SHREE SATHYAM COLLEGE OF ENGINEERING AND TECHNOLOGY

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Question Bank (16 Mark)

UNIT I - BASICS, ZEROTH AND FIRST LAW

1. In an isentropic flow through nozzle, air flows at the rate of 600 kg/hr. At inlet to the nozzle, pressure is 2 MPa and temperature is 127°C. The exit pressure is 0.5 MPa. Initial air velocity is 300 mig determine (i) Exit velocity of air (ii) Inlet and exit area of nozzle.

2. A centrifugal pump delivers 2750 kg of water per minute from initial pressure of 0.8 bar absolute to a final pressure of 2.8 bar absolute. The suction is 2 m below and the delivery is 5 m above the centre of pump. If the suction and delivery pipes are of 15 cm and 1.0 cm diameter respectively, make calculation for power required to run the pump

3. A reciprocating air compressor takes in 2 m3 /min air at 0.11 MPa, 293 K which it delivers at 1.5 MPa, 384 K to an after cooler 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.

4. A rigid tank containing 0.4 m3 of air at 400 kPa and 30°C 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°C at all times. Determine the heat transfer for this process.

5. 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 17°C 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.

6. In a gas turbine installation air is heated inside heat exchanger up to 750o C from ambient temperature of 27 0 C. Hot air then enters into gas turbine with the velocity of 50 m/s and leaves at 600 0 C. Air leaving turbine enters a nozzle at 60 m/s velocity and leaves nozzle at temperature of 500 o C For unit mass flow rate of air determine the following assuming adiabatic expansion in turbine and nozzle, a. Heat transfer to air in heat exchanger b. Power output from turbine c. Velocity at exit of nozzle. Take up for air as 1.005 kJ / kg. K.

7. 25 people attended a farewell party in a small room of size 10 _ 8 m and have a 5 m ceiling. Each person gives up 350 kJ of heat per hour. Assuming that the room is completely sealed off

and insulated, calculate the air temperature rise occurring in 10 minutes. Assume Cv of air 0.718 kJ/kg K and R = 0:287 kJ/kg K and each person occupies a volume of 0.05 m3. Take p = 101.325 kPa and T = 20o C.

8. Air at a temperature of 15o C passes through a heat exchanger at a velocity of 30 m/s where its temperature is raised to 800o C. It then enters a turbine with the same velocity of 30 m/s and expands until the temperature falls to 650o C. On leaving the turbine, the air is taken at a velocity of 60 m/s to a nozzle where it expands until the temperature has fallen to 500o C. If the air flow rate is 2 kg /s, Calculate (a) the rate of heat transfer to the air in the heat exchanger (b) the power output from the turbine assuming no heat loss, and (c) the velocity at exit from the nozzle, assuming no heat loss. Take the enthalpy of air as h = Cp.t, where Cp is the specific heat equal to 1.005 kJ / kg.K and t is the temperature.

9. A three process cycle operating with nitrogen as the working substance has constant temperature compression at 34o C with initial pressure 100 kPa. Then the gas undergoes a constant volume heating and then polytrophic expansion with 1.35 as index of compression. The isothermal compression requires – 67 kJ / kg of work. Determine (i) P, v and T around the cycle. (ii) Heat in and out (iii) Net work. For nitrogen gas, Cv = 0.7431 kJ / kg.K.

10. A room of four persons has two fans has two fans, each consuming 0.18 kW power, and three 100 W lamps. Ventilation air at the rate of 80 kg / hr enters with an enthalpy of 84 kJ / kg and leaves with an enthalpy of 59 kJ / kg. If each person puts out heat at the rate of 630 kJ / hr. Determine the rate at which heat is to be removed by a room cooler, so that a steady state is maintained in the room

11. A gas flows steadily through compressor. The gas enters the compressor at a temperature of 16o C, a pressure of 100 kpa, and an enthalpy of 391.2 kJ / kg. The gas leaves the compressor at a temperature of 245o C, a pressure of 0.6 MPa, and an enthalpy of 535.5 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

UNIT II - SECOND LAW & ENTROPY

1. 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 the 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.

