VALLIAMMAI ENGINEERING COLLEGE
DEPARTMENT OF MECHANICAL ENGINEERING
QUESTION BANK
ME 6301 - ENGINEERING THERMODYNAMICS

UNIT I

BASIC CONCEPT AND FIRST LAW

PART - A

1. **What do you understand by pure substance?**
2. **Define thermodynamic system.**
3. **Name the different types of system.**
4. **Define thermodynamic equilibrium.**
5. **What do you mean by quasi-static process?**
6. **Define Path function.**
7. **Define point function.**
8. **Explain homogeneous and heterogeneous system.**
9. **What is a steady flow process?**
10. **Prove that for an isolated system, there is no change in internal energy.**
11. **Indicate the practical application of steady flow energy equation**.
12. **Explain Mechanical equilibrium.**
13. **Explain Chemical equilibrium.**
14. **Explain Thermal equilibrium.**
15. **Define Zeroth law of Thermodynamics.**
16. **What are the limitations of first law of thermodynamics?**
17. **What is perpetual motion machine of first kind?**
18. **Differentiate between Microscopic and Macroscopic?**
19. **Differentiate Quasi static and non Quasi static process?**
20. **Differentiate reversible process and irreversible process?**

PART – B

1. **a) A rigid tank containing $0.4m^3$ of air at 400 kPa and 30^oC is connected by a valve to a piston cylinder device with zero clearance. The mass of the piston is such that a pressure of 200 kPa is required to raise the piston. The valve is opened slightly and air is allowed to flow into the cylinder until the pressure of the tank drops to 200 kPa. During this process, heat is exchanged with the surrounding such that the entire air remains at 30^oC at all times. Determine the heat transfer for this process.**

   b) A reciprocating air compressor taken in $2m^3$/min air at 0.11MPa, 293K which it delivers at 1.5 Mpa, 384 K to an after cooler where the air where the air is cooled at constant pressure to 298 K. the power absorbed by the compressor is 4.15 kW.

Determine the heat transfer in (i) the compressor (ii) the cooler. State your assumptions.

2. **In a turbo machine handling an incompressible fluid with a density of 1000kg/m^3 the conditions of the fluid at the rotor entry and exit are as given below:**

	1. Inlet	Exit
Pressure	**1.15 MPa**	**0.05MPa**
Velocity	**30 m/sec**	**15.5 m/sec**
Height above datum	**10 m**	**2m**

If the volume flow rate of the fluid is 40 m^3/s, estimate the net energy transfer from the fluid as work.

3. **Three grams of nitrogen gas at 6 atm and 160^{o}C is expanded adiabatically to double its initial volume and then compressed again at constant volume to its initial state. Calculate the work done on the gas. Draw the p-V diagram for the process. Specific heat ratio of nitrogen is 1.4.**
4. **Describe steady flow energy equation and**
    - **deduce suitable expression for the expansion of gas in a ga turbine with suitable assumptions.**
    - **apply the equation to a nozzle and derive an equation for velocity at exit.**
    - **Derive the suitable expression for the ideal compressor and specify the assumptions onder which such equation is aplicable.**
5. **a) Air expands isentropic process through a nozzle from 784 kPa and 220^{o}C to an exit presssure of 98 kPa. Detrmine the exit velocity and the mass flow rate, if the exit area is 0.0006m^2.**

   b) In an air compressor, air flows steadily at the rate of 0.5 kg/sec. At entry to the compressor, air has a pressure of 105 kPa and specific volume of 0.86 m^3/kg and at exit of the compressor those corresponding values are 705 kPa and 0.16 m^3/kg. neglect kinetic and potential energy change. The internal energy of air leaking the compressor is 95 kJ/kg greater than that of air entering. The cooling water in the compressor absorbs 60 kJ/sec. of heat from the air. Find power required to drive the compressor.
6. **Air contained in the cylinder and piston arrangement comprises the system. A cycle is completed by four process 1-2, 2-3, 3-4 and 4-1. The energy transfers are listed below. Complete the table and determine the network in kJ. Also check the validity of the first law of thermodynamics.**

Process	Q (kJ)	W (kJ)	ΔU (kJ)
1-2	40	?	25
2-3	20	-10	?
3-4	-20	?	?
4-1	0	+8	?

