**AALIM MUHAMMED SALEGH COLLEGE OF ENGINEERING**

**DEPARTMENT OF MECHANICAL ENGINEERING**

**QUESTION BANK**

**DEPARTMENT: MECH SEMESTER: III**

**SUBJECT CODE / Name: ME 6301 ENGINEERING THERMODYNAMICS**

**PART-B (16 MARKS)**

**UNIT-I**

1. (a) Apply steady flow energy equation for a nozzle. State the assumptions made. (6)

(b) 0.5 kg of a gas expands reversibly and adiabatically from the initial condition of 300 kN/m2 and 195º C. The final pressure of the gas after expansion is 95 kN/m2. The temperature falls by 160ºC during the expansion. Calculate (i) Work done during the process (ii) change in internal energy (iii) change in enthalpy and (iv) initial and final volume of the gas. Take R=0.29 kJ/kg K. (10)

1. (a) Prove that internal energy is a property. (4)

(b) 1 kg of gas at 1.1 bar, 27ºC is compressed to 6.6 bar as per the law pv1.3=C. Calculate work and heat transfer, if (i) When the gas is ethane (C2H6) with molar mass of 30 kg/k mol and Cp of 2.1 kJ/kg K. (ii) When the gas is argon (Ar) with molar mass of 40 kg/k mol and Cp of 0.52 kJ/kg K. (12)

1. A blower handles 1kg/sec of air at 293 K and consumes a power of 15 KW. The inlet and outlet velocities of air are 100m/s and 150m/s respectively. Find the exit air temperature, assuming adiabatic conditions. Take Cp of air as 1.005 kJ/kg K. (16)
2. (a) Derive an expression for the work transfer in an isothermal process. (4)

(b) In a gas turbine installation, the gases enter the turbine at the rate of 5kg/sec with a velocity of 50m/sec and enthalpy of 900 kJ/kg and leave the turbine with 150m/sec and enthalpy of 400 kJ/kg. The loss of heat from the gases to the surroundings is 25 kJ/kg. Assume R=0.285 kJ/kg K, Cp = 1.004 kJ/kg K and inlet conditions to be at 100 kPa and 27ºC. Determine the work done and diameter of the inlet pipe. (12)

1. 1.5 kg of certain gas at a pressure of 8 bar and 20ºC occupies the volume of 0.5 m3. It expands adiabatically to a pressure of 0.9 bar and volume 0.73 m3. Determine the work done during the process, gas constant, ratio of the specific heats, values of two specific heats, change in internal energy and change in enthalpy. (16)
2. In a steady flow system, a working substance flows at a rate of 4 kg/s enters a pressure of 620 kN/m2 at a velocity of 300 m/s. The internal energy is 2100 kJ/kg and specific volume 0.37 m3/kg. It leaves at a pressure of 130 kN/m2, a velocity of 150 m/s, internal energy of 1500 kJ/kg and specific volume of 1.2 m3/kg. During its passage in the system, the substance has a heat transfer loss of 30 kJ/kg to its surroundings. Determine the power of the system. State that it is from (or) to the system. (16)
3. A gas flows steadily through compressor. The gas enters the compressor at a temperature of 16ºC, a pressure of 100 kPa, and an enthalpy of 391.2 kJ/kg. The gas leaves the compressor at a temperature of 245ºC, a pressure of 0.6 MPa, and an enthalpy of 534.5 kJ/kg. There is no heat transfer to or from the gas as it flows through the compressor. Evaluate the external work done per unit mass of gas when the velocity at entry 80 m/s and that at exit is 160 m/s. (16)

**UNIT-II**

1. (a) “Two reversible adiabatic lines cannot intersect”. Is this statement true or false? Justify the answer. (3)

(b) A house hold refrigerator is maintained at a temperature of 275 K. every time the door is opened, warm material is placed inside, introducing an average of 420 kJ, but making only a small change in the temperature of the refrigerator. The door is opened 20 times a day, and the refrigerator operates at 15% of the ideal COP. The cost of work is Rs. 2.50 per kWhr. What is the bill for the month of April for this refrigerator? The atmosphere is at 303 K. (13)

1. (a) State Carnot theorem. (3)

(b) Deduce the expression for the entropy change in terms of pressure and temperature.

