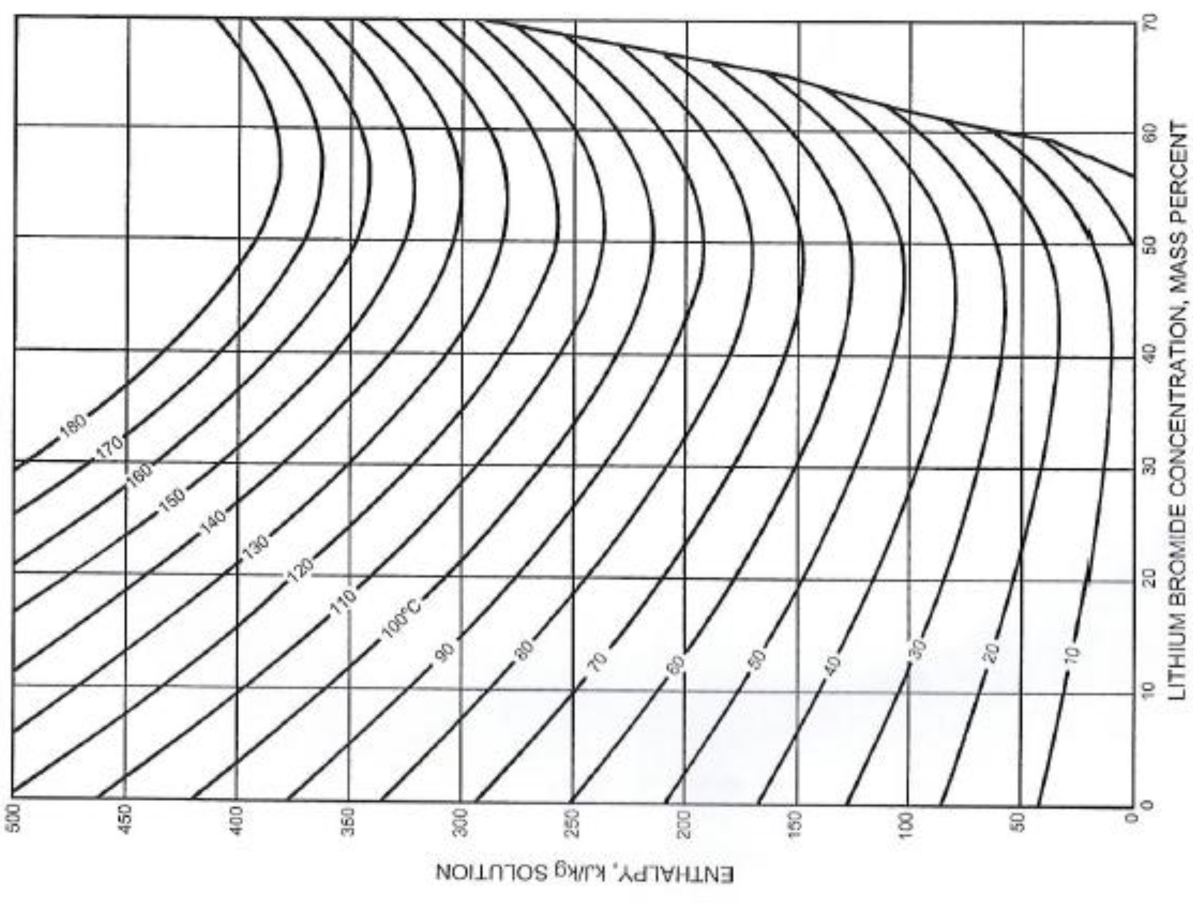
• Each person contributes 75 W sensible and 55 W latent heat
• Each computer dissipates 150 W, with a use factor of 0.8
• Lighting cooling load factor is 1.25
• Air density = 1.2 kg/m³

Analyze the various sources of heat gain in a room with 10 occupants, lighting, equipment, and ventilation, and calculate the total cooling load (in kW) required to maintain human comfort.</td><td>10</td><td>CO3</td></tr>
<tr><td colspan="4">SECTION-C
(2Qx20M=40 Marks)</td></tr>
<tr><td>Q 10</td><td>An air-conditioned building has a sensible cooling load of 60 kW and latent load of 40 kW. The room is maintained at 24 ^oC (DBT) and 50% RH, while the outside design conditions are: 34 ^oC (DBT) and 40% RH. To satisfy the ventilation requirement, outdoor air is mixed with re-circulated air in the ratio of 1:3 (by mass). Since the latent load on the building is high, a reheat coil is used along with a cooling and dehumidifying coil. Air is supplied to the conditioned space at 14 ^oC (DBT). The bypass factor of the cooling coil is 0.15 and the barometric pressure is 101.325 kPa. Create a design for an air conditioning system by determining the:
a) Mass flow rate of air supply,
b) Required cooling capacity of the cooling coil and heating capacity of the reheat coil</td><td>20</td><td>CO4</td></tr>
</table>