7. **Calculate the power developed and diameter of the inlet pipe, if a gas enters into the gas turbine at 5 kg/sec, 50 m/s with an enthalpy of 0.9MJ/kg. the heat loss to the surrounding is 0.025 MJ/kg. the heat loss to the surrounding is 0.025 MJ/kg. the heat loss to the surrounding is 0.025 MJ/kg. assume 100 kPa and 300 K at the inlet.**
8. **a. Define the following terms:**
   - **Thermodynamics**
   - **Macroscopic approach**
   - **Continuum**

   b. A gas of mass 1.5 kg undergoes a quasistatic expansion, which follows a relationship P=a+bV, where 'a' and 'b' are constants. The initial and final pressures are 1000 kPa and 200 kPa respectively and the corresponding volumes are 0.2 m^3 and 1.2 m^3. The specific internal energy of the gas is given by the relation U = (1.5PV – 85) kJ/kg, where P is in kPa and V is in m^3. Calculate the net heat transfer and the maximum internal energy of the gas attained during expansion.
9. **a) Define enthalpy. How is it related to internal energy?**
   b) A fluid is confined in a cylinder by a spring loaded, frictionless piston so that the pressure in the fluid is a linear function of the volume (p = a + bV) where U is in kJ, p is in kPa and V in cubic meter. If the fluid changes from an initial state of 170 kPa, 0.03 m^3 to a final state of 400 kPa, 0.06 m^3, with no work other than that done on the piston, find the direction and magnitude of the work and heat transfer.
10. **The electric heating system used in many houses consists of simple duct with resistance wire. Air is heated as it flows over resistance wires. Consider a 15 kW electric heating system. Air enters the heating section at 100 kPa and 17oC with a volume flow rate of 150 m3/min. if heat is lost from the air in the duct to the surroundings at a rate of 200 W, determine the exit temperature of air.**

UNIT II

SECOND LAW AND AVAILABILITY ANALYSIS

PART - A

1. **Define Clausius statement.**
2. **What is Perpetual motion machine of the second kind?**
3. **Define Kelvin Planck Statement.**
4. **Define Heat pump.**
5. **Define Heat engine.**

6. What are the assumptions made on heat engine?
7. State Carnot theorem.
8. What is meant by reversible process?
9. What is meant by irreversible process?
10. Explain entropy?
11. Define availability.
12. Define available energy and unavailable energy.
13. Explain the term source and sink.
14. What do you understand by the entropy principle?
15. What are the important characteristics of entropy?
16. What is reversed Carnot heat engine? What are the limitations of carnot cycle?
17. Why Rankine cycle is modified?
18. Name the various vapour power cycle.
19. Define efficiency ration.
20. Define overall efficiency.