(13)

1. 5 kg of air at 2 bar and 30ºC is compressed to 24 bar pressure according to the law pV1.2 =Constant. After compression air is cooled at constant volume to 30ºC. Determine (i) Volume and temperature at the end of compression, (ii)Change of entropy during compression, (iii)Change in entropy during constant volume cooling. Take Cp= 1.005 kJ/kg K, Cv = 0.718 kJ/kg K. (16)
2. (a) An inventor claims that his proposed engine has the following specification: Power developed = 50 kW; Fuel burnt = 3 kg/hr; Calorific value of the fuel = 75000 kJ/kg; Temperature limits = 27ºC and 627ºC. Find out whether it is possible or not. (4)

(b) Air in a closed vessel of fixed volume 0.15 m3, exerts pressure of 12 bar at 250ºC. If the vessel is cooled so that the pressure falls to 3.5 bar, determine the final temperature, heat transfer and change in entropy. (12)

1. One kg of ice at -5ºC is exposed to the atmosphere which is at 20ºC. The ice melts and comes into thermal equilibrium with the atmosphere (i) determine the entropy increase of the turbine (ii) what is the minimum amount of work necessary to convert the water back to ice at -5ºC? Assume Cp for ice as 2.093 kJ/kg K and the latent heat of fusion of ice as 333.3 kJ/kg. (16)
2. A heat engine is used to drive a heat pump. The heat transfer from the heat engine and from the heat pump is used to heat the water circulating through the radiators of building. The efficiency of the heat engine is 27% and COP of the heat pump is 4. (i) Draw the neat diagram of the arrangement and (ii) evaluate the ratio of heat transfer to the circulating water to the heat transfer to the heat engine. (16)
3. A single stage air turbine is to operate with air inlet pressure and temperature of 1 bar and 600 K. During the expansion the turbine losses are 20 kJ/kg to the surroundings which is at 1 bar and 300 K. For 1 kg of mass flow rate determine (i) Decrease in availability (ii) maximum work (iii) the irreversibility. (16)
4. 0.2 kg of air at 1.5 bar and 27ºC is compressed to a pressure of 15 bar according to the law pV1.25 = Constant. Determine work done on or by air, heat flow to or from the air, increase or decrease in entropy. (16)

**UNIT-III**

1. (a) What do you understand by dryness fraction? What is its importance? (3)

(b) A rigid tank of 0.03 m3 capacity contains wet vapour at 80 kPa. If the wet vapour mass is 12 kg, calculate the heat added and the quality of the mixture when the pressure inside the tank reaches 7MPa. (13)

1. (a) What are the methods for improving the performance of Rankine cycle? (3)

(b) Steam enters the turbine at 3 MPa and 400ºC and is condensed at 10 kPa. Some quantity of steam leaves the turbine at 0.6 MPa and enters open feed water heater. Compute the fraction of the steam extracted per kg of steam and cycle thermal efficiency.

(13)

1. A vessel of volume 0.04 m3 contains a mixture of saturated water and steam at a temperature of 250ºC. The mass of the liquid present is 9 kg. Find the pressure, mass, specific volume, enthalpy, entropy and internal energy. (16)
2. In a single heater regenerative cycle the steam enters the turbine at 30 bar and 400ºC and the turbine exhaust pressure is 0.10 bar. The condensate is heated in a direct contact type heater 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. Neglect pump work. (16)
3. A steam power plant uses steam at boiler pressure of 150 bar and temperature 550ºC with reheat at 40 bar and 550ºC at condenser pressure of 0.1 bar. Find the quality of steam at turbine exhaust, cycle efficiency and the steam rate. (16)
4. A reheat cycle operating between 30 and 0.04 bar has a superheat and reheat temperature of 450ºC. The first expansion takes place till the steam is dry saturated and then reheat is given. Neglecting feed pump work, determine the ideal cycle efficiency. (16)
5. In a regenerative cycle, the steam pressure at turbine inlet is 30 bar and the exhaust is at 0.04 bar. The steam is initially saturated. Enough steam is bled off at the optimum pressure of 3 bar to heat the feed water. Determine the cycle efficiency. Neglect pump work. (16)

**UNIT-IV**

1. (a) Write down the Dalton’s law of partial pressure and explain its importance. (3)