2. One kg of ail' is contained in a piston cylinder assembly at 10 bar pressure and 500 K temperature. The piston moves outwards and the air expands to 2 bar pressure and 350 K temperature. Determine the maximum work obtainable. Assume the environmental conditions to be 1 bar and 290 K. Also make calculations for the availability in the initial and final states.

3. 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 40W light bulb remains on continuously as a result of a malfunction of the switch. If the refrigerator has a coefficient of performance of 1.3 and the cost of electricity is Rs. 8 per kWh, determine the increase in the energy consumption of the refrigerator and its cost per year if the switch is not fixed.

4. 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

5. A Carnot heat engine receives heat from a reservoir at 1173 K at a rate of 800kJ/min and rejects 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 heat removal from the refrigerated space and the total rate of heat rejection to the ambient air.

6. 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.

7. A 200 m3 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 P0 = 100 kPa and T0 = 300 K. Determine the minimum work required for this process.

8. An engine is supplied with 1120 kJ/s of heat. The source and sink temperature are maintained at 560 K and 280 K. Determine whether the following cases represent the reversible, irreversible or impossible heat engines. (1) 900 kW of heat rejected (2) 560 kW of heat rejected (3) 108 kW of heat rejected.

9. A heat pump working on the Carnot cycle takes in heat from a reservoir at 5o C and delivers heat to a reservoir at 60o C. A heat engine is driven by a source at 840o C and rejects heat to a

reservoir at 60o C. The reversible heat engine, in addition to driving the heat pump, also drives a machine that absorbs 30 kW. If the heat pump extracts 17 kJ/s from the 5o C reservoir, determine (1) the rate of heat supply from the 840 C source, and (2) the rate of heat rejection to the 60o C sink.

10. A heat exchanger circulates 5000 kg/hr of water to cool oil from 150o C to 50o C. The rate of flow of oil is 2500 kg/hr. The average specific heat of oil is 2.5 kJ/kgK. The water enters the heat exchanger at 21o C. Determine the net change in the 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 21o C.

11. An ideal gas of 0.12 m3 is allowed to expand isentropically from 300kPa and 120o C 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?

12. 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 atmospheric is at 303 K.

13. A heat pump working on the Carnot cycle takes in heat from a reservoir at 5o C and delivers heat to a reservoir at 60o C. The heat pump is driven by a reversible heat engine which takes heat from reservoir at 840o C and rejects heat to a reservoir at 60o C. The reversible heat engine also drives a machine that absorbs 30 kW. If the heat pump extracts 17 kJ / s from the reservoir at 5o C, determine (1) the rate of heat supply from 840o C source, and (2) the rate of heat rejection to 60o C sink.

UNIT III AVAILABILITY AND APPLICATIONS OF II LAW

1. In a Carnot heat engine 50g of air acts as the working substance. The peak cycle temperature is 930 K and the maximum pressure is 8.4x 103 kPa. The heat addition per cycle is 4.2 kJ. Determine the maximum cylinder volume if the minimum temperature during the cycle is 315 K.

2. 5 kg of air expands isothermally from 1 m3 to 5 m3 . Assuming air to be ideal gas with constant specific heats, compute the change in entropy of air during the process.

3. An inventor claims to have developed an engine which receives 1000 kJ at a temperature of 160o C. It rejects heat at a temperature of 5o C and delivers 0.12 kWh of

4. In a closed system air is at a pressure of 1 bar, temperature of 300 K and volume of 0.025 m3 . The system executes the following processes during the completion of thermodynamic cycle: 1-2; constant volume heat addition till pressure reaches 3.8 bar, 2- 3; constant pressure cooling of air, 3-1; isothermal heating to initial state. Determine the change in entropy in each process. Take Cv = 0.718 kJ / kg K, R=287 J/kgK.

5. 1 kg of ice at -10o C is exposed to atmosphere at 30o C. After some time, the ice melts to water and water temperature becomes 30o C. Determine the entropy increase of the universe. Take Cp ice = 2.093 kJ / kgK and the latent heat of ice =333.3 kJ/Kg.

6. An refrigerator operating between two identical bodies cools one of the bodies to a temperature T2. Initially both bodies are at temperature T1. Deduce the expression for the minimum specific work input, taking their specific heat as c.