PART – B

1) Air is compressed by an adiabatic compressor from 100 kPa and 12°C to a pressure of 800 kPa at a steady rate of 0.2 kg/s. if the isentropic efficiency of the compressor is 80 percent, determine the exit temperature of air and the required power input to the compressor.
2) a) A 200 m^3 rigid tank initially contains atmospheric air at 100 kPa and 300 K and is to be used as storage vessel for compressed air at 1 MPa and 300 K. Compressed air is to be supplied by a compressor that takes in atmospheric air at P_o = 100 kPa and T_o = 300 K. determine the minimum work required for this process.
   b) The interior lighting of refrigerators is provided by incandescent lamps whose switches are actuated by the opening of the refrigerator door. Consider a refrigerator whose 40 W light bulp remains on continuously as a result of a malfuntion of the switch. If the refrigerator has a co efficient performance of 1.3 and the cost of electricity is Rs. 8 per kWh, determine the increase in the energy consumptionof the refrigerator and its cost per year if the switch is not fixed.
3) a. A carnot heat engine receives 650 kJ of heat from a source of unknown temperature and rejects 250 kJ of it to a sink at 297 K. determine the temperature of the source and the thermal efficiency of the heat engine.
   b. A carnot heat engine receives heat from a reservoir at 1173 K at a rate of 800 kJ/min and reject the waste heat to the ambient air at 300 K. the entire work output of the heat engine is used to drive a refrigerator that removes heat from the refrigerated space at 268 K and transfers it to the same ambient air at 300 K. determine the maximum rate of the heat removal from the refrigerated space and the total rate of heat rejection to the ambient air.
4) a. what are the conditions for reversibility? Explain.
   b. An heat exchanger circulates 5000 kg/hr of water to cool oil from 150°C to 50°C. The rate of flow of oil is 2.5 kJ/kg.K. the water enters the heat exchanger at 21°C. Determine the net change in entropy due to heat exchange process, and the amount

of work obtained if cooling of oil is done by using the heat to run a carnot engine with sink temperature of 21^oC.

5) **a. deduce clausius inequality and interpret it.**

b. An ideal gas of 0.12 m3 is allowed to expand isentropically from 300 kPa and 120oC to 100 kPa, 5 kJ of heat is then transferred to the gas at constant pressure. Calculate the change in entropy for each process. Assume γ=1.4 and Cp=1.0035 kJ/kg.K. if these two processes are replaced by a reversible polytropic expansion, find the index of expansion between original and final states. What will be the total changes in entropy?

6) **a) A heat engine operating between two reservoirs at 100 K and 300 K is used to drive heat pump which extracts heat from the reservoir at 300 K at a rate twice that at which engine rejects heat to it. If the efficiency of the engine is 40 % of the maximum possible and the co efficient of performance of heat pump is 50 % of the maximum possible, make calculations for the temperature of the reservoir to which the heat pump rejects heat. Also work out the rate of heat rejection from the heat pump if the rate of supply of heat to the engine is 50 kW.**

b) Two kg of air at 500 kPa, 80^oC expands adiabatically in a closed system until its volume is doubled and its temperature becomes equal to that of the surroundings which is at 100 kPa, 5^oC for this process, determine

The maximum work

The change in availability and

The irreversibility

For air taken, C_v = 0.718 kJ/kg. K, u=C_v T where C_v is constant and Pv = mRT where P is pressure in kPa, V volume in m^3, 'm' mass in kg, R a constant equal to 0.287 kJ/kg K and T temperature in K.

7) **a. deduce the efficiency of carnot cycle in terms of temperature from its p-V diagram.**

b. Air is compressed from 100 kPa and 300 K to 5 bar isothermally and then it receives heat at constant pressure. It is finally returns to its initial condition by a constant volume path. Plot the cycle on p-V and T-s diagram and calculate the net heat and work transfer.

8) **a) Bring out the concept of entropy and importance of T-s diagram.**

b) Five kg of water at 303 K is mixed with one kg of ice at 0^oC. The system is open to atmosphere. Find the temperature of the mixture and the changr of entropy for both ice and water. Assume C_p of water as 4.18 kJ/kg-K and latent heat of ice as 334.5 kJ/kg. comment on the result based on the principle of increase in entropy.

9) **a) define the tem 'Irreversible process' and 'Reversible process'. Give an example of each.**

b) In a Carnot cycle the maximum pressure and temperature are limited to 18 bar and 410^oC. The volume ratio of isentropic compression is 6 and isothermal expansion is 1.5. assume the volume of the air at the beginning of isothermal expansion as $0.18m^3$. show the cycle on p-V and T-s diagrams and determine

- **the pressure and temperature at main points**
- **thermal efficiency of the cycle**

10) **a. State and prove Clausius inequality.**
b. A metal block with m = 5 kg, c = 0.4 kJ/kg.K at 40^{o}C is kept in a room at 20^{o}C. It is cooled in the following two ways:

- **Using a Carnot engine (executing integral numbeer of cycles) with the room itself as the cold reservoir;**
- **Naturally**

In each case, calculate the changes in entropy of the block, of the air of the room and of the universe. Assume that the metal block has constant specific heat.