(b) 0.45 kg of CO and 1 kg of air is contained in a vessel of volume 0.4 m3 at 15ºC. Air has 23.3% of O2 and 76.7% of N2 by mass. Calculate the partial pressure of each constituent and total pressure in the vessel. Molar masses of CO, O2 and N2 are 28, 32 and 28 kg/K mol. (13)

1. (a) What is the use of Clausius clapeyron equation? And write it down for liquid-vapour region. (6)

(b) Explain the flow process of a real gas through a throttle valve. Derive the Expression for Joule Thompson coefficient and deduce its value for an ideal gas. (10)

1. Derive Tds equation when (i) T and V independent (ii) T and P independent and (iii) P and V independent. (16)
2. Explain and derive the (i) Joule Thompson coefficient (ii) Clausius clapeyron equation.

(16)

1. (a) Prove that the total pressure is the sum of partial pressures. (4)

(b) A closed vessel has a capacity of 0.5 m3. It contains 20% nitrogen and 20% oxygen 60% carbon dioxide by volume at 20ºC and 1 MPa. Calculate the molecular mass, gas constant, mass percentages, and the mass of mixture. (12)

1. A mixture of 2 kg oxygen and 2 kg Argon is in an insulated piston cylinder arrangement at 100 kPa, 300K. The piston is now compresses the mixture to half its initial volume. Molecular weight of oxygen is 32 and for argon is 40. Ratio of specific heats for oxygen is 1.39 and for argon is 1.667. (16)
2. A mixture of ideal gases consists of 3 kg of nitrogen and 5 kg of carbon dioxide at a pressure of 300 kPa and a temperature of 20ºC, Find (i) The mole fraction of each constituent (ii) The equivalent molecular weight of the mixture (iii) The equivalent gas constant of the mixture (iv) The partial pressures and partial volumes. (16)

**UNIT-V**

1. (a) Describe the adiabatic cooling process and deduce the expression for its enthalpy. (8)

(b) Air at 20ºC, 40% relative humidity is mixed adiabatically with air at 40ºC, 40% RH in the ratio of 1 kg of former with 2 kg of later (on dry basis). Find the final condition (humidity and enthalpy) of air. (8)

1. (a) Explain the process of cooling and dehumidification of air. (8)

(b) 30 m3/min of moist air at 15ºC DBT and 13ºC WBT are mixed with 12 m3/min of moist air at 25ºC DBT and 18ºC WBT. Determine DBT and WBT of the mixture assuming the barometric pressure is one atmosphere. (8)

1. Atmospheric air at 1.0132 bar has a DBT of 32ºC and a WBT of 26ºC. Compute (i) The partial pressure of water vapour, (ii) The specific humidity, (iii) The dew point temperature, (iv)The relative humidity, (v) The degree of saturation, (vi) The density of air in the mixture and (vii) The enthalpy of the mixture. Use thermodynamic table only.

(16)

1. An air- water vapour mixture at 0.1 MPa, 30ºC, 80% RH has a volume of 50 m3. Calculate the specific humidity, dew point, WBT, mass of dry air and mass of water vapour. (16)
2. Saturated air at 20ºC at a rate of 1.16 m3/sec is mixed adiabatically with the outside air at 35ºC and 50% RH at the rate of 0.5 m3/sec. Assuming adiabatic mixing condition at 1 atm, determine specific humidity, relative humidity, DBT and volume flow rate of the mixture. (16)
3. A steam of air at 1 atm, 18ºC, and a relative humidity of 30% is flowing at the rate of 14.15 m3/min. A second stream at 1 atm, 38ºC and a relative humidity of 50% is flowing at the rate of 8.5 m3/min. The two streams are mixed adiabatically to form a third stream at 1 atm. Determine the specific humidity, the relative humidity and the temperature of the third stream. (16)
4. An air conditioning system is designed under the following conditions:

Outdoor conditions 15ºC DBT and 10ºC WBT

Required conditions 20ºC DBT and 50% RH

Amount of free air circulated 0.25 m3/min person.

Setting capacity- 50 Persons

The required condition is achieved first by heating and then by adiabatic humidifying. Determine the following (i) Capacity of heating coil in kW and (ii) Capacity of humidifier. (16)