7. 5 m3 of air at 2 bar, 27o C is compressed up to 6 bar pressure following pv1.3 = constant. It is subsequently expanded adiabatically to 2 bar. Considering the two processes to be reversible, determine the network, net heat transfer, and change in entropy. Also plot the processes on T-S and P-V diagrams.

8. If the required input to run the pump is developed by a reversible engine which receives heat at 380o C and rejects heat to atmosphere, then determine the overall C.O. P. of the system.

9. A reversible heat pump is used to maintain a temperature of 0o C in a refrigerator when it rejects the heat to the surroundings at 25o C. If the heat removal rate from the refrigerator is 1440 kJ / min, determine the C.O.P. of the machine and work input required.

10. 3 kg of air at 500 kPa, 90o C expands adiabatically in a closed system until its volume is doubled and its temperature becomes equal to that of the surroundings at 100 kPa and 10o C. Find the maximum work, change in availability and irreversibility.

11. Two Carnot engines A and B are operated in series. The first one receives heat at 870o K and rejects to a reservoir at T. B receives heat rejected by the first engine and it turns rejects to a sink at 300o K. Find the temperature T for (1) Equal work outputs of both engines (2) Same efficiencies

12. Helium enters an actual turbine at 300 kPa, 300o C and expands to 100 kPa, 150o C. Heat transfer to atmosphere at 101.325 kPa, 25o C amounts to 7 kJ / kg. Calculate the entering

stream availability, leaving stream availability and maximum work. For helium, Cp = 5.2 kJ / kg and molecular weight = 4.003 kg /kg- mol.

13. An irreversible heat engine with 66% efficiency of the maximum possible is operating between 1000 K and 300 K. If it delivers 3 kW of work, determine the heat extracted from the high temperature reservoir and heat rejected to low temperature reservoir.

14. A metal block with m = 5 kg, c = 0.4 kJ / kg.K at 40o C is kept in a room at 20o C. It is cooled in the following two days: (1) Using a Carnot engine (executing integral number of cycles) with the room itself as the cold reservoir; (2) 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.

15. An aluminium block (Cp = 400 J / kgK) with a mass of 5 kg is initially at 40o C in room air at 20o C. It is cooled reversibly by transferring heat to a completely reversible cyclic heat engine until the block reaches 20o C. The 20o C room air serves as a constant temperature sink for the engine. Compute (1) The change in entropy for the block, (2) The change in entropy for the room air, (3) The work done by the engine

UNIT IV PROPERTIES OF PURE SUBSTANCES

1.Steam at 30 bar and 3500 C is expanded in a non flow isothermal process to a pressure of 1 bar. The temperature and pressure of the surroundings are 250 C and 100 kPa respectively. Determine the maximum work that can be obtained from this process per kg of steam. Also find the maximum useful work.

2.A vessel of volume 0.04m3 contains a mixture of saturated water and steam at a temperature of 2500 C. The mass of the liquid present is 9 kg. Find the pressure, mass, specific volume, enthalpy, entropy and internal energy.

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

4. Steam initially at 0.3Mpa, 2500 C is cooled at constant volume. At what temperature will the steam become saturated vapour? What is the quality at 800 C.Also find what is the heat transferred per kg of steam in cooling from 2500 C to 800 C.

5. Ten kg of water of 45o C is heated at a constant pressure of 10 bars until it becomes superheated vapour at 3000 C. Find the changes in volume, enthalpy, internal energy and entropy.

6. 1 kg of steam initially dry saturated at 1.1 MPa expands in a cylinder following the law pv1.13= C. The pressure at the end of expansion is 0.1MPa. Determine: (i) The final volume (ii) final dryness fraction (iii) work done (iv) The change in internal energy (v) the heat transferred.

7. Steam at a pressure of 15bar and 2500 C expands according to the law pV1.25=C to a pressure of 1.5 bar. Evaluate the final conditions, work done, heat transfer and change in entropy. The mass of the system is 0.8kg.