UNIT III

PROPERTIES OF PURE SUBSTANCE AND STEAM POWER CYCLE

PART - A

1. Define specific steam consumption of an ideal Rankine cycle.
2. Name the different components in steam power plant working on Rankine cycle.
3. What are the effects of condenser pressure on the Rankine Cycle?
4. Mention the improvements made to increase the ideal efficiency of Rankine cycle.
5. Why reheat cycle is not used for low boiler pressure?
6. What are the disadvantages of reheating?
7. What are the advantages of reheat cycles?
8. Define latent heat of evaporation or Enthalpy of evaporation.
9. Explain the term super heated steam and super heating.
10. Explain heat of super heat or super heat enthalpy.
11. Explain the term critical point, critical temperature and critical pressure.
12. Define dryness fraction (or) What is the quality of steam?
13. Define enthalpy of steam.
14. How do you determine the state of steam?
15. Define triple point.
16. Define heat of vaporization.
17. Explain the terms, Degree of super heat, degree of sub-cooling.
18. What is the purpose of reheating?
19.Why are the temperature and pressure dependent properties in the saturated mixture region?
20. what are the four processes that make up the simple ideal rankine cycle?

PART – B

1. **a) A 0.5 m^3 vessel contains 10 kg refrigerant 134a at -20^{o}C. Determine the pressure, the total internal energy and the volume occupied by the liquid phase.**
   b) A rigid tank with a volume of 2.5 m^3 contains 15 kg of saturated liquid vapour mixture of water at 75^{o}C. Now the water is slowly heated. Determine the temperature at which the liquid in the tank is completely vapourized. Also, show the processes on T-v diagram with respect to saturation lines.

2. **Consider a steam powerplant that operates on a reheat rankine cycle ans has a net power output of 80MW. Steam enters the high pressure turbine at 10MPa and 500^oC and the low pressure turbine at 1 MPa and 500^oC. Steam leaves the condenser as a saturated liquid at a pressure of 10kPa. The isentropic efficiency of the turbine is 80 percent, and that of the pump is 95 percent. Show the cycle on a T-s diagram with respect to saturation lines, and determine**
    - **The quality (or temperature, if superheated) of the steam at the turbine exit,**
    - **The thermal efficiency of the cycle, and**
    - **The mass flow rate of the steam.**
3. **In a closed vessel the 100 kg of steam at 100 kPa, 0.5 dry is to be brought to a pressure of 1000 kPa inside vessel. Determine the mass of dry saturated steam admitted at 2000 kPa for raising pressure. Also determine the final quality.**
4. **A steam power plant running on Rankine cycle has steam entering HP turbine at 20 MPa, 500^oC and leaving LP turbine at 90% dryness. Considering condenser pressure of 0.005 MPa and reheating occuring up to the temperature of 500^oC determine,**
    - **The pressure at which steam leaves HP turbine**
    - **The thermal efficiency.**
    - **Work done**
5. **Consider a steam power plant operating on the ideal Rankine cycle. Steam enters the turbine at 3 MPa and 623 K and is condensed in the condenser at a pressure of 10 kPa. Determine (i) the thermal efficiency of this power plant, (ii) the thermal efficicency if steam is superheated to 873 K instead of 623 K, and (iii) the thermal efficiency if the boiler pressure is raised to 15 MPa while the turbine inlet temperature is maintained at 873 K.**
6. **Consider a steam power plant operating on the ideal reheat Rankine cycle. Steam enters the high pressure turbine at 15 MPa and 873 K and is condensed in the condenser at a pressure of 10 kPa. If the moisture content of the steam at the exit of the low pressure turbine is not to exceed 10.4 percent, determine (i) the pressure at which the steam should be reheated and (ii) the thermal efficiency of the cycle. Assume the steam is reheated to the inlet temperature of the high pressure turbine.**
7. **a) Draw p-T diagram and label various phases and transitions. Explain the process of isobaric heating above triple point pressure with the help of p-T diagram.**
   b) 2 kg of water at 200^oC are contained in a 20m^3 vessel. Determine the pressure, enthalpy, mass and volume of vapour within the vessel.
8. **a) Draw rankine cycle with one open type feed water heater. Assume the condition of the steam before entering the turbine to be superheated. Sketch the cycle on T-s diagram.**
   b) in an ideal reheat cycle, the steam enters the turbine at 30 bar and 500^oC after expansion to 5 bar, the steam is reheated to 500$^oC$and then expanded to the condenser pressure of 0.1 bar. Determine the cycle thermal efficiency, mass flow rate of steam. Take power output as 100 MW.