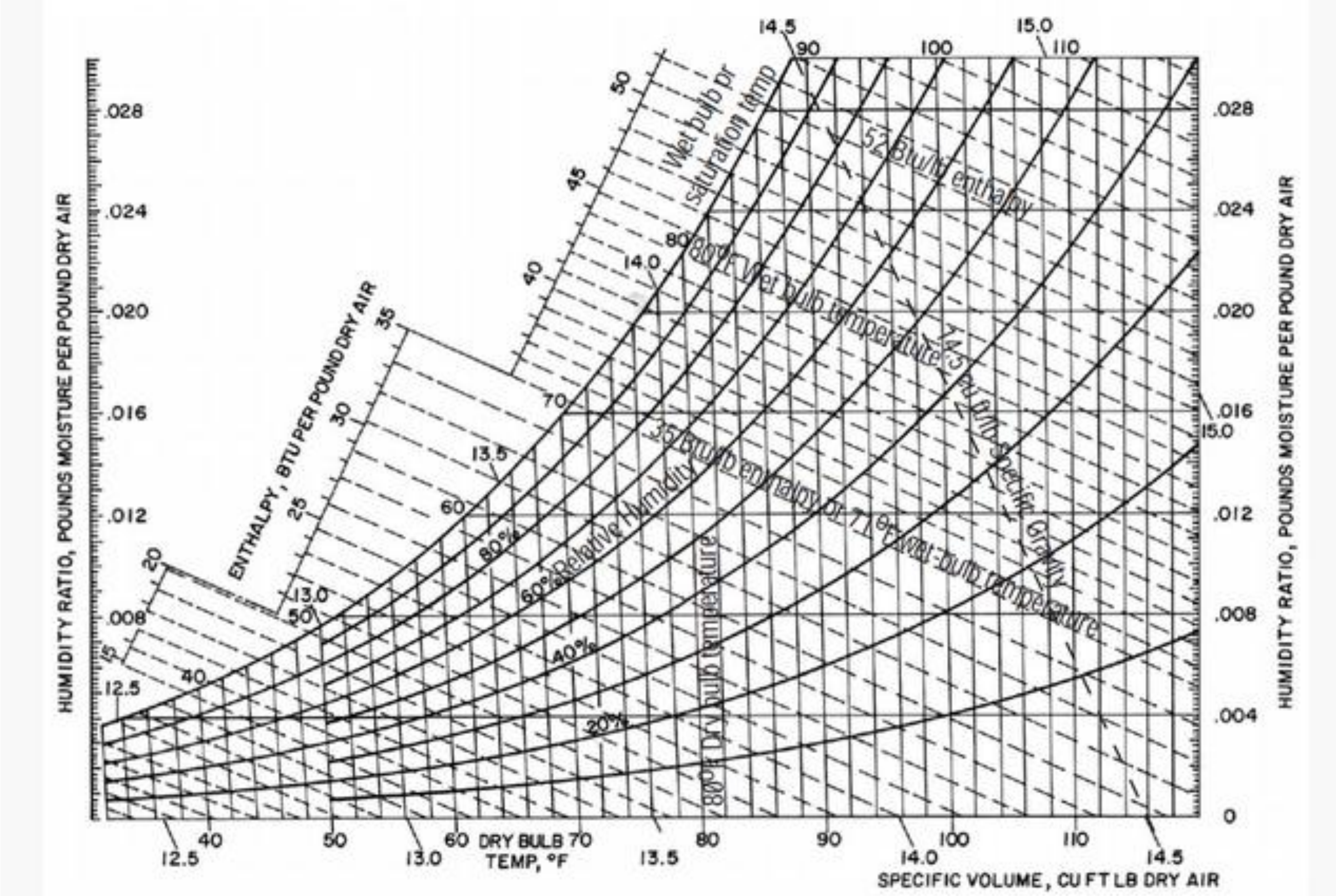
	OR In an air conditioning system air at a flow rate of 2 kg/s enters the cooling coil at 25 ^oC and 50% RH and leaves the cooling coil at 11 ^oC and 90% RH. The apparatus dew point of the cooling coil is 7 ^oC. **Create a design for an air conditioning system by determining the:** a) The required cooling capacity of the coil, b) Sensible Heat Factor for the process, and c) By-pass factor of the cooling coil. Assume the barometric pressure to be 1 atm. Assume the condensate water to leave the coil at ADP (hw = 29.26 kJ/kg)		
Q 11	A single stage vapour absorption refrigeration system based on H_2O-LiBr has a refrigeration capacity of 300 kW. The system operates at an evaporator temperature of 5 ^oC (Psat=8.72 mbar) and a condensing temperature of 50 ^oC (Psat=123.3 mbar). The exit temperatures of absorber and generator are 40 ^oC and 110 ^oC respectively. The concentration of solutions at the exit of absorber and generator are 0.578 and 0.66, respectively. Assume 100 percent effectiveness for the solution heat exchanger, exit condition of refrigerant at evaporator and condenser to be saturated and the condition of the solution at the exit of absorber and generator to be at equilibrium. Enthalpy of strong solution at the inlet to the absorber may be obtained from the equilibrium solution data. **Create a suitable design for a Vapour Absorption Refrigeration System (VARS) by determining the** a) The mass flow rates of refrigerant, weak and strong solutions b) Heat transfer rates at the absorber, evaporator, condenser, generator and solution heat exchanger c) System COP and second law efficiency, and d) Solution pump work (density of solution = 1200 kg/m^3).	**20**	**CO4**



Saturation temperature of pure water, °C
Vapor pressure, kPa
Solution temperature, 120°C
Crystallization
Lithium bromide in solution, % by mass



LITHIUM BROMIDE CONCENTRATION, MASS PERCENT
ENTHALPY, kJ/kg SOLUTION
100°C



HUMIDITY RATIO, POUNDS MOISTURE PER POUND DRY AIR
ENTHALPY, BTU PER POUND DRY AIR
DRY BULB TEMP, °F
SPECIFIC VOLUME, CU FT LB DRY AIR
Wet bulb or saturation temp
52 Btu/lb enthalpy
80°F Wet bulb temperature
35 Btu/lb enthalpy or 71°F wet-bulb temperature
60% Relative Humidity
80°F Dry bulb temperature
Specific Gravity
80%
40%
20%
.028
.024
.020
.016
.012
.008
.004
0
12.5
13.0
13.5
14.0
14.5
15.0
40
50
60
70
80
90
100
110
15
20
25
30
35
45