8. . In steam generator compressed water at 10 MPa, 300 C enters a 30 mm diameter tube at the rate of 3 litres /sec. Steam at 9 MPa and 4000 C exit the tube. Find the rate of heat transfer.

9. Steam at 0.8 MPa, 2500 C and flowing at the rate of 1 kg/s passes into a pipe carrying wet steam at 0.8 MPa, 0.95 dry. After adiabatic mixing the flow rate is 2.3 kg/s. Determine the properties of the steam after mixing.

10. Two streams of steam, one at 2 MPa, 3000 C and the other at 2 MPa, 4000 C, mix in a steady flow adiabatic process. The rates of flow of the two streams are 3 kg/min and 2 kg/min respectively. Evaluate the final temperature of the emerging steam, if there is no pressure drop due to the mixing process. What would be the rate of increase in the entropy of the universe? This steam with negligible velocity now expands adiabatically in a nozzle to a pressure of 1 kPa. Determine the exit velocity of the stream and exit area of the nozzle.

11. A rigid tank with a volume of 2.5 m3 contains 15 kg of saturated liquid vapour mixture of water at 75°C. Now the water is slowly heated. Determine the temperature at which the liquid in the tank is completely vaporized. Also, show the processes on T-v diagram with respect to saturation lines.

12. Steam flows through a small turbine at the rate of 5000 kg/h entering at 15 bar, 3000 C and leaving at 0.1bar with 4% moisture. The steam enters at 80m/s at a point 2 m above the discharge and leaves at 40m/s. compute the shaft power assuming that the device is adiabatic but considering kinetic and potential energies. Calculate the diameters of the inlet and discharge tubes.

13. A steam power plant running on Rankine cycle has steam entering HP turbine at 20 MPa, 5000 C and leaving LP turbine at 90% dryness. Considering condenser pressure of 0.005 MPa and reheating occurring up to the temperature of 5000 C determine, (i) The pressure at which steam leaves HP turbine (ii) The thermal efficiency. (iii) Work done.

14. . In a Rankine cycle, the steam at inlet to turbine is saturated at a pressure of 35 bar and the exhaust pressure is 0.2 bar. The flow rate of steam is 9.5 kg/s. Determine (1) the pump work (2) the turbine work (3) Rankine efficiency (4) condenser heat flow (5) work ratio and (6) specific steam consumption

15. Steam at a pressure of 2.5 MPa and 500°C is expanded in a steam turbine to a condenser pressure of 0.05 MPa. Determine for Rankine cycle: (i) The thermal efficiency of Rankine cycle (ii) Specific steam consumption. If the steam pressure is reduced to 1 MPa and the temperature is kept same 500°C. Determine the thermal efficiency and the specific steam consumption. Neglect feed pump work,

16. . 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 efficiency 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.

UNIT-V GASE MIXTURES AND THERMODYNAMIC RELATIONS

1. Write down the Dalton's Law of Partial Pressure and Explain its importance
2. ''Deive maxwell's equation''
3. Derive the clausis-clapey Equation
4. Derive the Vander waal's equation
5. Derive Tds equation taking temp, volume, and temp pressure a independent properties
6. Show that the Joule-Thamson Co-efficient of an ideal gas is zero
7. Describe Joule Kelvin effect with the help of T -P diagram
8. A certain ideal gas has (R)=290 J/kg.K and γ=1.35
   a. Determine the values of a C_p and C_v
   b. The mass of the gas it is filled in a vessel of 0.5m^3 capacity till the pressure
   c. c.inside becomes 4 bar gauge and the temp is 27^0C

If 40 kJ of heat is given to the vessel, when the vessel is closed.
Determine the resting temp and pressure take the atm presser=100 Kpa.

(9) A container of 3m^3 capacity contains 10 kg of co_2 at 27^0. Estimate the pressuree Exereted by co_2 by using

(1) Perfect gas equation
(2) Vander Waal's equation
(3) Beattie Bridgeman equation

10.One kg of ideal gas is heated from 50^oC to 150^oC. If R = 280 kj/kg.k and γ = 1.35 for the gas,

Determine,

(1) C_p and C_v

(2) Change in Internal energy

(3) Change in enthalpy

(4) Change in flow energ