9. **In a single heater regenerative cycle the steam enters the turbine at 30 bar, 400^oC and the exhaust pressure is 0.10 bar. The feed water heater is a direct-contact type which operates at 5 bar. Find**
    - **The efficiency and the steam rate of the cycle, and**
    - **The increase in mean temperature of heat addition, efficiency and steam rate as compared to the rankine cycle (with out re generation) neglect pump work.**
10. **One kg of steam is contained in an elastic baloon of spherical shape which supports an internal pressure proportional to its diameter. The initial condition of steam is saturated vapour at 110^oC heat is transferred to steam until pressure reaches 200 kPa. Determine:**
    - **Final temperature**
    - **Heat transferred. Take C_{ps} = 2.25 kJ/kg.K**

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UNIT IV

IDEAL AND REAL GASES AND THERMODYNAMIC RELATIONS

1. Define Ideal gas.
2. Define Real gas.
3. What is equation of state?
4. State Boyle's law.
5. State Charle's law.
6. Explain the construction and give the use of generalized compressibility chart.
7. What do you mean by reduced properties?
8. Explain law of corresponding states.
9. Explain Dalton's law of partial pressure.
10. State Avogadro's Law.
11. What is Joule-Thomson coefficient?
12. What is compressibility factor?
13. What is partial pressure?
14. Define Dalton's law of partial pressure.
15. How does the Vander Waal's equation differ from the ideal gas equation of state?
16. Using the definition of mass and mole fractions derive a relation between them?
17. What is significance of compressibility factor?
18. Write the maxwell equation and its significance?
19. Is water vapour is ideal gas? Why?
20. In atmospheric air (at 101325 Pa) contains 21% oxygen and 79% nitrogen (vol. %), what is the partial pressure of oxygen?

PART – B

1) a) A rigid tank contains 2 k mol of N_2 and 6 k mol of CO2 gases at 300 K and 15 MPa. Estimate the volume of the tank on the basis of
   - The ideal gas equation of state
   - Compresibility factors and Amagat's law, and
   - Compressibility factors and Dalton's law.

   b) An insulated rigid tank is divided into two compartments by a partition. One compartment contains 7 kg of oxygen gas at 40oC and 100 kPa, and the other compartment contains 4 kg of nitrogen gas at 20oC and 150 kPa. Now the partition is removed, and the two gases are allowed to mix. Determine
   - the mixture temperature
   - the mixture pressure after equlilibrium has been established.
2) a) Using the ideal gas equation of state, verify
   - the cyclic relation and
   - the reciprocity relation at constant P.

   b) Show that the internal energy of an ideal gas and an incompressible substance is a function of temperature only, u = u (T).

   c) Derive expression $(\frac{\partial u}{\partial P})_T$ and $(\frac{\partial h}{\partial v})_T$ in terms of P,v, and T only.
3) In 5 kg of mixture of gases at 1.013 bar and 300 K the various constituents gases are as follows, 80% N_2, 18% O_2, 2% CO_2. Determine the specific heat at constant pressure, gas constant for the constituents and mixture and also molar mass of mixture taking $\gamma = 1.3$ for CO_2 universal gas constant = 8314 J/kg.K.
4) Derive the Clausius Clapeyron equation and Vander Waal's equations.
5) a) Using the Claypeyron equation. Estimate the value of the enthalpy of vapourization of refrigerant R-134a at 293 K, and compare it with the tabulated value.

   b) Show that $C_p - C_v = R$ for an ideal gas.
6) a) Show that the Joule – Thomson co efficient of an ideal gas is zero.

   b) Using the cyclic relation and the first Maxwell relation, derive other three Maxwell relations.
7) a) Deduce the Maxwell relations

   b) Explain joule thompson effect with the help of T-p diagram and derive the expression for Joule Thompson co efficient. Show that the value of this co efficient for an ideal gas is zero.
8) a) what are the differences between real and ideal gases?

   b)write down the Vander Waal's equation of state for real gases and how is it obtained from ideal gas equation by incorporating real gas corrections?

   c) A tank contains $0.2m^3$ of gas mixture composed of 4 kg of Nitrogen, 1 kg of oxygen and 0.5 kg of carbon-di oxide. If the temperature is 20^oC, determine the total pressure, gas constant and molar mass of the mixture.

9) **a) Entropy is a function of any two properties like P and V, P and T etc., for a pure substance with the help of Maxwell's Equation. Prove**

- **Tds = Cv.dT + T [ß/k].dv**
- **Tds = Cv.dT – V.ßdp.T**
- **Tds = [K Cv/ß].dp + [Cp/vß].dv.**

b) Determine chage of Internal energy and change of entropy when the gas obeys Vander Waal's equation.

10) **a) write down the Dalten's law of partial pressure and explain its importance.**

b) 0.45 kg of CO and 1 kg of air iscontained in a vessel of volume 0.4 m^3 at 15_oC. Air has 23.3% of O_2 and 76.7% of N_2 by mass. Calculate the partial pressure of each constituents and total pressure in the vessel. Molar masses of CO,O_2 and N^2 are 28, 32 and 28 kg/k mol.

UNIT V

GAS MIXTURES AND PSYCHROMETRY

PART – A

1. **What is humidification and dehumidification?**
2. **Differentiate absolute humidity and relative humidity.**
3. **What is effective temperature?**
4. **Represent the following psychometric process using skeleton psychometric chart?**
5. **Define Relative humidity.**
6. **Define degree of saturation.**
7. **What is meant by dry bulb temperature (DBT)?**
8. **What is meant by wet bulb temperature (WBT)?**
9. **Define dew point depression.**
10. **What is meant by adiabatic saturation temperature (or) thermodynamic wet bulb temperature?**
11. **Define sensible heat and latent heat.**
12. **What are the important psychometric process?**
13. **What is meant by adiabatic mixing?**
14. **What are the assumptions made in Vander Waal's equation of state?**
15. **Define coefficient of volume expansion.**
16. **State Helmholtz function.**
17. **What are thermodynamic properties?**
18. **Define throttling process.**
19. **Define isothermal compressibility.**
20. **Define psychometric.**

PART – B

[1] a) A 5m x 5m x 3m room contains air at 25^{o}C and 100 kPa at a relative humidity of 75 percent. Determine

- The partial pressure of dry air,
- The specific humidity
- The enthalpy per unit mass of the dry air, and
- The masses of the dry air and water vapour in the room

b) the dry and the wet bulp temperatures of atmospheric air at 1 atm (101.325 kPa) pressure are measured with a sling psychrometer and determined to be 25^{o}C and 15^{o}C respectively. Determine

- the specific humidity
- the relative humidity
- the enthalpy per unit mass of the dry air, and
- the masses of the dry air and water vapour in the room.

[2] a) What is sensible heat? How is the sensible heat loss from a human body affected by the

- skin temperature
- environment temperature, and
- air motion.

b) Saturated air leaving the cooling section of an air conditioning system at 14^{o}C at a rate of 50 m^3/min is mixed adiabatically with the outside air at 32^{o}Cand 60 percent relative humidity, at a rate of 20 m^3/min. assuming that the mixing processes occurs at a pressure of 1 atm, determine the specific humidity, the relative humidity, the dry bulb temperature, and the volume flow rate of the mixture.

[3] a) For the atmospheric air at room temperature of 30^{o}C and relative humidity of 60%. Determine partial pressure of air, humidity ratio,dew point temperature, density and enthalpy of air.

b) Two streams of moist air, one having flow rate of 3 kg/s at 30^{o}C and 30% relative humidity, other having flow rate of 2 kg/s at 35^{o}C and 85% relative humiddity get mixed adiabatically. Determine specific humidity and partial pressure of water vapour after mixing. Take C_p; stream = 1.86 kJ/kg.K

[4] a) What is the lowest temperature that air can attain in an evaporative cooler if it enters at 1 atm, 302 K, and 40 percent relative humidity?

b) consider a room tjat contains air at 1 atm, 308 K, and 40% relative humidity. Using the psychrometric chart, determine: the specific humidity, the enthalpy, the wet bulb temperature, the dew point temperature and the specific volume of the air.

[5] An air conditioning system is to take in outdoor air at 263 K and 30 percent relative humidity at a steady rate of 45 m^3/min and to condition it to 298 K and 60 percent relative humidity. The outdoor air is first heated to 295 K in the heating section and then humidified by the injection of hot steam in the humidifying section. Assuming the entire process takes place at a pressure of 100 kPa, determine (i) the rate of heat supply in the heating section and (ii) the mass flow rate of the steam required in the humidifying section.

[6] a) Draw the psychrometric chart and show any two psychrometric processes on it.

b) A sample of moist air at 1 atm and 25°C has a moisture content of 0.01% by volume. Determine the humidity ratio, the partial pressure of water vapour, the degree of saturation, the relative humidity and the dew point temperature.

[7] a) Describe the process of adiabatic mixing of two streams in terms of humidity and / or enthalpy.

b) The temperature of the windows ina house on a day in winter is 5°C. When the temperature in the room is 23°C, and the barometric pressure is 74.88 cm Hg, what would be the maximum relative humidity that could be maintained in the room without condensation on the windows panes? Undr these conditions, find the partial pressure of the water vapour and air, the specific humidity and the density of the mixture.

[8]a) The atmospheric air at 30°C DBT and 75% RH enters a cooling coil at the rate of 200 m^3/min. the coil dew point temperature is 14°C and the by pass factor is 0.1 determine

- **The temperature of air leaving the coil**
- **Capacity of the cooling coil in TR**
- **The amount of water vapour removed.**
- **Sensible heating factor for the process.**

b) The volume flow rate of air is 800 m^3/min of re circulated at 22°C DBT and 10°C dew point temperature is to be mixed with 300 m^3/min of fresh air is 30°C DBT and 50% RH. Determine the enthalpy, specific volume, humidity ratio and dew point temperature of the mixture.

[9] a) Differentiate between

- **Dry bulb temperature and wet bulb temperature**
- **Wet bulb depression and dew point depression**

b) Air at 16°C and 25°C relative humidity passes through a heater and then through a humidfier to reach final dry bulb temperature of 30°C and 50% relative humidity. Calculate the heat and moisture added to the air. What is the sensible heat factor.

[10] a) In an adiabatic mixing of two streams, derive the relationship among the ratio of mass of streams, ratio of enthalpy change and ratio of specific humidity change.

b) Saturate air at 20°C at a rate of 1.167 m^3/sec is mixed adiabatically with the outside air at 30°C and 50% relative humidity at a rate of 0.5 m^3/sec. assuming adiabatic mixing condition of 1 atm, determine specific humidity, relative humidity, dry bulb temperature and volume flow rate of the mixture.